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Habitat of *Conocephalum conicum* (Snakeskin Liverwort) in Three Western North Carolina Streams

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Abstract

Aquatic liverworts are important primary producers in environments that do not contain many autochthonous sources of organic matter. They also retain nutrients that would otherwise be lost to the current and contribute to the structural integrity of the mats of vascular plants and bryophytes on the boulders they inhabit. Disturbance plays a crucial role in the life cycle of aquatic liverworts, with the frequency and type of disturbance critical to their survival success. *Conocephalum conicum* (Snakeskin liverwort) is a thallose liverwort that grows throughout North America and is most commonly found in streams and rivers in mountainous environments. There is virtually no published literature on this species, despite its widespread occurrence. My objectives were to determine the habitat attributes of *Conocephalum conicum* in three western North Carolina streams (Flat Creek, Corner Rock Creek and Staire Creek). I sampled a 3/4 mile stretch of each stream by randomly selecting patches of liverwort growing on boulders. For each patch, I measured distance and DBH of closest understory and canopy species, along with the aspect of the slope. The horizontal spread of each patch was traced with tracing paper, and a leaf area meter was used to quantify the area of the tracing. For each patch of liverwort, a nearby random boulder was selected, and the same habitat characteristics were measured. Paired t-tests were used to compare habitat variables for boulders with and without liverwort were different. Based on my observations, *C. conicum* was most abundant in Corner Rock Creek and least abundant in Staire Creek. Average patch area of *C. conicum* was largest in Flat Creek ($696cm^2$) and smallest in Staire Creek ($408cm^2$). All boulders with *C. conicum* supported other bryophytes. Boulders with and without *C. conicum* differed only in Flat Creek for: understory distance ($p= 0.04$) and azimuth ($p= 0.017$). This study provides a better understanding of this species and the niche it occupies in mountain streams.

1. Introduction

Aquatic liverworts are an important component of river and stream ecosystems, providing an organic mat that vascular plants and other bryophytes can colonize[1]. Aquatic liverworts also provide a food source for bryophyte-feeding moths[2]. They are important primary producers in environments that are generally allochthonous (detritus-based), retain nutrients within streams that would otherwise be lost to the current[3], and provide structural integrity to the mats of bryophytes and vascular plants on the boulders they inhabit.

Conocelphalum conicum (family Conocephalacae, order Marchantia) is a species of thallose (flattened, showing no differentiation into stem and leaves[4]) liverwort found throughout North America. It grows in flat mats of loosely woven, dichotomous or simple thalli[1], and can be identified by white pores that cause the dorsal surface to resemble "snake skin". The leaves emit a spicy smell when squeezed due to their high monoterpene content[5,6]. This species faces restricted distribution in streams due to its intolerance to submersion and the threat of competition with other aquatic bryophytes, including mosses[6].

Most published literature on *Conocephalum conicum* focuses on the terpenoids and sequiterpenoids in the leaves of the plant, as they are desirable for extraction. There are only vague published reports on the habitats where this species occurs, usually limited to statements that it occurs in and around mountain streams. The objective of my study is to provide a habitat description of the species in three local streams, with different levels of disturbance and environmental factors.

2. Methods

My study was conducted at three sites in western North Carolina that contain boulders with *Conocephalum conicum*: Flat Creek in Montreat, and Corner Rock Creek and Staire Creek in the Coleman Boundary of Pisgah National Forest. I surveyed a section of Flat Creek downstream of Lake Susan on the campus of Montreat College where Flat Creek flows through a residential area adjacent to Highway 9. The main overstory tree species was *Fagus grandifolia*. Corner Rock Creek flows along a gravel road in a forested area with low disturbance. The main overstory tree species was *Fagus grandifolia*. Staire Creek flows through a steep, narrow valley that is heavily shaded by large rock formations and also has low disturbance. The main overstory tree species was *Liriodendron tulipifera*. All three streams had a dense understory of *Rhododendron spp.* along the stream banks.

Each creek was surveyed between January and March, 2017 for patches of *C. conicum* growing on boulders. There were so many patches in Corner Rock Creek, I was unable to sample all of them so I used a random number table to select patches. In Flat Creek and Staire Creek I sampled all patches encountered. For each patch, the closest overstory tree and the closest understory species were identified, the distance from the patch to the closest overstory and understory stem was measured, and the diameter at breast height (DBH) of each stem was measured. The azimuth of the patch was determined with a compass. The presence of other bryophytes and vascular plants on the boulder were noted. Samples of other bryophytes were collected for future identification. The area covered by each patch of *C. conicum* was quantified by tracing the outline of the patch with tracing paper. The traced outlines were quantified with a laser leaf area meter (CI-202, CID Bio-Science). After the measurements were taken, a random boulder within 10 meters was selected via a random number table, and the same habitat variables were collected. Paired t-tests (alpha= 0.05) were used to compare habitat variables between boulders with and without liverworts in each stream.

