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Relationship between *Conocephalum conicum* (Snakeskin Liverwort) Distribution, Elevation and Water Quality in Western North Carolina Mountain Streams

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Abstract

Conocephalum conicum (Snakeskin Liverwort) is an aquatic liverwort that occurs in mountain streams in western North Carolina. Little has been published about this common species, although aquatic liverworts are important to nutrient and energy fluxes in streams. The objective of this study is to better understand how *Conocephalum conicum* is distributed in western North Carolina relative to elevation and water quality. Field research was conducted in Corner Rock Creek (mean elevation 875 m) and the Catawba River (mean elevation 515 m) near Asheville, North Carolina. At each site, 53 patches of *Conocephalum* were located, and elevation, water pH, water temperature, and conductivity were measured for each patch. Vascular plants and other bryophytes occurring within each patch were noted, and thallus material was collected from each patch for chlorophyll analysis. Water pH was similar between streams (7.55 for Corner Rock Creek, 7.77 for the Catawba River), but conductivity varied greatly, ranging from 18.5 µS/cm in Corner Rock Creek to 54.2 µS/cm in the Catawba River. Chlorophyll content was similar, averaging 145.5 mg/m^2 in Corner Rock Creek and 155 mg/m^2 in the Catawba River. *Conocephalum* always occurred with other bryophytes, and often occurred with vascular plants. There were no significant relationships between elevation and chlorophyll, pH and chlorophyll, or conductivity and chlorophyll. Results suggest *Conocephalum conicum* is a generalist in mountain streams, although it may benefit from circumneutral water pH.

Keywords: aquatic bryophyte, *Conocephalum conicum*, snakeskin liverwort

1. Introduction

Conocephalum conicum (Snakeskin Liverwort) is a common liverwort with a snakeskin-like pattern on its thallose. The thallose, or undifferentiated vegetative tissue, branches to form two or more amorphous lobes that often join to form a larger patch; this makes *Conocephalum* noticeable in and around streams. *Conocephalum* has a global distribution that includes the southern Appalachian mountains. Bryophytes are known to be ecologically important in mountain stream environments and mosses and liverworts specifically are thought to play an essential role in nutrient and energy fluxes in streams[2]. *Conocephalum* is virtually absent from habitats close to the surface of the river during low flow, but peaks in abundance on habitats situated above the water level[1]. *Conocephalum* is intolerant of submergence and may benefit from slower stream flow, as high flow carries away large amounts of bryophyte biomass[1]. Bryophyte abundance is often relatively high in aquatic ecosystems with low temperatures, low light levels, and limited flow variation or bed movement, such as spring-fed streams or streams controlled by impoundments[3]. Streams supporting liverworts have lower nutrient concentrations than streams with mosses, along with higher streambed stability, larger substrate, and steeper slopes. It has been observed that some mosses grow over previously established liverworts, possibly because the liverworts help facilitate the attachment of the moss to the substrate, and vice versa[3]. Despite the widespread distribution of *Conocephalum* in North America, little to no ecological research has been conducted on its habitat in western North Carolina. The objective of this research was to investigate *Conocephalum* distribution and habitat preferences in relation to elevation and water quality. It was hypothesized that *Conocephalum* would have higher levels of chlorophyll at lower elevation sites exhibiting higher levels of conductivity, as plant vigor can be related to chlorophyll.

2. Methods

Data was collected from two study sites: Corner Rock Creek in the Big Ivy region of Pisgah National Forest, and the Catawba River. These sites were chosen based on previous studies that noted existing patches of *Conocephalum* in the streams and the differing topographic features of the two sites. From January to March 2018, Corner Rock Creek was visited four times to gather data on *Conocephalum*. The stream was searched from the parking area (762 m) upstream to the vicinity of the headwaters (975 m). Each time a patch of *Conocephalum* was found on a boulder, elevation, position in creek (streambank or center), and azimuth were recorded. The presence of other bryophytes, vascular plants and overhanging rhododendron was noted. Patches of *Conocephalum* on soil were excluded from this study. A waterproof pH/CON 10 Meter water quality meter was used to record the pH, temperature and conductivity of the stream water adjacent to the patch. A pocket knife was used to gather three ~1cm^2 samples from each patch, selected using a random number table. Samples were placed in labelled Ziploc bags and kept refrigerated until chlorophyll levels were measured in the lab with an Opti Sciences CCM-300 chlorophyll fiber optic meter. Each sample was measured twice, and readings were averaged for each patch.

