Is dump material an effective small-scale deterrent to herbivory by leaf-cutting ants?1

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Abstract: It has been suggested that refuse dumps from leaf-cutting ant nests work as a herbivory deterrent for leaf-cutting ants because dumps harbour micro-organisms that are dangerous to ants and their symbiotic fungus. However, this deterrent effect was tested for the narrowly distributed Atta colombica only during a five-day period. We experimentally tested the refuse-deterrent effect for a longer period using the broadly distributed Acromyrmex lobicornis. Although refuse mounds around plants significantly delayed the initiation of attack by A. lobicornis, almost all plants (~90%) surrounded or not by refuse, were killed by leaf cutters in a few weeks. Therefore, the refuse-deterrent technique may not be useful as a widespread method of biological control for leaf-cutting ants. The refuse showed an improved deterrent effect when both refuse material and the leaf-cutting ant came from the same colony, suggesting that the pathogens for both ant and fungus found in refuse dumps might be host-specific.

Keywords: Acromyrmex lobicornis, biological control, dump material, herbivory, leaf-cutting ants, Patagonia.

Résumé : Les amas de déchets des nids de fourmis coupeuses de feuilles exerçaient un effet dissuasif contre les autres fourmis coupeuses de feuilles en raison de la présence dans ces amas de micro-organismes dangereux pour les fourmis l’attaque de A. colombica. Nous avons vérifié pendant une plus longue période l’effet dissuasif de ces amas de déchets chez une fourmi très familiée Acromyrmex lobicornis. Bien que des monticules de déchets placés autour de plantes aient retardé le défoliation, les attaques effectuées par A. lobicornis, presque toutes les plantes (~90%) ont été mises par les fourmis en quelques semaines, qu’elles aient été entourées ou non de déchets. Par conséquent, les amas de déchets ne seraient pas très utiles comme méthode de contrôle biologique des fourmis coupeuses de feuilles. Les détritus ont montré un meilleur effet dissuasif lorsque l’amas de déchets et les fourmis provenaient de la même colonie, ce qui suggère que les pathogenes sont spécifiques au nid à la fois pour les fourmis et les champignons.

Mots-clés : Acromyrmex lobicornis, contrôle biologique, déchets, herbivore, fourmis coupeuses de feuilles, Patagonie.


Introduction

Several forest insects considered pests are important limiting factors in forestry production and in native forest management and conservation (Carroll et al., 1990). Leaf-cutting ants (Atta and Acromyrmex) are one of the most serious insect pests of many crops and plantations in South and Central America (Blanton & Ewel, 1985; Cherrett, 1986a,b; Fowler et al., 1986). Fungi cultivated by leaf cutters can grow on a wide range of plant substrates; therefore, these ants are highly polyphagous and cause extensive damage to native forests as well as agricultural crops (Vilela, 1986; Vasconcelos & Cherrett, 1997). For example, a single colony of leaf-cutting ants caused 48% conifer seedling mortality and reduced growth of 40% of the surviving fraction in a 2-ha area in Venezuela (Jaffe, 1986). Similar reports are common in several American countries (Blanton & Ewel, 1985; Vilela, 1986) where forestry establishment depends on a reasonable degree of ant control (Cherrett, 1986a).

A wide range of control methods for leaf-cutting ants, including poison baits, thermal fogging, and the use of parasites and pathogens, have been used for the last 50 years (Cherrett, 1986b; Kermarrec et al., 1986). However, these techniques do not generally keep leaf-cutting ant populations below economic thresholds, and they have adverse effects on the environment and human health (Cherrett, 1986b; Vilela, 1986).

In a recent study, Zeh et al. (1999) reported a new approach to protecting plants from leaf-cutting ants that eliminates the risks associated with poison techniques and the introduction of exotic species. This method involves the use of refuse dumps from leaf-cutting ant nests. Plant parts harvested by leaf-cutting ants are transported to underground fungus gardens. Organic materials from the fungus culture and associated debris are known to harbour microorganisms harmful to both the ants and their symbiotic fungus (Bot et al., 2001; Hart et al., 2001). These materials are removed from the fungus gardens to subterranean chambers or external disposal areas known as refuse dumps (Farji-Brener & Medina, 2000). Zeh et al. (1999) suggested that external refuse dumps from Atta colombica colonies can be used as an effective control method to protect plants from leaf-cutting ant defoliation because ants avoided contact with the refuse. While leaf cutters remained and leaves were left in control plants, plants surrounded with a mound of ant refuse showed no damage during five days.

1Rec. 2002-08-05; ace. 2002-11-26.
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However, the following facts suggest that the available evidence in that study is not conclusive. As the leaf-cutting ant species used (Atta colombica) has a narrow geographic distribution (Holldobler & Wilson, 1990), the useful range of the refuse technique is restricted. In addition, ant nests were not used as replicates in the experimental design, and thus there was no information about variation of the refuse-deterrent effect between ant nests. Finally, and possibly the most important fact, there was no report about what happened after five days. It is clear that any biological control method to protect plants from defoliation by leaf-cutting ants requires a longer sampling period to prove whether it is effective or not. Therefore, we believe that the usefulness of refuse dumps as a widespread method for leaf-cutter control needs to be reassessed.

