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Front cover photo: Field study at rock faces near Johnsbach (Styria, Austria); © M. Sonnleitner
Back cover photo: “Workshop Alpine Land Snails” 2017 participants; © M. Sonnleitner

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"On the rocks"– Wissenschaft im Wirtshaus

Preface

The Workshop "Alpine Land Snails 2017" took place again in Johnsbach, Styria, Austria, this year from August, 20 - 26. Austrian biologists and colleagues from Slovenia, Russia, Montenegro, Italy, Greece, Germany, and Hungary have gathered in this extraordinary place in the Gesäuse to perform collecting trips and field experiments, to exchange results and experiences.
This year's theme was "On the rocks". We focused on rock dwelling snails and performed a field study on population size and species diversity at several rock sites. The scientific lectures (and some social events) were based at famous Kölblwirt as well as for two days at the renowned alpine refuge Hesshütte on the Hochtor Mountain massive at 1700 m.a.s.l. In the surrounding mountains, we collected data about the high alpine gastropod faunas. But this workshop again included also some "extra-snailities". Once more we had entomologists in the team and they searched for dragonflies in the region. Moreover, we staged again an evening for the public under the motto "Pub Science" ("Wissenschaft im Wirtshaus") which focused on the biology and ecological needs of rock dwelling animals and plants. This public event took place on Sunday, August 20th, at Köblwirt. The research activities lasted until August 26th.
The workshop was organized by the Natural History Museum Vienna together with the Nationalpark Gesäuse, supported by the society "Friends of the NHMW", the society "Mollusc Research Austria", and kindly hosted by our friends at Kölblwirt and Hesshütte.

Vienna, August 2018 Helmut Sattmann, Elisabeth Haring

Contents

Workshop schedule

Sunday 20th

Afternoon	Arriving at Kölblwirt
	First inspection of study sites / optional: Alm Excursion
Evening	18:00 Begrüßung – Welcome and introduction
	Wissenschaft im Wirtshaus: Leben am Fels
	Pub lectures: Living on rocks

Monday 21st

	8:45 Introductory lecture: Elisabeth Haring & Helmut Sattmann
Excursion start	9:30-12:00 Set up of rock site studies
Daytime	Excursion moors and wetland / optional: Odelstein Cave Tour
Afternoon	optional - rock site studies
Evening	17:30 Group photo at Kölblwirt
	19:00 *Snail lectures* – The genus *Montenegrina*

Tuesday 22nd

Excursion start	9:00
Daytime	Excursion Sulzkarsee / optional Sulzkarsee via Hartelsgraben
	Dragonflies, water molluscs, gorge molluscs
Evening	19:00 *Snail lectures* – Living on rocks in the Balkans

Wednesday 23rd

Excursion start	9:00 Rock site studies
Daytime	Excursions to Neuburgalm, Gscheidegg and Schneckenalm
Evening	19:00 *Snail lectures* – Open lecture
	Poster presentations

Thursday 24th

Excursion start	9:00 Departure from Kölblwirt / Ascent to Hesshütte
Afternoon	Excursion to surroundings: *Cylindrus obtusus* sightseeing
Evening	Debriefing

Friday 25th

Daytime	Excursion to Zinödl / Planspitze - Seekarsee / Hochtor
Evening	Farewell party

Samstag/Saturday 26th

Breakfast	8:00
	Descent from Hesshütte to Kölblwirt and departure from Johnsbach

Vorträge / Lectures

Sunday 20th

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Josef Greimler: Pflanzenleben im Fels
Michael Duda: Schnecken in Fels und Schutt
Daniel Kreiner: Federn im Fels – Vögel als Felsbewohner im Nationalpark Gesäuse

Monday 21st

Zoltan Feher: Range-constrained co-occurrence simulation reveals little niche partitioning among rock-dwelling *Montenegrina* land snails (Gastropoda: Clausiliidae)
Katharina Mason: Peculiar points in the phylogeny of the rock-dwelling land snail genus *Montenegrina*
Willy De Mattia: Stability and variability of anatomical traits in *Montenegrina* species (Gastropoda, Clausiliidae) against shell-based taxonomy: the case of *M. subcristata* and *M. perstriata*
Andjela Bulatovic & Jovana Markovic: Population size, density and dispersion patterns *Montenegrina subcristata* in the area of Virpazar (Montenegro)

Tuesday 21st

Sinos Giokas: Shell adaptations for heat and water management in a rock-dwelling snail
Raiko Slapnik: The subterranean snails of genus *Zospeum* (Eupulmonata, Ellobioidea, Carychiidae), what do we know about them.
Josef Harl: Phylogeny of the land snail genus *Schileykula* (Gastropoda: Pulmonata: Orculidae) based on mitochondrial and nuclear DNA sequences - Evidence for repeated hybridization

Wednesday 23rd

Ira Richling: Progress in understanding the European species of *Bythiospeum* with an outlook on Austrian taxa
Luise Kruckenhauser: Where is the border to neighbours garden? – assessing population size in *Cylindrus obtusus*
Anatoly Schileyko: Reduction as one of important ways of Pulmonata (Gastropoda) evolution

Poster presentation

Katharina Mason: MoFA – the newly founded Society for Molluscan Research in Austria
Iris Fischer & Marcia Sittenthaler: Summer in the city! DNA Barcoding and survey of dragonflies in Vienna: preliminary results

Abstracts
Wissenschaft im Wirtshaus / Pub lectures
Biodiversität – Vielfalt auf allen Ebenen

Arranged in chronological order of the program

Die Felsfluren und die darunterliegenden Schuttfluren

Josef Greimler

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Die steilen Felspartien bieten wenig Halt für größere Pflanzen. Auf kleinen Absätzen, Vorsprüngen, +/– waagrechten Leisten findet man immer noch Rasenfragmente vor allem mit der Polstersegge (*Carex firma*), Schuttpflanzen in grusigen Nischen wie das Kärntner Hornkraut (*Cerastium carinthiacum*) oder, wo es länger feucht ist, kleinste Gruppen von Schneeboden-Pflanzen, z.B. die Spalierweiden (*Salix retusa, S. reticulata*) und einige Steinbrech-Arten (*Saxifraga sedoides, S. stellaris, S. androsacea*). Ansonsten sind die Felswände das Reich der Petrophyten mit einigen speziellen Lithophyten (Cyanobakterien, Flechten, Moose). Die Cyanobakterien sind auch als Blaualgen bekannt und für die dunklen Tintenstriche an den Felswänden verantwortlich. Die Petrophyten bei den Höheren Pflanzen gliedert man in Oberflächen- und Spaltenpflanzen. Letztere wurzeln meist tief in den Felsspalten, wo sich Feinerde und Feuchtigkeit ansammelt. Das besonders windharte Clusius-Fingerkraut (Ostalpen-Fingerkraut: *Potentilla clusiana*) ist in den Felsspalten, auf felsigen Kuppen, steilen Abwitterungshängen von der tiefliegenden Waldgrenze bis in die alpine Stufe überall anzutreffen. Weitere typische Arten sind das Kugel-Schötchen (*Kernera saxatilis*), der Alpen-Hahnenfuß (*Ranunculus alpestris*), der Felsen-Baldrian (*Valeriana saxatilis*) und die Sternhaar-Zwerg-Gänsekresse (*Arabis stellulata*), die Zwerg-Glockenblume (*Campanula cochleariifolia*), das Zweiblütige Veilchen (*Viola biflora*), das Gabel-Habichtskrauts (*Hieracium bifidum*), der Jacquin-Pippau (*Crepis jacquinii ssp. jacquinii*) zusammen mit einige kleinen Streifen-Farnen (*Asplenium trichomanes* und *A. viride*). Am Fuß der kühlen, schattigen Nordwände findet man wieder Fragmente des Polsterseggen-Rasens mit *Carex firma* und ihren typischen Begleitarten. In den kühl-feuchten Felsspalten wachsen das Österreichische Alpenglöckchen *(Soldanella austriaca*), der Ostalpen-Baldrian (*Valeriana elongata*) und der Alpen-Blasenfarn (*Cystopteris alpina*). In den Schuttfluren unter den Wänden findet man Pflanzen, die mittels ihrer Legtriebe, Kriechtriebe und Ausläufer mit dem oft bewegten Schutt mitkriechen, die diesen überkriechen oder bis zu einem gewissen Grad auch stauen. Einige typische Arten sind die Österreich-Miere (*Minuartia austriaca*), die Wimper-Nabelmiere (*Moehringia ciliata*), das Kärntner Hornkraut (*Cerastium carinthiacum*), das Schutt-Blasen-Leimkraut (*Silene vulgaris subsp. glareosa*), der Alpenmohn *(Papaver alpinum ssp. alpinum = P. burser*i), das Alpen-Leinkraut *(Linaria alpina*), der Ruprechts-Farn (*Gymnocarpium robertianum*) und die Einblütige Binse (*Juncus monanthos*). In den tieferen Lagen findet man einige löwenzahnartige Korbblütler (*Chlorocrepis staticifolia, Leontodon hispidus ssp. hyoseroides*) und um Mitte Juni riecht man schon die Blüten der zierlichen Federnelke (*Dianthus plumarius ssp. blandus*).

Steep rock faces provide little space for taller plants. There are, however, several irregularities including tiny platforms, small ledges, etc., where fragments of the subalpine and alpine grasslands, especially those with *Carex firma* can be found. There is also some space for plants of scree and snow beds such as the Carinthian mouse ear *(Cerastium carinthiacum*), the creeping willows (*Salix retusa, S. reticulata*) and some rockfoils *(Saxifraga sedoides, S. stellaris, S. androsacea*). Otherwise the rock faces are the realm of petrophytes including some special lithophytes (cyanobacteria, lichens, and bryophytes). Cyonobacteria produce the so called „Tintenstriche“ (i.e. vertical dark lines on the rocks). The petrophytes of the higher plants include those rooting on the surface and those that are rooted deeply in the crevices, where soil and moisture has accumulated. Some of those common petrophytes are the cinquefoil of the Eastern Alps *(Potentilla clusiana*), a small crucifer with globous fruits (*Kernera saxatilis*), the alpine buttercup *(Ranunculus alpestris*), the rock valerian (*Valeriana saxatilis*) and a tiny rock cress (*Arabis stellulata*), the tiny bell flower (*Campanula cochleariifolia*), the yellow violet (*Viola biflora)*, some yellow cichorioids *(Hieracium bifidum, Crepis jacquinii ssp. jacquinii*) together with some tiny ferns (*Asplenium trichomanes* and *A. viride*).

At the base of the cool and shady north-faced walls fragments of the alpine grassland can be found again. Some specialists are found in the cool and humid rock crevices. These are, e.g., two endemics, the tiny snowbell (*Soldanella austriaca*) and the Eastern Alps valerian (*Valeriana elongata*) together with the alpine bladder fern (*Cystopteris alpina*). Other specialists thrive on the scree below the rock faces. They are adapted to the instable substrate by their growth forms, i.e. their stolons, runners, or simply by their robust basal leaf sheaths. Typical plants there are the Austrian eyebright *(Minuartia austriaca*), the ciliary sandwort (*Moehringia ciliata*), the Carinthian mouse ear (*Cerastium carinthiacum*) again, the bladder campion (*Silene vulgaris subsp. glareosa*), the alpine poppy *(Papaver alpinum ssp. alpinum = P. burseri*), the alpine flax weed *(Linaria alpina*), the limestone fern *(Gymnocarpium robertianum)* and the small single flowered rush *(Juncus monanthos*). Some dandelion-like composite plants, such as *Chlorocrepis staticifolia*, *Leontodon hispidus ssp. hyoseroides* thrive in lower elevations. There, by middle of June one can smell the magnificent odour of another endemic: the graceful feathered pink *(Dianthus plumarius ssp. blandus*).

Schnecken in Fels und Schutt

Michael Duda

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Kalkreiche Felsen, Klippen und Schutthalden stellen einen wesentlichen Lebensraum für speziell angepasste Landschnecken dar. Neben diesen Spezialisten nutzen auch einige weiter verbreitete Arten, die durchaus auch in anderen Habitaten vorkommen, Fels- und Schuttlandschaften als Lebensraum. Ein besonderer Aspekt von Fels- und Schutthabitaten ist die Kargheit dieser Lebensräume, in denen sich keine durchgehende Pflanzendecke ausbilden kann. Dies bedingt, dass Temperatur- und Feuchtigkeitsverhältnisse an den Außenflächen und im Inneren sowie am oberen und am unteren Ende von Schutthalden und Felsen sich stark unterscheiden. Die

Oberfläche von Felswänden und speziell Felsspitzen sind wetterbedingt zumeist starken Schwankungen von Temperatur und Feuchtigkeit ausgesetzt, wohingegen im Inneren von Spalten, Ritzen und Hohlräumen sowie überschatteten Hangfußbereichen relativ stabile Verhältnissen herrschen. Dies kann wiederum zu drei grundsätzlichen Anpassungen der Lebensweise führen. Eine Möglichkeit ist das komplette Zurückziehen in Höhlen und tiefere Schuttbereiche, was von einigen Arten tatsächlich praktiziert wird. Der Nachteil hierbei ist die fehlende Nahrung. Viele felsbewohnende Schneckenarten nutzen daher Spalten und Löcher, um extrem heiß-trockene Phasen zu überdauern. In der Nacht oder bei feuchtem Wetter kommen sie an die Oberfläche, um Flechten oder Detritus aufzunehmen. Einige wenige Arten verbringen sogar ihr ganzes Leben an der Felsoberfläche. Der extreme Lebensraum bringt auch spezielle Anpassungen an die Schalenform. Einige Fels und Schutt bewohnende Arten besitzen stark abgeflachte, scheibenförmige Schalen, welche ein Abrutschen auf steilen Wänden verhindern sollen. Eine weitere Strategie sind schlanke, langgezogene oder kornförmige Schalen, welche zum Hineinkriechen in Spalten und Löcher geeignet sind. Die besondere Anpassung an den Lebensraum, die Kleinräumigkeit und Isolation mancher Felslebensräume sowie die Tatsache, dass sie in Verbindung mit Gebirgszügen oft über Millionen Jahre stabile Lebensbedingungen bieten, führen gerade bei Landschnecken zur Ausbildung von Endemiten. Einige Vertreter nur kleinräumig vorkommender Felsschnecken, die auch im Gesäuse zu finden sind, werden in diesem Vortrag vorgestellt.

