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EXPLORATORY ASSESSMENT OF ASSOCIATION BETWEEN INVERTEBRATE "EPT" TAXA AND THE INCIDENCE AND SEVERITY OF WHIRLING DISEASE IN TRIBUTARIES OF THE BLACKFOOT RIVER, MONTANA

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Indroduction

In an earlier pilot study, we investigated whether patterns in stonefly (Plecoptera) assemblages could suggest the presence of whirling disease in streams tributary to the Blackfoot River. In this study, we include 2 other aquatic insect orders, mayflies (Ephemeroptera) and caddisflies (Trichoptera). These 3 groups comprise the so-called "EPT" orders of aquatic insects, which are often considered to be general indicators of clean water and undisturbed habitat conditions.

Methods

Sampling methods and laboratory processing and identification protocols are described in the previous paper (Bollman et al. 2006), to which the reader is referred. Random subsamples of 500 organisms from all aquatic invertebrate groups were taken from whole samples, and these were identified. Physical and chemical data, as well as data related to the incidence (percent of reaches with infection >3 in 2005) and severity (mean McConnell-Baldwin scale value in 2005) of whirling disease in each stream were made available by Montana Fish Wildlife and Parks. Correlation matrices (Spearman rank R) were constructed using these data and the invertebrate data, and the matrices were examined for suggestive associations. In all, 22 metric expressions (listed in Table 1) summarizing the invertebrate data were analyzed for correlation with the 2 whirling disease measures. Ephemeroptera and Trichoptera taxa from both the random subsamples and the total sample collections were removed and identified, and these data were combined with the Plecoptera data generated for the earlier study. The relative abundance of each EPT taxon was examined for correlative association with whirling disease measures. As before, Bear Creek was not included in this analysis, since the status of whirling disease in that stream in 2005 was not known. The EPT fractions of the whole samples were further analyzed with an ordination study (nonmetric multidimensional scaling: McCune and Grace 2002). For this analysis, the Sorenson (Bray-Curtis) distance measure was used. The resulting plot was examined to see if groupings of invertebrate assemblages distinguished infected sites from uninfected sites. Bear Creek was included in this analysis.

Results

Sixty-seven EPT taxa were identified in the 13 samples. A total of 10,644 EPT individuals were present.

Significant correlation could be demonstrated between both measures of whirling disease and 4 metric expressions summarizing the invertebrate assemblages. Table 2 summarizes the correlation coefficients of these relationships. Figures 1-4 graph the results of each metric individually against the percentage of stream reaches with infection severity greater than 3, as measured on the MacConnell-Baldwin scale.

Several taxa were collected only in streams with no incidence (i.e. 0% of reaches with >3 on the MacConnell-Baldwin scale) of whirling disease. A few taxa were only collected from streams with whirling disease infection. These data are summarized in Tables 3 and 4. Taxa that were collected at a single site were not included in the tables.

Figure 5 illustrates the ordination plot of the aquatic invertebrate assemblages collected at the 13 sites. Final stress for this analysis was 7.02, indicating a good fit of the ordination model to the data.

Table 1. Metrics tested for association with incidence and severity of whirling disease.

Measures of habitus, physiology, or life history	***Functional measures***
Air Breather Richness	Filterer Richness
Burrower Richness	Predator Richness
Clinger Richness	***Taxonomic composition measures***
Cold Stenotherm Richness	Baetidae/Ephemeroptera
Hemoglobin Bearer Richness	E Richness
Semivoltine Richness	EPT Richness
Swimmer Richness	Hydropsychidae/Trichoptera
Univoltine Richness	P Richness
Tolerance measures	T Richness
Hilsenhoff Biotic Index	Taxa Richness
Metals Tolerance Index	
Pollution Sensitive Richness	
Sediment Sensitive Richness	
Sediment Tolerant Richness	

Table 2. Spearman rank order correlation coefficients (R) for associations between 2 measures of whirling disease and 4 metric expressions derived from invertebrate taxonomic data from 13 samples. Correlations are significant at p < .05000.

	2005 mean infection	**% reaches > grade 3 infected**
2005 mean infection	1.000000	0.913293
% reaches > grade 3 infected	0.913293	1.000000
Cold Stenotherm Richness	-0.673981	-0.710569
EPT Richness	-0.600712	-0.608616
Metals Tolerance Index	0.744218	0.842184
Pollution Sensitive Richness	-0.691541	-0.745014

Figure 1. Association between cold stenotherm taxa richness and incidence of whirling disease (R = -0.71, $p <$ 0.05). Dotted lines indicate 95% confidence intervals.

