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Abundance of *Boyeria vinosa* larvae in the Enoree River basin, USA: chemical, physical, and biological correlates (Odonata: Aeshnidae)

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Abstract

Boyeria vinosa is a common anisopteran in the southeastern United States. Here we describe relationships between the abundance of *B. vinosa* larvae and the chemical, physical and biological properties of the Enoree River of South Carolina and nine of its tributary stream systems. Chemical profiles were conducted weekly for seven weeks at 63 sites in May-July 1999 and at 64 sites in May-July 2000. Fish, salamanders, crayfish, and odonate larvae were collected once at each site by electrofishing and seining, and were counted, sorted, and preserved. The abundance (number/sample) of *B. vinosa* was positively correlated with stream means for pH, bicarbonate, silicon, magnesium, and calcium ($p < 0.01$). Also, *B. vinosa* were more abundant in streams with a higher frequency of sandy bottoms sites ($r = 0.622$, $p = 0.05$). At the site scale, sites with *B. vinosa* had significantly more crayfish, fish, and other odonates, higher pH, and dissolved oxygen, and less chloride than sites without *B. vinosa* (Mann-Whitney U tests, $p < 0.05$). Where *B. vinosa* were present, abundance was positively correlated with fish abundance, odonate abundance, pH, conductivity, and concentrations of sodium, calcium, magnesium, bicarbonate, bromine, silicon, and aluminum ($p < 0.05$). As such, larval abundance of *B. vinosa* was strongly correlated with chemical and physical parameters at both site and stream scales, but only covaried with the abundance of other organisms at the site scale. Larval abundance did not correlate with the abundance of predatory centrarchid fish at either scale.

Introduction

Boyeria vinosa Say is one of the most common anisopterans in streams of the eastern Unites States (Williamson 1932). Although a few life-history studies have been conducted on this abundant species (Paulson & Jenner 1971; Smock 1988; Galbreath & Hendricks 1992), the dearth of general ecological information is surprising (Galbreath &

Hendricks 1992). The purpose of this study was to describe the broad niche parameters of *B. vinosa* larvae in piedmont streams of South Carolina.

Niche parameters for odonate nymphs can be subdivided into chemical, physical, and biological factors. Many odonates are broadly tolerant to most chemical parameters (Roback & Westfall 1967; Cannings & Cannings 1987). However, low pH, low dissolved oxygen, and solutes such as chloride and nitrite may limit the distribution of some species or change the relative abundance of tolerant and intolerant species (Carchini & Rota 1985; Romero 1988; Corbet 1999). Physical factors such as substrate and flow dynamics are also critically important and can influence oviposition site selection, foraging efficiency, and predator avoidance (Corbet 1999). Finally, biological factors may have a significant effect. Odonate larvae are a primary foodstuff of centrarchid fishes and predation by fishes can reduce larval survivorship (Crowder & Cooper 1982; Martin et al. 1991) and change community composition (Morin 1984). Anthropogenic impacts may affect all three classes of factors through direct input of toxins, changes in erosion and channelization patterns, and indirect effects mediated through trophic webs.

The Enoree River basin is a 1,193 km^2 sixth-order watershed in the piedmont of South Carolina, USA. It contains 170 km of perennial streams that drain a variety of habitat types; it is an excellent location to describe the niche parameters of odonates. In 1995, 53.7% of this watershed was forested, 25.6% was cultivated/grassland, and 10.0% was urbanized (Lahlou et al. 1998). The southern half of the watershed is a mixture of forested and agricultural land and includes parts of Sumter National Forest. The northern third of the watershed is more urbanized, and includes the Greenville-Spartanburg metropolitan area. Over the last 20 years in this urban area, the human population has increased by 50%, the acreage of impervious surfaces has doubled, and the amount of farmland converted to development has increased by 400% (Spartanburg County, S.C. Planning Commission 1998). In 1999-2000, our multidisciplinary research team conducted a chemical and biological inventory of the Enoree River and selected tributaries to describe the impact of suburban development on water quality. In this paper, we present results from this survey and describe the relationships between physical, chemical, and biological properties of streams and the abundance of *B. vinosa* larvae.