Snails on rocks and boulders

Calcareous rocks, cliffs and boulders are an essential habitat for specially adapted land snails. Besides such specialized rock dwelling species, more widespread species, which use a wider range of habitats, can live in rock and boulder landscapes, too. A striking aspect is the poverty of these habitats as they do not show continuous vegetation. This is due to the fact that temperature and humidity conditions between the outer surfaces and interior crevices, as well as between the upper and lower ends of boulders and rocks show big differences. The rock faces and rock peaks are exposed to wind and weather and therefore usually subjected to severe fluctuations of temperature and humidity, while within crevices and cavities as well as at slope toes relatively stable conditions prevail. This can lead to three basic adaptions of phenology. One adaption is to spend the complete live span in caves and deeper debris area, which can actually be found with some species. The disadvantage of this strategy is the lack of nutrition. Many rock-dwelling snail species therefore use crevices and holes to sustain extremely hot-dry phases. In the night or during damp weather they move to the surface to pick lichen or detritus. Another few species spend their whole life span on the rock surface. The extreme habitat conditions also lead to special adaptations of the shell shape. Some snail species dwelling on rocks and boulders show strongly flattened, disk-shaped shells, which should prevent slipping on steep walls. Another strategy is used by snails with slim, elongated or grain-shaped shells, which enable creeping into crevices and holes. The special habitat adaptations, the small spatial extension and isolation of some rocky habitats lead to the evolution of endemics among land snails, triggered by stable living conditions of these habitats over millions of years. Some of these specialized rock-dwellers can be found in the Gesäuse region too and will be presented.

Federn im Fels – Vögel als Felsbewohner im Nationalpark Gesäuse

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Je höher man im Gebirge steigt, desto weniger Leben bekommt man zu Gesicht. Nur einige wenige Vogelarten haben sich auf das Brüten im Fels spezialisiert, es sind jedoch mehr, als man im ersten Moment denkt. Die harschen Lebensbedingungen wie große Hitze und Kälte bzw. deren schneller Wechsel, Extremereignisse wie Steinschlag und Lawinen sowie Nahrungsknappheit und eine kurze Brutzeit aufgrund der knapp bemessenen Vegetationsperiode müssen gemeistert werden. Deshalb findet man oft spezielle Anpassungen im Körperbau, der Ernährung, Fortpflanzung und im Verhalten, um mit den Anforderungen zurecht zu kommen. Andererseits profitieren die Tiere auch von der Höhe und der dort vorherrschenden Artenarmut – es kommt zu weniger Konkurrenz und einem verringerten Raubfeinddruck. Nicht selten gibt es einander entsprechende Tal- und Gebirgspendants, die sich gegenseitig ökologisch ersetzen: So findet man den Gartenrotschwanz meist im Tal, der Hausrotschwanz dagegen ist ein Felsnischenbrüter der höheren Lagen. Manche haben überhaupt ein Sekundärhabitat in den „steinigen" Häuserschluchten der Großstädte gefunden, so etwa Mauersegler und Turmfalke. Zu den Klassikern der Felsbewohner zählen jedoch Wanderfalke, Uhu, Steinrötel, Schneesperling und Alpensegler. Der Vortrag beleuchtet insbesondere die Biologie, Gefährdungsursachen sowie Schutzmaßnahmen des Nationalparks bei Steinadler, Mauerläufer, Felsenschwalbe und Alpenschneehuhn. Die Spezialisten der Hochgebirge mögen nicht so zahlreich sein, doch ihr Dasein als Überlebenskünstler ist umso faszinierender und dementsprechend schützenswert!

Fig. 1. Adlerkamera im NP Gesäuse (Foto: NP Gesäuse)

The higher you climb the mountains, the less life you encounter. Only very few bird species managed to specialize on breeding inbetween cliffs and rocks, though they are higher in number than one might think at first glance. Living conditions are harsh as great heat and bitter cold alternate quickly, extreme events such as rock falls and avalanches are common and, due to a short vegetation period, food is scarce and the breeding season passes by rapidly. Therefore, a number of adaptations evolved to adjust the mode of nutrition, reproduction, body structure and overall behavior. On the other hand, the rock specialists also benefit from the highness of their natural habitat: The areas are rather poor in species, and so competition as well as predation is less pressing. Quite often, there are species counterparts with one occurring in the mountains and the other one down in the valley as they substitute each other

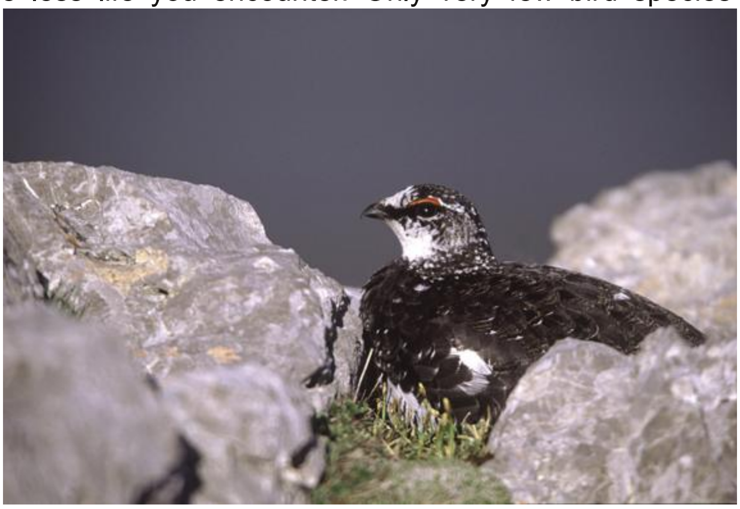

Fig. 2. Alpenschneehuhn

and correspond ecologically. For instance, the common redstart is a bird species breeding in the lowlands, whereas the black redstart is native to higher altitudes. Some species such as common swift and kestrel, which are originally adapted to enduring in rocky areas, even found a secondary habitat in the house facades and street canyons of towns and big cities. Classic rock dwellers include peregrine, eagle owl, rock-thrush, snowfinch and alpine swift. The presentation focuses on the biology, causes of threat as well as conservation measures taken by the national park concerning the species golden eagle, wallcreeper, crag martin and ptarmigan. Birds breeding in the rocks might not be that high in number, but their survival is all the more fascinating and worth protecting as such!

Abstracts
Talks
Alpine and other land snails

Arranged in chronological order of the program

Range-constrained co-occurrence simulation reveals little niche partitioning among rock-dwelling *Montenegrina* land snails (Gastropoda: Clausiliidae)

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Taxon co-occurrence analysis is commonly used in ecology, but it has not been applied to range-wide distributional data on partly allopatric taxa because existing methods cannot distinguish between distribution-related effects and taxon interactions. Our first aim was to develop a taxon co-occurrence analysis method that is also capable of taking into account the effect of different ranges and can handle faunistic records from museum databases or biodiversity inventories. Our second aim was to test the independence of taxon co-occurrences of rock-dwelling gastropods at different taxonomic levels, with special focus on the subfamily Alopiinae of the family Clausiliidae, and in particular the genus *Montenegrina*.

We introduced a taxon-specific metric that characterizes the occurrence probability at a given location. This probability was calculated as a distance-weighted mean of the taxon's presence and absence records at all sites. We applied corrections to eliminate the distorting effects of varying sampling intensity in our data set. Then we used probabilistic null-models to simulate taxon distributions under the null hypothesis of no taxon interactions and calculated pairwise and

cumulated co-occurrences. Independence of taxon distributions was tested by comparing observed co-occurrences to simulated values.

Significantly fewer co-occurrences among species and intra-generic lineages of *Montenegrina* were observed than expected under the assumption of no taxon interaction. This indicates that species divergence preceded niche partitioning and suggests a primary role for non-adaptive processes in the speciation of rock-dwelling gastropods. The method can account for the effects of distributional constraints in range-wide datasets of records, making it suitable for testing ecological, biogeographical or evolutionary hypotheses where interactions of partly allopatric taxa are in question.

Acknowledgements

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Peculiar points in the phylogeny of the rock-dwelling land snail genus *Montenegrina*

Katharina Mason[1], Elisabeth Haring[2,3], Sonja Bamberger[2], Helmut Sattmann[1], Luise Kruckenhauser[2] & Zoltán Fehér[1]

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Montenegrina is a hyper-diverse land snail genus with 29 known species and 106 subspecies, although its distribution range is restricted to the western part of the Balkan Peninsula. The current systematics of *Montenegrina* is mainly based on conchological traits (Fehér & Szekeres, 2016). In the present study we aimed to test the congruency with molecular genetic data based on sections of three mitochondrial genes, *cytochrome c oxidase subunit 1*, *16S rRNA*, *12S rRNA (COI, 16S, 12S)* as well as a short section of two nuclear histone genes (*histone 3 and histone 4*), including the spacer region (*H3H4*). We included nearly 800 individuals assigned to 104 different taxa from 368 localities, covering the whole distribution range. Phylogenetic trees were calculated and compared with the current taxonomic system of Montenegrina. Furthermore, the diversity, based on average p-distances, was calculated between and within species as well as between and

Fig. 1. In the course of sampling all taxa of the rock-dwelling genus *Montenegrina* we came across very interesting places, like this hermitage Panayia Eleoussa which dates back to the beginning of the 15th century (right, Foto: H. Sattmann). It is located on the shore of the Prespa lake, where *Montenegrina dofleini prespaensis* (left, Foto: Z. Fehér) occurs.

within populations and clades. The results show a high concordance between traditionally gained taxonomy and the phylogenetic tree. Only in a few cases (around 5%) big discrepancies were found. Possible explanations for these cases and peculiar stories behind the ecology and lifestyle of several interesting taxa are the main focus in this talk. Generally, this study revealed high genetic diversity within this rock-dwelling door snail genus and indicates that the large number of taxa, which mostly have very narrow distribution ranges, are not the result of a taxonomic over-splitting, but reflects mostly actual phylogenetic relationships.

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Acknowledgements

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Stability and variability of anatomical traits in *Montenegrina* species (Gastropoda, Clausiliidae): the case of *M. subcristata* and *M. perstriata*

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The genus *Montenegrina* O. Boettger, 1877 (Clausiliidae) has been recently revised by Fehér & Szekers (2016) on the basis of a study of shell morphology. Many new taxa have been described due to the discovery of new populations. Moreover, the systematic position and nomenclature of many other taxa have been reconsidered and eventually modified by virtue of synonymyzation and moving one taxon from a species to another. Often, subspecific taxa have been elevated to species-rank or vice versa. In fact, Fehér and Szekeres (2016) clearly highlighted the complicated nomenclatural history that marks almost all the Montenegrina taxa, with remarkable changes in their specific position. These swings were mostly due to the different points of view of the authors, who dealt with the shell morphology, rather than by an univocal and thorough morphological-anatomical approach.

As a further step in the study of this speciose clausiliid genus, an extensive morphological study of the genitalia has been performed and it is currently ongoing with the aim to identify new characters and features to better define the taxonomy and the systematics of this genus. This comprehensive analysis represents even a new approach for the whole family Clausiliidae. To date, 86 out of the 107 (approximately 81%) taxa of *Montenegrina* (as listed in Fehér & Szekeres, 2016) have been dissected, in total 116 populations and 203 specimens. These numbers will increase as new populations have been recently collected.

The morphological analysis of the genital apparatus revealed an intriguing overall situation. First, it allowed to ascertain the limits of the shell-based taxonomy concerning this clausiliid group. This is here exemplified by the two species *Montenegrina perstriata* (Wagner, 1919) and *Montenegrina subcristata* (Pfeiffer, 1848). Both species show a degree of plasticity and variability of the shell, since all the investigated populations presented slight but somehow significant differences in their morphology. This is reflected both by their high number of subspecific taxa and their systematic-nomenclatural history. Following a thorough anatomical investigation focused on the inner features of the distal genital apparatus, the two species present a diametrically opposite situation. *Montenegrina subcristata*, despite its large distributional range and the good number of investigated populations, shows a remarkable stability of the genital features that fully meets the recent view of Fehér and Szekeres (2016) (also in accord with unpublished molecular genetic data) to merge all the former subspecific taxa and synonymize them into the nomial taxon. On the contrary, the subspecific taxa of *Montenegrina perstriata* revealed an astonishing genital diversity among all the populations. In the case of *Montenegrina perstriata drimica* Nordsieck, 1972, a subspecies ditributed along the Upper valley of the Crni Drin between the Globočica Lake and Debar in Macedonia, seven populations have been subjected to genital morphological analysis. The different populations, ascribed to this subspecies following the shell morphology, presented anyway a slight variabilty in the shell features but likewise showed substantial anatomical differences seen in Fig. 1. The four populations depicted in Fig. 1 (13-24) present three distinct genital arrangements, in particular concerning the inner ornamentation of the vagina and penis.

Combinig these totally new anatomical-morphological results with the upcoming molecular genetic data will probably allow to redefine the systematics and the nomenclature of the whole *Montenegrina* genus by means of a new integrative approach.

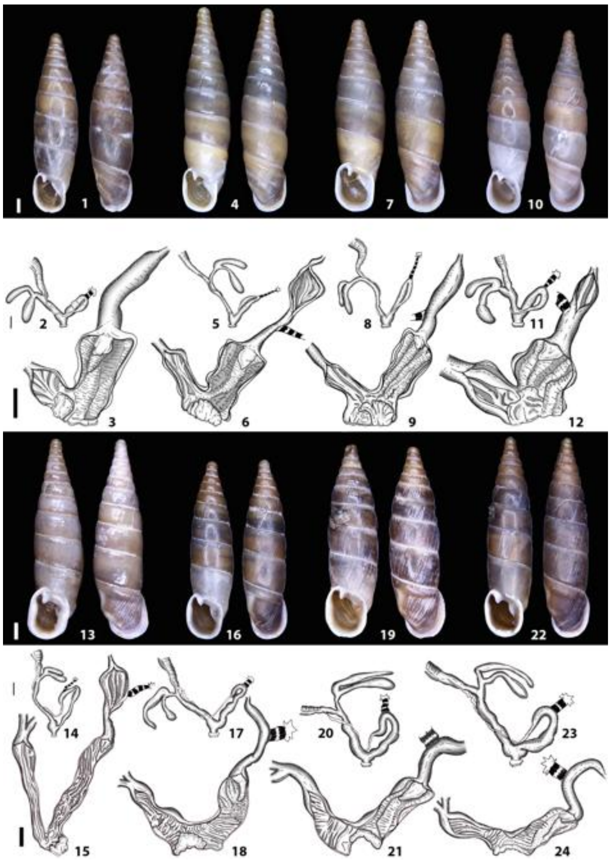

Fig. 1. *Montenegrina spp.* 1-12 *Montenegrina subcristata*: 1-3 Albania, Shkodër district, Shkodër, S side of Rozafa Hill, 1 shells, 2 whole distal genitalia, 3 inner distal genitalia; 4-6 Montenegro, Cetinje, on walls W of the the town, 4 shells, 5 whole distal genitalia, 6 inner distal genitalia; 7-9 Montenegro, Rijeka Crnojevica, rocks along the road, 7 shells, 8 whole distal genitalia, 9 inner distal genitalia; 10-12 Montenegro, Nikšić, ca. 2 km on the road to Podgorica, 10 shells, 11 whole distal genitalia, 12 inner distal genitalia; 13-24: *Montenegrina perstriata drimica* (sensu Fehér & Szekeres, 2016): 13-15 Macedonia, Lukovo, 13 shells, 14 whole distal genitalia, 15 inner distal genitalia; 16-18 Albania, Dibrë district, gorge of Lumi i Drinit te Zi, 16 shells, 17 whole distal genitalia, 18 inner distal genitalia; 19-21 Macedonia, Prov. Debar, Debar, at the dam of Crni Drin River, 19 shells, 20 whole distal genitalia, 21 inner distal genitalia; 22-24 Mecdonia, Prov. Struga, Crni Drin valley, Modrić junction, 22 shells, 23 whole distal genitalia, 24 inner distal genitalia

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Population size, density and dispersion patterns of *Montenegrina subcristata* in the area of Virpazar (Montenegro)

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Introduction

Snails of the genus *Montenegrina*, which includes a large number of taxa (29 species and more than 100 subspecies) are distributed in the southwestern part of the Balkan Peninsula (Fehér and Szekeres 2016). Several studies on this genus have been performed concerning its taxonomy, phylogeny, phylogeography and distribution. However, knowledge about biology and ecology of the species of the genus *Montenegrina* is scarce, like in many terrestrial snails. Only some general assumptions related to similar species are existing (e.g., Schilthuizen 1994; Schilthuizen and Lombaerts 1994, 1995; Welter-Schultes 2000). But such knowledge would facilitate to understand evolutionary processes and mechanisms of speciation. In the present study we focused on population ecology of *Montenegrina subcristata* during one season. In a topotypic population of the subspecies *M. subcristata sublabiata* Wohlberedt 1907, at one site in Virpazar, a monitoring pilot study was perfomed. The aim of this research was to monitor the population, to estimate population size, density and dispersion on a small scale and to record activity patterns. One assumption was that the migration behavior of the snails and also their number would be influenced by microclimatic conditions. We expected that the snails would be quite inactive during warm and sunny days, mostly hidden in crevices while the highest activity will be certainly noticeable after the precipitation, when the conditions for their activity are also most favorable.

