Arianta	Volume 7	23 - 25	Wien, Oktober 2019

Density and distribution of a *Pyramidula* sp. population in Johnsbach (Styria, Austria)

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Abstract: A limestone rock site in northern Styria/Austria, which had been studied in 2017 with respect to population ecology parameters of some rock dwelling gastropods, was revisited one year later. The aim of the excursion study was to compare population densities and micro-distribution particularly of *Pyramidula pusilla*/*saxatilis* and to look up if some of the individuals of this and other species, marked with coloured nail polish, could be found again after one year. In the 2018 survey, total counts of *P. pusilla*/*saxatilis* as well as densities were considerably higher compared to 2017. In contrast to 2017, the vertical distribution of snails revealed no significant deviation from homogeneous distribution. Several snails marked in 2017 were recaptured in 2018 including *P. pusilla*/*saxatilis,* indicating that nail polish serves as a good marker even for smaller snails. Temperatures showed less extreme values in the snails microhabitat than in the nearby weather station and humidity was in general higher at the rock sites.

Key words: *Pyramidula* sp., population density, rock dwelling, gastropod marking

Zusammenfassung: Während des Workshops "Alpine Land Snails" im August 2017 in Johnsbach/Steiermark/Österreich war eine Freilandstudie an einer Kalkfelswand durchgeführt worden mit dem Ziel, Daten über die Dichte und kleinräumige Verteilung von Fels bewohnenden Schneckenarten zu sammeln (Haring et al. 2018). In dieser Untersuchung waren die Schnecken mit farbigen Nagellack markiert und ihre Aufenthaltsplätze am Felsen registriert worden. Bei *Pyramidula pusilla*/*saxatilis* konnte 2017 eine signifikant inhomogene Höhenverteilung festgestellt werden, wobei die größten Dichten in einer Höhe von 100 – 150 cm über dem Waldboden (Beginn des anstehenden Felsens) festgestellt wurden. Im August 2018 führten wir eine erneute Exkursion zum Untersuchungsgebiet durch, wobei das Ziel war, für die dort am häufigsten gefundene Art *Pyramidula pusilla*/*saxatilis* nachzuprüfen, ob sich nach einem Jahr die Populationsdichten und die Mikroverteilung am Fels verändert haben. Außerdem interessierte uns, ob wir markierte Schnecken (auch anderer Arten) vom Vorjahr wiederfinden würden. In der Auswertung von 2018 war die Populationsdichte deutlich höher als im Jahr 2017. Die klare vertikale Mikroverteilung konnte allerdings nicht mehr festgestellt werden. Mehrere 2017 markierte Individuen konnten 2018 wiedergefunden werden, sowohl von *Pyramidula pusilla*/*saxatilis* als auch von *Chondrina avenacea* und *Orcula gularis.* Die Eignung von buntem Nagellack hat sich als beständiges Medium für das Markieren kleinerer Landschnecken bestätigt. Die Temperaturen in den Mikrohabitaten zeigten deutlich geringere Extreme, die Luftfeuchte war an den Mikrohabitaten (der Schnecken) generell höher als in der nahegelegenen Wetterstation.

Introduction

In the course of the workshop "Alpine Land Snails" in Johnsbach (Styria, Austria) in August 2017 a field study at a limestone rock had been carried out to gather data on population density and micro-distribution of several rock-dwelling snail species (Haring et al. 2018). In that study, snails were marked and their distribution on the rock face was recorded. Concerning *Pyramidula pusilla*/*saxatilis*, a statistically significant deviation from uniform height distribution within the areas was observed in 2017 with the highest abundance at heights about 100 – 150 cm above ground. In August 2018 we performed a second survey at that site concentrating on *P. pusilla*/*saxatilis*. Especially we were interested if snail densities had changed within one year and if the patterns of micro-distribution of *P. pusilla*/*saxatilis* could be confirmed or not. Furthermore, we also were curious, if we could rediscover some marked shells (also of other species) after one year.

To obtain data of the microclimate at the site we placed five data loggers at rock crevices, approximately 2 m above ground, close to denser snail occurrences. Three of these loggers recorded humidity in addition to temperature. Data were recorded every 30 min. The climate data recorded were compared with general climate data from one meteorological station nearby (Köblwiese; Bogner & Lehner Messtechnik) over the same period including the time of the field campaign.

