tion of both shoot and root length at sections 4, 7 and 9 (Figure 1). Stimulation of shoot length was observed in sections 1–3, 5, 6 and 8. The effect on root length is less but still not negligible (sections 3, 5, 8). Three phenolic spots were observed in sections 8, 9, one in section 5 and two in section 3.

Inhibition in shoot and root length caused by *A. erioloba* pulp extract is not 100% at the dilution used (higher conc. is not feasible because of the nature of the pulp) but is nevertheless considerable. It is approx. 46–54% (shoot length) and 69–75% (root length).

Three inhibitors and three stimulators are present in the pulp extract of *A. erioloba*. Incidentally, all three stimulators are clear because they are separated by inhibitors.

Six phenolic spots have been found, of which two (in sections 5 and 9) coincide with a stimulator and an inhibitor respectively. Nevertheless, the possibility remains that the stimulatory and inhibitory agents are unknown substances coinciding with these phenolics. Further characterization of these phenolics might shed more light on this problem. The stimulator ranging from 1 to 3 is maximal at section 3, it is also considerable at section 2 but there is no phenolic spot trailing up to section 2. It is, therefore, more likely that this stimulator is not either of the two phenolics revealed in section 3.

Inhibitors in the fruit pulp prevent premature germination and as such may have been selected for, because it is to the interest of both the mother plant and seeds. Parent–offspring conflict in plants is an important subject that has drawn considerable attention[5] and it is even possible that pulp inhibitor or seed dormancy reduces such conflict.

Again, mangrove fruit pulp should contain no inhibitors because the seed germinates in the fruit while attached to the tree; it is even likely that there may be stimulators. But it has been found that here, too, there are inhibitors, though, apparently, the mangrove seedling can overcome the effect of these[6] and slight stimulators of rice grains.

The above results show that inhibitors are present even in those fruit pulp where there is no such theoretical necessity. Furthermore, there are more than one inhibitor and stimulator, the synergistic effect of which is inhibition.

1. Mayer, A. M. and Poljakoff-Mayer, *Germination of Seeds*, Pergamon Press, Oxford, 1982.
2. Howe, H. F., in *Seed Dispersal* (ed. Murry, D. R.), Academic Press, London, 1986.
3. Midya, S. and Brahmachary, R. L., *J. Trop. Ecol.*, 1991, **7**, 537–538.
4. Stahl, E., *Thin Layer Chromatography*, Academic Press, London, 1969, 2nd edn.
5. Uma Shaanker, R., Ganeshaiah, K. N. and Bawa, S. Kamaljit, *Annu. Rev. Ecol. Syst.*, 1988, **19**, 177–205.
6. Mandal, S., Tapaswi, P. K. and Brahmachary, R. L., *J. Indian Bot. Soc.*, 1995, **74**, 361–362.

ACKNOWLEDGEMENTS. R.L.B. thanks the African Foundation, Otjiwarongo, Namibia. Without their co-operation and hospitality the work on *A. erioloba* would have been impossible. We thank Prof. P. K. Tapaswi, N. Banik and T. Modak of Embryology Unit, ISI for valuable assistance in the laboratory.

SUPARNA MANDAL
R. L. BRAHMACHARY*

*Embryology Research Unit,*
*Indian Statistical Institute,*
*Calcutta 700 035, India*
**21B, Flat No. 10,*
*Motijheel,*
*Calcutta 700 074, India*

# Why do plants possess laxatives?

The functional significance of fruit pulp in plants could extend beyond merely offering nutrient rewards for their dispersers. Murray *et al.*[1] showed that fruit pulp of *Witheringa solanacea* increases the passage of seeds through the gut of the avian disperser *Myadestes melanops*. They found that seeds encapsulated in the agar blocks treated with the pulp extract passed significantly faster through the gut of its disperser than those encapsulated in untreated agar. The seeds that passed rapidly through the gut germinated better and remained viable for a longer time than those that passed slowly. Murray *et al.*[1] proposed that reducing the seed retention time might increase the fitness of the plant and hence that selection might favour the evolution of laxative chemicals in the fruits so as to enhance seed passage rates. Thus seed retention time appears to be an important component of fitness in plants. Accordingly we predict that selection shall favour the evolution of laxative chemicals predominantly in fruits and seeds (in structures such as seed coat and aril) of the species that are especially dispersed by animals as opposed to those dispersed by wind, water or passive means; unlike animal-dispersed species, wind and passively dispersed species do not require such laxatives. Here we test this prediction by analysing the association between the occurrence of laxative property in plants and their respective dispersal modes.