From March to April 2018, the Catawba River in Old Fort, NC, was visited four times to gather data on *Conocephalum* in the same way. Patches of *Conocephalum* were selected beginning from a foot bridge (488 m) and ascending to 564 m. Fifty-three patches were located at each site. Chlorophyll, water pH, and conductivity were compared between the two sites using two-tailed t-tests.

3. Results

The main results of this study can be found in Table 1 and Figures 1-3. A map has been included which includes all of the streams in Buncombe County where data has been recorded on Conocep*halum*. The circles that contain stars delineate the two study sites considered in this study.

Table 1. *Conocephalum conicum* and stream characteristics

Variable	Corner Rock Creek	Catawba River
N	53	53
Mean elevation (m)	875.0	515.3
Mean azimuth (degrees)	196.6	141.3
Mean pH	7.5	7.7
Mean conductivity (us/m)	18.5	54.2
Mean chlorophyll (mg/m^2)	145.5	155.0
Mean temperature (Celsius)	7.2	11.5
Patches with other bryophytes (%)	100.0	100.0
Patches with vascular plants (%)	71.7	43.4
Patches shaded by Rhododendron (%)	67.9	37.7
Patches found in center of stream (%)	20.8	35.8
Patches found on streambanks (%)	79.2	64.2

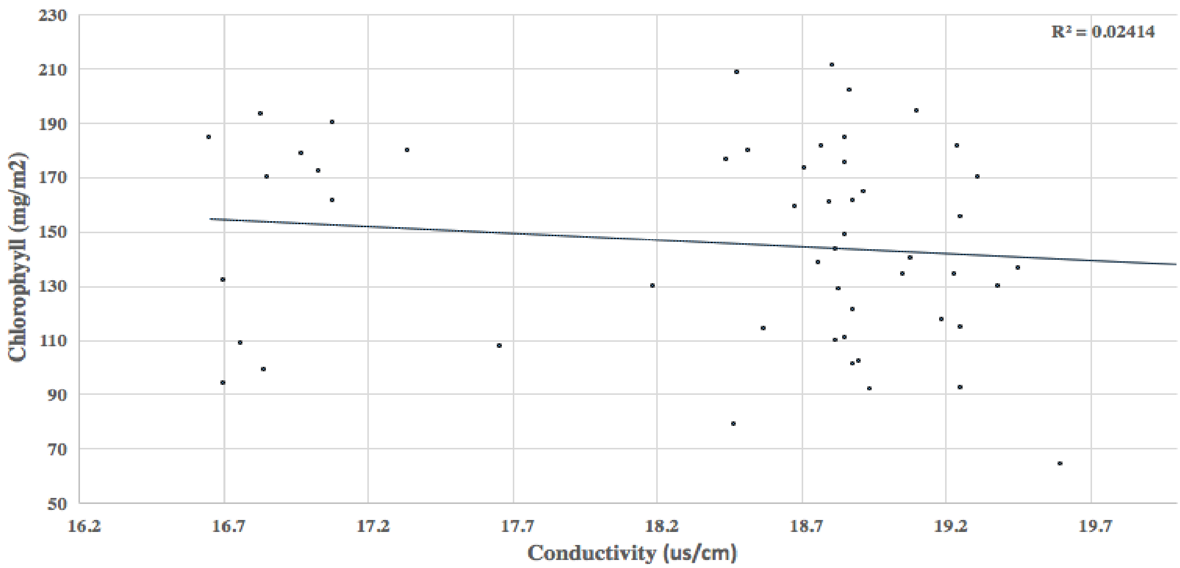


Figure 1. Conductivity and chlorophyll in Corner Rock Creek.