Methods

Fig. 1. Study site in the Virpazar area, Montenegro

Three points (A, B and C) were selected in the Virpazar area where the research is being carried out. Based on photos, maps of the study sites have been drawn. At each location, temperature and humidity was monitored at several spots. We started monitoring in April 2017 and it will be performed during one season. The three areas were investigated once a week. First, the snails were searched and registered, counted, and their location in the habitat was documented by photographs as well as via digital maps and translated into a spreadsheet format via a coordinate system. We classified the size and life stage of the snails as juvenile, subadults and adults. Subadults and adults were marked individually with a letter/number code using non-toxic water proof markers. Juvenile individuals were marked with a dot. During each field visit, marked individuals were documented and their position mapped on a photographic map. New individuals were marked. For recaptured individuals distances from the previous place were measured as a dispersive distance. A protocol was

established to document the counts and mark-recapture procedure.
Estimating the size and density of the population should be done by the "Capture, mark, recapture" method *(CMR)*. Concerning dispersion, every new distance from the previous place is calculated as a dispersive distance. After analysis of mark-recapture data, population size, density and dispersion ability of these animals can be determined. Furthermore, dispersion distance can be calculated, when all distances are accumulated.

Results

First results show that numbers of newly marked individuals (juvenile, subadults and adults) are quite different between these three study areas. Area A is the most dominant one, followed by point B and finally point C, which is recognized as the poorest among them. As we have assumed, the highest activity and the highest number of the registered individuals, both newly marked and already marked, was observed during cloudy and rainy days. During warm and sunny days, the snails were inactive, usually hidden in crevices, between plants and some of them found their shelter in small holes in the soil. As far as their migration is concerned, it is interesting to see that some marked adults from area A were registered on area B and vice versa. From April till July we have noticed a significant change in the number of individuals (all categories included) in all areas. Monitoring is still going on and calculations will be performed at the end of the season. Preliminary results will be presented here.

Fig. 2. *Montenegrina subcristata*

Conclusion

Research of this type has not been done in this snail genus before, and thus represents an innovative approach delivering data that may help to answer various crucial biological questions. The obtained results will help to address important issues of the evolution of this group and mechanisms such as adaptations, selection and speciation. This research can provide comparative data for some similar research on other species.

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Acknowledgements

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Shell adaptations for heat and water management in a rock-dwelling snail

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Morphological variation often is attributed to differential adaptations to diverse habitats, but adaptations to a similar environment do not necessarily result in similar phenotypes. Adaptations for water and heat budget are crucial for organisms living in arid habitats, and in snails variation in shell morphology has been frequently attributed to selection by stressful environmental factors (Cook 2001). However, their phenotypic divergence often is not accompanied by a relevant niche differentiation and consistent relationships with environmental correlates are lacking (Goodfriend 1986, Gittenberger 1991).

In the species-rich pulmonate genus *Albinaria*, there is great size and shape variation between and within species, and there are two major shell sculpture morphotypes (ribbed and smooth). However, little was certain about its inter- and intra-specific geographical size, shape and ribbing variation. Therefore, we used an inclusive set of *Albinaria* (62 populations of 28 species) to investigate the agents that favor the evolution and maintenance of alternative shell phenotypes, in a context of ecological and evolutionary tradeoffs, considering the effects of phylogeny, and unbiased size and shape estimates, derived from geometric morphometrics. First, we examined whether distinct sculpture morphotypes are associated with size and shape changes and can be unambiguously recognized among and within species. Second, in lab experiments, we investigated whether shell traits are correlated to water and heat budget and, thus, with an ability of these snails to overcome stressful conditions in semi-arid ecosystems. Third, we examined if climatic and geographical gradients are important in shaping the variation of shell traits, and hence, whether these shell characteristics evolve nonrandomly, converging differently in dissimilar climatic regimes.

We found unambiguous size and shape discrimination between the two morphotypes. Ribbed shells are lighter, taller, and slimmer and have a smaller aperture than the smooth ones.

Moreover, significant correlations between shell traits and heat/moisture budget and climate/ geography were revealed. Ribbed and taller shells retain more water on their shell surface and, on the other hand, smooth shells exhibit lower water permeability. Therefore, two strategies are being used to prevent water loss, active retention or resistance to loss.

Consequently, different alternative solutions evolved and were retained as responses to the same stressful factor by the two distinct shell morphotypes. Larger shells occur in southern latitudes, mostly on islands, and at sites where there is a shortage of rainfall. Therefore, the variation of the examined traits is nonrandom with respect to location and to climate, and their evolution can be attributed to selection by environmental factors, with water availability being the key driving agent of body-size variation.

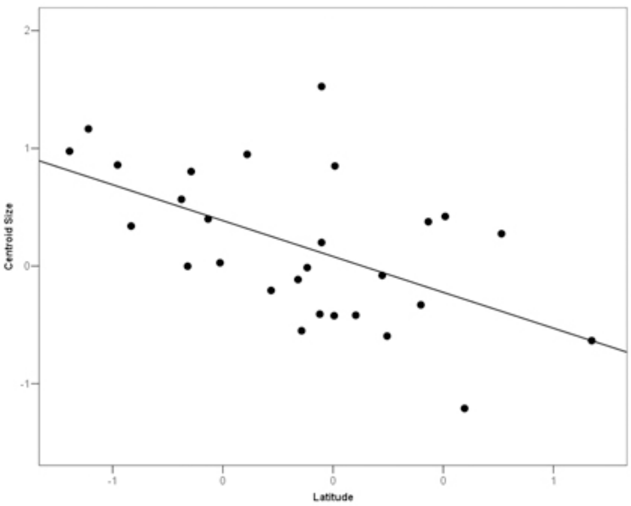

Fig. 1. Regression of centroid size vs. latitude using Phylogenetic Independent Contrasts Analysis.

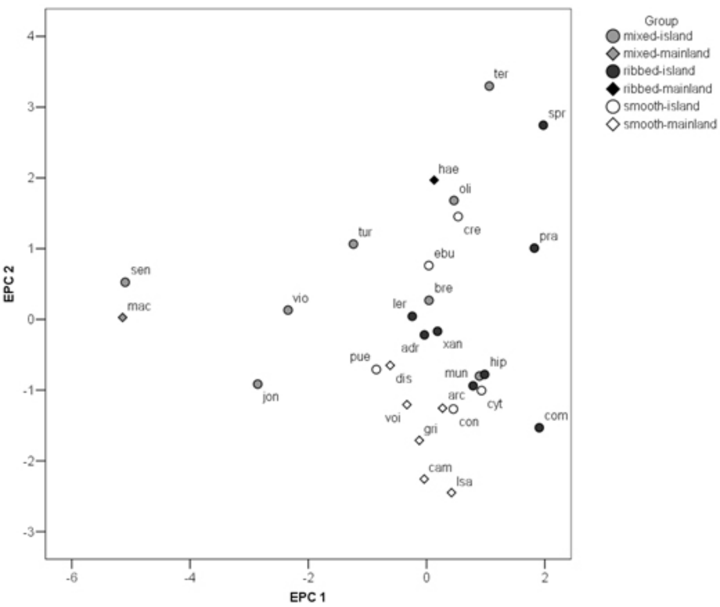

Fig. 2. Ordination of the studied *Albinaria* species with EPCA (Evolutionary Principal Components Analysis) using five predictive variables. The scatterplot of species factor scores shows that most species are grouped near the plot origin. However, on the right upper part of the graph are species having large and slimmer shells, reflect more, retain more water on their surface and are losing more water through their shell. On the left lower part are small and wider species that reflect less, retain less water on their surface and are losing less water through their shell.

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The subterranean snails of genus *Zospeum* (Eupulmonata, Ellobioidea Carychiidae), what do we know about them

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The minute troglobiotic snails of the genus *Zospeum* inhabit caves of Northern Spain to the Balkan Dinarides. Most species were described in the latter half of the 19th and 20th centuries based on shell characters such as whorl number, aperture dentition, and shell size as well as shape and number of lamellae circumscribing the columella. Zospeum shells typically tend to be very variable in shape from one population to the other and frequently show wide variability within the same population. Twenty-four species and ten subspecies have been described (Jochum et al., 2015). There are questions concerning the validity of many of these species.

Six anatomical studies provide the current knowledge upon which morphological findings of this investigation are based. Bole (1974) anatomically examined four different species and subspecies of *Zospeum*, emphasizing that his findings provided nothing taxonomically remarkable. Giusti (1975) conducted the first anatomical investigations on *Zospeum spelaeum* (Rossmässler, 1839) and Zospeum tellinii Pollonera, 1889. De Mattia (2003) specifically compared the genital anatomy of *Zospeum spelaeum* from six populations from different caves and one population of *Z. isselianum* from the widely cavernous region of Trieste. Weigand et al. (2011) conducted the first molecular analysis of seven Dinaric *Zospeum morphospecies*. Jochum et al. (2015) find high intraspecific variation for *Zospeum* collected in different caves while a high incidence of cryptic allopatric speciation for several taxa was uncovered.

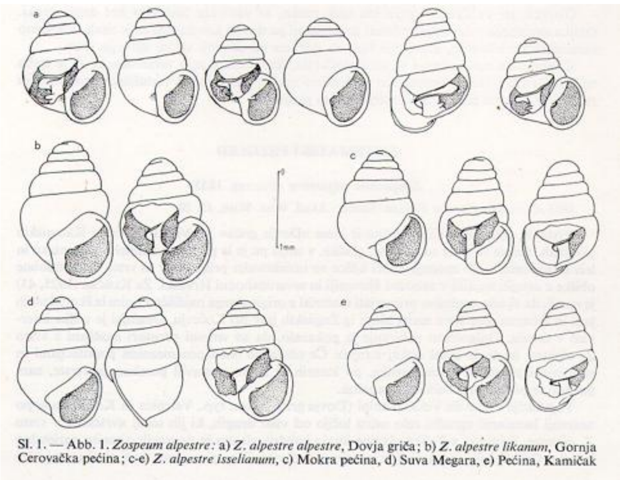

Fig. 1. *Zospeum alpestre* from different caves (drawing J. Bole)

Knowledge about the ecology of the *Zospeum* species is very scarce. It is known that they live in caves and fissures and that they probably feed on the detritus that is found in loam and in cave sediments. In caves, they occur on walls, on the ground beside puddles, or on organic matter (rotten wood) (Slapnik, 2001).

We also know something about activity and movements in undisturbed snails of *Zospeum isselianum* in the "alpine karst" caves. The snails passed over distances from 1 to 15 cm per week. Snails were more or less creeping around the place where they were first found, or they moved to the upper part of the sampling surface (Slapnik, 2001).

Fig. 2. *Z. spelaeum schmidtii* (Foto: R. Slapnik)

Fig. 3. Distribution map of genus *Zospeum*

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Phylogeny of the land snail genus *Schileykula* (Gastropoda: Pulmonata: Orculidae) based on mitochondrial and nuclear DNA sequences - Evidence for repeated hybridization

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The land snail genus *Schileykula* Gittenberger, 1983 is distributed in arid limestone areas, from western Turkey to north-western Iran. The cylindrical shells are small (4.7–11.8 mm in height) and the last shell whorls bear several inner lamellae and plicae, which probably serve as barriers against predators and body-water loss. These structures of the aperture play an important role in species recognition. In his revision on Asian Orculidae, Hausdorf (1996) classified eight species and eight subspecies within *Schileykula*, two species were described only recently.

In the present study, we performed a molecular genetic study on nine out of ten species including all four subspecies of *Schileykula trapezensis* and three of six subspecies of *Schileykula scyphus*. A section of the mitochondrial *cytochrome oxidase subunit 1* gene was analyzed in 56 specimens of *Schileykula* and 31 specimens of the outgroup *Sphyradium doliolum*. For 35 *Schileykula* and nine *Sphyradium* specimens we additionally obtained partial sequences of the mitochondrial genes for the *12S rRNA* and the *16S rRNA*, and a section of the nuclear *H4/H3* gene cluster.

The results of the phylogenetic studies based on the mitochondrial and nuclear makers disagree with the present morphology-based classification. As a consequence, some taxonomical conclusions are drawn (some subspecies are elevated to species level, and one species is classified as a subspecies of another species). The patterns in the mitochondrial and nuclear trees differ in regard to the grouping of some species or specimens, providing evidence for at least two independent hybridization events. The present results exemplify the importance of integrating morphological and genetic data and imply that (at least sporadic) hybridization across distantly related lineages might occur more frequently than previously assumed.

Progress in understanding the European species of *Bythiospeum* with an outlook on Austrian taxa

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Species of the genus *Bythiospeum* Bourguignat, 1882 are confined to groundwater systems in Europe. First molecular analyses and additional morphological studies of Central European *Bythiospeum* revealed that the currently accepted concept with a comparatively high number of mostly endemic species with narrow ranges is not reflected in the genetic diversity (RICHLING et al. 2016). Data suggest that the number of well differentiated species in Germany drops from 25 to three with one locally endemic and two more widely distributed species. The recent distribution pattern and low diversification within the clades/species is best explained by postglacial recolonisation of Southern Germany. However, the localisation of possible refugia still remains obscure because the samples did not yet cover the – newly understood – full range of the species. Therefore, we extended the sampling towards the Southwest and East, i. e. Southeastern France and Austria. Equally to Germany with its previously assumed high diversity of *Bythiospeum*, current inventories of the Austrian mollusc fauna list twelve endemic species and additional taxa in the genus *Iglica*. The latter is not clearly understood in its phylogenetic relationship to and differentiation from *Bythiospeum*. The current presentation will show and discuss preliminary results.