Several traditional health care systems, such as Ayurveda and Siddha, predominantly use plant products for curing human ailments. These systems of medicine have been very popular in the Indian sub-continent and even today enjoy a substantial patronage. We surveyed three compendia of these health systems[2–4] for information on plant species and their parts exhibiting laxative property. Plants listed to serve as purgatives were considered to possess laxative property and the dispersal modes of these species (animal or wind or passive) were obtained from the *Flora of the Presidency of Madras*[5] and from our own data source[6]. We then tested for the independence of the laxative property of the species with their dispersal mode. For this we computed the expected frequency of the species with different dispersal modes based on the data provided by Lokesha *et al.*[6] on the dispersal modes of a set of 770 species of angiosperms. These frequencies were compared with those with the laxative properties.

Nearly 60% of the 114 species with laxative property in their seeds and fruits are dispersed by animals (Table 1). Significantly more animal-dispersed species exhibited laxative property than would be expected by chance ($N = 114$ species, $\chi^2 = 19.42$, $df = 1$, $p < 0.001$; Table 1). There were fewer wind and passively-dispersed species with laxative properties than expected. Thus it appears that plants with laxative property are more likely to be dispersed by animals than by other means.

Fruits and seeds generally constitute a small proportion of the total biomass of the plants and range from 10 to 30% in annuals, and much less in perennials[7,8]. Accordingly, if the laxatives are randomly distributed in the vegetative and reproductive parts of the species studied, then the proportion (frequency) of species with the laxatives in fruits and seeds shall roughly correspond to these proportions. Our results showed that fruits and seeds together constituted nearly 58% of the plant parts having laxative effects (Figure 1). Thus as predicted, we found a strong association between the mode of dispersal and the laxative property of fruits and seeds and that seeds and fruits constitute predominant source of laxative chemicals in plants.

**Table 1.** Association between modes of dispersal of seeds and fruits and their laxative property[†]

| Dispersal modes | Species | |
|---|---|---|
| | Observed | Expected |
| Animal | 68 | 45 |
| Others* | 46 | 69 |

Plants listed to serve as purgatives in their seeds and fruits were considered to possess laxative property and the dispersal mode of these species (animal or wind or passive) were obtained from Gamble[5] or Lokesha *et al.*[6]. We then tested for the independence of the laxative property of the species with their dispersal mode. For this we computed the expected frequency of the species with different dispersal modes based on the data provided by Lokesha *et al.*[6] on the dispersal modes of a set of 770 species of angiosperms; these samples represent random collection of species from the world flora. These frequencies were compared with those with the laxative properties. $N = 114$ species; raw data from references 2 to 4. $\chi^2 = 19.42$, $df = 1$, $p < 0.001$.

*includes wind and passively-dispersed species.

[†]The list of plants and plant parts possessing laxative properties and their dispersal modes is deposited with the editorial office. Those interested in obtaining the list may contact the editorial office or the authors.

