The effect of cover on *Heliconia wagneriana* bract occupation by copepods and mosquito larvae

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Abstract. Different rates of dispersal may influence the spatial distribution of copepods and mosquito larvae living in *Heliconia wagneriana* bracts. I predicted mosquitoes which have a free-flying stage would be more evenly distributed between *H. wagneriana* patches than copepods which are dispersed by wind. I also predicted vegetative cover above a bract would increase the probability that organisms will be present in the bract because of decreased washout by rain. I sampled 48 bracts in five patches of *H. wagneriana* around La Selva Biological Station, C.R. Mosquitoes and copepods did not differ in the evenness of their distribution between patches. As expected, the probability that mosquitoes or copepods would be present in a bract increased as cover above the bract increased. The mechanisms by which increased vegetative cover changes the community composition in *H. wagneriana* bracts could be further studied.

Key Words: aquatic invertebrates, colonization, diapause, harpacticoid, metapopulation, phytotelmata

Introduction

Dispersal patterns influence the spatial distribution of organisms. Slow dispersers may be more aggregated than those that can quickly disperse over long distances. *Heliconia wagneriana* flowers for 11-13 weeks during the dry season (Seifert 1976) and occurs in aggregated patches. The distribution of bracts within *H. wagneriana* patches provide a model system for correlating an organism's distribution pattern with its dispersal ability. The fluid-filled bracts of *H. wagneriana* inflorescences contain aquatic invertebrates with different dispersal abilities. Harpacticoid copepods are entirely aquatic and can be found in *H. wagneriana* bracts but are dessication-resistant as diapausal eggs. Dispersal mechanisms for zooplankton resting eggs are little known, but it is thought that eggs are wind-blown and disperse in the same passive diffusion pattern as many plant seeds which decline in density with distance from a source (Begon et al. 1990) and presumably colonize nearby clumps sooner than distant clumps. Mosquito larvae and pupae also occupy *H. wagneriana* bracts but have an active dispersal strategy. As adults they can fly among *H. wagneriana* bracts to lay eggs and thus possibly colonize distant patches faster than copepods. The structure of the surrounding environment may also influence the likelihood of colonization and survival in each bract.

In this study, I hypothesized that there would be a difference in the distribution of copepods and mosquitoes among *Heliconia* bracts as a result of their different dispersal strategies and that the colonization of both organisms would be affected by the extent of cover over a bract. I predicted that the distribution of mosquitoes among patches would be more even than that of copepods, as a result of the mosquitoes' ability to colonize distant patches more quickly. Bracts unprotected by vegetative cover may be washed out by rain, so I predicted that both mosquitoes and copepods would be absent more often from unprotected bracts than bracts protected from rain.

Methods

I sampled the second to last bract on every inflorescence occurring in five patches of *H. wagneriana* in a 200 m area near the entrance of La Selva Biological Station, Costa Rica. I noted whether inflorescences occurred in a relatively clumped distribution within a patch or were more evenly distributed

throughout the patch. For patches in which there was a clumped distribution I also noted to which clump each inflorescence belonged. I also noted the number of open bracts on each inflorescence and categorized the tree and leaf cover above the inflorescence as covering none (0), some (1), or most (2). Bracts which seemed totally unprotected from rain without *H. wagneriana* leaves or a tree's canopy or both above them were categorized as (0), bracts with any protection above them as (1), and bracts which seemed almost totally protected from rain as (2).

I extracted the fluid from each bract with a pipet and condensed most of the samples using a filter before adding alcohol. I examined the 48 samples under a dissecting microscope, and noted the presence(1) or absence(0) of adult harpacticoid copepods and those mosquito larvae and pupae which were > 1 cm in length.

I tested the effect of cover on the presence of the studied species using a Chi-Square test. To compare mosquito and copepod distributions, I calculated the variance of their presence within each patch, and compared the log of the variances between the two organisms using a t-test.