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Where is the border to neighbors garden? – Assessing population size in *Cylindrus obtusus*

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Sampling strategies are always among the first and most important decisions to make in a zoological project. In the course of our numerous excursions to collect Alpine land snails we have been wondering how large a snail population might be and how to define snail populations. How distant should individuals be collected from each other to avoid getting only members of the same snail family? As population genetic analyses were part of our study on *Cylindrus obtusus* (Helicidae), we chose this species to have a closer look on population size. *C. obtusus* is a hermaphroditic land snail, endemic in the Austrian Alps, which is restricted to high elevations (1600 to 2500 m asl) and limestone. As a specialist of high alpine rocky habitats, *C. obtusus* has a quite patchy distribution area (Klemm 1974). Previous investigations revealed geographic differences in the genital apparatus: All specimens from the more western populations had one stylophore and two equally developed mucus glands more than twice the length of the stylophore. In contrast, in individuals from the eastern margin of the species these structures were highly variable (Schileyko, 1996, 1997; Schileyko et al. 2016; Zopp et al., 2017). Microsatellite data showed that all eastern populations (from Veitsch to Schneeberg) have a high excess of homozygous individuals. Nearly all individuals are homozygous in all microsatellite loci (although different alleles were found within populations). Kruckenhauser et al. (2017) concluded that in the eastern populations selfing as predominant reproducing strategy is the cause of this excess of homozygotes.

However, it also might be that population structures in the two geographic regions are different and the observed phenomenon is due to extremely high population sub-structuring in the eastern populations. Earlier investigations on individual numbers and dispersal rates by Bisenberger et al. (1999) in the Gesäuse were a first attempt to estimate population size in *C. obtusus*. In the present study we take a new approach: Nine researchers located 3 m to 28 m apart from each other collected 20 individuals in a one-meter radius. This procedure was followed in one of the selfing populations on the Schneeberg, and in an outcrossing population on the Hohe Nock mountain. The 348 samples were analysed with the same microsatellite loci as in Kruckenhauser et al. (2017). Data analysis with Bayesian cluster analysis and principal component analysis will show, whether the populations at these two sampling grids are sub-structured and will give a better assessment of the population size of *C. obtusus*.

Fig. 1. *Cylindrus obtusus*

Fig. 2. Sampling grid on the Hohe Nock. Six of the nine samplings sites are indicated by persons, one by a rucksack.

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Reduction as one of the important ways of Pulmonata (Gastropoda) evolution

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In the stated subject the main question to be discussed is: reduction of what? Let us consider separately the main components of an organism.

1. Shell. Numerous cases of shell reduction at all stages are known in the row: snail – semislug – slug.

2. Cephalopodium and its elements. Cases of the cephalopodium reduction are unknown, but in some small mollusks (Vertiginoidea) the lower tentacles are absent. This phenomenon is secondary and, perhaps, connected with miniaturization.

3. Nervous system. Evident cases of reduction are not established.

4. Digestive system. Cases of reduction are unknown, but in the streptaxid genus *Careoradula* (Seychelles) both odontophore and radula are totally absent (Gerlach, Bruggen, 1998). Shortened (reduced) intestine in carnivorous mollusks is not a real reduction and is connected with their specific nutrition. The same phenomenon is observed in all carnivorous animals.

5. Excretory system. Cases of reduction are unknown.

6. Respiratory system. Cases of reduction are unknown, but in slugs the lung is comparatively smaller than in related snails. Seemingly, this is connected with a reduction of volume of the visceral sac and an increasing importance of skin breathing.

7. Circulatory system. Cases of reduction are not established but in the majority of small snails vascularization of the lung roof is very weak (*Vertigo, Truncatellina, Punctum*).

8. Muscular system. Cases of reduction are unknown.

9. Reproductive tract. Cases of reduction of this apparatus as a whole are not known, but there are numberless cases of reduction of various additional organs and their elements (flagellum, stylophores and their derivatives, sarcobelum, penial or epiphallic caecum, mucus glands, etc.).

Thus, the regular and permanent reduction down to full disappearance concerns two structures only: shell and additional organs of the reproductive tract. That is why pulmonate taxonomy is mainly based on just these structures. In essence, the current systematics of Pulmonata is the systematics of reproductive tract and, to a lesser degree, their shell.

The phenomenon of shell reduction I have already considered here, in our previous seminar (Schileyko, 2014). In short, I consider the shell as a “break” of biological progress, since the shell, being an effective protection, significantly inhibits the progressive evolution of mollusks, since for any external influences the snail responds with a stereotyped reaction – by withdrawing into the shell. A slug, devoid of such protection, must assess the situation more critically – to crawl away, to stay in the place, to hide in a shelter or something else. In other words, slugs are “cleverer” and more flexible in their behaviour than snails. This is confirmed by the fact that the density of synapses in the procerebrum of a slug (*Limax maximus*) is much higher than in the brain of a snail (*Helix pomatia*) (Zs.-Nagy and Sakharov, 1970). That is why it is no surprise that we observe a universal tendency to the loss of shell among many taxa (there are more than 20 cases of independent shell reduction in Stylommatophora) in the extant species.

Let us consider the cases of reduction of elements of the reproductive tract. In this context, I would like to recall a well-known fact: the reproductive tract is the only system that does not play a vital role in maintaining the life of the individual and the only system that ensures the continuation of the life of the species. From this fact, in particular, it follows that the morphological

transformations of the reproductive tract can be carried out beyond any connection with the evolution of other organs and systems of an organism.
For further discussion one has to answer the question: what is the original state for the pulmonate reproductive tract – simplicity (additional organs are absent) or complexity (genitalia have accessory organs)?

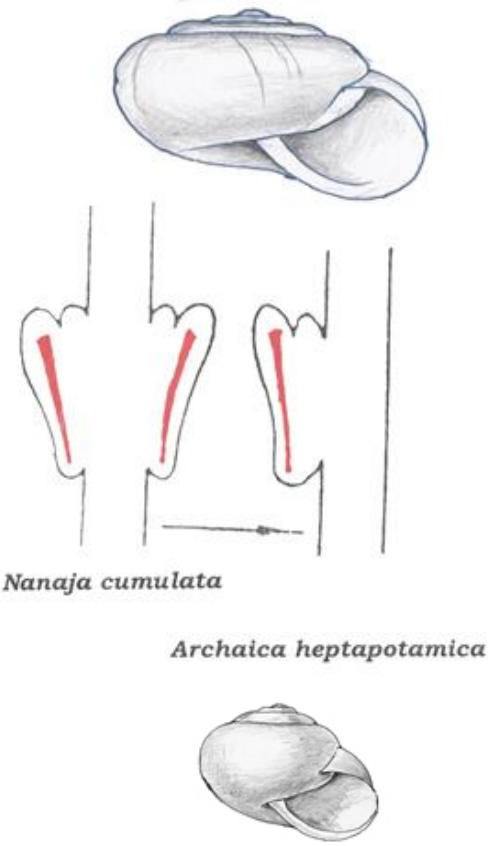
Simplicity can be of a twofold nature: either it is the initial condition, or it is a consequence of the reduction (disappearance) of some additional elements. So, there is an important problem: what is the plesiomorph condition for Pulmonata and, in particular, for Stylommatophora – simplicity of the reproductive tract or complexity. I presume that the plesiomorph condition for Pulmonata is simplicity. It follows from the fact that the genitalia of all Basommatophora, as a rule, do not possess any accessory organs, and that Stylommatophora originated from basommatophoran ancestors.
There are a number of groups whose reproductive tract is always and, seemingly, originally simple: Partuloidea, Endodontoidea, Streptaxidae, Polygyridae, Acavidae, Achatinidae, Clavatoridae, Bulimulidae, Urocoptidae, Clausiliidae, Zonitidae, and Succineidae. So, these groups are out of the current discussion. At the same time, for many groups the initially complex genitalia are very characteristic: Pupilloidea, Enidae, Bradybaenidae, Xanthonychidae, Epiphragmophoridae, Cochlicellidae, Helicarionidae, Helicodontidae, Hygromiidae, and Helicidae. The cases of reduction of accessory organs of the reproductive tract in listed taxa are numerous and various.
Thus, for orthurethral groups which, as a whole, are characterized by the presence of a peculiar penial appendix consisting of five sections, in Odontocycladinae (Orculidae) there is the genus *Walklea* with normally developed appendix, and the related genus *Odontocyclas*, which has no appendix. In Orculinae we see the series *Orculella-Schileykula-Orcula*: species of *Orculella* have a modified but quite developed appendix, in the genus *Schileykula* the appendix is rudimentary, and in *Orcula* the appendix is absent. In the species of African genera (*Anisoloma, Fauxulus*) the appendix is also absent, but I think, the reduction of the appendix in European and African Orculidae took place independently.

In the family Pupillidae the appendix is normally developed, but in the related family Vertiginidae the appendix is absent.
Among Enidae the majority of the genera have the traditional appendix, but a number of taxa have no appendix (*Mordania* s. str., *Chondrula, Meijeriella* and some others). Among three closely related genera of Multidentulinae *Multidentula* has both diverticle of the spermarhecal duct and appendix, Improvisa has no diverticle but an appendix is present, Senaridenta has a diverticle but appendix is absent. In two representatives of Enidae – *Brephulopsis bidens* and *Geminula isseliana callilabris* – partial reduction of the penial appendix was observed in some populations.
In Bradybaenidae the members of the Aegistinae subfamily have a flagellum while in Bradybaeninae the flagellum is absent.

Among Hygromiidae: members of Trochulinae have 4 stylophores (upper pair is rudimentary, without darts) while in Hygromiinae there are 2 stylophores which occupy an unilateral position on the vagina (upper one is rudimentary).

In the Helicidae family there is a genus Helix. Nearly all representatives of this genus have a stylophore and branched mucus glands; however, in the monotypic subgenus *Naegelea* both stylophore and mucus glands are totally absent.
In Helicarionoidea (Helicarionidae, Ariophantidae, Euconulidae) the genitalia have a very complex structure and the full set of additional organs includes sarcobelum, spiral caecum, and lime sac. However, in reality we see a lot of taxa with deprived organs in different combinations.

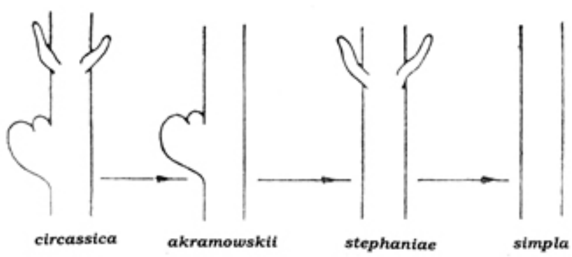
Reduction can occur in two ways: gradually, over several generations, or instantaneously, through a single mutation. Evidently, the reduction of the shell can occur only gradually, and the sudden mutagenic origin of shell loss can be excluded. Reduction of accessory organs of the reproductive tract may be brought about, as it was noted, in both ways.



1. Gradual reduction is the more orthodox route, the main stages of which one can trace in the chain of recent forms. Such an evolutionary path has been established, for example, for such correlatively related organs as the flagellum and diverticle of the spermathecal duct, the length of which can vary within one population (sometimes down to total disappearance). The gradual reduction is characteristic for the upper pair of stylophores of Hygromiidae where it is possible to trace all stages of reduction. Mucus glands of *Cylindrus obtusus* also demonstrate all stages of reduction.

2. “Instant” and full reduction of organs by mutation. A vivid example of a mutagenic disappearance of organs is a pair of Central Asian species – *Nanaja cumulata* and *Archaica heptapotamica* (Hygromiidae). These two species live together in proportion of about 50/50 and differ by only one feature: the first has two pairs of stylophores, while in the second there is one pair occupying an unilateral position on the vagina.

subspecies (?) of **Circassina circassica**



Another good example of mutagenic (instantaneous) reduction, also of Hygromiidae, is *Circassina circassica*. In this species there are four groups of populations (subspecies?) with all possible combinations: a pair of stylophores and mucus glands is present *(Circassica circassica)*; stylophores are present but mucus glands are absent *(Circassica akramowskii)*; stylophores are absent but mucus glands are present *(Circassica stephaniae)*; both stylophores and mucus glands are absent *(Circassica simpla)*. It should be emphasized that no one has ever seen these organs in a rudimentary state - they are either normally developed or there are none at all. The mentioned example with *Helix* – *Naegelea* shows one more case of instant disappearance of all accessory organs.

A particular case of mutagenic reduction is the partial disappearance of additional elements of the reproductive tract. As has been mentioned, this is a rare and rather exotic method of reduction, which is known for two species of Enidae only – Crimean *Brephulopsis bidens* and Asian *Geminula isseliana callilabris*. In these two species, among specimens with a normal penial appendix, specimens have been found in which the basal section of the appendix (A-1) is absent, and A-2 falls directly into the penis. These examples demonstrate that the reduction of accessory organs is a common and widely spread pathway in the evolution of pulmonates.

Naturally, the question arises what could be the causes of organ reduction. I would suggest that there are at least two correlated reasons.

1. Necessity of economy of energy. Indeed, the mentioned additional organs (mucus glands,

stylophores etc.) consist predominately of glandular and muscular tissues which consume much energy.

2. As the reduction concerns mainly the reproductive tract, it is logical to assume that the appearance and complication of various appendages are somehow connected with copulation in the broad sense of the word, in particular, with the formation and complication of isolating mechanisms which could minimize the risk of introgression. Probably the most archaic way to create such mechanisms is morphological complication. However, the appearance of additional morphological structures inevitably entails an additional expenditure of energy.

Theoretical basis for our consideration is the principle of oligomerization of homological organs proposed by V.A. Doghel (1954). The essence of this principle is that the newly formed organs often have multiple anlage, and in the course of further evolution oligomerization takes place, i.e. the number of elements is reduced. As an example, one can specify the American genus *Humboldtiana*, whose members have 4 stylophores, and each of them contains two darts, i.e. the number of stylophores in the hypothetical ancestor was 8. However, there is a monotypic subgenus Oreades which has neither stylophores nor mucus glands.

Thus, I have tried to demonstrate that the reduction is a really common method of evolution of pulmonate molluscs.