Methods

A total of 127 sites were sampled in May-July 1999 (63 sites) and May-July 2000 (64 sites) in the Enoree River and nine of its major tributaries (Fig. 1). Water chemistry was described at each site, each week, for seven weeks each summer. Temperature, pH, conductivity, and dissolved oxygen were measured *in situ* with YSI meters. At each site, 250 ml and 125 ml water samples were collected for chemical analyses and were filtered (0.45 μl filter) in the lab within 8 h of collection. The 125 ml sample was preserved with nitric acid and used for cation analysis (aluminum, calcium, iron, magnesium, manganese, potassium, silicon, sodium, and zinc) with a Varian ICP-AES (Inductively coupled plasma-atomic emission spectrometer). The 250 ml sample was left unpreserved

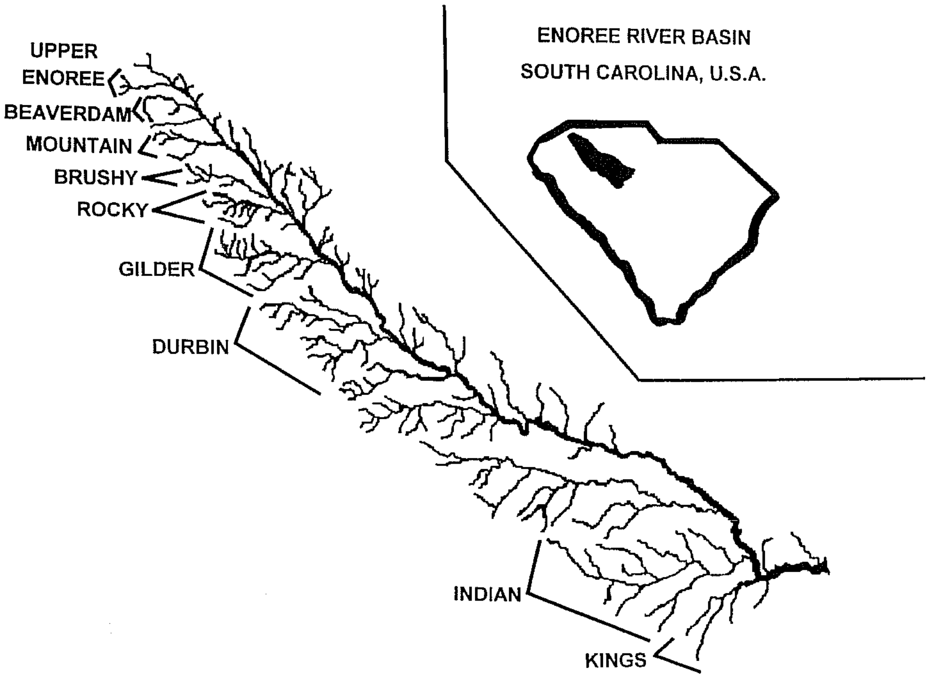

Figure 1. The Enoree River basin, South Carolina, USA. Sites in the Enoree River and in the nine labeled tributary systems that were sampled in this study.

for analysis of anion concentrations (phosphate, nitrate, fluorine, bromine, chlorine, and nitrite) using a Dionex DX-120 ion chromatograph, and alkalinity measurements by potentiometric titration using either the low alkalinity method (Eaton et al. 1995) or the Gran method. All alkalinity was assumed to be in the form of bicarbonate based on the pH, chemical composition of the samples, and charge balance considerations. One unfiltered 125 ml sample was collected for analysis of turbidity using a LaMotte 2020 Turbidimeter. Data collected over the seven weeks was averaged for each site, and these site means were used in the analyses.

At each site, fish, salamanders, and aquatic macroinvertebrates were collected by electrofishing for a total of eight minutes using a Smith-Root Backpack Electrofisher. The substrate was kicked vigorously during the shocking period to dislodge organisms. Immobilized animals were collected with a seine (1.5 m x 3.3 m; mesh size = 3.0 mm) and dip nets (mesh size = 3.0 mm). The predominate substrate type (sandy or rocky) was noted. Different microhabitats (pool, run, riffle) within each site were sampled in order to collect as many taxa as possible. However, animals from these different microhabitats were collected and stored together so analyses of habitat preference at the microhabitat scale were not possible. Each site was sampled once for animals. All specimens were sorted, counted, and preserved. All macroinvertebrates, including *Boyeria vinosa* larvae, were preserved in 75% EtOH and stored in the Entomology Collection of Furman University.

