

SHORT COMMUNICATION

**Seed dispersal of *Asplundia peruviana*
(Cyclanthaceae) by the primate *Saguinus
fuscicollis***

CHRISTOPH KNOGGE*, ECKHARD W. HEYMANN* and EMÉRITA R.
TIRADO HERRERA†

* *Abteilung Verhaltensforschung/Ökologie, Deutsches Primatenzentrum, Kellnerweg 4,
D-37077 Göttingen, Germany*

† *Universidad Nacional de la Amazonía Peruana, Facultad de Biología, Iquitos, Perú*
(Accepted 24 June 1997)

KEY WORDS: seed dispersal, *Asplundia peruviana*, *Saguinus fuscicollis*, digestive
physiology, diarrhoea.

The reproductive success of plants depends to a very large degree on the quantity and quality of seed dispersal. If dispersal is by animals (zoochory), characteristics of fruits such as colour, size, shape and nutritional content have been shown to influence the likelihood of visitation by frugivores or the rate of fruit removal (e.g. Fuentes 1994, Howe 1983, Murray *et al.* 1993). While these characteristics function in the attraction of dispersers, plants may also evolve characters that manipulate the behaviour or the physiology of dispersers after the consumption of fruits and the ingestion of seeds. An example of such post-consumption manipulation of dispersers' behaviour by plants is provided by mistletoes. The viscous mistletoe seeds stimulate the disperser (usually birds) to either rub the cloaca (when seeds are passed through the gastro-intestinal tract) or the bill (when seeds are regurgitated) on a branch (e.g. Reid 1991). It has also been proposed that fruits might manipulate the disperser's physiology by including laxatives that determine the optimal passage time through the disperser's gut (Murray *et al.* 1994), although this view has recently been challenged (Witmer 1996).

Mistletoe seeds must be dispersed to a branch or a stem of a compatible host, all other sites, e.g. forest floor, are unsuitable (Sargent 1995). This is

also true for epiphytic and hemi-epiphytic plants. Post-consumption manipulation of dispersers might be expected if only a few seeds can be produced or if the fruit crop can be depleted by a disperser during a single visit. Here we report a possible case of disperser manipulation in a hemi-epiphytic plant, *Asplundia peruviana* Harling (Cyclanthaceae).

The role of two sympatric tamarin species, *Saguinus mystax mystax* Spix and *Saguinus fuscicollis nigrifrons* I. Geoffroy (Callitrichidae; Primates) as seed dispersers was studied between February 1994 and May 1995 at the Estación Biológica Quebrada Blanco, located at 4°21'S 73°09'W in north-eastern Peru. The study site is dominated by high ground forest ('bosque de altura', Encarnación 1985). For details of the study site and the tamarins see Heymann (1995).

The two tamarin species disperse seeds of at least 92 identified plant species from 35 families (C. Knogge, unpubl. data). Amongst these are the seeds of *A. peruviana*. Fruits of *A. peruviana* consist of berries united in a cream-coloured spadix (length of spadix: 10–15 cm, diameter: 3 cm). Each plant produces only a single spadix with more than 1000 small seeds (0.18 cm × 0.09 cm × 0.02 cm, mass: 0.00017 g). Feeding on fruits of this hemi-epiphyte, that grows on the trunks of small trees, was observed on several occasions in *S. fuscicollis* (31 individual feeding visits to 23 different *A. peruviana* plants), but never in *S. mystax*. The mean height of *A. peruviana* on trunks was 6.6 m (± 1.1 m, SD; range 5–9 m, $n = 23$). *S. fuscicollis* uses lower forest strata, particularly during travel and foraging than does *S. mystax* (7.7 ± 5.0 m, $n = 1628$ records of height use, vs. 15.7 ± 5.2 m, $n = 1554$) and are thus more likely to encounter *A. peruviana* plants. The fruit of the single spadix of *A. peruviana* plants was always depleted during the feeding visit by one or two tamarins. On eight occasions we observed diarrhoea in individuals of *S. fuscicollis* after they had fed on *A. peruviana* fruits. While clinging to vertical trunks (which *S. fuscicollis* does much more often than *S. mystax*: 53.8% [$n_{\text{total}} = 1119$] vs. 6.5% [$n_{\text{total}} = 814$] of records on orientation of substrates used by the tamarins), the liquid faeces ran down the trunk. Upon examination, we always detected seeds of *A. peruviana* that remained stuck to the bark. Diarrhoea was only observed after feeding on *A. peruviana*, but we also detected small numbers of seeds of *A. peruviana* mixed with other seeds in normal faecal samples.

For terrestrial plants, sites for seed dispersal cannot easily be characterised as suitable or unsuitable for seedling establishment, growth and survival. Rather, the quality of dispersal sites varies continuously (Janzen 1983) and may be unpredictable in time and space (e.g., Schupp 1988, Wheelwright & Orians 1982). However, for epiphytic and parasitic plants, some sites are clearly unsuitable: seeds of these plants dropped to the forest floor might germinate, but there is no chance of establishment and survival of a seedling. Epiphytes and parasites therefore have a specific dispersal requirement: seeds must be dispersed to the branch or stem of a suitable host. Figs may attain this by producing very large numbers of fruits that attract many different dispersers (e.g. Janzen 1979). However, plants like *A. peruviana* which produce

only a limited amount of fruit that furthermore can be depleted by one or a few dispersers during a single visit should manipulate the behaviour or the digestive physiology of dispersers in order to increase the probability that their seeds are dispersed to suitable sites.