Taxonomy, study site and methods

As shown by Razkin et al. (2016) *Pyramidula pusilla* and *Pyramidula saxatilis* co-occur in the Eastern Alps. Since morphological assignment presently seems impossible (Kirchner et al. 2016) we treat the taxon as *Pyramidula pusilla*/*saxatilis* in this paper.

The study location (at 47°32'17" N, 14°37'26" E) was at the same steep limestone rocks as in the survey of 2017. It is situated at 1020 m asl at the formation Wolfbauer Mauer, east of the Wolfbauer Wasserfall in Johnsbach (Styria, Austria). The exposition of the nearly vertical rock face is south to southwest. The areas selected changed to

some extend in comparison to the first survey 2017 for several reasons: Areas that proved to harbour only very few snails (rock face 2017-2) were excluded and, instead, another nearby area (rock face 2018-2) was surveyed. Furthermore, the height of the areas was extended and surveyed using ladders. Altogether, three rock faces were selected for the investigation: **rock face 2018-1** (5.0 m in length and 3.6 m high), **rock face 2018-2** (6.0 m x 4.0 m), and **rock face 2018-3** (4.8 m x 3.2 m). These three rock faces were divided into two sections each and surveyed between 9:30 – 11:30 on August 20th 2018. Photographs of the rock faces were overlaid with grids and the recording person marked the positions of *P. pusilla/saxatilis* on the printouts. After the field survey, individuals were counted for each section of the three rock faces. The vertical distribution of snails in each sector was analysed by a Chi-squared test. Since numbers of snails differed significantly between adjacent sections (1A vs. 1B, 4A vs 4B: $p < 0.001$; 3A vs 3B: $p < 0.01$), each section was treated separately for the calculations.

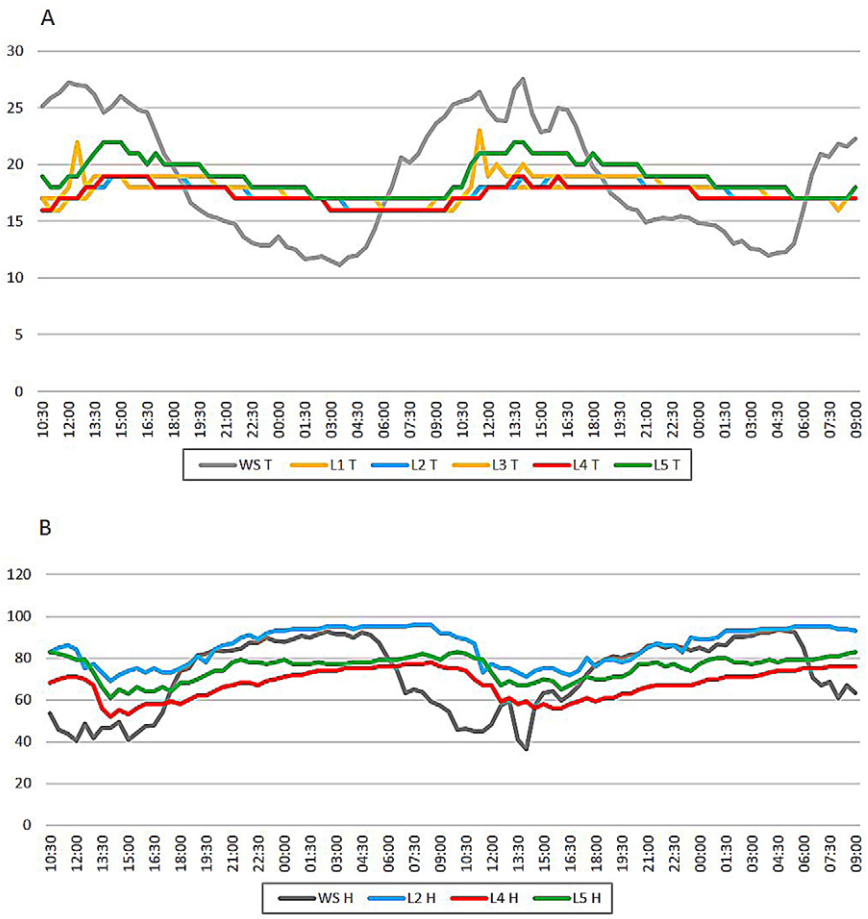

Fig. 1. A. Temperature profiles from five data loggers at the study site (L1 T – L5 T) and from the meteorological station Kölblwiese, Johnsbach (WST) (Bogner & Lehner Messtechnik) in the period 20. – 22. 8. 2019. **B.** Relative humidity profiles from three data loggers at the study site (L2 H, L4 H, L5 H) and from the meteorological station in the same period (WSH).