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Abstracts
Posters

Arranged in chronological order of the program

MoFA – the newly founded Society for Molluscan Research in Austria

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We are pleased to announce the foundation of the society "Mollusken Forschung Austria – MoFA" („Mollusc Research Austria"), which was authorised by public authority in August 2016. MoFA is a society based in Austria aiming to promote activities of Austrian malacologists and encourage the communication with national and international professional working groups and initiatives. Another task of the society is the enhancement of information exchange and coordination of scientific projects and studies. The society was happily welcomed by several mollusk-related working groups and led already to two small meetings with interesting discussions. More information about MoFA, about molluscs in general and links concerning related initiatives and platforms are provided on our new webpage *www.molluskenforschung.at*. At the moment MoFA counts 26 members and everyone interested in malacological research in Austria is welcome to join our society and/or sign up for our Mail-Newsletter via the webpage.

Contact: team@molluskenforschung.at

Summer in the city! DNA Barcoding and survey of dragonflies in Vienna: preliminary results

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For Austria, a total of 78 dragonfly species are known. Due to the fact that Vienna provides a mosaic of different biogeographic regions and habitats, the city harbours a high percentage of dragonfly species diversity: 61 species (78 %) have been recorded in Vienna so far. But few is

known about their current number and distribution in the city, especially concerning endangered dragonfly species.

Thus, the overall objective of our three-year project, started in April 2017, is a complete survey of the dragonfly fauna in the rural areas of Vienna, focusing on two specific aims: (1) the occurrence and distribution of two species listed in the Flora-Fauna-Habitat (FFH) Directive, the Balkan Goldenring (*Cordulegaster heros*) and the Yellow Spotted Whiteface *(Leucorrhinia pectoralis)*; (2) the acquisition of species specific DNA barcodes of most of the Viennese dragonfly species, including the setup of a reference database comprising the archiving of reference material and the specific DNA sequences of sampled dragonfly specimens.

Data gained in this project on the one hand will help to fulfil the monitoring guidelines of the Flora-Fauna-Habitat Directive of the European Union, on the other hand we will support and contribute to the Austrian Barcode of Life (ABOL) project, a national initiative in biodiversity research.

Within the first project year we record the dragonfly species inventory, particularly focusing on the distribution of *Cordulegaster heros* in streams in deciduous forest areas (Wienerwald and Lainzer Tiergarten), and of *Leucorrhinia pectoralis* in the water bodies of the Lobau, a characteristic floodplain and alluvial forest area. Both species have already been recorded among 43 other species in these areas. Additionally, an unexpected first evidence of Leucorrhinia albifrons, also listed as FFH species, was obtained for Vienna. Up to now, DNA samples and reference specimens of 36 species have been collected. Within the second and third year of the project we will survey additional areas of Vienna, focusing on species which have not been recorded or collected within the first year.

As part of this study the DNA barcoding method will also be tested and optimized for DNA samples from exuvia sampled in the field. Moreover, the project includes a pilot study using water samples, which are assumed to contain remains of dragonfly larvae, as DNA source (environmental barcoding; environmental DNA). In a next step, the species inventory obtained by observation of imagos can be compared with the species number detected via environmental barcoding. Both methods, the usage of exuviae and the eDNA approach, depend on a reference database, which will be established within this study. Especially in dealing with species under protection with high biomonitoring value, non-invasive methods like these have a high potential to contribute to the modern biodiversity research, filling the gaps of knowledge of the distribution of dragonfly species.

Fig. 1. *Cordulegaster heros* (Foto: I. Fischer)

Fig. 2. *Leucorrhinia pectoralis* (Foto: I. Fischer)

Acknowledgments

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Articles

SNAILS ON THE ROCKS

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Abstract

A pilot study was carried out at three adjacent rock faces at a location in the Northern calcareous Alps (Johnsbach,Styria, Austria) to estimate population sizes, densities, activity range and small-scale distribution patterns of selected rock-dwelling snails. The study site was a about 15 m long rock face naturally divided into three parts. These three rock faces were subdivided into 10 sections each 1.5 m wide and 3 m high. Those were again subdivided by a grid of 50 × 50 cm cell size on printed photographs of the sections to facilitate recording of positions of snails. On two days (21.08.2017, 23.08.2017) between 10:00 – 11:30 a.m. each section was investigated by a team of three people. Each team used particular colors for marking the snails to enable recapture. Eight species of land snails were recorded, with *Pyramidula pusilla/ saxatilis* and *Chondrina avenacea* being the most abundant. Only sparse dispersal of snails from one section to another section was recorded. The re-capture rate was in general high, but could not be evaluated for species encountered in low frequencies only (*Cochlodina laminata, Chilostoma achates* and *Petasina unidendata*). For *Chondrina avenacea*, *Neostyriaca corynodes*, *Clausilia dubia* and *Orcula gularis* there was a high re-capture rate. Together with the observation that snails almost never crossed borders of sections, one can assume that these species were quite immobile at least at the timescale of the study. Concerning *Pyramidula pusilla/saxatilis*, the calculated values of population size/densities were considerably higher than the counts. This can be explained by higher activity / mobility but might also be due to low visibility and finding probability. For *Pyramidula pusilla/saxatilis* there was a statistically significant deviation from uniform height distribution within the areas investigated. It was mostly absent below 50 cm above ground and most abundant in heights about 100 – 150 cm above ground.

Keywords: rock dwelling, terrestrial gastropods, population sites, microdistribution, dispersal

INTRODUCTION

While for many gastropods knowledge on biology, behaviour and ecology is minimal, such information would help to address questions of evolutionary processes and mechanisms like adaptation, selection and speciation. Some studies have addressed ecological questions on snails which partly occur on rocky habitats (e.g. Ledergerber et al. 1997; Bisenberger et al. 1999; Kleewein 1999; Baumgartner et al. 2000; Junker 2015; Junker 2016) and only a few studies particularly focused on typical rock-dwelling snails (e.g. Baur & Baur 1995; Giokas & Mylonas 2004; Schmera et al. 2015; Marković et al. 2018).

In general, details of life history, micro-habitat preferences, reproductive biology and food ecology of terrestrial snails are much in demand. In the course of the Alpine land snails workshop 2017 a pilot study was carried out at a rock face near Johnsbach (Styria, Austria). The aims were to determine occurrence of rock dwelling land snail species composition at this site as well as to estimate population sizes and densities and to get insights into activity range and small-scale distribution patterns. The study also includes a descriptive part as information on the rock face, e.g., variation in the texture, plant communities, as well as observation of other invertebrate animals, were recorded.

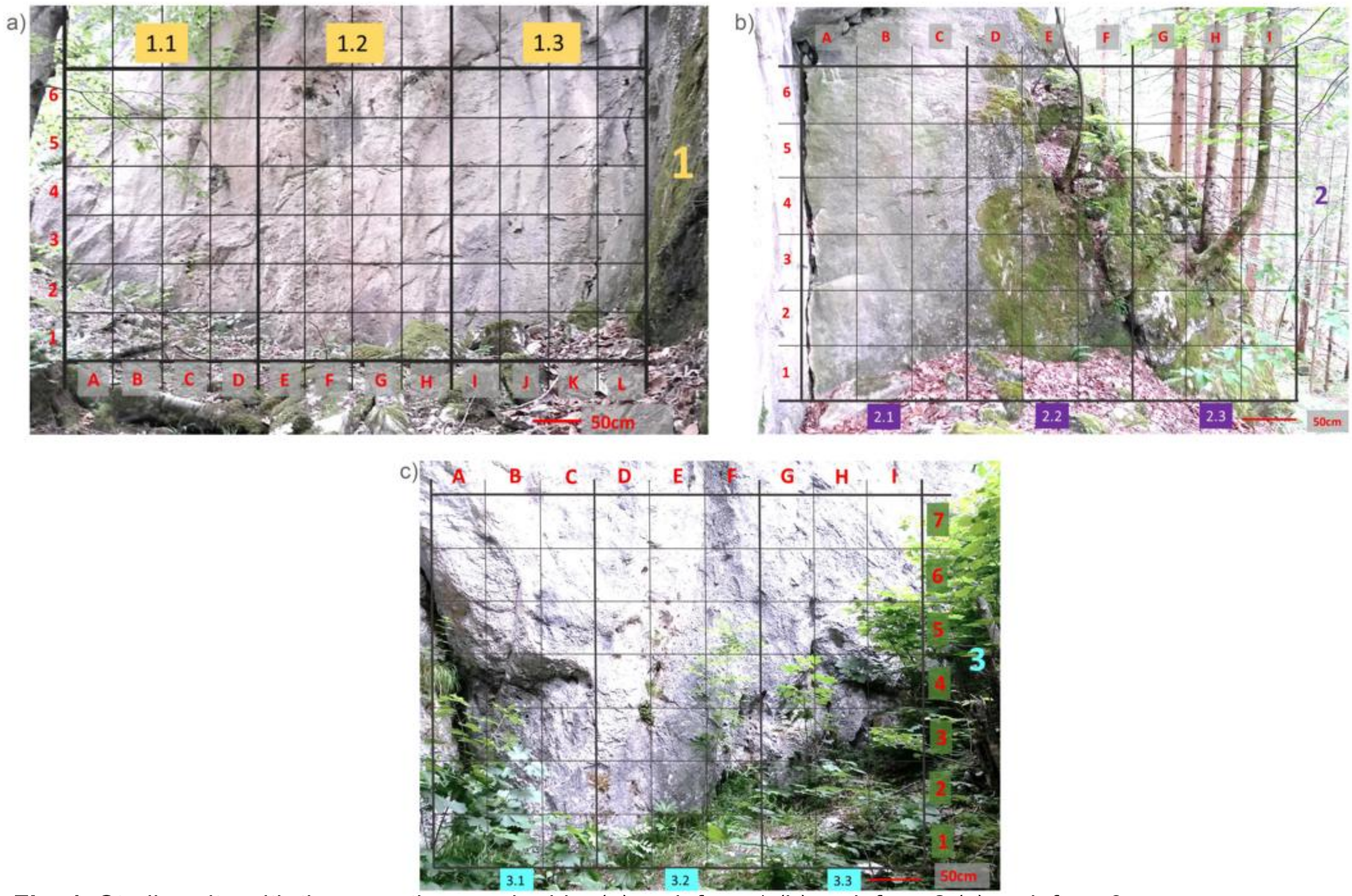

Fig. 1. Studies site with three sections and grids. (a) rock face 1 (b) rock face 2 (c) rock face 3

MATERIAL AND METHODS

Description of sampling site

The study site (at 47°32'17" N, 14°37'26" E) is a steep limestone rock face situated at the formation Wolfbauer Mauer, to the east of the Wolfbauer Wasserfall in Johnsbach (Styria, Austria). These calcareous rocks represent Middle Triassic Steinalm formation (Kreuss 2014). The study site is located in a montane spruce-fir-beech forest on limestone, which is the most frequent forest type in the National Park Gesäuse (Carli 2007). The exposition of the nearly vertical rock face is south to southwest. The altitude of the rock base is 1020 m asl, the height of the entire wall reaches approximately 80 m.

The site studied is approximately 15 m long and is naturally divided into three rock faces with varying exposition (Fig. 1). The entire study area was further subdivided into 10 sections each 1.5 m wide and 3 m high. These sections were marked with chalk on the rock face. On printed photographs of the sections each was subdivided by a grid of 50x50 cm cell size to facilitate recording of the positions of snails (see description of sampling). To allow comparisons between the sampling areas, the same raster was used for all of them. Since it turned out that some peripheral squares could not be screened as they were either partly covered with vegetation (near the ground) or not well reachable, such parts of the sections were identified and excluded from the calculations. Areas with their grids are illustrated in figure 1.

During the period of investigation the weather was fine without rain, average humidity 75-80% and temperatures between 5 – 21 °C, recorded at the weather station Oberkainz nearby (koelblwirt.at/de/webcams-wetterstation-messdaten.html). The microclimate was humid due to pretty much shadowing of the site by trees, the proximidy of a waterfall and small runlets ouzing out at some spots. This became also visible from some of the vegetation (e.g. mosses).

a) b)

Fig. 2. (a) View of the study site. (b) *Neostyriaca corynodes* marked at section 1

Sampling & marking

On two days (21.8.2017, 23.8.2017, in the following "day 1" and "day 2") between 10:00 – 11:30 a.m. each section was investigated by a team of three people (Fig. 2). Each of the ten teams used different colors for marking. For marking, dots of nail enamel were placed with a fine brush to the shells. Only the few individuals of the large shelled species *Chilostoma achates* were marked with numbers. On day 1 the examiners recorded the positions of the snails with single small letters on their graduated section map. On day 2 the same procedure started, but marked (recaptured) animals were recorded on new copies of the maps with small letters, while new records were marked on the maps with capital letters. To support the observer teams, three additional people formed the consulting team for determination support (e.g. for subadult animals), another two people did a vegetation survey and an "other invertebrate" survey respectively at the study site.

Taxonomic notes

The taxonomy of *Pyramidula* is still under discussion. While Klemm (1974) listed *P. rupestris* for Austria, Gittenberger & Bank (1996) assigned eastern Alpine *Pyramidula* to *pusilla*. According to morphological and genetic results Kirchner et al. (2016) hypothesised that both species might occur in Austria. According to a later study of Razkin et al. (2016) only *P. pusilla* and *P. saxatilis* are assumed to occur in the Eastern Alps. Since morphological assignment is not possible we decided to keep this open and use *Pyramidula pusilla/saxatilis* in this paper. Further molecular studies and more detailed morphological studies are needed to solve this question.

Data analysis

Calculation of species densities were done based on the estimated section sizes (see above).

Vertical distribution of snails on the rock faces (i.e., height of position above ground) were analysed in detail for *Pyramidula pusilla/saxatilis*: A Chi-Square test (degrees of freedom = 3) was performed to test whether *Pyramidula pusilla/saxatilis* was distributed in a non-uniform way over the height zones. For these calculations sections 1.1 to 2.1 as well as 3.1 and 3.2 were used. Sections 2.2 and 2.3 were excluded because of too low nunmbers of individuals found. One section (3.3) had to be excluded from the capture re-capture analysis because of erroneous records on the map of day 2. For sections 1.1 to 2.1 height zones 2 to 5 were included, (parts of the other height zones had been excluded; see above). For sections 3.1 and 3.2, height zones 1 – 4 were included.

Population sizes (N) and their standard deviations were calculated with the Lincoln Index (Mühlenberg 1989): $N = m \times c/r$ (m= number of marked animals at first catch; c= number of animals at second catch; r = number of marked animals recorded at second catch). Standard deviation is the square root of s^2 with $s^2 = (m^2 \times c(c-r))/r^3$.