The number of *B. vinosa* and other animals captured after 8 minutes of shocking time at a site is defined as the "abundance/sample" (hereafter "abundance"). The biological niche parameters used in this study were the abundance/sample of salamanders (Plethodontidae: *Desmognathus* and *Eurycea* spp.), crayfish (Order Decopoda: Astacidae), fish, and other odonates. The purpose of correlating *B. vinosa* abundance with these biological parameters was to examine, at a very coarse level, whether *B. vinosa* was consistently excluded from some sites by predation (by salamanders, fish, or other odonates) or competition for food or habitat (by salamanders, crayfish, or other odonates).

The relationship between chemical, physical and biological niche parameters and the abundance of *B. vinosa* larvae were analyzed at two spatial scales. Patterns at the 'sampling site' scale were described by correlating *B. vinosa* abundance with the site means for the niche parameters (Pearson product-moment correlations; abundances were $\log_{10}$ transformed). Only sites containing *B. vinosa* were included in these correlation analyses. In addition, differences in the chemical and biological characteristics between sites where *B. vinosa* larvae were absent and sites where *B. vinosa* larvae were present were described with Mann-Whitney U-tests (Sokal & Rohlf 1995). Chi-square tests were used to compare the frequency of *B. vinosa* occurrence at sites with different substrate types.

Comparisons were also made at the 'stream' scale. First, a discriminant function analysis (DFA) was used to describe differences in chemical composition among the 10 stream systems (Sokal & Rohlf 1995). Mean *B. vinosa* abundance/stream (the average of abundance/sample values in each stream) was correlated with DFA centroid loadings along the first two discriminant function axes. Also, stream system means were computed for all niche parameters by averaging the site means in each stream. Pearson product-moment correlations were used to describe the relationship between mean *B. vinosa* abundance/stream and the niche parameters. In addition, variation in substrate type was analyzed by comparing the frequency of sandy and rocky sites across the ten streams (Chi-Square test, Sokal & Rohlf 1995). The mean abundance of *B. vinosa* was correlated with the percentage of sandy sites/stream with a Spearman's rank correlation.

Results

Comparisons at the stream scale

Differences in the chemical environments of the streams were described with a DFA. The first two discriminant functions explained 72.4% and 10.9% of the variance among streams, respectively ($p < 0.0001$). The concentrations of silicon and bicarbonate were the only chemical parameters significantly correlated with the first discriminant function ($r = 0.570$, $p < 0.05$; $r = 0.451$, $p < 0.05$, respectively). This axis separated the two downstream tributaries, Indian Creek and Kings Creek, from the other streams (Fig. 2). Bicarbonate concentrations at Indian Creek and Kings Creek were at least twice the concentrations found in any other stream (Table 1). The only chemical parameter that

