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Macroinvertebrate Community Effects From the Exclusion of Mammalian Predators

by Victoria Graham

(Biology 110)

The Assignment: Conduct original research and write a technical paper about the research.

The objective of the experiment was to determine if Illinois tallgrass prairie macroinvertebrate communities are significantly impacted by the exclusion of small mammals at higher trophic levels. Enclosures were installed adjacent to a pond located in a re-created prairie; each enclosure was paired with an associated control site nearby. After five years, both macroinvertebrate and flora communities were inventoried at all sites. Correspondence analysis results show both macroinvertebrate and flora enclosure communities are less diverse than control communities supporting the theory of top-down predator-prey effects. Enclosed flora communities, however, lie outside the range of the control flora communities and provide possible evidence of bottom-up control. Although both top-down and bottom-up components may be present, conclusions about the relative importance in defining the macroinvertebrate community could not be drawn. Expanded data collection and trend analysis will enable greater scrutiny of the underlying forces that determine the tallgrass prairie ecosystem.

Introduction

There is debate whether predators shape their community from the top of the food chain down or, conversely, the community is actually shaped from the bottom of the food chain up. The top-down argument is based on the delayed density-dependent oscillations in prey communities (Turchin et al., 1999) and observed negative predator impact on prey (Nelson et al., 2004). Under high resource conditions, predators can increase prey diversity by feeding on the more plentiful, aggressive prey limiting their impact and allowing room for more niche species (Bonsall and Holt, 2003). Without predator feeding, more successful prey would dominate and drive other prey species into extinction. Contrary to that position, laboratory and field experiments performed in North American inter-tidal marshes lead to the conclusion that bottom-up impacts were more pronounced (Denno et al., 2003). *Spartina* cordgrass productivity had a stronger impact on the planthopper prey community than the wolf-spider predator under test. Would a Midwest tallgrass prairie support the bottom-up theory as well?

A re-created mesic tallgrass prairie was selected as the site for research. Prairies are recognized as an ecosystem with high species diversity providing plentiful data and reflecting more distinctly any resultant effects (Hoffman et al., 2001). Native perennial plants support abundant consumer feeding with little or no indication of resource limitation so primary productivity is high (Agrawal and Malcolm, 2002; Evans, 1989; Root and Capuccino,1992). Active microbial symbionts act in conjunction with plants to establish an enriched base for higher trophic levels (Clay, 2001; Klironomos and Hart, 2001). Kneitel and Chase (2004) show that not only resource levels and predation but disturbance as well all interact to determine the composition and abundance of a community. Prairies, however, are in a stable climax state with disturbance. Possible concerns about colonizer-successor cyclic plant population patterns should not be an issue (Wiegand et al., 1998.)

The top trophic level predators were small mammals common to tallgrass prairie, i.e. foxes, raccoons, shrews, moles and voles. These animals were excluded for five years from seven mesh-fenced enclosure sites extending 15 cm subsurface. The prey community consisted of above ground macroinvertebrates, primarily insects and spiders all unrestricted by the mesh screening. Macroinvertebrates are of interest because they have a broad influence in all ecosystems comprising three-quarters of all known species in the United States (Cunningham et al., 2005). The experiment objective is to determine whether the species in the enclosed areas are a noticeably different community than the control areas. Under top-down control, theoretically, lower trophic levels should be more similar (less diverse) in the enclosed regions when higher trophic levels are excluded. However, if prairies are under bottom-up control, there should be normal variance in the species but no distinct difference between the enclosed and control communities.

Site Description & Methods

The study site is the 15 ha Russell Kirt Tallgrass Prairie at the College of DuPage in Glen Ellyn, IL. Prairie re-creation began in 1985 and has been extended over subsequent years. Kirt (1996) provides a description of the flora community. Shrews, foxes and raccoons have been observed in the prairie in conjunction with a healthy insect community. This experiment was performed in September 2004 around a pond within a ten-year-old portion of mesic tallgrass prairie maintained with biennial burns. The last burn of the experimental site was in March of 2002.

