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

Michael Duda[1], Elisabeth Haring[2,3] , Anđela Bulatović[4], Astrid Hille[5], Luise Kruckenhauser[2], Oliver Macek[1], Jovana Marković[4], Doris Pinsker, Wilhelm Pinsker[2], Susanne Reier[2,3], Kristina Sefc[6], Raiko Slapnik[7], Marcia Sittenthaler[2], Michaela Sonnleitner[2], Janja Valentinčič[7], Helmut Sattmann[1]

[1] *3rd Zoological Department, Museum of Natural History, Vienna, Austria*

[2] *Central Research Laboratories, Museum of Natural History, Vienna, Austria*

[3] *Department of Integrative Zoology, University of Vienna, Vienna, Austria*

[4] *Department of Biology, University of Montenegro, Podgorica, Montenegro*

[5] *Botanical Department, Museum of Natural History, Vienna, Austria*

[6] *Institute of Biology, University of Graz, Austria.*

[7] *ZOSPEUM, Molluscs, Cave & Karst Biological Consulting, Kamnik, Slovenia*

Correspondence: Helmut Sattmann, helmut.sattmann@nhm-wien.ac.at

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 sterri*, *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 columell*a, 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.

ACKNOWLEDGEMENTS

We thank the Steiermärkische Landesregierung/ Abteilung Naturschutz (ABT13-53S-7/1996-156) and the Nationalpark Gesäuse for providing collecting permits and the team of Hesshütte for their hospitality.

REFERENCES

Baur B, Baur A (2013) Snails keep the pace: shift in upper elevation limit on mountain slopes as a response to climate warming. Can. J. Zool. 91: 596–599, dx.doi.org/10.1139/cjz-2013-0036

Baur B, Meier T, Baur A, Schmera D (2014) Terrestrial gastropod diversity in an alpine region: Disentangling effects of elevation, area, geometric constraints, habitat type and land-use intensity. Ecography 37(4): 390-401, doi: 10.1111/j.1600-0587.2013.00312.x

Bishop MJ (1977) The habitats of Mollusca in the central Highlands of Scotland. J. Conchology 29: 189–197.

Cameron RAD, Greenwood JJD (1991) Some montane and forest molluscan faunas from eastern Scotland: effects of altitude, disturbance and isolation, pp. 437–442. In: Meier-Brook C. (ed.), Proceedings of the Tenth International Malacological Congress, Tübingen

Dirnböck T, Essl F, Rabitsch W (2011) Disproportional risk for habitat loss of high-altitude endemic species under climate change. Glob. Change Biol. 17: 990–996, doi: 10.1111/j.1365-2486.2010.02266.x

Duda M, Kruckenhauser L, Haring E, Sattmann H (2010) Habitat requirements of the pulmonate land snails *Trochulus oreinos oreinos* and *Cylindrus obtusus* endemic to the Northern Calcareous Alps, Austria. Eco.mont. 2: 5–12, doi.org/10.1553/eco.mont-2-2s5

Duda M, Bamberger S, Jaksch K (2017) Weichtiere der FFH-Richtlinie im Nationalpark Gesäuse. Schriften des Nationalparks Gesäuse 13: 39–42.

Dullinger S, Gattringer A, Thuiller W, Moser D, Zimmermann NE, Guisan A, Willner W, Plutzar C, Leitner M, Mang T, Caccianiga M, Dirnböck T, Ertl S, Fischer A, Lenoir J, Svenning JC, Psomas A, Schmatz D R, Silc U, Vittoz P, Hülber K (2012) Extinction debt of high-mountain plants under twenty-first-century climate change. Nature Climate Change 2: 619–622, doi:10.1038/nclimate1514

Franz H (1954) Die Nordostalpen im Spiegel ihrer Landtierwelt. Eine Gebietsmonographie. Innsbruck 644 pp.

Gittenberger E, Bank RA (1996) A new start in *Pyramidula* (Gastropoda Pulmonata: Pyramidulidae). Basteria, 60: 71–78.