RESULTS

Species spectrum, frequencies and densities of species

One section (3.3) had to be excluded from the capture re-capture analysis because of erroneous records on the map of day 2. Altogether eight species were recorded at the sampling site. Absolute specimen numbers counted on the first day as well as frequencies of species are given in table 1. The most abundant species was *P. pusilla/saxatilis* followed by *Chondrina avenacea, Neostyriaca corynodes, Orcula gularis*, and *Clausilia dubia*. Three species were found only in very low numbers: *Cochlodina laminata, Chilostoma achates, Petasina unidentata* (table 1). Interestingly, *Arianta arbustorum*, which was recorded at the site in spring 2017, was not encountered at all. *Chilostoma achates* was observed in sections 1.4 and 3.2 (one individual each) on day 1, and in section 3.1 (two unmarked individuals) on the second day. One individual of *Petasina unidentata* was found on day 1 in section 1.2, another one (unmarked) in the same section on day 2, as well as one unmarked individual each

Table 1. Species counts and mark recapture calculations

	Day 1			Day 2			Mark-recapture	
Species	**m**	**%**	**c**	**r**	**r (%)**	**N (calc)**	**s**	**Z (obs)**
Chondrina avenacea	136	28.6	129	109	80.1	161	6.1	156
Cochlodina laminata	3	0.6	3	2	66.7	-	-	4
Neostyriaca corynodes	50	10.5	29	26	52	56	3.5	53
Clausilia dubia	38	8	24	17	44.7	54	7	45
Pyramidula pusilla/saxatilis	196	41.2	252	155	79.1	319	15.9	293
Orcula gularis	49	10.3	30	20	40.8	74	9.5	59
Chilostoma achates	2	0.4	2	0	0	-	-	4
Petasina unidentata	1	0.2	3	0	0	-	-	4
Sum		475	100	472	329			618

Note: m = specimens counted on day 1 at the sampling area (sum of all sections); % = frequencies of species; c= number of animals recorded on day 2; r = number of marked animals recorded on day 2; N(calc) = number of specimens calculated from mark-recapture data (only for species with counts >20; rounded); s = standard deviation; Z(obs) = sum of observed individuals (day 1 plus day 2)

in sections 2.3 and 3.1 on day 2.

Results of day 2 calculated over all sections are also summarized in table 1. The highest recapture rates (80 %) were observed for *Chondrina avenacea* and *Pyramidula pusilla/saxatilis*. Among the frequent species, *Clausilia dubia* and *Orcula gularis* had the lowest recapture rates. In general, numbers of individuals calculated from mark-recapture data are similar to the sum of individuals observed on both days.

Recordings of each section separately are given in table 2. Frequencies of species were not uniform among the sections. Specifically, *Chondrina avenacea* was most frequently observed in sections 1.1 and 1.2., whereas *Pyramidula pusilla/saxatilis* was very abundant in all sections except 2.2 and 2.3.

Dispersal and activity

Based on information of marked individuals there was almost no indication for dispersal of snails from one section to another section during the observation period: On day 2, one individual of *Neostyriaca corynodes* had moved from section 1.1. to 1.2, and one *Pyramidula pusilla/saxatilis* from 3.2 was found in 3.1. Within sections some

Table 2. Species counts and mark recapture calculations for sections

Section/Species	**1.1**	**1.2.**	**1.3**	**1.4**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**
C. avenacea	28/32/28	40/42/38	14/9/6	9/9/0	13/17/12	13/7/5	2/1/1	5/1/1	12/11/9
	32 (1.7)	44 (3.2)	-	-	-	-	-	-	-
N. corynodes	14/4/3	8/5/4	8/8/8	6/6/6	3/3/2	2/0/0	4/2/2	4/1/1	1/0/0
	-	-	-	-	-	-	-	-	-
C. dubia	4/0/0	3/2/2	2/0/0	3/2/1	3/4/3	8/6/4	9/6/5	2/0/0	4/4/2
	-	-	-	-	-	-	-	-	-
P. pus./sax.	20/31/16	43/46/40	36/38/21	26/34/21	23/40/16	2/3/1	2/2/2	30/34/24	14/24/14
	39 (1.7)	49 (4.5)	65 (4.2)	42 (2.5)	58 (2.9)	-	-	42 (3.7)	-
O. gularis	2/0/0	9/5/5	11/8/7	6/6/4	0/3/0	1/1/1	3/2/0	8/2/0	9/3
	-	-	-	-	-	-	-	-	-

Note: m/c/r: specimens counted at the nine sections on day 1 (m) compared to day 2 (c) as well as marked individuals on day 2 (r); for species with counts >20 the second line shows estimated N calculated from mark-recapture data (rounded; standard deviation in parentheses). *Cochlodina*, *Chilostoma* and *Petasina* were excluded because of too low numbers.

Table 3. Species densities

Section/Species	1.1	1.2.	1.3	1.4	2.1	2.2	2.3	3.1	3.2	d_av	d_calc
Chondrina avenacea	8.62	11.43	3.73	3.35	3.15	4.52	1.14	3.22	4.27	5.04	5.96
Neostyriaca corynodes	4.31	2.29	2.13	2.23	0.73	0.7	2.29	1.78	0.36	1.85	2.07
Clausilia dubia	1.23	0.86	0.53	1.12	0.73	2.78	5.14	0.89	1.42	1.41	2
Pyramidula pusilla /saxatilis	6.15	12.29	9.6	9.67	5.58	0.7	1.14	13.33	4.98	7.26	11.81
Orcula gularis	0.62	2.57	2.93	2.23	0	0.35	1.71	3.56	3.2	1.81	2.74

Note: Densities of individuals per m^2 (counted for the recording on day 1) recorded in each section; d_av = average over all sections. d_calc = densities (average over all sections) based on calculated population size N. *Cochlodina, Chilostoma* and *Petasina* were excluded because of too low numbers.

movements were recorded as positions with snails marked on day 1 were empty on day 2, while on day 2 newly recorded as well as marked snails were found at positions which were empty on day 1. Since snails were not marked individually (e.g. with numbers), dispersal distances could not be measured. However, snails marked on day 1 were frequently found in the same position on day 2, although there is no proof that these were indeed the same individuals.

Capture-recapture

The calculations were based on nine sections (3.3 excluded, see above). Comparing snail counts on day 1 and day 2 resulted, with a few exceptions, in quite similar numbers for all species (table 2). Yet, considering marked and unmarked individuals reveals that sometimes a considerable proportion of snails from day 1 were not recorded on day 2, while new snails appeared. One of the main questions of this study was to assess to which extent numbers of counted snails in a certain area reflect the actual number of individuals. For this task we performed the capture-recapture calculations for each section separately as well as for the whole site. Results for the whole site (3 areas, 9 sections) for all species recorded in numbers >20 are included in table 1, while the results for each section are shown in table 2. In general, calculated numbers are similar to the actually counted individuals. However, for *Pyramidula pusilla/saxatilis* the calculated values were considerably higher in some sections.

Vertical distribution of *Pyramidula pusilla/ saxatilis* on the rock face

Besides the fact that *Pyramidula pusilla/saxatilis* and *Chondrina avenacea* apparently were non-uniformly distributed among the sections (see table 2) and even were almost absent in some sections, there seemed to be an uneven distribution regarding the height where they were positioned. Height distribution was calculated for the most abundant species *Pyramidula pusilla/saxatilis* which was mostly absent in the first zone (50 cm above ground) and most abundant in zones 3 and 4 (100 – 150 cm above ground). To test whether there was a significant preference, we performed a Chi-Square test for the sections 1.2 - 2.1. A significant deviation from uniform distribution was found in sections 1.2, 2.1 and 3.1 ($p<0.001$), in section 3.2 ($p<0.01$) as well as in section 1.1 in ($p<0.05$). Over all five sections there was a highly significant result indicating non-uniform distribution ($p<0.001$). Although in sections 3.1 and 3.2 the pattern seemed similar, they could not be included in the calculation since the species was present only in three height zones.

Remarks on sampling site – characterization of vegetation cover and arthropod fauna

The dominant tree species in the immediate vicinity of the studied location were *Fagus sylvatica* and *Picea abies*. Additionally saplings of other woody species could be found, e.g. *Fraxinus* *excelsior, Acer platanoides, Sorbus aria, Ulmus glabra* and *Sambucus nigra*. Herbaceous plant species in the understorey were represented by *Aruncus dioicus, Lactuca muralis, Lilium martagon, Helleborus niger, Sanicula europaea, Adenostyles alliariae, Geranium robertianum, Oxalis acetosella, Mercurialis perennis* etc. and ferns like *Polypodium vulgare* and *Dryopteris filix-mas*. Limestone blocks were densely overgrown by bryophyte species like *Hypnum cupressiforme*.

Rock face 1: This part of the rock site was almost vertical with a few narrow crevices. The vegetation cover amounted to approximately 1% only, restricted to the crevices. The most frequent species was *Asplenium trichomanes*, a very common rock dwelling fern. Further observed plant species were: *Asplenium ruta-muraria, Lactuca muralis, Primula auricula, Kernera saxatilis, Hieracium murorum, Carex* spp.

Rock face 2: This rock face was inclined to approximately 75 degrees and exhibited a dense moss cover to about 60 % of the area. Due to the less extreme situation humus accumulation allowed other plant species to occur, some of them taller growing species. We observed spruce, maple and elder seedlings, *Geranium robertianum* and *Aruncus dioicus* which are not characteristic for steep rock habitats. As representatives of rock inhabiting species e.g. *Asplenium trichomanes* and *Kernera saxatilis* were present.

Rock face 3: The almost vertical third rock face was covered by vegetation to approximately 5%. Crevices were slightly more prominent compared to rock face 1. The following species were observed: *Asplenium trichomanes, Asplenium ruta-muraria, Potentilla clusiana, Kernera saxatilis, Erica carnea, Hieracium murorum, Carex* spp. and some grass species.

Arthropods of the following groups were observed: spiders, harvestmen, woodlice, pill millipeds (*Glomeris pustulata* and *Glomeris hexasticha*) and jumping bristletails (*Machilis* sp.). Web building spiders were observed in nearly every bigger rock fissure except those located at wet parts of the rock (section 3.1). Woodlice were spotted frequently on the rock face and also in high numbers in the dry leave litter at the foot of the rock. Pill millipedes were found at the sunny parts of rock face 3. Both woodlice and pill millipedes are known for their preference of environments rich in lichens and limestone.

DISCUSSION

Species spectrum, frequencies and densities of species

The spectrum of taxa observed comprised species common in the area and this particular environment. Some of the species were more generalists. Half of the species are mainly rock dwelling or rock-associated species: *Pyramidula pusilla/saxatilis*, *Chilostoma achates* and *Orcula gularis*, and *Chondrina avenacea*. The fact that numbers of individuals calculated from mark-recapture data were similar to the sum of individuals observed on both days suggests that the snails were quite active and visible because of good seasonal and climatic conditions.

Whether species densities were influenced significantly by co-ocurrence of other snail species would be interesting to be analysed for such a relatively high number of species (comp. Baur & Baur 1990). But apparently, as our study shows, population densities are highly dependent on the microhabitat (e.g. almost no individuals on the moss-covered areas).

Mobility and horizontal dispersal

Although for some species observed numbers were quite small, it was apparent that with the exception of *Chilostoma achates* and *Petasina unidentata* the other species were rather immobile in the observed time slot and environment. Nevertheless, it was not possible to calculate distances of movements because the snails were not marked individually. From the distribution pattern of snail frequencies at the two study days and from the very few records of individuals crossing from one to a neighboring section, we deduce that mobility and dispersal tendency for the frequent and small species is very low. From our observations we estimate that activity did not exceed more than few centimeters (within 2 days).

The low dispersal activities of the investigated clausiliids are apparently as low as or even lower than those recorded in a former study for *Cochlodina laminate* by Junker (2015). The same can be said for *Chondrina avenacea*, which has similar low activities with maximum 0.5 m per day, which were also reported for *Chondrina clienta* by Baur & Baur 1995). But we assume that activity might vary with altering climatic and environmental conditions or including seasonal migration as indicated by Junker (2015) for *Cochlodina laminata*. Furthermore, snails may drop down from steep structures or be dispersed passively by other vehicles. At the study site it is planned to test individual marking methods (Henry & Jarne 2007) and to use this to acquire more reliable data for particular species.

Non-uniform distribution

Apparently, distribution of species and individuals was not uniform, with respect to the three rock faces as well as concerning vertical distribution and positions within sections. These differences can be explained by different vegetation cover, particularly the dense of the moss layer. In section 2.1 species occurrence as well as specimen counts were in the same range as in other parts of the whole site, while in sections 2.2 and 2.3 much lower numbers of most species were found. These two sections are characterized by extensive covering by moss as well as larger plants like trees and shrubs. Only one species, *Clausilia dubia*, was found in higher numbers in sections 2.2 and 2.3 compared to the other sections. However, it was found mainly on the lower parts of a tree trunk which grew amidst the rock. In general, only a few snails were found on the moss at all, while most individuals were encountered on the rocky surface between moss patches.

Overall, observers recognized that snails were distributed preferentially near crevices or otherwise structured parts of the areas. While this seems quite reasonable from an ecological point of view and considering the low mobility, it is not possible to quantify such site preferences with the present study design.

Concerning differences in the observed height distribution of *Pyramidula pusilla/saxatilis,* one might argue that it could be due to a sampling artefact, since the height with the densest occurrence corresponds with the most convenient position for collecting for adult humans. However, we do not regard this as a likely explanation because the observers were instructed to specifically take care to avoid such a bias. Presently it is not possible to put forward a reasonable hypothesis for the observed bias in the distribution of *P. pusilla/saxatilis*. Several factors could influence the distribution, e.g., microclimate, microhabitat factors (vegetation, food availability, e.g., lichens) or predator interactions.

Similar distribution patterns (i.e., height zones; structured/unstructured areas) might hold true also for the other species, but the specimen counts were too low to address this issue by statistical tests in the present analysis.

Mark-recapture analyses

In general, the recapture rate was high, but the results have to be differentiated. For three species (*Cochlodina laminata, Chilostoma achates* and *Petasina unidendata*) counted numbers were too low to draw any conclusions. For *Chondrina avenacea, Neostyriaca corynodes, Clausilia dubia,* and *Orcula gularis* there was a high recapture rate and together with the observation that snails almost never crossed borders of sections one can assume that they are quite immobile.

For the smallest species, *P. pusilla/saxatilis*, the calculated values were considerably higher than the counts on day 1. This can be explained by higher activity / mobility but might also be due to low visibility and finding probability. Nevertheless, also for *P. pusilla/saxatilis*, only one individual was recorded to cross a section border. Thus, it appears likely that they may frequently hide in crevices.

Critical comments on methods

For further studies it should be tested if the nail polish (solvent or pigments) might harm the snails or negatively influence their mobility. Similarly, any potential influence of the chalk marking on the rocks on snail movements should be tested under standardized conditions.

As a matter of fact, with this study design we surveyed a comparatively small area only and it was not possible to evaluate the distribution patterns of the various species in the upper regions of the rock face. We do not know whether in higher elevations above the investigated area the distribution is similar and according to the results from our study it might vary considerably. Therefore, it is not possible to extrapolate numbers for the "whole population". Furthermore, seasonal aspects were not covered. However, we could at least get first insights into population densities as well as relative frequencies of several co-occurring rock-dwelling snail species.

