Do clearwater and blackwater streams in the southeast US have different physical and biological characteristics?

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Introduction

- Clearwater and blackwater streams are prevalent in the southeastern coastal plains of the United States
- Blackwater streams are stained from humic and tannic material and appear dark in color, while clearwater streams are transparent(Fig. 1)
- Sandy-bottom stream types are often associated with local variation in geology, hydrology, and gradient
- Few studies have examined the biological variation in macroinvertebrate and fish composition between southeaster blackwater and clearwater streams, despite recognition of high regional biodiversity[1]
- Several headwater streams that fit these conditions at Ft. Benning Military Installation, Columbus, GA were compared in 2018 (Fig. 2)

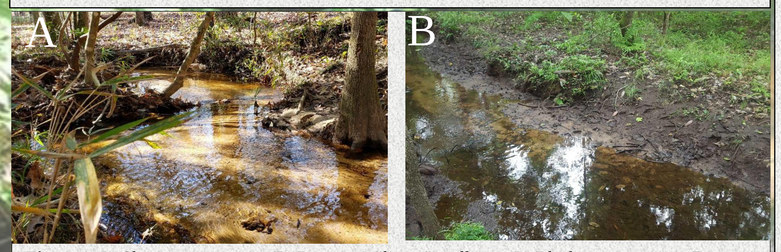

Figure 1. A: Clearwater stream in Ft. Benning Military Installation. **B**: Blackwater stream in Ft. Benning Military Installation.

Objective

- Determine ecosystem differences in blackwater and clearwater streams using physicochemical, basin-scale, macroinvertebrate, and fish data

Figure 2. Site map of Ft. Benning Military Installation, GA. Blackwater sites are marked with yellow ◘ (K23N, K20N, KM, F10, BC, K23W) while the clearwater sites are marked with red ◘ (SB4, F1E, SB3, LPK, HB). All sites are on the eastern half of the installation.

Methodology

- 5 clearwater streams and 6 blackwater streams were identified based on visual assessment (Fig. 1). All streams were 1st to 2nd order.
- Reach-scale physicochemical parameters (temperature, pH, and specific conductance) were measured on site and basin-scale parameters (basin slope, mean channel slope, drainage area, relief, and relief ratio) were determined using USGS StreamStats 4.0.
- Macroinvertebrates were collected via 36 jab samples across all habitats in the reach with a standard 243 µm D-frame net. Collected individuals were subsequently counted and identified to genus.
- Fish were collected via 2-pass depletion with a Smith Root LR-24 electrofisher across the entire reach and subsequently counted and identified to species

Methodology

- T-tests were used to determine significant differences between blackwater and clearwater physicochemical, basin-scale, fish, and macroinvertebrate data
- Macroinvertebrate and fish assemblages were described with NMDS (Nonmetric Multidimensional Scaling) based on relative abundance data
- MRPP (Multi-response Permutation Procedure) was used to test whether pre-determined stream types were significantly different based on biotic assemblages
- ISA (Indicator Species Analysis) was used on resulting significant MRPP groupings to determine if any particular taxa were significantly associated with a given stream type

Results

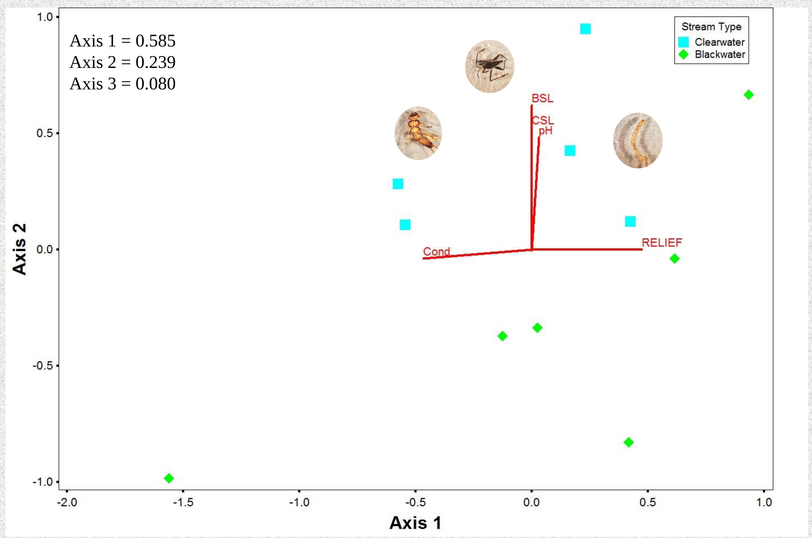

Figure 3a. NMDS ordination of clearwater and blackwater streams using macroinvertebrates (71 iterations, instability = 0.00001, stress = 3.63). Vectors represent physicochemical and basin-scale parameter correlations: Cond = conductance, BSL = basin slope, CSL = change in elevation, pH, and RELIEF = maximum – minimum elevation.

