Variation in macro-invertebrate distribution in the Rio Tempisque marshland of Palo Verde National Park

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Abstract: Manipulating an ecosystem to improve habitat for one group of organisms often has secondary effects on other organisms. A proposed clearing of cattail vegetation to improve waterfowl habitat in the wetlands of Palo Verde National Park may affect the distribution and abundance of aquatic macro-invertebrates. We studied the macro-invertebrates in different wetland types before the restoration project to provide information on how the project could affect their distribution and abundance in the future. We hypothesized that macro-invertebrate abundance would vary among the sedge, grass and cattail dominated habitats of the wetlands. We found that total abundance of macro-invertebrates was greater in sedge and grass habitats than in cattail habitat. Three orders of invertebrates were most abundant in grass, one in sedge and none in cattails. Such differences in macro-invertebrate abundance between wetland habitats may be explained by relative predation risk and habitat structure. For instance, the inability of macro-invertebrates to forage efficiently in dense cattails may explain why they were less abundant there. Another explanation for low species composition and abundance in cattails is that food resources for some invertebrates may be poor in the cattail habitat. Continued study after the proposed disturbance would help to clarify the relationship between macro-invertebrates and habitat type in this tropical wetland.

Key Words: aquatic invertebrates, disturbance, tropical wetlands, wetland diversity

Introduction

Anthropogenic manipulation of wetland areas may have implications that extend beyond the intended effect. The Costa Rican government has proposed to manipulate and manage the vegetation in the marsh near the OTS Biological Station in Palo Verde National Park. An increase in aquatic vegetation cover, particularly cattails (*Typha dominguensis*), over the last two decades has brought about the displacement of large numbers of waterfowl and other aquatic birds to farms adjacent to the park (E. Gonzalez, pers. comm.). The proposed clearing of aquatic vegetation is intended to increase open water habitat, draw waterfowl back to the park, and protect these waterfowl from farmers concerned about their crops. Besides the project's potential direct impact on waterfowl, there may be other indirect effects on waterfowl prey, like many of the macro-invertebrates. The goals of our project were to examine how macro-invertebrate distributions vary among habitats within the marsh, particularly in the area that will be manipulated soon. This information will be useful in evaluating the proposed manipulation of these wetlands.

Carson et al. (1995) found that zooplankton abundance differed significantly between the littoral and open-water zones in the Palo Verde marsh. They suggested that zooplankton distribution reflects a balance between foraging efficiency and predation risks for the constituent taxa. Assuming that macro-invertebrates must also balance foraging return and predation risk, we hypothesized that the abundance and distribution of aquatic invertebrates would vary with habitat type. Cattail habitat consisted of denser vegetation than the other habitat types in the marsh; therefore, we predicted a lower abundance of macro-invertebrates in cattails than in other habitats.

Methods

On 12 and 13 January 2002, we sampled aquatic invertebrates in sedge, grass and cattail dominated regions of the marsh at Palo Verde. Both sedge and grass habitat contained mixtures of mimosa (*Neptunia plena*), water lily (*Nymphaea ampla*), water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiules*). However, sedge habitat was dominated by sedge (largely *Cyperus tennerimus*), and contained more patches of open water than grass habitat. The surface vegetation mat in the grass habitat was thicker than the floating mat in the sedge habitat and could support a researcher's weight without breaking through. Cattail habitat contained no open water and consisted almost exclusively of dense stands of cattails.

A satellite image of the marsh in ArcView was used to locate the corners of the proposed 60 ha rectangle to be restored, which contained mostly grass and cattail habitat at the time of our study. In the field we used GPS to determine the bounds of the proposed restoration area and to record the location of sampling points (see Appendix).

We randomly sampled 15 points, 5 in each of the three habitats. Ten points were located within the proposed restoration area, 5 in grass and 5 in cattail habitats. The other 5 points in sedge were outside the restoration area adjacent to the southern border. Randomly located points were separated by 8 - 40 m from the nearest other sampling point. Each point was sampled by sweeping through the aquatic vegetation for 4.5 min with an aquatic sweep net. All sweeps were within ~1 m radius of the point. Samples were taken from throughout the water column, in areas where water depth ranged from 60 - 90 cm. All invertebrates > 5 mm in length were counted and identified to order.