In the case reported here, manipulation of the dispersers' digestive physiology is highly likely. Diarrhoea was observed in the tamarins after the consumption of *A. peruviana* fruits, but never on other occasions. Whether diarrhoea was caused, or not, seemed to depend on the amount of consumption of *Asplundia* fruits, since small numbers of *Asplundia* seeds were found in normal faeces, along with seeds from other fruit species dispersed by the tamarins. No information is available yet on the chemistry of *Asplundia* fruits (see Duke & Vasquez 1994, Hegnauer & Hegnauer 1963, Schultes & Raffauf 1990). Our observations suggest that *A. peruviana* fruits contain a laxative that has evolved to manipulate the digestive physiology of the disperser, but phytochemical analysis of *Asplundia* fruits is clearly required to reach definite conclusions.

ACKNOWLEDGEMENTS

We are grateful to the Dirección Regional Agraria – Región Loreto for permission to carry out the study (authorization No. 003–94-GRL-CTAR-DRA), to Enrique Montoya G. and Filomeno Encarnación C. from the Proyecto Peruano de Primatología in Iquitos for their help and support, to Ney Shahuano for excellent assistance in the field, to Roger Eriksson from the University of Göteborg for information about seed dispersal in Cyclanthaceae, and Jörg U. Ganzhorn, David M. Newbery and an anonymous reviewer for helpful comments on the manuscript. The study was supported by grants from the Deutsche Forschungsgemeinschaft to EWH (He 1870/3–1 and He 1870/3–3).

LITERATURE CITED

- DUKE, J. A. & VASQUEZ, R. 1994. *Amazonian ethnobotanical dictionary*. CRC Press, Boca Raton. 215 pp.
- ENCARNACIÓN, F. 1985. Introducción a la flora y vegetación de la Amazonía peruana: estado actual de los estudios, medio natural y ensayo de una clave de determinación de las formaciones vegetales en la llanura amazónica. *Candollea* 40:237–252.
- FUENTES, M. 1994. Diets of fruit-eating birds: what are the causes of interspecific differences. *Oecologia* 97:134–142.
- HEGNAUER, R. & HEGNAUER, M. 1963. *Chemotaxonomie der Pflanzen. 2: Monocotyledonae*. Birkhäuser Verlag, Basel. 540 pp.
- HEYMANN, E. W. 1995. Sleeping habits of tamarins, *Saguinus mystax* and *Saguinus fuscicollis* (Mammalia; Primates; Callitrichidae), in northeastern Peru. *Journal of Zoology, London* 237:211–226.
- HOWE, H. F. 1983. Annual variation in a neotropical seed-dispersal system. Pp. 211–227 in Sutton, S. L., Whitmore, T. C. & Chadwick, A. C. (eds). *Tropical rain forest: ecology and management*. Blackwell Scientific Publications, Oxford, UK.
- JANZEN, D. H. 1979. How to be a fig. *Annual Review of Ecology and Systematics* 10:13–51.
- JANZEN, D. H. 1983. Seed and pollen dispersal by animals: convergence in the ecology of contamination and sloppy harvest. *Biological Journal of the Linnean Society* 20:103–113.
- MURRAY, K. G., RUSSELL, S., PICONE, C. M., WINNETT-MURRAY, K., SHERWOOD, W. & KUHLMANN, M. L. 1994. Fruit laxatives and seed passage rates in frugivores: consequences for plant reproductive success. *Ecology* 75:989–994.
- MURRAY, K. G., WINNETT-MURRAY, K., CROMIE, E. A., MINOR, M. & MEYERS, E. 1993. The influence

- of seed packaging and fruit color on feeding preferences of American robins. Pp. 217–226 in Fleming, T. H. & Estrada, A. (eds). *Frugivory and seed dispersal: ecological and evolutionary aspects*. Kluwer Academic Publishers, Dordrecht.
- REID, N. 1991. Coevolution of mistletoes and frugivorous birds? *Australian Journal of Ecology* 16:457–469.
- SARGENT, S. 1995. Seed fate in a tropical mistletoe: the importance of host twig size. *Functional Ecology* 9:197–204.
- SCHULTES, R. E. & RAFFAUF, R. F. 1990. *The healing forest*. Dioscorides Press, Portland. 484 pp.
- SCHUPP, E. W. 1988. Factors affecting post-dispersal seed survival in a tropical forest. *Oecologia* 76:525–530.
- WHEELWRIGHT, N. T. & ORIAN, G. H. 1982. Seed dispersal by animals: contrasts with pollen dispersal, problems of terminology, and constraints on evolution. *American Naturalist* 119:402–413.
- WITMER, M. C. 1996. Do some bird-dispersed fruits contain natural laxatives? A comment. *Ecology* 77:1947–1948.