The seven 2m x 2m enclosure sites were established in 1999. Galvanized chicken wire was buried to a depth of 15 cm and extended 30cm above surface. The 5 mm mesh size acted to prevent larger mammalian predator invasion. Each control site (C_{1-7}) was selected within 2 m of a corresponding enclosure site (E_{1-7}) and was established along the same approximate slope proceeding to the retention pond.

Data were gathered during multiple sampling sessions in September 2004. Macroinvertebrate inventories were recorded according to morphotype at the lowest possible taxonomic level. Prairie flora were classified by genus and species. Descriptive soil temperature and moisture data were taken using an Aquaterr Temp-200 meter (Aquaterr Instruments, Costa Mesa, CA). Assemblage structures of the macroinvertebrate communities and floral communities were summarized using correspondence analysis. The ordination technique offers to reduce community data to coordinates on a multidimensional plane. Only the first two dimensions for macroinvertebrates and flora as listed in Table 1 were considered here as they explain most of the variance in data. Communities which are more similar should have coordinates that are closer together than communities which are less similar. The Shannon index was used to measure diversity within each sample site.

Results

Inventories of macroinvertebrates and plants found from the sample sites can be obtained by contacting the Biology Department of the College of DuPage. Table 1 provides physical measurements and coordinates derived from correspondence analysis. The macroinvertebrate eigenvalue results in Figure 1 show there is more similarity in the enclosure sites than in the control sites. Enclosure Dimension 1 eigenvalues have a 1.2 value range and Dimension 2 values have a 1.3 value range. Control Dimension 1 eigenvalues have a 2.9 value range and Dimension 2 values have a 2.6 value range. Macroinvertebrate enclosure eigenvalue points lie within the range of the control eigenvalue points. Overall, 39 macroinvertebrate species were found. Greater species richness was found in the enclosure area: 29 species versus the 26 species found in the control area. The enclosures had a non-significantly high Shannon diversity value (1.941 ± .446) than the controls (1.525 ± 0.477) ($t = 1.682$; $p=0.118$; $df=12$). The results indicate enclosure species richness is within normal variance of the control.

Again, the flora eigenvalue results in Figure 2 show more similarity within the enclosure sites than the control sites. Enclosure Dimension 1 eigenvalues have a 1.5 value range and Dimension 2 values have a 1.0 value range. Control Dimension 1 eigenvalues have a 2.6 value range and Dimension 2 values have a 2.2 value range. Flora enclosure eigenvalue points, for the most part, lie outside the range of the control eigenvalue points. Enclosure and control areas each contained 22 different flora species out of the 31 total species found. Variance did not need to be assessed. The presence of *Liatris* (Blazingstar) was most notable in that it was located in four out of the seven enclosure sites but was not found in any control sites.

Discussion

Theoretical top-down effects are supported by the two-dimensional eigenvalue plots showing greater similarity in data from the enclosed sites than the control sites. A definitive cause-and-effect relationship was not explored, however. It is unclear why the enclosed site flora eigenvalue points fall outside the range of the control flora eigenvalue points. Evidence of initial overlap among control and enclosure points followed by a gradual shift in the set of enclosure points over time could lead to a stronger top-down control conclusion. Direct correlation with the exclusion of small mammals could be confirmed by reintroduction of small mammals through removal of the enclosures. Periodic inventory of the same control and previously enclosed sites would enable verification of any future eigenvalue data shifts back to the control data ranges in support of top-down effects.

The current flora eigenvalue point segregation of enclosure and control site data leaves room for other interpretations than strictly top-down control. One possible explanation is that it simply reflects the normal sampling variation in the prairie environment. Bottom-up symbiont effects or specific plant toxicities could explain the enclosure macroinvertebrate eigenvalue point constraints (Harper, 1977; Janzen, 1969). As a test, additional control sites could be chosen around the pond including plant species not present in existing control sites. If the new control site eigenvalues for both flora and macroinvertebrates overlap with the enclosure results, then normal prairie sampling variance is the more likely explanation and bottom-up effects can explain the present data.