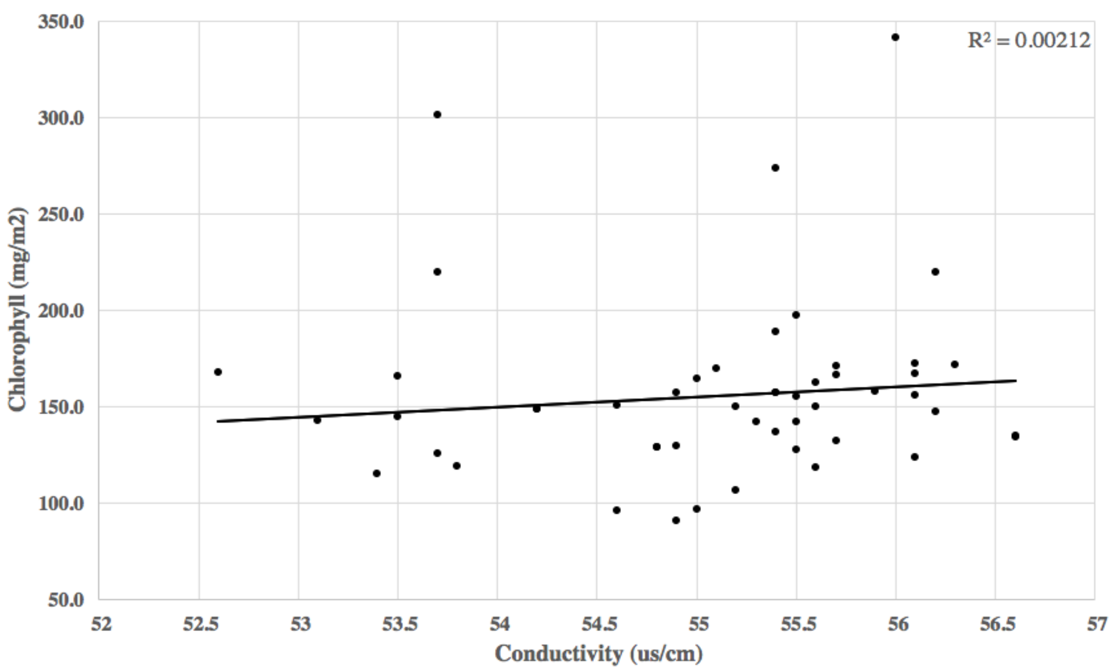


Figure 2. Conductivity and chlorophyll in Catawba River.

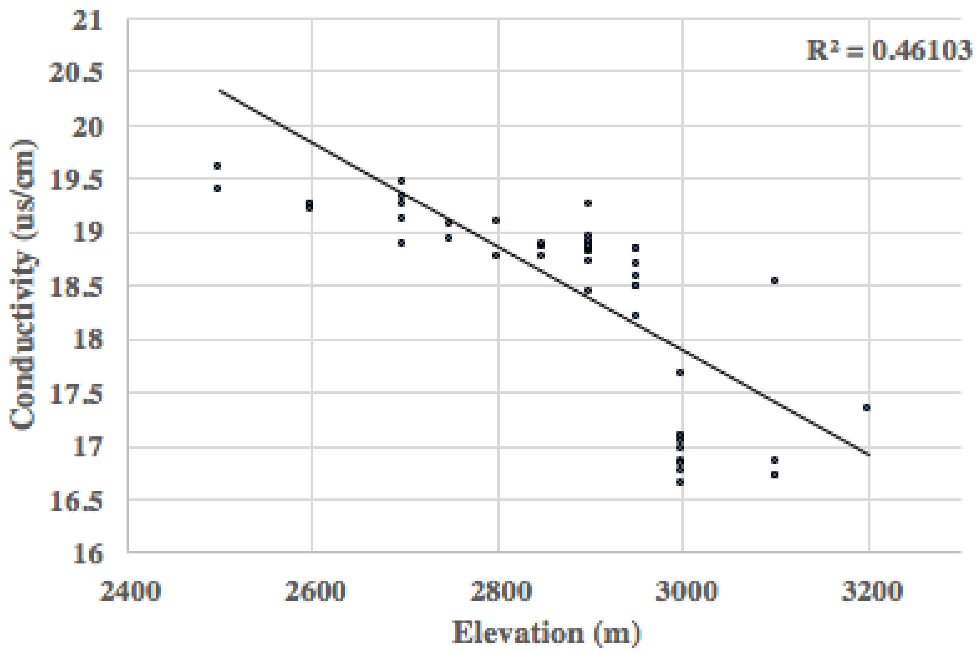
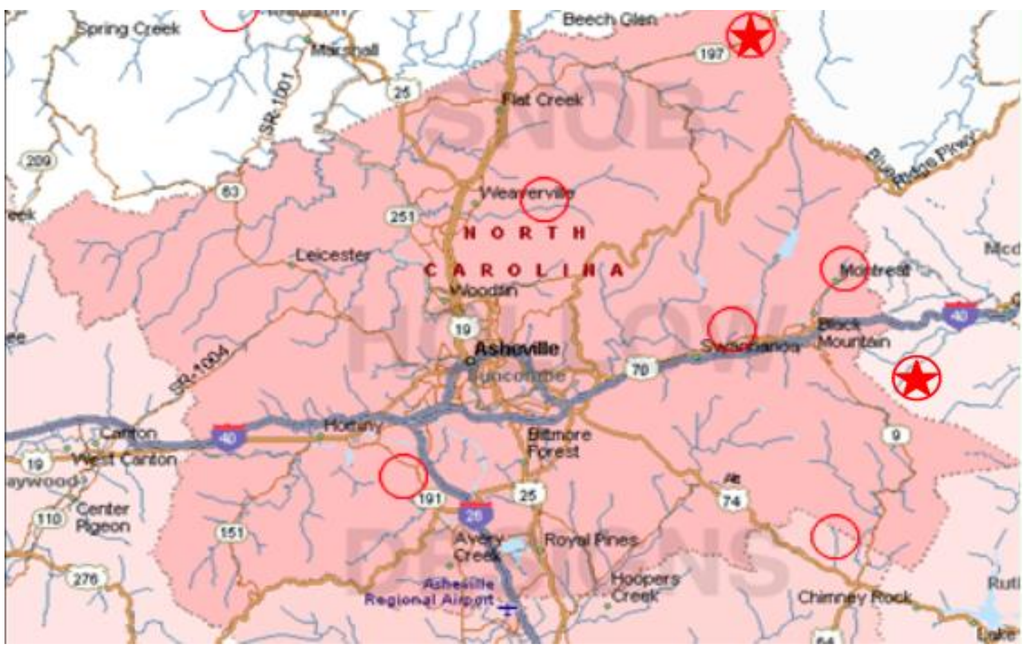