The monitoring was possible only with a large group of investigators. But, such a survey would not have been possible with completely unexperienced people. All of the persons involved had some experiences in monitoring and observing snails. Nevertheless, the differentiation of species, especially of juveniles, might sometimes be problematic. We did not exclude juveniles as this might have resulted in too low counts. Moreover, for assessing whether a specimen should be regarded as adult the need of manipulating individuals would have been counterproductive, since we were striving to intervene as little as possible. It has to be mentioned that during the survey snails only rarely fell down when being marked. In general, we tried to prevent possible problems of species assignment by including taxonomic experts as supervisors.

For similar studies as presented here it is essential to employ a high number of people and in principle such surveys appear attractive for "citizen science" projects. Yet, we recommend to involve experts and trained people as well as to provide adequate training for all participants.

Conclusion

The present pilot study provided insights into occurrences of snail species and their relative frequencies on a rock face in the eastern Alps. Species densities and populations sizes estimated from the data varied among sections along the rock face. The most relevant factor seemed to be moss coverage. Areas with moss proved to be almost completely devoid of snails. Mobility and dispersal tendency for the frequent and small rock-dwelling species is very low and the re-capture rate was in general high. *Chilostoma achates* and Petasina unidentata occurred only in low numbers and were quite mobile. Mobility even of small snail species could be further explored by individual marking using various colors. Moreover, the uneven distribution concerning height above ground as well as with respect to structuring should be investigated in detail including a higher number of sites.

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THE SNAIL SUMMITEERS - GASTROPOD FAUNAS OF SOME EXPOSED ALPINE LOCATIONS IN THE GESÄUSE NATIONAL PARK

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Abstract

A species list of gastropods on several mountain summits in the Gesäuse region was generated, as the knowledge of the species composition of alpine areas will serve as valuable reference for further surveys and monitoring in the view of global warming. During the Workshop Alpine Landsnails 2017, the participants spent two days at the alpine refuge Hesshütte (Johnsbach, Styria, Austria) and surroundings and collected terrestrial snails at ridges and summits about ~ 1950 - 2360 m asl within the Hochtorgruppe/Ennstaler Alps. Altogether 14 species were recorded. More than half of the species recorded (*Arianta arbustorum*, *Chilostoma achates*, *Orcula gularis*, *Neostyriaca corynodes*, *Petasina unidentata*, *Pupilla stern*i, *Pyramidula pusilla/saxatila*, *Vitrea subrimata*) are known as ecological generalists, rock inhabitants or grassland dwellers, which ocurr in elevations from lower altitudes to alpine environments. Five species are known to be specially adapted to lower temperatures and tend to occur in higher elevations. The two Austrian endemics *Trochulus oreinos* and *Cylindrus obtusus* are restricted to primarly treeless habitats above the timberline. *Eucobresia nivalis* and *Macrogastra badia* are bound to cooler habitats from the montane zone up to the alpine zone, but also occur below the timberline. *Columella columella* represents a cold-adapted relict of the glacial times, which is nowadays restricted to high altitudes of the Alps, the Carpathians and Scandinavia. Observations of intrusion of lowland forest species to higher alpine regions may trace climate change in high peaks of the region and – accompanied by monitoring in other regions – uncover dynamics in species composition.

Keywords: Gastropoda, Gesäuse, summits, global warming

INTRODUCTION

It is known that terrestrial gastropod species numbers decrease with increasing elevation (Bishop 1977; Baur et al. 2014; Rabitsch et al. 2016; Volkmer 2017) and, in addition, exposed summit regions with harsh climatic and environmental conditions are expected to host very low numbers of species. On the other hand, due to climate change, species of lower elevations enlarge their ranges upwards and for some cold-adapted species, shifting of distribution ranges to higher elevations might be a solution to avoid detrimental effects of too warm conditions (Baur & Baur 2013). Therefore, the knowledge of summit faunas and their assessment over time will give valuable information about faunal changes and processes. For these reasons, species lists of gastropods on mountain summits will serve as valuable reference for further surveys and monitoring.

During the Workshop Alpine Landsnails 2017, the participants spent two days at the alpine refuge Hesshütte (Johnsbach, Styria, Austria) and surroundings and collected terrestrial snails at ridges and summits above 2000 m within the Hochtorgruppe/Ennstaler Alps. These mountain peaks are among the highest of the region. Geologically they belong to the Dachstein formation, a Triassic limestone sediment (Kreuss 2014). The region is rich in endemics in plants as well as in invertebrates, including gastropods (Rabitsch & Essl 2009). Despite several lists of the terrestrial gastropod faunas of the Gesäuse region in general (Franz 1954; Klemm 1974; Reischütz 2000; Sattmann et al. 2000; Duda et al. 2017) almost no detailed data was published on the alpine faunas of this area. Generally, there are only scarce data on gastropod faunas in summit regions (Scharff 1928; Bishop 1977; Cameron & Greenwood 1991; Baur et al. 2014). Recently, a master thesis dealing with gastropod assemblages of the Gesäuse mountains was published (Volkmer 2017). In this study 54 sampling sites subdivided into four regions (Großer Buchstein, Tamischbachturm, Planspitze Rosskar, Zinödl) were investigated. Our study included several exposed summits and ridges above 1950 m asl. of the Hochtorgruppe (including Zinödl and Planspitze; Fig. 1).

METHODS

Snails were collected at several summits and ridges of the Hochtorgruppe from ~ 1950 - 2360 m on August 25/26 2017. Those environments are bare of trees and characterised by patchy ground vegetation, abundant calcareous rocks and rock gravel covered mainly by patchy *Caricetum-firmae* meadows (Duda et al. 2010). Shells and living snails were collected by hand. Additionally, soil

Figure 1. Collecting site close to Hochtor summit 2.300 m asl

Table 1. Localities, geographic coordinates, elevation of the collecting sites and main habitat structures

	Guglgrat East	Hochtor Summit	Josefinensteig	Planspitze Fuss	Peternscharte	Hochzinödl-Summit
Elevation (m asl)	2250	2360	2030	1950	2040	2191
Longitude E	14°38.133‘	14°37.950‘	14°38.516‘	14°38.213‘	14°38.064‘	14°39.960‘
Latitude N	47°33.533‘	47°33.700‘	47°33.445‘	47°34.243‘	47°38.064‘	47°33.930‘
Grass	1	1	1	1	1	1
Boulder	1	1	1	1		1
Rocks	1	1	1	1	1	1
Stones					1	1

samples of 1-2 litre were taken from all sites investigated. From the latter, shells were gained by sieving with mesh sizes of 4,0 and 0,5 mm. Shells were determined by classical morphological characterization according to the literature (Kerney et al. 1983; Welter-Schultes 2012; Horsák et al. 2013).

Table 1 lists localities, date of collecting, geographic coordinates and the elevation of the collection sites. Each locality was surveyed for approximately 30 minutes by three to seven persons.

Taxonomic notes

Pyramidula: The taxonomy of *Pyramidula* is still under discussion. While Klemm (1974) listed P. rupestris for Austria, Gittenberger & Bank (1996) assigned eastern Alpine *Pyramidula* to *pusilla*. According to morphological and genetic data Kirchner et al. (2016) hypothesised that both species might occur in Austria. According to later studies of Razkin et al. (2016, 2017) only *P. pusilla* and *P. saxatilis* are assumed to occur in the Eastern Alps. Since morphological assignment is not possible we decided to keep this open and name it *P. pusilla/saxatilis* in this paper. Further molecular studies and more detailed morphological studies are requested to solve this question.

Subspecies: Klemm (1974) and other authors differentiated many subspecies, which partly were based on the formerly used term “forma”. In many cases thorough investigations concerning the reliability of these taxa are lacking. Therefore, in the present study we refrain from assigning subspecies.

RESULTS & DISCUSSION

The elevation of the six collection sites ranged from 1950 - 2360 m asl. Weather conditions were dry and sunny. Altogether 14 species were recorded. The particular results for each site are shown in table 2. The most diverse locality was Peternscharte with 7 species. A crosscheck with Klemm (1974) showed that all species collected have already been recorded from these mountain stocks except *Columella columella*, from which the closest known record in Klemm (1974) came from “Leobner Berg” (regarded as “Leobner” in many maps), a mountain approximately 7,5 kilometres south of Hochtor. Furthermore, Klemm (1974) mentioned 19 species and subspecies from the locality “Hochtor”, including four of the five species we collected in the present study. However, it should be considered that in old records often the peaks were not distinguished from the mountain stock in general which can be expected to be more diverse than the mere summit faunas. The investigated sampling sites correspond with respect to their elevation to the altitudinal belts H3 (1900-2099 m asl) and H4 (2100-2223 m asl) defined by Volkmer (2017). In that study a maximum species number of 7 per sampling site was recorded, too.

Table 2. Species recorded

	Guglgrat East	Hochtor Summit	Josefinensteig	Planspitze Fuss	Peternscharte	Hochzinödl-Summit	Zinödl >2000 m §
Arianta arbustorum	L	L	E	L	L	L	+
Chilostoma achates						E	
Cylindrus obtusus	L	L	E		L		
*Ena montana**		E					
Neostyriaca corynodes					E	E	+
Orcula gularis					L		
Petasina unidentata	L		E	E			
Pupilla sterri					E		
Pyramidula pusilla/saxatila	L	L		L	L	L	+
Trochulus oreinos	L	L	E		L	L	+
Columella columella			L				
Eucobresia nivalis				E			
Vitrea subrimata				L			+
Macrogastra badia				L		E	
Vertigo alpestris							+

Note: § = Zinnödl above 2000 m, reported by Volkmer (2017) Q17, 19. L = living; E = empty shells; + = record of Volkmer (2017); * = in bird faeces

More than half of the species recorded are known as ecological generalist or more or less generalistic rock inhabitants and grassland dwellers, which live in elevations from lower altitudes to alpine environments: *Arianta arbustorum, Chilostoma achates, Orcula gularis, Neostyriaca corynodes, Petasina unidentata, Pupilla sterrii, Pyramidula pusilla/saxatila, Vitrea subrimata*.

Five of the species recorded are known to be specially adapted to cooler temperatures and tend to occur in higher elevations. Two of them – the Austrian endemics *Cylindrus obtusus* and *Trochulus oreinos* – are strictly restricted to primarly treeless alpine and subalpine habitats (comp. Duda et al. 2010). Another two species – *Eucobresia nivalis* and *Macrogastra badia badia* – are bound to cooler habitats from the montane zone up to the alpine zone. They are not compulsory bound to primarily treeless habitats, but also occur in mountain forests (Ložek 1966; Klemm 1974). The last of these cold adapted species – *Columella columella* – represents a relict of the glacial times and is nowadays restricted to high altitudes of the Alps, the Carpathians and Scandinavia (Welter-Schultes 2012; Horsák et al. 2013).

A very specific finding recorded by us from Hochtor summit was *Ena montana*. This species is common in the whole region, but preferably lives in montane and subalpine forests and avoids treeless rock and rock debris settings (Klemm 1974). We collected one single shell, which was still packed in bird faeces. It was obviously brought by a bird to the highest peak of the Gesäuse. However, this finding conveys an idea about possible dispersal mechanisms of snails. Snails might be transported by birds over long distances, not only adhered to the feathers or legs, but also by surviving the intestinal passage – and hereby colonize new areas (Wada et al. 2012; Gittenberger 2012).

Concerning the species composition Volkmer (2017) achieved similar results, but according to his higher number of sampling sites (58) he also found a higher number of species (18 in elevations of 1900-2099 m, 8 in elevations of 2100-2233 m). Only one of the species additionally recorded by Volkmer (2017) can be seen as more or less cold adapted (Vertigo alpestris), the remaining species are far-spread (*Acicula lineata, Peudofususlus varians, Eucobresia diaphana, Macrogastra plicatula, Aegopinella nitens, Arion sp., Semilimax semilimax, Aegopis verticicllus*).

With respect to biogeographic considerations, five of the recorded species have their main distribution in the Eastern Alps. Two of them (*Cylindrus obtusus, Trochulus oreinos*) represent Austrian endemics; another species (*Orcula gularis*) is a sub-endemic (Reischütz & Reischütz 2009). The remaining two (*Macrogastra badia, Neostyriaca corynodes*) are mainly Eastern Alpine species (Klemm, 1974), but also occur in other mountain ranges. The comparatively high number of endemics found in high elevations as mentioned by Rabitsch & Essl (2009) and Volkmer (2017) is often explained with the fact that the unglaciated alpine zone at the margins of the Northeastern Alps provided stable habitat conditions through long time periods and, therefore, triggered the radiation of endemics (Rabitsch & Essl 2009; Duda et al. 2010). Yet, it might be partly due to the recognition of a high number of subspecies, which, however, required further detailed studies.

Populations of cold-adapted species might come under stress, when their climatic optimum reaches the high alpine zone and they become trapped at the summits. Such phenomena were mainly recorded for alpine plants (e.g. Grabherr et al. 1994; Dirnböck et al. 2011; Dullinger et al. 2012), but also discussed for snails (Duda et al. 2010; Baur & Baur 2013; Baur et al. 2014). Similarly, species of lower altitudes might enlarge their range upwards. In this context, it is interesting that Volkmer (2017) found the pronounced forest species *Aegopis verticillus* and *Acicula lineata* in elevations of 1900-2099 m. If this could be a first sign of climatic change or just untypical findings, cannot be decided at the current stage of knowledge. Further observations may trace faunal changes in high peaks of the region and – accompanied by monitoring in other regions – uncover dynamics in species composition.

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MALACOLOGICAL EXCURSION TO VORARLBERG (AUSTRIA) IN THE COURSE OF THE AUSTRIAN BARCODE OF LIFE PROJECT

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Abstract

In June 2016, an excursion to Vorarlberg, the westernmost Austrian federal country, took place. It was conducted by the Natural History Museum Vienna in the course of the ABOL pilot project mollusca. Aim of this excursion was to obtain fresh material of non-marine molluscs of this area, as most of the few material from Vorarlberg in the mollusc collection of the NHMW was not younger than 1974. Sampling took place in the following regions: Bregenzer Wald, Vorarlberger Rheintal, Walgau, Rätikon and Klostertal. Altogether, 69 species of Gastropoda were sampled or observed at 23 sites. Besides the first record of Trochulus clandestinus, which was already published in a previous paper, the first unambiguous record of Trochulus striolatus senso stricto could be documented.

Keywords: Gastropoda, Vorarlberg, ABOL

INTRODUCTION

From 11th to 15th June 2016, members of the Natural History Museum Vienna (NHMW) undertook a malacological excursion to Vorarlberg in the course of the ABOL pilot project Mollusca.