Denno et al. (2003) state complex communities include both top-down and bottom-up forces; plants play a role in determining their relative strength. This underlying structure creates the environment to which herbivorous macroinvertebrates respond. Findings in this current study do not confirm nor refute Denno et al. (2002). Data under conditions of changing productivity were not collected so the relative importance of higher trophic level predation versus primary productivity cannot be determined. Site inventory during reduced productivity intervals occurring at different times of year in the tallgrass prairie or following environmental disturbance (i.e. a managed burn) could help to determine the relative influence.

Ongoing research into the complex population dynamics of the prairie community will improve our ability to manage restored and re-created tallgrass prairies for maximum resilience. Expanded data gathering and trend analysis will enable more thorough scrutiny of the factors that determine the tallgrass prairie ecosystem.

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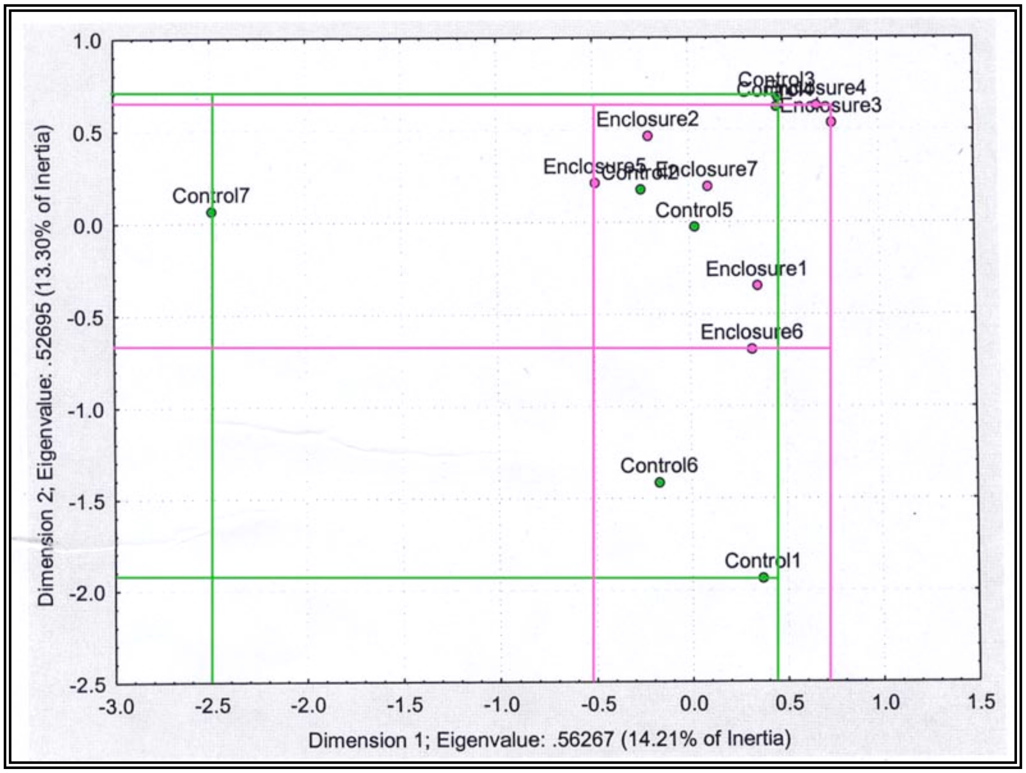

Figure 1. Enclosure and control site macroinvertebrate eigenvalues.