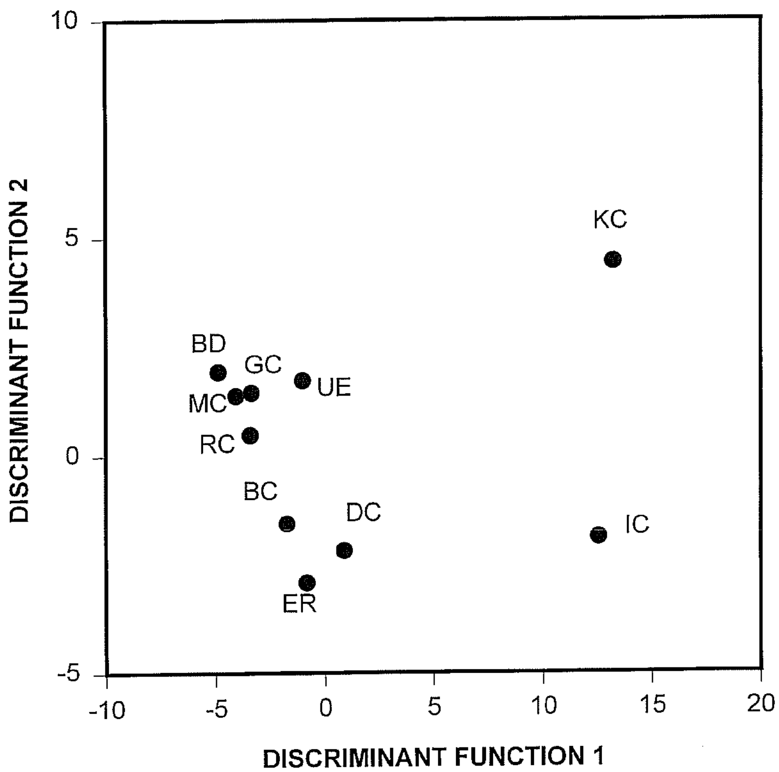

Figure 2. Plot of centroid scores from a discriminant function analysis of chemical characteristics of the Enoree River (ER) and nine tributaries. Listed from the headwaters downstream, the tributaries are: Upper Enoree (UE), Beaverdam Creek (BD), Mountain Creek (MC), Brushy Creek (BC), Rocky Creek (RC), Gilder Creek (GC), Durbin Creek (DC), Indian Creek (IC), and Kings Creek (KC). Concentrations of silicon and bicarbonate are significantly correlated with the first discriminant function, and dissolved oxygen correlates with the second (see text).

correlated with the second discriminant function was dissolved oxygen (Do, $r = 0.451$, $p < 0.05$). The six upstream tributaries had mean DO concentrations above 7.0 mg l^{-1}, whereas the downstream tributaries and the Enoree River had mean dissolved oxygen concentrations less than 7.0 mg l^{-1} (Table 1).

Boyeria vinosa abundance correlated with the chemical differences among streams. Mean *B. vinosa* abundance/stream was positively correlated with stream centroid scores along discriminant function 1 ($r = 0.877$, $p < 0.01$), but not discriminant function 2 ($r = 0.069$, ns). Results from correlation analyses were consistent with the discriminant function analysis; mean *B. vinosa* abundance/stream was positively correlated with mean concentration/stream of silicon and bicarbonate, but not with DO (Table 1). Mean *B. vinosa* abundance/stream was also positively correlated with mean stream pH, magnesium, and calcium (Table 1), but not with any other chemical variables ($p > 0.05$).

Table 1. Pearson correlations between the abundance of *Boyeria vinosa* larvae ($\overline{X} \pm 1$ sd) and the chemical, physical, and biological attributes of the Enoree River (ER) and nine of its tributaries. Only chemical parameters that correlated with *B. vinosa* abundance are included. "Abundance" of *B. vinosa* and centrarchids is the number caught/site. Listed from the headwaters downstream, the tributaries are: Upper Enoree (UE), Beaverdam Creek (BD), Mountain Creek (MC), Brushy Creek (BC), Rocky Creek (RC), Gilder Creek (GC), Durbin Creek (DC), Indian Creek (IC), and Kings Creek (KC).

Stream (*N*)	*B. vinosa* abundance	pH	Si^{4+} (mg l^{-1})	HCO_3^- (mg l^{-1})	DO (mg l^{-1})	Mg^{2+} (mg l^{-1})	Ca^{2+} (mg l^{-1})	% sandy sites	Centrarchid abundance
UE (13)	1.5 ± 4.0	6.6 ± 0.3	7.3 ± 0.9	13.9 ± 4.5	7.8 ± 0.3	1.7 ± 1.1	4.9 ± 3.1	53.8	8.6 ± 11.7
BD (10)	4.2 ± 3.7	6.5 ± 0.2	4.8 ± 1.0	9.4 ± 2.2	8.3 ± 0.3	0.8 ± 0.2	1.9 ± 0.6	60.0	5.5 ± 11.9
MC (14)	2.8 ± 3.9	6.6 ± 0.2	4.8 ± 0.7	11.4 ± 4.3	7.8 ± 0.5	0.8 ± 0.2	2.0 ± 0.9	21.4	6.4 ± 9.1
BC (14)	0.8 ± 1.2	6.7 ± 0.2	5.9 ± 0.9	17.8 ± 2.5	7.0 ± 0.7	1.1 ± 0.2	3.8 ± 0.7	78.6	5.1 ± 8.5
RC (12)	1.1 ± 1.6	6.6 ± 0.2	5.0 ± 0.8	14.7 ± 2.0	7.4 ± 0.5	1.0 ± 0.2	4.0 ± 1.4	58.3	20.8 ± 20.6
GC (14)	3.7 ± 4.3	6.6 ± 0.2	5.8 ± 1.5	16.7 ± 5.8	8.0 ± 0.5	1.0 ± 0.2	4.3 ± 2.1	57.1	5.6 ± 7.7
DC (15)	4.2 ± 5.0	6.8 ± 0.2	8.9 ± 1.5	22.7 ± 7.9	6.2 ± 0.4	1.3 ± 0.4	5.8 ± 3.3	100.0	7.1 ± 6.3
IC (10)	11.4 ± 17.5	7.3 ± 0.3	16.1 ± 2.3	65.3 ± 11.6	6.1 ± 0.6	4.4 ± 1.1	10.8 ± 3.0	100.0	4.9 ± 4.5
KC (8)	8.6 ± 14.8	7.0 ± 0.2	19.2 ± 2.5	49.9 ± 7.4	6.4 ± 0.7	2.5 ± 0.8	7.9 ± 1.3	100.0	1.4 ± 1.5
ER (17)	3.8 ± 5.5	6.8 ± 0.2	6.4 ± 0.7	21.9 ± 6.5	6.4 ± 0.7	1.6 ± 0.4	4.5 ± 1.4	94.1	3.4 ± 4.1
Correlation with *B. vinosa* abundance		r = 0.845 $p = 0.002$	r = 0.863 $p = 0.001$	r = 0.919 $p = 0.001$	r = -0.526 n.s.	r = 0.866 $p = 0.001$	r = 0.826 $p = 0.003$	r = 0.622* $p = 0.055$	r = -0.477 $p = 0.163$