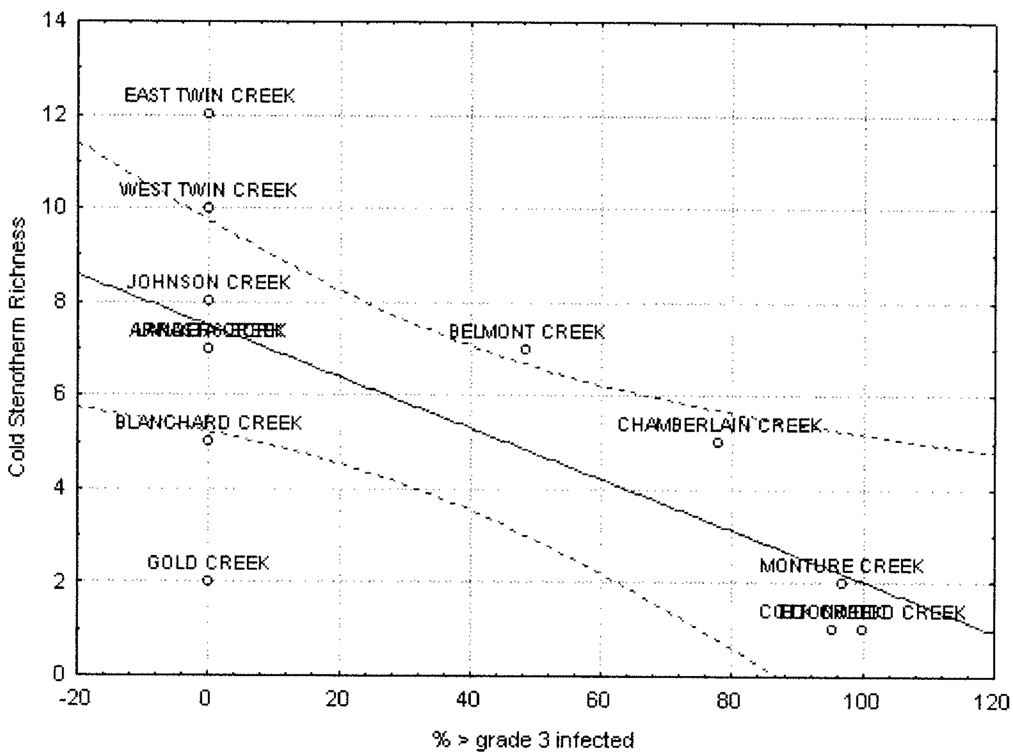


Figure 2. Association between EPT richness and incidence of whirling disease (R = -0.61, $p < 0.05$). Dotted lines indicate 95% confidence intervals.

