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Seed cleaning of *Cupania vernalis* (Sapindaceae) by ants: edge effect in a highland forest in south-east Brazil

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The integrity of ecological interactions, such as pollination and seed dispersal, has been recognized as important for long-term conservation of biodiversity (Asquith *et al.* 1999, Buchmann & Nabhan 1997, Howe 1984, Pizo 1997). This is illustrated by the fact that the loss of large-bodied animals like birds and mammals after habitat fragmentation can result in population changes or even extinction of many plant species (Silva & Tabarelli 2000). In the absence of primary seed dispersers (vertebrates), the importance of invertebrates such as ants, that can carry or clean seeds, probably increases.

The effects of ants on seeds are well known for myrmecochorous plants, which have diaspores bearing a food reward called the elaiosome (Beattie 1985, Wolff & Debussche 1999). However, ants may also alter the seed shadow of non-myrmecochorous species (Kaspari 1993, Pizo & Oliveira 1998). In these cases, ants affect seedling establishment by reducing density-dependent predation (Pizo & Oliveira 1998). In addition, ants reduce fungal attack on seeds on the forest floor and facilitate seed germination by removing the fleshy material from the seed surface (Leal & Oliveira 1998, Oliveira *et al.* 1995).

Forest fragmentation also affects the composition of the ground-foraging ant assemblage (Carvalho & Vasconcelos 1999, Majer *et al.* 1997, Nicholas & Vilela 1995). In turn, this probably affects the interactions between non-myrmecochorous seeds and ants. This may be particularly pronounced at the margin of the fragment, where edge effects change abiotic and biotic factors

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that are likely to influence seed survivorship, such as humidity, light, temperature and seed-predator abundance and composition (Buchmann & Nabhan 1997, Janzen 1983).

This study investigates the interaction between seeds of camboatá, *Cupania vernalis* Camb. (Sapindaceae) and ground-foraging ants in a forest fragment in south-east Brazil. Our main objectives were: (1) to record the ant species that interact with *C. vernalis* seeds in the edge and inside the forest; (2) to understand how seed cleaning of *C. vernalis* by ants might influence survivorship of seeds on the ground; and (3) to see how edge effects influence these interactions.

Cupania vernalis occurs in both primary and secondary highland semi-deciduous forest (Lorenzi 1992). The fruits are dehiscent and contain 2–3 black seeds covered by yellow arils around the funicle region. Birds are the main dispersers of *C. vernalis* (W. Zaca and M. Galetti, pers. comm.). In absence of their arboreal seed dispersers, the arillate seeds of *C. vernalis* fall intact on the ground. In the study site, fruiting of *C. vernalis* occurs between November and December (warm-wet season) (Morellato 1992).

Fieldwork was carried out during early December 1999, in the Serra do Japi, Jundiaí, São Paulo state, south-east Brazil (23°15′S, 47°10′W). This is a highland semi-deciduous forest of more than 35 000 ha (Morellato 1992).

We carried out two simultaneous experiments. In the first, our aim was to elucidate how ants interact with the seeds and how edge effects influence these interactions. We placed ten stations on the forest edge and another ten stations in the interior. Edge stations were placed exactly on the forest edge which is delimited by a side road. The stations were 100 m apart and received ten uncleaned seeds each. We checked all stations 24 h after seed placement and recorded the proportion of cleaned seeds (arils totally removed). We excluded all seeds removed from the data analysis.

In the second experiment we used the same experimental design but with cleaned seeds. Experiment duration was 24 h also. Our aim was to investigate how edge effects influence seed predation of cleaned seeds. We assumed that all cleaned seeds that were removed had been preyed on.

After these experiments, the seeds were replaced and the stations were monitored for another 24 h to identify the ant species that interacted with the seeds. The stations were replaced at 06h30 and checked at 10h30, 14h30, 18h30, 22h30 and 06h00. In each census, we substituted seeds cleaned and removed by intact ones.

We also tested the influence of the aril on seed germination by a laboratory germination test, using arillate and non-arillate seeds (n = 375 seeds in each treatment). Seeds were separated in groups of 25, which were kept in a 11 × 11 × 3-cm plastic box, in ambient temperature and under constant light. Germination (radicle protrusion) was monitored after a month.