* = Spearman Rank Correlation

At each site, the substrate was characterized as sandy or rocky. Streams differed in the frequency of sandy sites ($\chi^2 = 40.19$, df = 9, $p < 0.0001$). Upper tributaries had an even mix of sandy and rocky sites, whereas lower tributaries and the Enoree River had only sandy substrates (Table 1). The mean *B. vinosa* abundance/stream was weakly correlated with the proportion of sandy sites/stream (r = 0.622, $p = 0.055$, Table 1). Mean *B. vinosa* abundance/stream did not correlate significantly with any biological parameters at the stream scale, including the mean abundance of predatory centrarchids (Table 1), salamanders (r = -0.108, ns), crayfish (r = 0.231, ns), all fish (r = 0.246, ns), or other odonates (r = 0.533, ns, $N = 10$ for all correlations).

Comparisons at the site scale

The chemical and biological parameters of sites where *B. vinosa* was absent were compared with sites where it was present using Mann-Whitney U tests for non-parametric data (Table 2). Sites containing *B. vinosa* had significantly more crayfish, fish, and other odonates, higher DO and pH, and lower chloride than sites where *B. vinosa* was absent (Table 2). Where *B. vinosa* was present, larval abundance/site ($\log_{10}$ transformed) was positively correlated with the abundance of fish ($\log_{10}$ transformed), the abundance of other odonates ($\log_{10}$ transformed), pH, conductivity, and concentrations of sodium, calcium, magnesium, bicarbonate, bromine, silicon, and aluminum (Table 2). Following Roback (1974), we also list the extreme values where *B. vinosa* was found for each variable, in an effort to describe the tolerance range for this species (Table 2).

The importance of substrate type was measured by comparing the frequencies of sandy and rocky sites occupied by *B. vinosa*. When all sites were included, there was no difference between the percentage of rocky sites occupied (50%) and the percentage of sandy sites occupied (63.7%; $\chi^2 = 2.025$, df = 1, $p = 0.155$). However, in the lower tributaries and the Enoree River, there were only sandy substrates so no habitat choice was possible. When only the six upper tributaries were analyzed, there was a statistically significant pattern: *B. vinosa* occupied 71% of the sandy sites but only 48% of the rocky sites ($\chi^2 = 4.19$, df = 1, $p = 0.04$).

Discussion

The objective of this study was to describe the chemical, physical, and biological niche parameters of *Boyeria vinosa* at two spatial scales in the Enoree River basin of South Carolina, USA. *B. vinosa* abundance was significantly correlated with several physical and chemical attributes. At both the stream and site scales, *B. vinosa* was associated with sandy-bottom habitats with higher pH, bicarbonate, silicon, and dissolved cations. At the site scale, the presence of *B. vinosa* was also associated with higher dissolved oxygen. These patterns are not unusual; odonate abundance is often correlated with these variables (Corbet 1999). The ranges of chemical conditions occupied by *B. vinosa* in this study are consistent with those previously reported by Roback (1974) for pH, chloride, dissolved oxygen, calcium, magnesium, sulfate, and turbidity. However, *B. vinosa* in this study were found at sites with much higher nitrate concentrations (30.86 mg l^{-1})