Results

Mosquitoes were present in some inflorescences in all multi-inflorescence patches, while copepods were more variable in their distribution, ranging from absent from all, present in all, or present in only some of the inflorescences in multi-inflorescence patches (Table 1). However, the variance of copepod presence between patches was not significantly different from that of mosquito presence (ANOVA, $F = 1.03$, $df = 4$, $P = 0.37$). Of the bracts sampled, nine had no cover, 25 had some covered inflorescences, and 14 were mostly covered (Table 1). Cover above *H. wagneriana* increases the likelihood of copepod and mosquito presence in the second to last bract ($\chi^2 = 5.97$, $df = 2$, $P = 0.05$; Fig. 1).

Discussion

There are several possible explanations for why the different dispersal strategies of mosquitoes and copepods did not affect their distribution between patches: 1) the difference between distribution may be too small to record without a larger sample size; 2) the strategy of wind dispersal may be as effective a colonization method as flying; 3) a sufficient amount of time has passed since the opening of the bracts for both copepods and mosquitoes to colonize most *H. wagneriana* patches at their respective rates. A study which samples either more patches or a few patches over time at the beginning of a flowering season may find a different pattern of bract colonization between the two organisms.

Table 1. Measure of cover above and arthropod occupancy of the second to last bract of *H. wagneriana* inflorescences by harpacticoid copepods and mosquito larvae or pupae.

Patch	Clump	Overhead cover	# Inflorescences in clump	# bracts occupied by copepods	# bracts occupied by mosquitoes
1	1	some	1	0	0
2	2	none	8	0	2
3	3	some	9	9	7
3	4	none	4	2	2
3	5	some	3	1	2
3	6	some	1	0	0
3	7	most	2	2	1
3	8	most	11	9	7
4	9	most	8	6	6
5	10	most	1	1	0

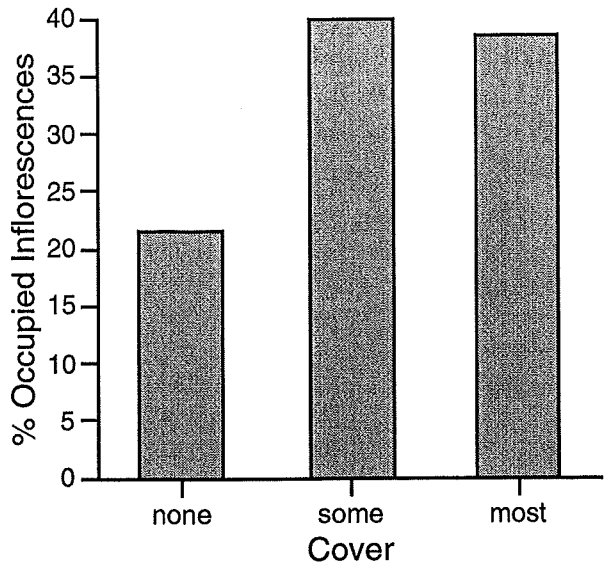

Fig. 1. Percent of inflourescences with copepods or mosquitos present. See methods for definitions of cover categories and results for sample sizes.

Copepods and mosquitos were absent more often from uncovered bracts than from covered bracts, indicating that vegetative cover is influencing aquatic invertebrate colonization or survival in each bract. Rainfall wash-out could be reducing copepod and mosquito occupancy in the bottom bracts of *H. wagneriana* inflorescences and may be even more of a negative factor for aquatic communities in the younger, higher, less protected bracts. Cover could increase colonization and survival probability in a bract by several other mechanisms as well. For example, vegetative cover may obstruct wind and filter out the wind dispersed eggs of copepods, increasing their colonization probability. Similarly, adult mosquitoes may preferentially lay their eggs into uncovered bracts. On the other hand, the abiotic factors of increased sunlight, increased temperature fluctuation (Laessle 1961) or decreased pH of bract fluid from rain (Bronstein 1986) may create less favorable conditions and a lower survival probability for copepods and mosquitoes in less covered bracts. Further study of variation between conditions in covered and uncovered bracts as well as in initial colonization and survival of copepods and mosquitoes could elucidate the mechanisms by which cover increases bract occupancy.

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