Journal of Plant Interactions
Vol. 6, Nos. 2–3, June–September 2011, 175–176

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SHORT COMMUNICATION

A native predator affects the indirect interaction between exotic herbivorous insects on an invaded plant

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(Received 28 November 2010; final version received 29 November 2010)

Research on invasive insects has long focused on the direct interactions such as predation or parasitism. This is partly because many weed control projects showed the unsuccessful establishment in herbivorous insects specializing invasive plants through native natural enemies. However, there is increasing appreciation of the importance of plant-mediated indirect effects in determining abundance of insect herbivores.

We examined (1) how the lacebug, *Corythucha marmorata*, indirectly affects leaf consumption by the leaf beetle, *Ophraella communa*, on the ragweed, *Ambrosia artemisiifolia*, and (2) how the predacious lady beetle, *Harmonia axyridis*, influences the indirect interaction between both insect herbivores.

Keywords: ragweed; leaf beetle; lace bug; lady beetle; weed control; Japan

Introduction

Research on invasive insects has long focused on the direct interactions such as predation or parasitism (Hunt-Joshi et al. 2005). This is partly because many weed control projects showed the unsuccessful establishment in herbivorous insects specializing invasive plants through native natural enemies (Goeden and Louda 1976). However, there is increasing appreciation of the importance of plant-mediated indirect effects in determining abundance of insect herbivores (Ohgushi 2005; Ohgushi et al. 2007).

We examined (1) how the lacebug, *Corythucha marmorata*, indirectly affects leaf consumption by the leaf beetle, *Ophraella communa*, on the ragweed, *Ambrosia artemisiifolia*, and (2) how the predacious lady beetle, *Harmonia axyridis*, influences the indirect interaction between both insect herbivores. The ragweed came from North America approximately 100 years ago in Japan. Both insect herbivores also invaded to Japan in late 1990s from North America. The seasonal occurrence of the lacebug is earlier than that of the leaf beetle in Japan.

Materials and methods

We measured leaf consumption by the leaf beetle in the field. From 24 June to 10 July, we planted 25 ragweed seedlings individually in pots. Then, these potted plants were placed in a common garden and were covered with 1 mm mesh net to protect from natural herbivory. We introduced 10 adult lacebugs each of 10 pots for feeding in mid-August. Other 15 plants remained intact without lacebug herbivory. From 2 to 5 October, six adult leaf beetles were introduced to each of all pots, and four adult lady beetles were introduced to each of five pots with lacebugs and eight pots without lacebugs. Thus, we assigned 25 potted ragweeds to four treatments (five pots with lacebugs, eight pots with lady beetles, five pots with lacebugs and lady beetles, and seven pots without both insects). Approximately 10 days later, we collected 1–6 damaged leaves from each plant, and estimated leaf area consumed by the leaf beetle using Win Folia 2007 in a laboratory. Leaf damage by the leaf beetle is easily discriminated from that by the lacebug. In addition, we conducted a food choice test using the lady beetle in a laboratory condition. We set each of seven adults and nymphs of the lacebug, seven leaf beetle adults, and one adult lady beetle in a Petri dish. We counted their numbers one day later.

Results and discussion

Although there were no significant direct effects of the lacebug and the lady beetle on the leaf beetle herbivory, we found a marginal significant interaction effect of the lacebug and lady beetle (Figure 1). Food choice test showed that lady beetle strongly preferred the lacebug nymphs over the lacebug adults and the leaf beetle (mean number consumed $\pm$SEM; leaf beetle, 0.11 ± 0.11; adult lacebug, 0.11 ± 0.11; nymph lacebug, 4.56 ± 0.80; Friedman's method, $k = 3$, $m = 9$, $S = 339$, $p < 0.001$).

Because the lady beetle rarely consumed the leaf beetle, the predation did not explain the difference in the leaf consumption among four treatments. Rather, the lady beetle predation on lacebug nymphs could indirectly generate the difference in the leaf beetle

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ISSN 1742-9145 print/ISSN 1742-9153 online

DOI: 10.1080/17429145.2010.544411
http://www.informaworld.com

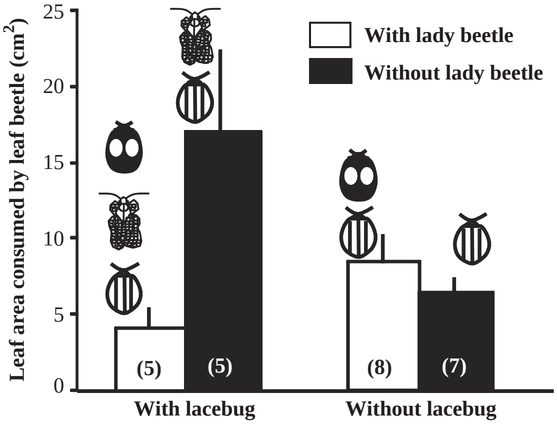

Figure 1. Leaf area consumption by the leaf beetle (ANOVA; lacebug $F_{1,21} = 0.12$, $p = 0.74$, lady beetle $F_{1,21} = 2.36$, $p = 0.14$, lacebug × lady beetle $F_{1,21} = 4.05$, $p = 0.057$). Data were Box-Cox transformed prior to the analysis. Number in parenthesis shows sample size. Values represent mean + SEM.

herbivory among treatments. Future studies need to pay more attention to the effect of predators on indirect interactions between herbivorous insects sharing a host plant.

Acknowledgements

This study was supported by the Ministry of Education, Culture, Sports, Science, and Technology Grant-in-Aid for Scientific Research (B-20370010) to T. Ohgushi and the Global COE program (A06) at Kyoto University.

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