We used the broadly distributed Acromyrmex lobicornis ant species to examine whether refuse material can be used as an effective natural deterrent to protect plants from leaf-cutting ant attack. We also checked the refuse-deterrent effect using ant nests as replicates and extended our study period for more than five days. Finally, we investigated the possibility that the refuse-deterrent method varied if dump material was from the same nest or from another conspecific nest (nest-dependent effect). In addition to its biological relevance, this point is important if we want to test the practicality of the refuse-deterrent method.

Methods

Leaf-Cutting Ant Species and Study Site

Acromyrmex lobicornis is one of the leaf-cutting ant species with the widest latitudinal range, reaching from subtropical areas in southern Brazil and Bolivia (23° s) to Patagonia (44° s) (Farji-Brener & Ruggiero, 1994). Acromyrmex lobicornis occurs in a broad range of plant communities and is a major pest of agricultural and forestry areas (Bonetto, 1959; Coll, 1997; Pillati et al., 1997). Acromyrmex lobicornis waste, such as organic material from the fungus culture, dead ants and debris are transferred to the soil surface, forming conspicuous external refuse dumps (Farji-Brener, 2000).

The study was carried out during November and December 2001 (summer season) along the eastern border of the Nahuel Huapi National Park, Argentina (41° s, 71° w). The mean annual temperature is 8°C, and the mean annual precipitation is about 600 mm. The experiment was conducted in an area covered by herbaceous/shrub steppe vegetation, where the density of A. lobicornis is very high (Farji-Brener, 2000).

Methodology

We employed seedlings (15 cm height) of Goedetia spp. (F1 hybrid), a common ornamental plant highly palatable for leaf-cutting ants. Seedlings rather than adult plants were used because they are preferred by leaf cutters (Vasconcelos & Cherrrett, 1997) and they facilitate a randomized, replicated experimental design.

We selected 10 A. lobicornis adult nests (mounds 1 m in diameter) separated by approximately 20 m. Around each nest (1-2 m away from the mound) and near active foraging trails (15 cm), we planted 4 randomly selected seedlings. One of the following four treatments was randomly assigned to each seedling: (1) seedling surrounded by a refuse mound from the sampled nest (own refuse), (2) seedling surrounded by a refuse mound from another randomly selected nest (foreign refuse), (3) seedling surrounded by a mound of soil to control for mound effects (mound control), and (4) seedling with no mound around it (control). Following Zeh et al. (1999), mounds in treatments 1-3 were ca 7 cm high and had a diameter of 20 cm. We counted the leaves on each seedling before planting. Each replication in this experiment consisted of an adult nest of A. lobicornis (n=10) with four treatment conditions. The mean number of leaves (± SE) at the beginning of the experiment (51 ± 2) did not differ significantly among the four treatment conditions (F16=0.84, P=0.48). We watered the seedlings daily for the first 15 days and then every other day until the 28th day (end of the experiment). At the same time, we checked each seedling for the presence of A. lobicornis damage and counted the number of leaves.

Variation in defoliation levels was examined using analysis of variance. Prior to analysis we tested dependent variables for normality, and when necessary we used arcsine transformations. We examined differences in defoliation level and timing using a one-way, repeated measures randomized block design (Zar, 1999). Each ant nest was considered as a block because the foraging activity of each colony may influence defoliation levels. By the fourth day, leaf cutters had harvested all the leaves of treatments 3 and 4, so we employed the above-described analysis twice: first, to detect differences in defoliation levels between all the treatments on day four; and second, to detect differences in defoliation levels between the remaining treatments (1 and 2) until the end of the study period.

Results and discussion

Considering the first four days of sampling, there was a highly significant effect on the seedlings' defoliation level due to time (F1.32=9.7) and treatment (F1.32=34.5; both P<0.001). The percentage of leaves remaining decreased during the sampling period, and seedlings surrounded by refuse suffered much less leaf-cutter attack than control and mound control seedlings (Figure 1). This effect was marginally influenced by ant nests (F1.32=2.0, P=0.07). On the fourth day of sampling, all leaves from seedlings without refuse were gone; seedlings with own and foreign refuse had 68 ± 3.5% and 46 ± 4.3% of their leaves intact, respectively, mean ± SE (Figure 1).

Between days 5 and 28 there was a marginally significant difference between own and foreign refuse defoliation level (F1.9=3.2, P=0.10) and a significant difference between nests (F3.9=3.6, P=0.03). At the end of the experiment (day 28), the percentage of leaves that were intact on own refuse seedlings was slightly higher than that on foreign refuse seedlings (30 ± 5% versus 10 ± 2% respectively, mean ± SE, Figure 1, paired t-test, t=1.75, P=0.057).

Our experiment demonstrates that mounds of refuse material cannot be considered as a highly effective biological control method to protect plants from defoliation by A. lobicornis. Although refuse mounds significantly
On the other hand, the results of our experiment show the possibility of studying a novel aspect of the refuse-dump biology of leaf-cutting ants. Surprisingly, the refuse had an enhanced deterrent effect when both the dump material and the attacking ant came from the same colony (Figure 1). This suggests that many of the pathogens and competitors for both ant and fungus found in refuse dumps may be nest specific.

Acknowledgements

Thanks to M. L. Tadeo, C. Pedrozoa, K. Poveda, W. Eberhard, B. Wcislo, and two anonymous reviewers for comments on early versions of this manuscript.

Literature cited