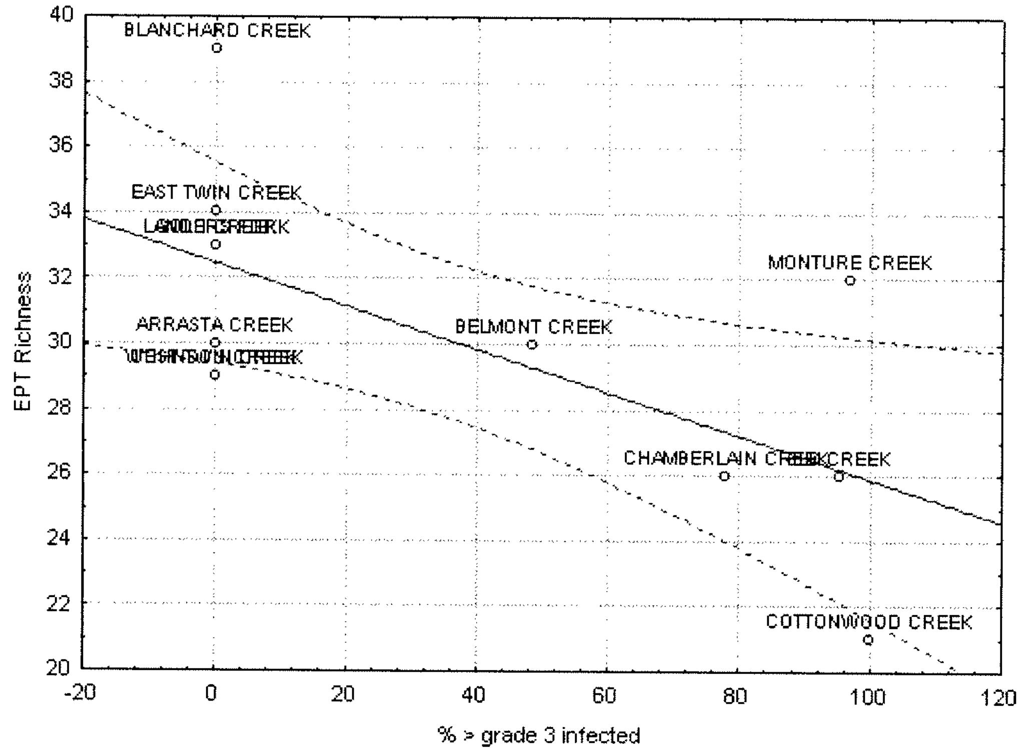


Figure 3. Association between the metals tolerance index and incidence of whirling disease (R = 0.84, $p < 0.05$). Dotted lines indicate 95% confidence intervals.

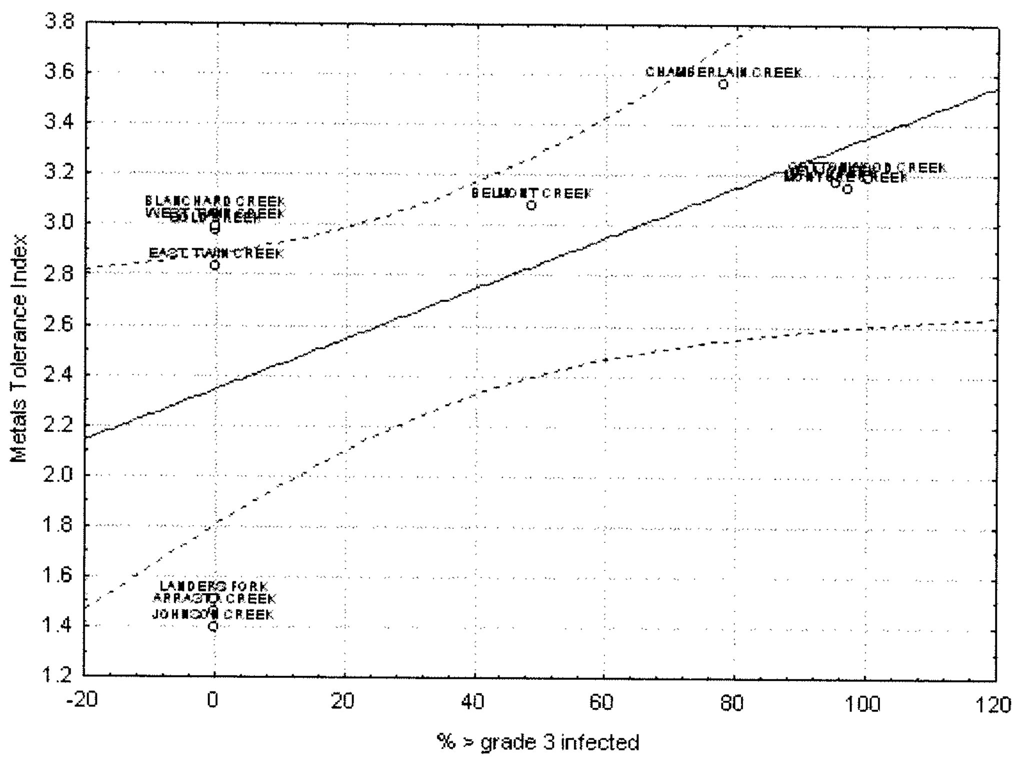


Figure 4. Association between pollution sensitive taxa richness and the incidence of whirling disease (R = -0.74, $p < 0.05$). Dotted lines indicate 95% confidence intervals.