After 24 h, the median proportion of seeds that was cleaned per station inside the forest (0.53) was significantly higher than the proportion on the edge (0.06) (Mann–Whitney U-test, $P < 0.05$).

While 12 seeds on the edge (in four different stations) were preyed on, in the forest interior no seed predation occurred (Mann–Whitney U-test, $P < 0.05$).

Only cleaned seeds germinated. The total number of cleaned seeds that germinated was 153 (40.8%). After 4 wk, fungi attacked all arillate seeds and 189 (50.4%) cleaned ones.

Ants visited more arillate seeds (54 observations) than cleaned seeds (5 observations) (χ^2 test; $P < 0.001$). Thirteen ant species visited the stations, of which six were only found on the edge, four species were only found in the forest interior and three were common to both (Table 1). Ant species showed different behaviours for cleaning the seeds: *Pheidole* sp. 1 and *Paratrechina* sp. 2 recruited a large number of workers (from 10 to more than 100) and removed the aril on the spot; *Solenopsis* sp. 1 also recruited a large number of workers, but covered the seeds with sand before removing the arils. *Atta sexdens* recruited 4–10 individuals and either removed the aril or the entire seed. Besides the ant species present in the stations, solitary individuals of *Pachycondyla* sp. were observed in the study site removing large portions of aril from seeds on the ground (both on the edge and in the forest interior).

Large amounts of fruits and arillate seeds fell intact beneath the parent tree in the study site, where no vertebrate dispersers were seen eating them during field work. These seeds were quickly cleaned or removed by many ant species on the forest floor. Ant activity probably increases seed survival under the parent tree, by reducing fungal attack and increasing germination success. In addition, *Solenopsis* ants, by burying the seeds, may create adequate microhabitats for germination. Although these interactions may not be so important for

Table 1. Number of observations of each ant species on the stations in the edge and forest interior sites at the Serra do Japi, south-east Brazil.

Ant species	Edge	Inside
Formicinae		
Paratrechina sp. 1	1	–
Paratrechina sp. 2	1	7
Myrmicinae		
Atta sexdens	2	3
Crematogaster sp.	–	1
Pheidole sp. 1	6	1
Pheidole sp. 2	1	–
Pheidole sp. 3	–	2
Pheidole sp. 4	1	–
Solenopsis sp. 1	3	–
Solenopsis sp. 2	1	–
Solenopsis sp. 3	1	–
Solenopsis sp. 4	–	1
Ponerinae		
Gnamptogenys sp.	–	2

C. vernalis dynamics in regions where vertebrate dispersers are present, in disturbed areas this may be the only recruitment strategy of the camboatá.

The creation of forest edges significantly affected the interactions between ants and seeds. Seed cleaning was reduced on forest edges, while seed predation increased. This is likely to have a detrimental effect on the recruitment of seedlings. As far as we know this is the first study that demonstrates edge effects in an interaction between ants and non-myrmecochorous seeds.

Less than 10% of Atlantic forests still remain, mainly in the form of fragments (Fonseca 1985, Ranta *et al.* 1998, Viana *et al.* 1997). Fragmentation and associated processes (edge effects, hunting, alien species invasion) may have a great impact on ecological interactions (Asquith *et al.* 1999, Calvo-Irabién & Islas-Luna 1999, Galetti 1992, Pizo 1997). Understanding how each of these changes influences animal–plant interactions and, consequently, the plant recruitment dynamics is fundamental to regeneration and to programmes aimed at maintaining biodiversity in reserves.

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LITERATURE CITED

ASQUITH, N. M., TERBORGH, J., ARNOLD, A. E. & RIVEROS, C. M. 1999. The fruits the agouti ate: *Hymenaea courbaril* seed fate when its disperser is absent. *Journal of Tropical Ecology* 15:229–235.

BEATTIE, A. J. 1985. *The evolutionary ecology of ant–plant mutualisms.* Cambridge University Press, Cambridge. 182 pp.