Table 1. mean values of azimuth, patch area, overstory distance, overstory dbh, understory distance, understory dbh of boulders with *c. conicum* on corner rock creek, staire creek and flat creek

Stream Site	Corner Rock Creek	Staire Creek	Flat Creek
$\bar{x}$ Patch Area ± SE (cm^2)	505 ± 104	408 ± 80	696 ± 109
$\bar{x}$ Azimuth ± SE (degrees)	187 ± 18	120 ± 41	211 ± 23.5
$\bar{x}$ Overstory Distance ± SE (m)	5.1 ± 0.5	8.8 ± 4.0	5.4 ± 0.5
$\bar{x}$ Overstory ± SE DBH	42.6 ± 3.5	32.3 ± 4.4	42.4 ± 3.4
Overstory Species Richness	6	4	7
$\bar{x}$ Understory Distance ± SE (m)	2.6 ± 0.3	2.8 ± 0.6	3.4 ± 0.3
$\bar{x}$ Understory DBH ± SE	6.0 ± 0.8	1.8 ± 0.2	4.9 ± 0.7
Understory Species Richness	8	1	2

3. Results

Conocephalum conicum was most abundant in Corner Rock Creek (19 patches) and least abundant in Staire Creek (10 patches). Fourteen patches were quantified in Flat Creek. However, patches were largest in Flat Creek (696cm^2) and smallest in Staire Creek (408cm^2) (Table 1). In each of the creeks, every boulder that harboring *C. conicum* also harbored other bryophytes, but not all boulders supported rooted vascular plants. Flat Creek had the highest prevalence of vascular plants on boulders with *C. conicum* (93% of boulders) and Staire Creek had the lowest prevalence (50% of boulders: Table 2). For random boulders without *C. conicum*, <21% of boulders harbored rooted vascular plants at all sites (Table 2). *C. conicum* patches in Flat Creek and Corner Rock Creek faced generally SSW, whereas patches in Staire Creek were faced ESE (Table 1). The only habitat variables that varied between boulders with an without *C. conicum* were azimuth ($p = 0.017$) and distance to understory species ($p=0.04$) in Flat Creek. Boulders with *C. conicum* had a higher mean azimuth and were located farther from understory species (Table 1).

Table 2. percent of boulders with and without *c. conicum* with bryophytes and/or vascular plants at corner rock creek, staire creek and flat creek

	Boulders with *C. conicum*		Boulders without *C. conicum*	
Stream	% of Boulders with Bryophytes	% of Boulders with Vascular Plants	% of Boulders with Bryophytes	% of Boulders with Vascular Plants
Corner Rock Creek	100	65	95	20
Staire Creek	100	50	90	10
Flat Creek	100	93	93	21

Table 3. mean values of azimuth, patch area, overstory distance, overstory dbh, understory distance, understory dbh of boulders without *c. conicum* on corner rock creek, staire creek and flat creek

Stream Site	Corner Rock Creek	Staire Creek	Flat Creek
$\bar{x}$ Azimuth ± SE (degrees)	155 ± 22	192 ± 35	118 ± 19
$\bar{x}$ Overstory Distance ± SE (m)	4.3 ± 0.5	4.7 ± 0.5	5.0 ± 0.4
$\bar{x}$ Overstory DBH ± SE	49.6 ± 4.8	46.3 ± 12.7	38.3 ± 3.7
Overstory Species Richness	10	4	9
$\bar{x}$ Understory Distance ± SE (m)	2.9 ± 0.4	2.8 ± 0.3	2.3 ± 0.3
$\bar{x}$ Understory DBH ± SE	5.3 ± 0.6	3.7 ± 1.2	5.5 ± 0.9
Understory Species Richness	4	3	3

4. Discussion

Based on my observations in the field, *C. conicum* was most abundant in Corner Rock Creek and least abundant in Staire Creek. One difference between Corner Rock Creek and the other sites were that the understory species richness was higher for boulders with *C. conicum* (Table 1), indicating more species other than *Rhododendron* spp. In contrast, Staire Creek understory richness was the lowest of the three sites, with only *Rhododendron* spp. found for boulders with *C. conicum* (Table 1).

The presence of other bryophytes on boulders in a stream influenced the presence of *C. conicum,* as all patches on boulders were growing on top of an existing bryophyte layer. This may reflect a need for water, as the bryophyte layer would retain moisture on these boulders, which are hostile environments. I collected samples of co-occuring bryophytes, for identification in the future. It is important to note that *C. conicum* is not solely an epiphytic species. At Corner Rock Creek, we observed it on soil and on logs within the stream channel. We included only boulder substrates in our study because liverworts on other substrates were often covered by fallen leaves.

Conocephalum conicum patches were largest in Flat Creek. This may be due to higher light and nutrient levels, as the stream had less riparian cover, the channel was widest, the area is much more developed with runoff from private properties (gardens and lawns). The smallest patches occurred in Staire Creek, which was the most heavily shaded and had the narrowest channel. The differences in patch size between the sites may be based largely on differences in sunlight. Liverworts are adapted to perform particularly well in low-light environments but this does not necessarily mean that they perform poorly in fully lighted conditions[8]. They may increase growth and branching in response to higher light levels[8]. When I compared boulders with and without *C. conicum*, the only site with significant differences was Flat Creek, where boulders with liverwort were located further from understory species and more south-facing. This could one reason that the patches in Flat Creek were larger than the other sites.

Riparian cover is important for mosses and liverworts as they thrive in low-light, moist habitats. It is commonly held that bryophytes are especially well adapted to the very low light levels in shaded streams[8]. The streams in my study are heavily shaded year round, as the understory layers are dominated by the evergreen shrub *Rhododendron* spp.

In each stream, *C. conicum* patches often occurred in aggregate groups with several patches on the same boulder and upwards of 40m between boulders supporting liverworts. This may be due to local dispersion and very unique habitat variables needed for the liverwort to establish or thrive. Further study is needed to examine patch dynamics and the relationship between patches in streams.

My investigations show specific habitat variables of *C. conicum* in three Western North Carolina streams. *C. conicum* was most abundant in Corner Rock Creek and least abundant in Flat Creek. Flat Creek patches were the largest possibly due to higher light levels and increased nutrient input from development nearby. The presence of other bryophytes on boulders in a stream influenced the presence of *C. conicum,* as all patches were found on an existing bryophyte layer. Complementary work on patch dynamics and increased light levels on *C. conicum* growth is needed to provide a more complete understanding of this species.

5. Literature Cited

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