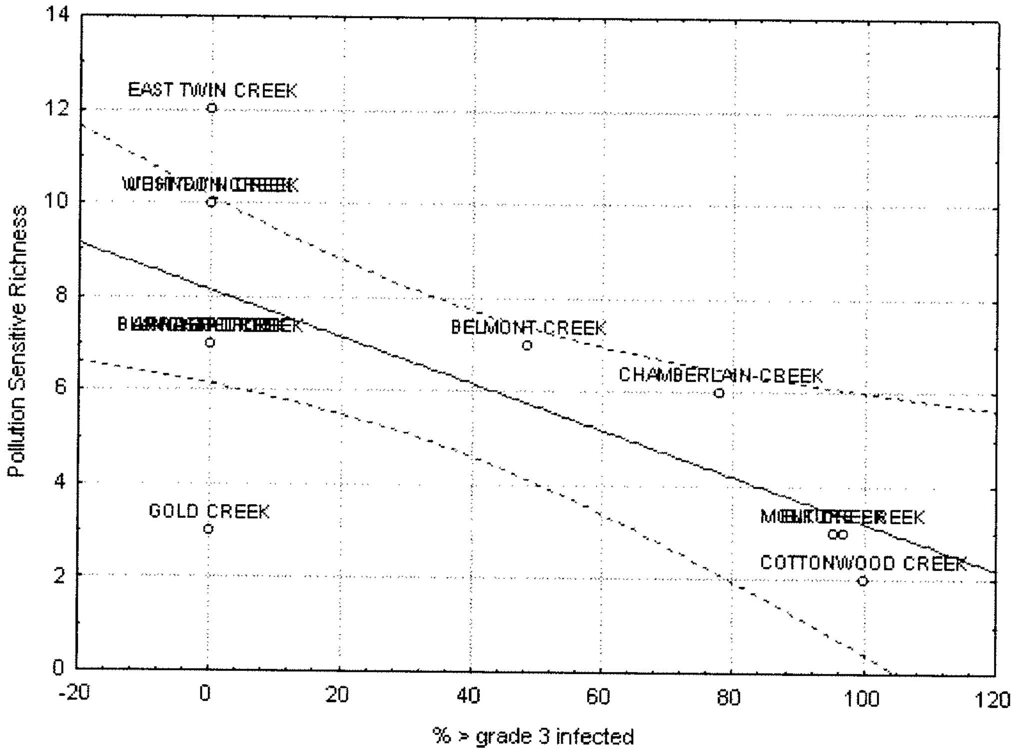


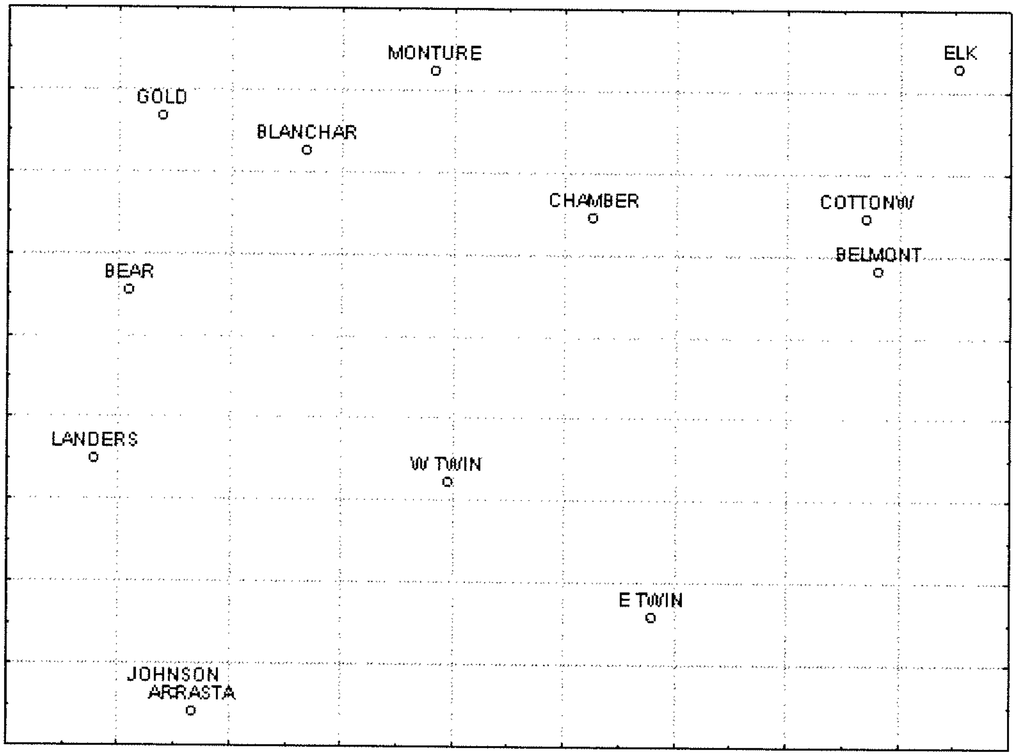
Table 3. Taxa collected only from streams without documented whirling disease infection. The number of sites where the taxon was collected is indicated in parentheses. Taxa collected at only a single site are not included in the table.