Table 2. Relationships between the chemical and biological attributes of 127 sampling sites in the Enoree River watershed and the presence or abundance of *Boyeria vinosa* larvae. Characteristics of sites with and without *B. vinosa* are presented ($\overline{X} \pm 1$ sd), and are compared with Mann-Whitney U tests (U, Z, and *p*). Ranges for sites containing *B. vinosa* are also presented. Relationships between variables and *B. vinosa* abundance are described with Pearson Product-Moment Correlations; only sites containing *B. vinosa* were included; animal abundances were $\log_{10}$ transformed prior to correlation analyses. All abundances are number captured/site.

VARIABLE	*B. vinosa* absent $\overline{X} \pm 1$ s.d.; $N = 51$	*B. vinosa* present $\overline{X} \pm 1$ s.d.; $N = 76$	Mann-Whitney U	Z	*p*	Range (*B. vinosa* present)	Correlation r	*p*
Crayfish abundance	2.80 ± 8.80	6.47 ± 9.40	1122.5	-3.63	0.0001	0 - 40	0.193	n.s.
Salamander abundance	4.90 ± 9.72	6.09 ± 8.72	1558.5	-1.51	n.s.	0 - 52	-0.023	n.s.
Fish abundance	79.97 ± 107.06	107.94 ± 99.04	1439.5	-2.45	0.01	1 - 471	0.211	0.07
Centrarchid abundance	7.91 ± 11.87	6.26 ± 9.84	1785.0	-0.76	n.s.	0 - 56	-0.053	n.s.
Abundance other Odonata	20.25 ± 41.15	79.66 ± 125.89	861.0	-5.30	0.0001	0 - 798	0.581	0.0001
Temperature (°C)	22.76 ± 1.85	22.53 ± 1.35	1915.0	-0.11	n.s.	17.76 - 26.80	-0.092	n.s.
Conductivity (μS/L)	75.33 ± 49.69	71.82 ± 66.79	1603.0	-1.65	n.s.	18.83 - 401.06	0.252	0.03
DO (mg l^{-1})	6.88 ± 0.91	7.32 ± 0.91	1419.5	-2.55	0.01	5.26 - 8.79	-0.183	n.s.
Turbidity	9.81 ± 9.38	9.20 ± 7.37	1901.0	-0.82	n.s.	1.53 - 55.22	0.048	n.s.
Na^+ (mg l^{-1})	6.44 ± 5.26	6.96 ± 10.24	1641.0	-1.41	n.s.	1.66 - 62.22	0.233	0.04
K^+ (mg l^{-1})	2.13 ±1.03	2.10 ± 1.14	1848.0	-0.44	n.s.	0.72 - 6.53	0.071	n.s.
Ca^{2+} (mg l^{-1})	4.85 ± 3.09	4.75 ± 3.00	1798.0	-0.69	n.s.	1.07 - 12.58	0.271	0.02
Mg^{2+} (mg l^{-1})	1.58 ± 1.22	1.47 ± 1.02	1712.0	-1.11	n.s.	0.50 - 5.45	0.264	0.02
Cl^- (mg l^{-1})	8.85 ± 14.09	6.72 ± 12.76	1409.0	-2.62	0.009	1.46 - 77.70	0.179	n.s.
SO_4^{2-} (mg l^{-1})	3.06 ± 2.93	3.04 ± 3.38	1862.0	-0.37	n.s.	0.75 - 16.26	0.005	n.s.
HCO_3^- (mg l^{-1})	21.78 ± 16.36	22.98 ± 16.74	1914.0	-0.12	n.s.	6.60 - 78.39	0.319	0.005
NO_3^- (mg l^{-1})	2.65 ± 2.12	3.11 ± 5.24	1622.0	-1.55	n.s.	0.39 - 30.86	0.112	n.s.
PO_4^{3-} (mg l^{-1})	0.10 ± 0.22	0.15 ± 0.44	1808.0	-0.69	n.s.	0.00 - 2.50	0.128	n.s.
NO_2 (mg l^{-1})	0.02 ± 0.05	0.03 ± 0.12	1875.0	-0.33	n.s.	0.00 - 0.99	-0.027	n.s.
Br (mg l^{-1})	0.02 ± 0.03	0.07 ± 0.35	1722.0	-1.10	n.s.	0.00 - 3.00	0.271	0.02
F (mg l^{-1})	0.31 ± 1.37	0.13 ± 0.14	1848.0	-0.44	n.s.	0.04 - 1.21	0.038	n.s.
Si^{4+} (mg l^{-1})	7.71 ± 3.94	7.86 ± 4.66	1785.0	-0.76	n.s.	2.78 - 23.30	0.312	0.006
Zn^{2+} (mg l^{-1})	0.58 ± 2.43	0.03 ± 0.01	1819.0	-0.61	n.s.	0.00 - 0.73	-0.098	n.s.
Mn^{2+} (mg l^{-1})	0.17 ± 0.40	0.09 ± 0.16	1786.0	-0.75	n.s.	0.01 - 1.35	0.002	n.s.
Al^{2+} (mg l^{-1})	0.17 ± 0.10	0.15 ± 0.05	1840.5	-0.48	n.s.	0.00 - 0.25	0.223	0.053
Fe^{2+} (mg l^{-1})	0.33 ± 0.29	0.26 ± 0.20	1654.0	-1.40	n.s.	0.02 - 0.90	0.122	n.s.