BUCHMANN, S. L. & NABHAN, G. P. 1997. *The forgotten pollinators*. Island Press, Washington, DC. 320 pp.

CALVO-IRABIÉN, L. M. & ISLAS-LUNA, A. 1999. Predispersal predation of an understory rainforest herb *Aphelandra aurantiaca* (Acanthaceae) in gaps and mature forest. *American Journal of Botany* 86:1108–1113.

CARVALHO, K. S. & VASCONCELOS, H. L. 1999. Forest fragmentation and its effects on litter-dwelling ants. *Biological Conservation* 91:151–157.

FONSECA, G. A. B. 1985. The vanishing Brazilian Atlantic forest. *Biological Conservation* 34:17–34.

GALETTI, M. 1992. *Sazonalidade na dieta de vertebrados frugívoros em uma floresta semidecídua do Brasil*. Masters thesis. Universidade Estadual de Campinas.

HOWE, H. F. 1984. Implications of seed dispersal by animals for tropical reserve management. *Biological Conservation* 30:261–281.

JANZEN, D. H. 1983. No park is an island: increase in interference from outside as park size decreases. *Oikos* 41:402–410.

KASPARI, M. 1993. Removal of seeds from neotropical frugivore droppings: ants response to seed number. *Oecologia* 95:81–88.

LEAL, I. R. & OLIVEIRA, P. S. 1998. Interactions between fungus-growing ants (Attini), fruits and seeds in cerrado vegetation in Southeast Brazil. *Biotropica* 30:170–178.

LORENZI, H. 1992. *Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil*. Editora Plantarum Ltda, Nova Odessa. 352 pp.

MAJER, J. D., DELABIE, J. H. C. & MCKENZIE, N. L. 1997. Ant litter fauna of forest, forest edge and adjacent grassland in the Atantic forest region of Bahia, Brazil. *Insectes Sociaux* 44:255–266.

MORELLATO, L. P. C. 1992. *História natural da Serra do Japi. Ecologia e preservação de uma área florestal do sudeste do Brasil*. Editora da Unicamp/Fapesp, Campinas. 321 pp.

NICHOLAS, J. T. & VILELA, E. F. 1995. Trends in leaf-cutting ant density and distribution following deforestation along the transamazon highway in Pará, Brazil. *Boletim do Museu Paranaense Emílio Goeldi, série Zoologia* 11:3–15.

OLIVEIRA, P. S., GALETTI, M., PEDRONI, F. & MORELLATO, L. P. C. 1995. Seed cleaning by *Mycocepurus goeldii* ants (Attini) facilitates germination in *Hymenaea courbaril* (Caesalpiniaceae). *Biotropica* 27:518–522.

PIZO, M. A. 1997. Seed dispersal and predation in two populations of *Cabralea canjerana* (Meliaceae) in the Atlantic Forest of southeast Brazil. *Journal of Tropical Ecology* 13:559–578.

PIZO, M. A. & OLIVEIRA, P. S. 1998. Interaction between ants and seeds of a nonmyrmecochorous neotropical tree, *Cabralea canjerana* (Meliaceae), in the Atlantic forest of southeast Brazil. *American Journal of Botany* 85:669–674.

RANTA, P., BLOM, T., NIEMELA, J., JOENSUU, E. & SIITONEN, M. 1998. The fragmented Atlantic rain forests of Brazil: size, shape and distribution of forest fragments. *Biodiversity and Conservation* 7:385–403.

SILVA, J. M. C. & TABARELLI, M. 2000. Tree species impoverishment and the future of flora of the Atlantic Forest of the Northeast Brazil. *Nature* 6773:72–74.

VIANA, V. M., TABANEZ, A. A. J. & BATISTA, J. L. F. 1997. Dynamics and restoration of forest fragments in the Brazilian Atlantic moist forest. Pp. 351–365 in Laurance, W. F. & Bierregaard, R. O. (eds). *Tropical forest remnants: ecology, management, and conservation of fragmented communities*. The University of Chicago Press, Chicago. 504 pp.

WOLFF, A. & DEBUSSCHE, M. 1999. Ants as seed dispersers in a Mediterranean old-field succession. *Oikos* 84:443–452.