Gittenberger E (2012) Long-distance dispersal of molluscs: 'Their distribution at first perplexed me much'. Journal of Biogeography 39: 1365–2699.

Grabherr G, Gottfried M, Pauli H (1994) Climate effects on mountain plants. Nature 369: 448.

Horsák M, Juříčková L, Picka J (2013) Měkkýši České a Slovenské republiky. Molluscs of the Czech and Slovak Republics. Kabourek, Zlín

Kerney MP, Cameron D, Jungbluth J (1983) Die Landschnecken Nord- und Mitteleuropas. Paul Parey, Hamburg

Kirchner S, Harl J, Kruckenhauser L, Duda M, Sattmann H, Haring E (2016) Phylogeography and systematics of *Pyramidula* (Pulmonata:

Pyramidulidae) in the eastern Alps: still a taxonomic challenge. Journal of Molluscan Studies 82: 110–121, doi:10.1093/mollus/eyv047

Klemm W (1974) Die Verbreitung der rezenten Land-Gehäuse-Schnecken in Österreich. Denkschriften der Österreichischen Akademie der Wissenschaften (mathematisch-naturwissenschaftliche Klasse), 117: 1–503.

Kreuss O (2014) (kompil): Geofast 100 Hieflau. geological map, Geologische Bundesanstalt Wien

Rabitsch W, Essl F (2009) (Eds): Endemiten – Kostbarkeiten in Österreichs Pflanzen und Tierwelt. Umweltbundesamt, Klagenfurt, 924 pp.

Rabitsch W, Graf W, Huemer P, Kahlen M, Komposch C, Paill W, Reischütz A, Reischütz PL, Moser D, Essl F (2016) Biogeography and ecology of endemic invertebrate species in Austria: A cross-taxon analysis. Basic and Applied Ecology 17: 95–105.

Razkin O, Sonet G, Breugelmans K, Madeira MJ, Gómez-Moliner BJ, Backeljau T (2016) Species limits, interspecific hybridization and phylogeny in the cryptic land snail complex *Pyramidula*: The power of RADseq data. Molecular Phylogenetics and Evolution 101: 267–278.

Razkin O, Gomez-Moliner BJ, Vardinoyannis K, Martínez-Ortí A, Madeira MJ (2017) Species delimitation for cryptic species complexes: case study of *Pyramidula* (Gastropoda, Pulmonata). Zoologica Scripta 46: 1463–6409, doi.org/10.1111/zsc.12192

Reischütz PL (2000) Die Nacktschnecken des Gesäuses (Ennstal, Steiermark). Arianta III - Berichte der Arbeitsgruppe Alpine Landschnecken: 52–55.

Reischütz A, Reischütz PL (2009) Mollusca (Weichtiere). In: Rabitsch W., Essl F. (Eds): Endemiten – Kostbarkeiten in Österreichs Pflanzen und Tierwelt. Umweltbundesamt, Klagenfurt, 318–372.

Sattmann H, Kleewein D, Baumgartner G (2000) Landgehäuseschnecken im Gesäuse. Arianta III - Berichte der Arbeitsgruppe Alpine Landschnecken: 56–62.

Scharff RF (1928) On terrestrial molluscs of the high alps and their origin. In: Allorge, R. Benoist et al. (Eds) : Contribution al Etude du Peuplement des Hautes Montagnes. P. Le Chevallier (Paris), 1–5.

Volkmer H (2017) Die Landschneckenfauna des Nationalparks Gesäuse. Ökologie der alpinen Landgastropoden, mit besonderer Berücksichtigung endemischer Arten. (Gastropoda, Mollusca). Master thesis, University of Graz

Wada S, Kawakami K, Chiba S (2012) Snails can survive passage through a bird's digestive system. Journal of Biogeography 39: 69–73.

Welter-Schultes FW (2012) Eropean nonmarine molluscs, a guide for species identification. Planet Poster Edition, Göttingen, 679 pp.