The Austrian Barcode of Life (ABOL, http://www.abol.ac.at/en/) is an initiative that aims to generate and provide DNA barcodes of all species recorded from Austria. Vorarlberg, the westernmost federal country of Austria, is situated at the border between the Western and the Eastern Alps (Friebe 2007) with more biogeographic connections to Switzerland and south western Germany, than to the rest of Austria. During the last glacial maximum it was covered by an ice shield and post-glacial recolonisation by organisms took place from south-western and north-western refuge areas (Van Husen & Reitner 2011, de Graaff et al. 2007). Concerning gastropods, this becomes apparent by e.g. the westerly distributed land snail *Trochulus villosus*, whose origin lies very likely in the French Jura and Central Switzerland (Depráz et al. 2008). In contrast, the eastern parts of the Austrian Alps were presumably re-colonized from refuges east and north-east of the formerly glaciated areas (e.g., *Orcula dolium*: see Harl et al. 2014a & b), from refuge areas within the Alps as proposed for plants by Schönswetter et al. (2005) or land snails (e.g., *Cylindrus obtusus*: Kruckenhauser et al. 2017) or even from the northern Balkans (e.g., *Caucasotachea vindobonensis*: Kajtoch et al. 2017). Thus, the malacofauna of Vorarlberg differs remarkably from the rest of Austria and is therefor of special interest for the ABOL project. Until now, there was only few material from Vorarlberg in the mollusc collection of the NHMW, most of it not younger than 1974. The main goal of this excursion was to obtain recent data and samples of terrestrial molluscs of Vorarlberg. Participants of this excursion were (in alphabetical order): Michael Duda, Elisabeth Haring, Oliver Macek, Luise Kruckenhauser, Helmut Sattmann, Sara Schnedl and Julia Schindelar.

MATERIAL & METHODS

Collection areas were determined by studying the literature concerning the malacofauna of Vorarlberg (Klemm 1974, Sperling 1972, Reischütz 1993) and surveying the material of the mollusc collection of the NHMW. The 12 selected collection areas belong to the following regions: Bregenzer Wald, Vorarlberger Rheintal, Walgau, Rätikon, and Klostertal. Within these 12 areas (Table1) snails were recorded and collected at 22 sampling sites (minimum distance within areas 200 m). Individuals were collected by hand catch and at some sampling sites in the Bürser Schlucht also by sieving of leaf litter. The sampling sites are listed in Table 1 including the coordinates they cover (exactness: 1 minute) and some brief description. The specimens collected during this excursion are stored in the mollusc collection of the Museum of Natural History Vienna under the acquisition

Table 1. Sampling areas visited from Monday, 11.07.2016 to Friday, 15.07.2017. Number of sampling sites within each area are indicated.

	Area	Date	Coordinates, elevation	Description	No. sampling sites
1	Bregenzerwald, Bezau, Rimsbach	Monday, 11.07.2016	47°22'N 09°55'E 702 m asl	mixed forest in a small valley, creek with perennial herbs, forest edge	1
2	Bregenzerwald, Bezau, Greben	Monday, 11.07.2016	47°22'N 09°54'E 677 m asl	meadow with rocks on forest edge	1
3	Bregenzerwald,Bezau, Unterdorf	Monday, 11.07.2016	47°22'N 09°53'E 646 m asl	well on wayside	1
4	Vorarlberger Rheintal, Götzis, Örflaschlucht	Tuesday, 12.07.2016	47°19'N 09°39'E 493-640 m asl	river canyon with mixed forest, rocks and forest edges	3
5	Bregenzerwald, Schwarzenberg / Andelsbuch Bregenzer Ache	Tuesday, 12.07.2016	47°24'N 09°51'E 723 m asl	river canyon with mixed forest, high perennial herbs and rocks	1
6	Bregenzerwald, Mellau / Au, Kanisfluh	Tuesday, 12.07.2016	47°19'N 09°55'E 1520-1530 m asl	alpine meadows, rocks, forest edge	2
7	Walgau, Bludenz, Montikel	Wednesday, 13.07.2017	47°09'N 09°49'E 600-743 m asl	mixed forest with rocks and rock faces	4
8	Rätikon, Brand, Seetal - Böser Tritt	Thursday, 14.07.2016	47°03'N 09°45'E 1594 m asl	rocks (scree) with alpine meadows and single mountain pines	1
9	Rätikon, Bürs, Bürser Schlucht	Thursday, 14.07.2016	47°08'N 09°49'E 558-711 m asl	river canyon with mixed forest and rocks	4
10	Rätikon, Brand, Palüdhütte, Melkboden	Thursday, 14.07.2016	47°06'N 09°43'E 1695 m asl	alpine meadow with forest edge and rocks	1
11	Klostertal, Dalaas, Radonatobel	Friday, 15.07.2016	47°07'N 10°01'E- 47°08'N 10°01'E 962-1331 m asl	mixed forest with forest edge, subalpine meadow and creek	3
12	Klostertal, Stuben, Rauzmähder	Friday, 15.07.2016	47°08`N 10°10'E 1813 m asl	alpine meadow with rocks and boulders	1

numbers:
NHMW 109000/AL/00968 - NHMW 109000/AL/01024,
NHMW 109000/AL/01114 - NHMW 109000/AL/01123,
NHMW 109000/AL/01129,
NHMW 109000/AL/01265 - NHMW 109000/AL/01347,
NHMW 109000/AL/01412 - NHMW 109000/AL/01415,
NHMW 109000/AL/01521 - NHMW 109000/AL/01523.

RESULTS & DISCUSSION

The recorded snails are summarized in table 2. Altogether, 69 species were sampled or observed at 23 sites. Sampled areas with a higher number of recorded species (see also table 2) were Bürser Schlucht (30), Montikel (23), Örfla Schlucht (21) and Rimsbach (18). In general, it can be stated that the higher number of species within these areas is not only a result of a higher number of sampling sites, but also results from the habitat diversity of rocks facing river canyons, which inhabit a many of different microclimates. The number of recorded species of Montikel and Bürser Schlucht also differs from already published records of these areas (Brandstetter & Stummer 1995, Falkner & Stummer 1996). Notable findings were those of *Trochulus clandestinus* (first record in Austria, see Duda et al. 2017) and *Trochulus striolatus* (first unambiguously documented record for Vorarlberg) as the occurrence of these taxa in Vorarlberg were not clear so far. Klemm (1974) mentioned the taxa *Trichia striolata subcarinata* (Clessin, 1874) and *Trichia striolata subtecta* (Clessin, 1874) to occur possibly in Vorarlberg. Reischütz (1993) mentioned *T. rufescens* (synonym of *T. striolatus*) with a question mark in his preliminary red data book concerning molluscs of Vorarlberg. He also mentioned *T. suberectus* sensu Forcart 1965, which he suspected to be more likely connected to the Swiss taxa *(T. caelatus, T. clandestinus* or *T. montanus*) than to *T. striolatus*. Our results reconfirm that both *T. striolatus* sensu stricto as well as a Western Alpine taxon currently named *T. clandestinus* occur in Vorarlberg. According to traditional nomenclature, which is used e.g. in the Austrian Red Lists (Reischütz & Reischütz 2007), the recorded specimens of *T. striolatus* would be most likely assigned to the nominate subspecies *Trochulus striolatus striolatus*, as the next known populations in South Germany also belong to this taxon (Duda et al. 2014). Nevertheless, Procków et al. (2017) claim that *T. striolatus* should not be subdivided into subspecies, as there exist neither morphological nor genetic hints for a clear subdivision of populations. Concerning *T. clandestinus,* it has to be stated that there are no good traits to separate the three West Alpine taxa *T. caelatus, T. clandestinus* and *T. montanus* neither by genetics nor by morphology (Proćków et al. 2014). Nevertheless, the findings of Duda et al. (2017) represent a new record for Austria, as the recorded snails definitely belong to a West-Alpine distributed species group, which was hitherto not detected in Austria. As long as the question about the correct name or separation within this taxon group is not resolved satisfactorily, we follow the approach of Falkner et al. (2017), who used the name *T. clandestinus* for those populations of this species group, which are widespread outside the Jura mountains. The question raised by Reischütz (1993), whether *T. suberectus* sensu Forcart 1965 could represent a synonym of *T. clandestinus* cannot be answered, as the drawings of Forcart 1965 do not show inner structures of genitalia, which would be necessary to reconfirm this assumption. Concerning the genus *Oxychilus* it is worth mentioning, that only two specimens in the sampled area Örfla Schlucht resembled by shell size and form *Oxychilus mortiletti*, but after penial dissection (Giusti & Manganelli 1997) and genetic barcoding (data not yet published) they were also assigned to *O. draparnaudi*. This reveals the need for a revision of other *O. mortiletti* findings in regions north of the Southern Alps.

Table 2. Taxa recorded in the 12 sampling areas. Numbers refer to area numbers in table 1. L = living snails; E = empty shells

	1	2	3	4	5	6	7	8	9	1	11	12
Taxon	**Rimsbach**	**Greben**	**Bezau Oberdorf**	**Örflaschlucht**	**Bregenzer Ache**	**Kanisfluh**	**Montikel**	**Böser Tritt**	**Bürser Schlucht**	**Palüdhütte**	**Radonatobel**	**Stuben**
Abida secale secale	-	-	-	-	-	-	L	-	L	-	-	-
Acicula lineata lineata	-	-	-	-	-	-	-	-	E	-	-	-
Acanthinula aculeata	-	-	-	-	-	-	-	-	E	-	-	-
Aegopinella nitens	L	-	-	-	-	-	-	-	L	-	-	L
Arianta arbustorum ssp.	L	-	-	L	-		L	-	L	-	-	L
Arion distinctus	-	-	-	-	-	-	L	-	-	-	-	-
Arion fuscus	-	-	-	L	-	-	-	L	-	L	-	-
Arion rufus	-	-	-	-	-	L	-	-	-	-	-	-
Arion silvaticus	-	-	-	-	-	-	-	-	L	-	L	-
Arion vulgaris	L	-	-	-	-	-	-	-	-	-	-	-
Balea biplicata ssp.	-	-	L	-	-	L	-	-	-	-	-	-
Bulgarica cana cana	L	-	-	L	-	-	L	L	L	-	-	-
Carychium minimum	-	-	-	-	-	-	-	-	L	-	-	-
Carychium tridentatum	-	-	-	-	-	-	-	-	E	-	-	-
Cepaea hortensis	-	-	-	L	-	-	L	-	-	-	-	-
Cepaea nemoralis	L	-	-	-	-	-	-	-	-	-	-	-
Cepaea nemoralis	-	-	-	-	-	-	L	-	-	-	-	-
Chondrina arcadia clienta	-	-	-	-	-	-	L	-	-	-	-	-
Chondrina avenacea	-	-	-	-	-	-	L	-	-	-	-	-
Chondrina burtscheri	-	-	-	-	-	-	L	-	-	-	-	-
Clausilia cruciata cruciata	-	-	-	-	L	-	-	-	-	-	-	-
Clausilia dubia ssp.	-	-	-	-	-	-	L	-	-	-	-	-
Clausilia rugosa parvula	-	-	-	L	L	-	L	-	L	-	-	-
Cochlicopa lubrica	-	-	-	-	-	-	-	-	-	-	L	L
Cochlodina laminata ssp.	L	-	-		-	-	L	-	L	-	-	-
Columella edentula	-	-	-	-	-	-	-	-	E	-	-	-
Deroceras laeve	-	-	L	-	-	-	-	-	-	-	-	-
Deroceras sp. juv.	-	-	-	L	-	-	-	-	-	-	-	-
Deroceras reticulatum	-	-	L	-	-	-	-	-	-	-	-	-
Discus rotundatus	L	-	-	L	-	-	L	-	L	-	-	-
Ena montana	L	-	-	L	-	-	L	-	L	-	-	L
Eucobresia nivalis	-	-	-	-	-	-	-	-	-	L	-	-
Euconulus fulvus	-	-	-	-	-	-	L	-	L	-	-	-
Euconulus praticola	-	-	-	-	-	-	-	L	-	-	-	-
Fruticicola fruticum	L	-	-	L	-	-	-	-	-	-	-	-
Galba truncatula	-	-	L	-	-	-	-	-	-	-	L	-
Helicigona lapicida	-	-	-	L	L	-	-	-	-	-		-
Helicodonta obvoluta	-	-	-	L	-	-	L	-	L	-	-	-
Helix pomatia	L	-	-	-	-	-	-	-	-	-	-	-
Isognomostoma isognomostomos	L	-	-	L	-	-	-	-	L	-	-	L
Limax cinereoniger	L	-	-	-	-	-	-	-	-	-	-	-
Macrogastra attenuata lineolata	L	-	-	L	L	-	L	-	-	-	-	-
Macrogastra plicatula ssp.	-	-	-	L	L	-	-	L	L	L	L	L
Macrogastra ventricosa ssp.	-	-	-	L	-	-	L	-	-	-	-	-
Merdigera obscura	-	-	-	-	-	-	L	-	-	-	-	-
Monachoides incarnatus	-	L	-	L	L	-	L	-	-	L	-	-
Nesovitrea hammonis	-	-	-	-	-	-	-	-	E	-	-	-
Oxychilus alliarius	-	-	-	-	-	-	L	-	-	-	-	-
Oxychilus cellarius	-	-	-	-	-	-	-	-	L	-	-	-
Oxychilus draparnaudi/"mortiletti"	-	-	-	L	-	-	-	-	L	-	-	-
Oxychilus glaber glaber	-	-	-	-	-	-	-	-	-	-	L	-
Oxychilus sp. juv.	-	-	-	-	-	L	-	L	-	-	-	-
Perpolita petronella	-	-	-	-	-	-	-	L	-	-	-	-
Petasina edentula helvetica	L	-	-	-	-	-	-	-	-	-	-	-
Petasina unidentata ssp.	-	-	-	-	-	-	L	L	L	L	L	L
Platyla polita	-	-	-	-	-	-	-	-	E	-	-	-
Punctum pygmaeum	-	-	-	-	-	-	-	-	L	-	-	-
Pyramidula pusilla	-	L	-	L	-	-	L	L	E	-	-	L

Succinea putris	L	-	-	-	-	-	-	-	-	-	-	-
Trochulus clandestinus	L	-	-	-	-	-	-	-	-	-	-	-
Trochulus hispidus	L	-	-	L	-	-	-	-	L	-	-	-
Trochulus "sericeus"	-	-	-	L	-	-	-	-	-	-	-	-
Trochulus striolatus ssp.	-	-	-	-	-	-	-	-	-	-	L	-
Trochulus villosus	L	-	-	L	-	-	-	-	-	-	-	-
Truncatellina cylindrica	-	-	-	-	-	-	-	-	E	-	-	-
Truncatellina monodon	-	-	-	-	-	-	-	L	-	-	-	-
Vallonia enniensis	-	-	-	-	-	-	-	-	E	-	-	-
Vitrea subrimata	-	-	-	-	-	-	-	-	E	-	L	-
Vertigo alpestris	-	-	-	-	-	-	-	-	L	-	-	-
Vertigo pusilla	-	-	-	-	-	-	-	-	L	-	-	-
No. species/living	18	2	4	21	5	3	23	8	20	5	8	8
No. species/empty shells	0	0	0	0	0	0	0	0	10	0	0	0
No. species/total	18	2	4	21	5	3	23	8	30	5	8	8

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