than found by Roback (1974; 1.91 mg l^{-1}). Our study is the first to report tolerance ranges for this species for sodium, potassium, phosphate, nitrite, bromine, flourine, silicon, and the heavy metals zinc, aluminum, manganese, and iron.

Tolerance to these chemicals is particularly important, as many are associated with agricultural and industrial inputs. For instance, Watson et al. (1982) found that odonates were completely excluded from sites below a sewage effluent where zinc concentrations were greater than 0.018 mg l^{-1} and chloride was as high as 1.1 mg l^{-1}. However, the concentrations of other chemicals such as copper may have been toxic, as well. In our study, one stream was strongly influenced by industrial inputs. In 1988, the waste container of a galvanizing plant ruptured and spilled HCl and heavy metals into the groundwater above the headwaters of the Upper Enoree River. We analyzed water from this stream in 1999. At the first sampling site 0.3 km below the spill location, average concentrations of chloride (76.8 mg l^{-1}), zinc (13.47 mg l^{-1}), manganese (2.28 mg l^{-1}), and aluminum (0.55 mg l^{-1}) were very high, even 11 years after the spill. This site contained no macroscopic animal life. However, concentrations of these inputs declined quickly downstream and animal abundances increased. *B. vinosa* was found 2.4 km below the spill site, where chloride (6.16 mg l^{-1}), zinc (0.73 mg l^{-1}), manganese (0.28 mg l^{-1}) and aluminum (0.16 mg l^{-1}) concentrations had decreased significantly. However, these concentrations are still much higher (6x for chlorine and 40x for zinc) than those excluding odonates in the study by Watson et al. (1982). These differences may reflect adaptations to local conditions, species-specific differences in tolerance, or the cumulative effects of zinc and copper toxicity in Watson et al. (1982).

Biological parameters also correlated with *B. vinosa* abundance. These relationships were inconsistent across scales, however, suggesting scale-dependent dynamics. At the site scale, *B. vinosa* abundance was positively correlated with the abundance of fish and other odonates. Also, sites with *B. vinosa* present had more crayfish, fish, and other odonates, on average, than sites where *B. vinosa* was absent. This suggests that sites favorable to *B. vinosa* are also favorable to other aquatic organisms. Correlated abundances may represent correlated patterns of habitat selection within a stream. At the stream scale, however, there were no significant correlations between mean *B. vinosa* abundance and any biological indices, including the abundance of other odonates. Apparently, correlated habitat selection is not a primary determinant of stream occupancy or mean abundance in a drainage. Stream selection may be a function of colonization patterns and histories unique to each taxon. There were no significant negative correlations between *B. vinosa* abundance and the abundance of other animal taxa. So, it does not seem that predation or competition strongly affects *B. vinosa* abundance at the site or stream scale.

In conclusion, *B. vinosa* is broadly tolerant to a wide range of chemical and physical conditions. Nonetheless, the abundance of this species was strongly correlated with chemical and physical attributes of habitats at two spatial scales. In particular, abundance correlated with parameters typically affected by anthropogenic inputs. As such, additional work is needed to describe the response of odonate species and communities to human disturbance and habitat modification.

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