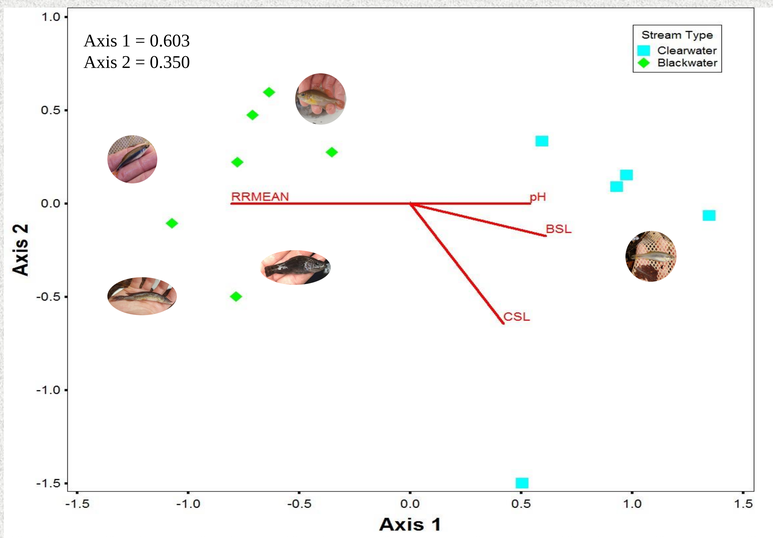

Figure 3b. NMDS ordination of clearwater and blackwater streams using fish composition data (123 iterations, instability = 0.00001, stress = 5.27). Vectors represent physicochemical and basin-scale parameter correlations: RRMEAN = relief ratio, pH, BSL = basin slope, and CSL = change in elevation.

Results

- Clearwater streams had a significantly higher BSL (p=0.01), CSL (p=0.01), and pH (p=0.02)
- Blackwater streams had a significantly higher RRMEAN (p=0.002)
- No significant differences were found between blackwater and clearwater RELIEF (p=0.83), drainage area (p=0.06), water temperature (p=0.33), or conductance (p=0.66)
- 53 macroinvertebrate genera were represented in the 11 sites
- No significant differences were found between blackwater and clearwater macroinvertebrate abundance (p=0.92), richness (p=0.87), or Shannon's diversity (p=0.52)
- Macroinvertebrate composition significantly differed between clearwater and blackwater streams (A=0.098, p=0.033) including significant indicator species (Fig. 3a, Table 1)
- 17 fish species were represented in the 11 sites
- No significant difference was found between blackwater and clearwater fish abundance (p=0.90)
- Fish species richness (p=0.001) and Simpson's diversity (p=0.01) were higher in blackwater streams (Fig. 4a & 4b)
- Fish composition significantly differed between clearwater and blackwater streams (A=0.369, p=0.0009) including significant indicator species (Fig.3b, Table 2)

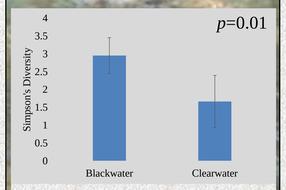

Figure 4a. Mean (+SD) Simpson's diversity for fish species of blackwater and clearwater streams.

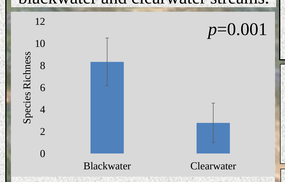

Figure 4b. Mean (+SD) species richness for fish species of blackwater and clearwater streams.

Table 1. Macroinvertebrate indicator species according to ISA.

Blackwater	Clearwater
None	*Eccoptura*
	Hexatoma
	Cordulegaster
	Rhagovelia

Table 2. Fish indicator species according to ISA.

Blackwater	Clearwater
Esox	*Semotilus*
Aphrododerus	
Lepomis	
Pteronotropis	

Discussion

- There are clear basin-scale and limited reach-scale physicochemical differences between clearwater and blackwater streams
- Clearwater streams have higher basin slopes and changes in elevation, likely resulting in higher water velocity and oxygen-sensitive macroinvertebrates
- Blackwater streams have lower basin slopes and changes in elevation, likely resulting in slower water velocity and fishes adapted to slow and/or poorly-oxygenated water
- These data suggest that blackwater and clearwater streams are unique in their physicochemical conditions and biotic signatures, and confirm patterns seen in nearby systems of south Alabama[1]
- This study reinforces that these categories should be considered unique entities in stream classification systems and resource management decisions[1].

Acknowledgements

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References

[1] Colvin, S., B. Helms, D. DeVries, J. Feminella. 2020. Environmental and fish assemblage contrasts in blackwater and clearwater streams. Transactions of the American Fisheries Society. Vol 149, Iss 3
Fish pictures obtained from www.outdooralabama.com