Ephemeroptera	Plecoptera	Trichoptera
Drunella spinifera (2)	*Visoka cataractae* (2)	*Parapsyche elsis* (4)
Caudatella edmundsi (2)	*Calineuria californica* (2)	*Agraylea* sp. (2)
Epeorus deceptivus (2)	*Megarcys signata* (4)	*Lepidostoma unicolor* (4)
Epeorus longimanus (5)		*Rhyacophila alberta* (3)
Rhithrogena sp. (4)		
Ironodes sp. (2)		
Baetis alius (2)		
Baetis flavistriga (2)		

Table 4. Taxa collected only from streams with documented whirling disease infection. The number of sites where the taxon was collected is indicated in parentheses. Taxa collected at only a single site are not included in the table.

Ephemeroptera	Plecoptera	Trichoptera
Timpanoga hecuba (3)	*Pteronarcella badia* (2)	*Brachycentrus occidentalis* (3)
	Claassenia sabulosa (2)	*Hydropsyche oslari* (2)

Figure 5. Ordination (nonmetric multidimensional scaling) of aquatic invertebrate assemblages from 13 stream sites in the Blackfoot drainage.



Discussion

The significant association of EPT taxa richness with whirling disease incidence and severity supports the finding reported by McGinnis and Kerans (citation?) for western Montana drainages. These investigators determined that the risk of whirling disease in watersheds increased as EPT richness diminished ($r^2 = 0.35$, $p = 0.07$). Neither E richness, P richness, nor T richness, when considered singly, produced significant correlation with the incidence of whirling disease, suggesting that different groups may have been advantaged in different environs. Although the association of EPT richness with whirling disease incidence was strong in our analysis, both Monture Creek and Belmont Creek supported relatively large numbers of EPT taxa despite the presence of whirling disease; EPT richness in samples collected in these drainages equaled or exceeded EPT richness in 3 drainages (Arrastra Creek, Johnson Creek, and West Twin Creek) that apparently did not harbor the infection. These findings suggest that it may be important to consider the presence or absence of individual taxa instead of metric summations of taxa richness.

Since both mean water temperature and July-August maximum water temperature were significantly associated with the incidence of whirling disease ($R = 0.621$ $p < 0.05$ and $R = 0.799$ $p < 0.05$ respectively), it was not surprising that the number of cold stenotherm taxa present in samples was also significantly correlated with whirling disease incidence. Pollution sensitive taxa are often cold stenothermic; the significant relationship between that metric and the whirling disease measures is predictable given the overlap between those 2 groups of aquatic invertebrates. However, similar to EPT richness, neither cold stenotherm richness nor pollution sensitive richness were perfect predictors of the presence of whirling disease.

These correlations suggest that the incidence and severity of whirling disease may be related to water temperature. Those taxa that were collected only in infected streams (Table 4) are generally tolerant of warmer thermal conditions, while those collected only in uninfected streams (Table 3) are generally cold stenotherms. A thermal association with whirling disease is also evident in the ordination. While no strong clustering of sites is apparent, the ordination suggests a sorting of assemblages with respect to temperature tolerances. There is a temperature gradient evident from the lower left corner of the plot to the upper right corner when July-August maximum temperature is considered. The plot suggests that sites with higher July-August maximum temperature tend to be infected with whirling disease. Other than Arrastra Creek, which demonstrated a low mean severity and 0% severely infected reaches, all infected sites plot in the upper right of the ordination space.

The significant association between whirling disease incidence and the metals tolerance index was an unexpected result. Among the group of sites studied, the incidence of whirling disease tended to be higher in streams where the invertebrate assemblage was more tolerant to metals contamination, when tolerance was measured by this index.

Curiously, sites in watersheds with a high percentage of reaches (48.5% and greater) with whirling disease incidence have higher forest cover as a percentage of watershed area than uninfected watersheds ($R = 0.853$ $p < 0.05$). Forested area ranges from 73.4% to 87.3% in drainages without demonstrated whirling disease infection, and from 88.9% to 95.1% in infected drainages.

References

Bollman, W., R. Pierce and L. Eby. 2006. A pilot assessment of the association between stonefly assemblages and the incidence and severity of whirling disease in tributaries of the Blackfoot River, Montana. Unpublished report to Montana Fish Wildlife and Parks. Ron Pierce, project manager.

McGinnis, S. and B.L. Kerans. ???? A preliminary assessment of land use and aquatic invertebrates as indicators of whirling disease risk in Montana. ????