Results

Counts and densities are given in Table 1. The total number of *P. pusilla/saxatilis* were generally high ranging from 36 to 339 individuals for each section. The absolute number of individuals over all three rock faces was 1217. In 2017 the absolute number of *P. pusilla/saxatilis* (293 in two days) was considerably lower. Yet, since the sizes of investigation areas differed between the two years, densities are more meaningful: densities of *P. pusilla/saxatilis* ranged from 4.2 – 58.9 individuals per m^2 (mean 24.9) in the present survey. Densities in 2017 were considerably lower, ranging from 5.0 – 13.3 individuals per m^2 (mean 9.3).

Table 1. n = number of individuals counted in each section. d = density (individuals/sqm)

Section	n	d
2018-1A	36	4,170
2018-1B	215	24,880
2018-2A	303	30,060
2018-2B	55	5,460
2018-3A	339	58,850
2018-3B	269	46,700

With the exception of section 1A, where the total number of snails (36) was too small for the test, the vertical distribution of snails in each sector was analyzed by a Chi-squared test, which revealed no significant deviation from uniform height distribution ($p < 0.001$ for sections 2018-1B, 2018-2A, 2018-3A, 2018-3B, $p < 0.01$ for 2018-2B). While in the year before the densities significantly decreased at the lower levels (up to 0.5 m from the ground) and reached a peak at 1.5 m height, this time no preference in height distribution became apparent. Even in the higher parts the distribution was in some sections similarly high. Nevertheless, at all sites the distribution was patchy.

After a year time we detected several marked snails including *P. pusilla/saxatilis*. Only in rock face 2018-1 snails marked in 2017 were recorded again: 21 individuals of *P. pusilla/saxatilis* (16.8 % of the total number of marked individuals at rock face 2017-1), one *Chondrina avenacea* (1.1 % of 2017), and two *Orcula gularis* (7.1 % of 2017) were recaptured. From these findings we conclude: (1) The marking with nail polish was well gratifying for the period of one year. (2) Since we did mark adult specimens only, we obtained some information about the life span of individuals, i.e., 1.5 to 2 years at minimum.

Comparison of temperature shows that the five temperature loggers recorded very similar data ranging from 16 – 23° C. The general climate data (from the weather station) showed a much broader range of temperatures in that period (11 – 28° C). (Fig. 1A). Humidity data from the three rock faces differed considerably (Fig. 1B). Compared with the values of the weather station ranging from 34 – 94 %, the study sites were generally more humid and did not fall below 48 % (range 48 – 96 %).

Comparison of the two years exemplifies that population size and density are subject to stochastic fluctuations, a fact that is often ignored. Still "population cycles are one of nature's great mysteries" (Myers 2018), and long-term studies would be necessary to better assess the influence of, e.g., humidity, temperature or predation. In the present study, we gathered additional data and experience on population size and density of terrestrial gastropods (see also Bulatovic et al. submitted). Our results can be used for the planning of more detailed long-term monitoring.

Acknowledgements

We are grateful the following persons who helped in the survey: Agnes Bisenberger, Max Bisenberger, Michael Duda, Sabine Fischer, Josef Harl, Sandra Kirchner, Luise Kruckenhauser, Oliver Macek, Marco Neiber, Doris Pinsker, Susanne Reier, Anatoly Schileyko, Julia Schindelar, Lisa-Maria Schmidt, Kristina Sefc, Marcia Sittenthaler, Michaela Sonnleitner, Barbara Tautscher, Karl Tautscher. We thank Manfred Bogner for providing meteorological data (Bogner & Lehner Messtechnik). We are much obliged to Andreas Wolf for permission to perform this investigation on his land.

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