We calculated the total abundance of macro-invertebrates in each habitat type and analyzed distributions across each habitat type with an ANOVA. We then used a Tukey-Kramer test to determine which habitat contained the greatest abundance of macro-invertebrates. We also analyzed total abundance of selected orders in the different habitats using Kruskal-Wallis, ANOVA and Tukey-Kramer tests.

Results

We found 6 orders of adult and larval macro-invertebrates in our surveys. Annelida, Coleoptera, Gastropoda, Hemiptera and Odonata were found in all three habitat types, while Arachnida were found in grass and sedge habitats but not in cattail habitat. Some invertebrates, mainly insect larvae, could not be identified and were scored as "unidentified larvae".

Total abundance of macro-invertebrates differed between habitat types ($F_{2,12}$ = 8.16, P = 0.01; Fig. 1). More macro-invertebrates were found in the grass and sedge habitats than in the cattails, but abundances in grass and sedge did not differ. Coleoptera, Odonata and Hemiptera were most abundant in grass (Fig. 2). Coleoptera adult and larval abundance was greater in grass and sedge than in cattails, and tended to be greater in grass than in sedge (Kruskal-Wallis χ^2 = 8.58, df = 2, P = 0.04). Odonata larval abundance differed by habitat type ($F_{2,12}$ = 3.69, P = 0.06), and were more abundant in the grass than in sedge or cattail habitats. Hemiptera tended to have greater abundance in grass than in sedge or cattail habitats, but the differences

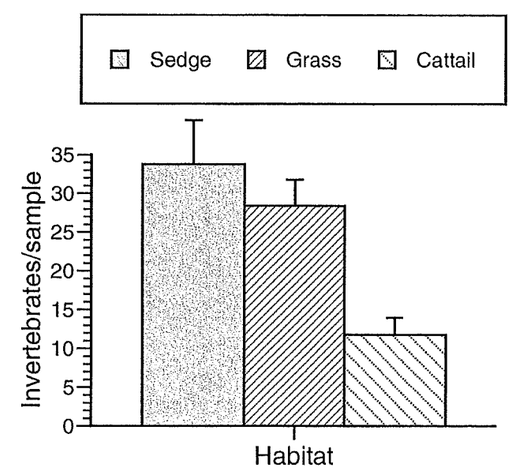

FIG. 1. Mean macro-invertebrate abundance in three habitat types in the Palo Verde marsh in January 2002 (n = 5 plots/ habitat).

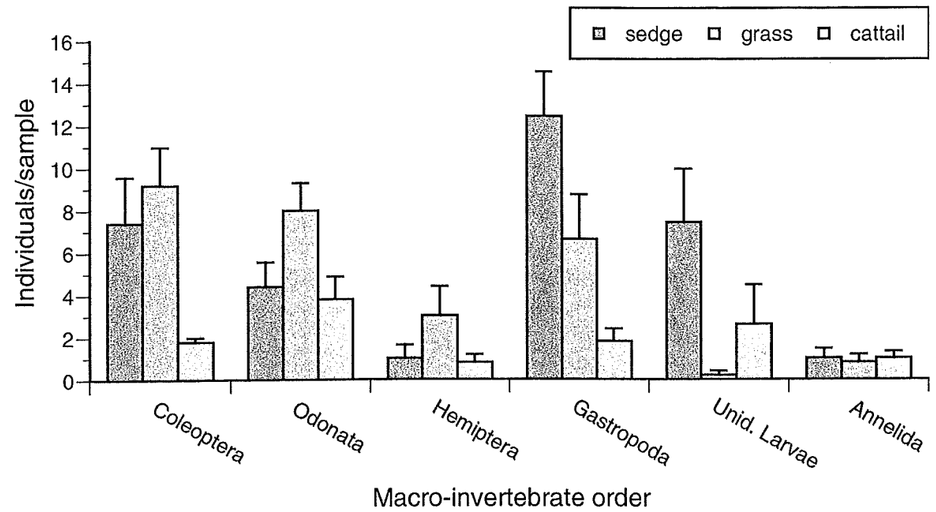

FIG. 2. Mean (±SE) abundance of macro-invertebrate taxa collected in three vegetation types in the Palo Verde marsh (n = 5 plots for each cover type).