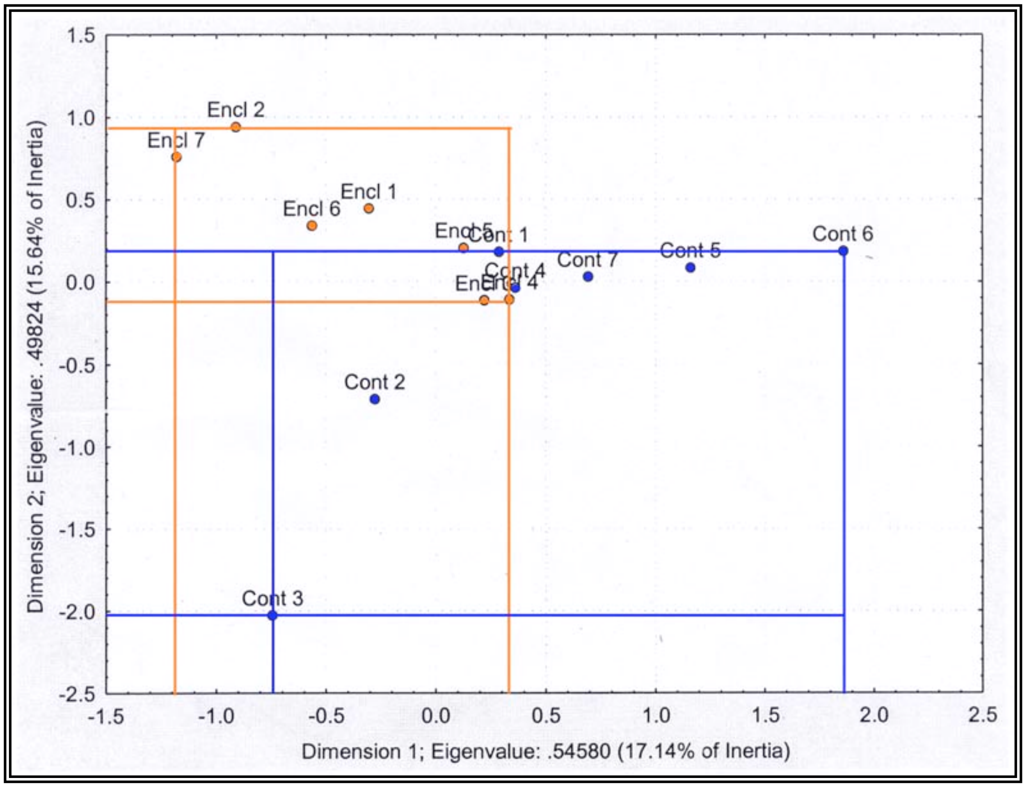

Figure 2. Enclosure and control site flora eigenvalues.

Table 1. First two dimensional coordinates from correspondence analysis (CA) of the macroinvertebrate communities and floral communities, soil temperature at 10 cm depth, and soil moisture at 10 cm depth according to sample site. Symbols: Ei = enclosure site i and Ci = control site i.

Site	Macroinvertebrate community coordinates of CA		Soil temperature (C^o)	Soil moisture (%)	Floral community coordinates of CA	
	Dim 1	Dim 2			Dim 1	Dim 2
E1	0.35	-0.35	25.8	37	-0.30	-0.45
E2	-0.21	0.47	26.1	40	-0.91	0.94
E3	0.75	0.53	26.7	54	0.22	-0.11
E4	0.67	0.63	27.2	52	0.33	-0.11
E5	-0.49	0.22	26.7	61	0.13	0.21
E6	0.32	-0.69	27.2	58	-0.56	0.34
E7	0.10	0.20	26.7	47	-1.18	0.76
C1	0.37	-1.93	20.8	26	0.29	0.81
C2	-0.25	0.18	20.8	51	-0.28	-0.71
C3	0.47	0.68	26.7	59	-0.74	-2.03
C4	0.46	0.62	26.7	63	0.36	-0.04
C5	0.03	-0.03	25.8	52	1.16	0.08
C6	-0.17	-1.41	26.7	48	1.86	0.18
C7	-2.49	0.07	27.8	52	0.69	0.03