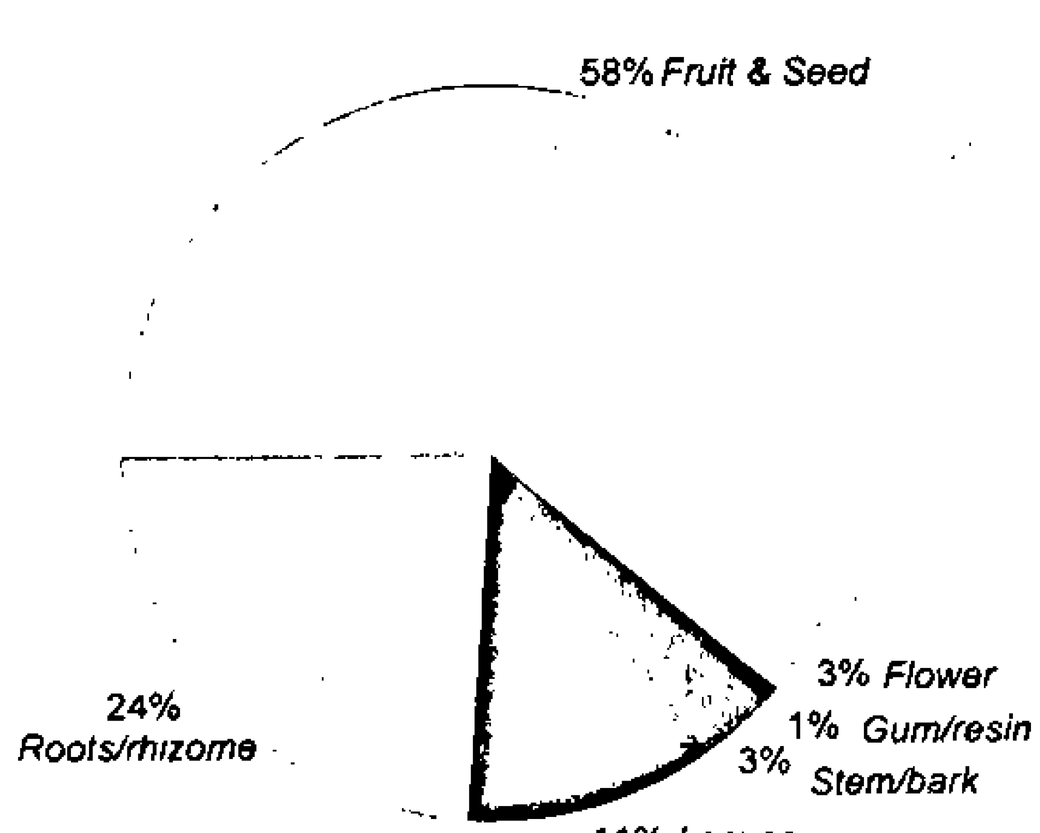


**Figure 1.** Percentage of various plant parts exhibiting laxative properties ($N = 112$ species, raw data from ref. 2).

Apart from the immediate function of enhancing seed passage rates, laxative in fruits may confer certain other advantages as well. Putz[9] argued that rapid passage of seeds would facilitate their deposition in a greater number of fecal clumps, probably leading to reduced post-dispersal competition. Further, frequent defecation also favoured a greater fruit consumption rate by birds, which may lead to greater removal of fruits from plants[10]. In fact Sorensen[11] found that feeding preferences of the European blackbirds (*Turdus merula*) were positively correlated with seed passage rates.

Plant products have been extensively used as curatives for a wide range of human ailments by both traditional and allopathic health systems. Yet the functional significance of these products to the plants themselves largely remains unaddressed. While it has been suggested that these products may constitute secondary plant metabolites, with no apparent function in the plants[12], it is also conjectured that they may have evolved as chemical defenses against predation or pathogenic infection[13]. Our study suggests that at least in some cases (in this study with reference to the laxative property), the acclaimed curative property of plants is an adaptive consequence to enhance their own fitness. Indigenous and allopathic health systems have apparently taken advantage of such selection of laxative chemicals in the fruits and seeds of animal-dispersed species to their own use as curatives. It is likely that several other curative properties of plants such as anti-helminthic may also have an adaptive basis.


1. Murray, G. K., Russell, S., Picone, C. M., Winnett-Murray, K., Sherwood, W. and Kuhlman, M. L., *Ecology*, 1994, **75**, 989–994
2. Nadkarni, K. M., *Indian Materia Medica*, Popular Prakashan, Bombay, 1976, vol. 1 and 2.
3. Dastur, J. F., *Medicinal Plants of India and Pakistan*, D. B. Taraporevala, Bombay, 1952.
4. Chopra, R. N., Nayar, S. L. and Chopra, I. C., *Glossary of Indian Medicinal Plants*, Council for Scientific and Industrial Research, New Delhi, 1956.
5. Gamble, J. S., *Flora of the Presidency of Madras*, Adlard, London, 1915–1934, vol. 1–3.
6. Lokesha, R., Hegde, S. G., Uma Shaanker, R. and Ganeshaiah, K. N., *Am. Nat.*, 1992, **140**, 520–525.
7. Donald, C. M., *J. Aust. Inst. Agric. Sci.*, 1962, **28**, 171–178.
8. Evans, L. T., in *Crop Physiology: Some Case Histories* (ed. Evans, L. T.), Cambridge University Press, Cambridge, 1975.
9. Putz, F. E., *Bull. Ecol. Soc. Am.*, 1993, **74**, 177.
10. Levey, D. J. and Grajal, A., *Am. Nat.*, 1991, **129**, 471–485.
11. Sorensen, A. E., *J. Anim. Ecol.*, 1984, **53**, 545–557.
12. Adzet, T. and Camarasa, J., in *Herbs, Spices and Medicinal Plants: Recent Advances in Botany, Horticulure and Pharmacology* (eds Craker, L. E. and Simon, J. E.), Oryx Press, Arizona, 1988, vol. 3, p. 25.
13. Cox, P. A. and Balick, M. J., *Sci. Am.*, 1994, **270**, 60–65.


ACKNOWLEDGEMENT. This work was partially supported by grants from the DST.

R. UMA SHAANKER[1]
K. V. RAVISHANKAR[1,*]
K. N. GANESHAIAH[2,†]

[1]*Department of Crop Physiology and*
[2]*Department of Genetics and Plant Breeding,*
*University of Agricultural Sciences, GKVK Campus,*
*Bangalore 560 065, India*
**Present address : Department of Biotechnology*
*Indian Institute of Horticultural Sciences,*
*Bangalore 560 089*
[†]*For correspondence*