Figure 3. Elevation and conductivity in Corner Rock Creek.



Map 1: Buncombe County and *Conocephalum*. Circles indicate streams where *Conocephalum* has been found and data has been recorded, circles with a star indicate the site was used to collect data for this study.

4. Discussion

Conocephalum occurred with other bryophytes on every patch in both streams (Table 1).This species is easily dislodged by fast-moving water, and other bryophytes may help ensure patches stay in place on boulders. This supports the suggestion that mosses play an important role in keeping liverworts attached to rocky substrates in turbulent streams[3]. A greater percentage of *Conocephalum* patches supported vascular plants in Corner Rock Creek when compared to the Catawba River, perhaps because Corner Rock Creek is a smaller body of water that experiences smaller flooding events that could dislodge vascular plants. More *Conocephalum* patches were shaded by rhododendron in Corner Rock Creek compared to the Catawba River, due to the narrower stream channel. At both sites, more *Conocephalum* patches occurred on streambanks rather than in the center of the channel. This suggests *Conocephalum* is more successful in areas with less turbulence, supporting previous studies[3]. Boulders supporting Conocephalum faced generally southeast to southwest. This may have been due to streams flowing downhill in this direction; *Conocephalum* was generally attached to the downstream portions of boulders.

Although the pH of Corner Rock Creek was lower than that of the Catawba River ($P < 0.001$), there was no significant relationship between pH and chlorophyll in either stream, implying water pH may not affect plant vigor. However, *Conocephalum* did not occur in portions of the stream with a pH <6.5 in Corner Rock Creek or <7.4 in the Catawba River, suggesting this liverwort may prefer more neutral to basic water. Water conductivity was three times higher in the Catawba River than in Corner Rock Creek ($P < 0.001$, Table 1). The Catawba River is wider and warmer, and has a lower gradient. There is a greater level of disturbance in the surrounding area that could deposit sediments in the water, causing a higher level of water conductivity. Despite this, there was no significant relationship between conductivity and chlorophyll in either stream (Figures 1 and 2), and chlorophyll levels in *Conocephalum* did not differ between sites ($p=0.255$). The relationship between elevation and chlorophyll levels in both study sites was found to be insignificant. There was a moderate relationship between elevation and conductivity in Corner Rock Creek ($r^2=0.46$), showing that as elevation increased, water conductivity decreased (Figure 3). For *Conocephalum*, higher levels of conductivity found in lower elevations at the Catawba River site resulted in larger patches, suggesting *Conocephalum* benefits from the dissolved ions in higher levels of conductivity. The hypothesis that *Conocephalum* would contain higher chlorophyll in water with higher conductivity could not be confirmed due to the lack of correlation between conductivity and chlorophyll at both sites.

5. Conclusion

The results of this study suggest *Conocephalum conicum* is a generalist in mountain streams, although it may benefit from higher levels of water conductivity and near neutral pH. Bryophytes and vascular plants may help stabilize *Conocephalum* on rocky substrates in turbulent streams, supporting findings from previous studies in other parts of the world.

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7. References

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