were not significant (Kruskal-Wallis $\chi^2 = 2.74$, df = 2, P = 0.25).

Other orders of macro-invertebrates were most abundant in sedge (Fig. 2). Gastropod abundance was greater in sedge than in grass and cattail habitats (Kruskal-Wallis $\chi^2 = 9.18$, df = 2, P = 0.01). Unidentified larvae were more abundant in sedge than in grass and cattail habitats (Kruskal-Wallis $\chi^2 = 8.22$, df = 2, P = 0.02).

Annelid abundance did not differ across vegetation type ($F_{2,12} = 0.09$, P = 0.91; Fig. 2). Only two Arachnid specimens were found, one each in grass and sedge habitats.

Discussion

We expected to find the lowest abundance of macro-invertebrates in the cattail habitat and more in the grass and sedge habitats. Our data supported this prediction; invertebrates in 5 of 6 orders were more abundant in grass or sedge than in cattail habitat and no order was most abundant in the cattail zone. Food resources in the cattails may be limited by the homogeneity of the structural vegetation. Further, the high density of stems in cattail habitat might compromise the foraging efficiency of macro-invertebrate predators. Alternatively, the low abundance in cattails may be explained by the difficulty of sampling in this habitat with sweep nets. This may have produced a systematic bias in our results but we doubt that such a bias would erase the observed pattern. Future studies should consider modified sampling methods to minimize this bias.

Coleoptera, Odonata and Hemiptera tended to be more abundant in grass than in sedge (Fig. 2). Sedge habitats had more gaps in the surface vegetation than grass habitats, allowing more light to penetrate to the water. Increased light availability exposes macro-invertebrates to visual predators, such as fish, birds or other predatory macro-invertebrates, but also allows them more flexibility in movement to find food.

Gastropods and unidentified larvae were more abundant in sedge than grass. Gastropods may be less vulnerable to fish predation than other orders of macro-invertebrates because they have protective shells. However, the high Gastropod abundance is surprising since shells do not protect them

from avian predators like snail kites (*Rostrhamus sociabilis*) and limpkins (*Aramus guarauna*), which are often seen hunting for snails in the grass and sedge habitat (R. T. Holmes, pers. comm.). In the sedge, greater predation risk for Gastropods may be outweighed by improved foraging efficiency.

Unidentified larvae were the only group that was least abundant in grass. Sedge habitat may provide these small larvae protection from predatory macro-invertebrates in the grass. Additionally, large predators in the sedge may not detect the larvae as well as they detect larger invertebrates.

If the cattail habitat is cleared and replaced by sedge or grass mat, we expect that macro-invertebrate abundance will increase. This increase might have cascading effects such as increases in predatory bird and fish populations. The restoration project provides a unique opportunity to study changes in macro-invertebrate abundance and diversity after habitat alteration.

Literature Cited

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APPENDIX. GPS location of the sample points in the grass, cattail and sedge wetland types in the marsh in Palo Verde National Park.

Habitat	Location	UTM Projection	
Grass	1	681355	1143908
	2	681341	1143901
	3	681353	1143881
	4	681366	1143889
	5	681374	1143920
Cattail	6	681309	1143909
	7	681298	1143909
	8	681368	1143924
	9	681307	1143899
	10	681311	1143900
Sedge	11	681767	1143902
	12	681753	1143894
	13	681746	1143896
	14	681752	1143890
	15	681712	1143873