derived from the harvested food by way of reducing the energy spent on searching and handling it. A selective mode of harvest of mobile organisms in large areas as that of fish in extensive water involves a greater expenditure of energy than collective harvest and discarding the unwanted. Hence, it is justifiable that humans will naturally resort to the second method of harvest although it involves considerable wastage. In this regard, both traditional and modern approach, as one would expect, would not vary considerably.

Having mentioned a couple of negative examples regarding sustainable harvest of natural resources we may now consider a few positive cases. In south India, the month of July (the onset of southwest monsoon) traditionally used to be a closed season with little harvest of sea fish. Incidentally, this is also the season when most of the choice fish such as seer and pomphrets breed. They come closer to the shore for spawning. Mechanized boats which are being used currently all through the year in all our coastal waters are netting large females and males ready to spawn, considerably reducing the potential for future generations. Although the sea is usually rough during this season, discouraging the use of traditional rafts and boats, one may very well interpret the closed season that used to be observed in the past as a prudent TEK in favour of sustainable harvest of fish.

Instances of local humans using plant poisons to temporarily paralyse fish in pools of freshwater, collecting the select individuals and allowing the rest to 'recover' from the shock are in favour of TEK of sustainable harvest. This is a common practice over most of the south Indian hills. (No effort has, however, been made to record the incidental killings in this method.)

Thus, one can argue back and forth quoting examples which either support or contradict the 'TEK of sustainability' hypotheses. If there are positive examples, there certainly exists an equal number of opposing evidences in this context. Yet the purpose of this article is not to make the readers feel that there is no truth in TEK when it comes to sustainable use of natural resources. This system which has been tried and practised over a few thousand years cannot be ignored altogether. What is needed, however, is an emphasis on more carefully collected and analysed data which is scientifically scrutinized and interpreted. Kenneth Ruddle, writing for UNESCO, says 'study of tribal knowledge in my opinion is not going to tell us more about sustainable harvest but help us understand that they are ecofriendly and can be allowed to exist even within protected areas'. Quoting Ruddle further while closing this brief article on TEK, it is appropriate to state the following. 'The romantic and uncritical espousal of traditional ecological knowledge and management is as extreme and almost as unfortunate as that of dismissing it. Traditional peoples have not lived in some preternatural state of harmony with nature. Some of their abuses of natural resources have been and remain substantial'[4].

1. Inglis, J., *Nat. Res.*, 1994, 30(1), 2–4.
2. Harp, W., *Nat. Res.*, 1994, 30(1), 23–27.
3. Kunstadter, P., in *People of the Tropical Rainforest* (eds Denslow, J. S. and Padoch, C.), University of California Press, 1988, pp. 93–110.
4. Ruddle, K., *Nat. Res.*, 1994, 30(1), 29–37.

R. J. RANJIT DANIELS
JAYASHREE VENCATESAN

M.S. Swaminathan Research Foundation,
3rd Cross Street,
Taramani Institutional Area,
Madras 600 113, India.

Endophytes – A crucial issue

Microorganisms are known to interact with plant surfaces as well as interior tissues. Microbes which live with interior tissues of healthy plants without causing disease symptoms are called 'endophytes', the term synonym of 'mutualists'. Although this concept was confined initially to fungi, later it was expanded to include all microbes which colonize internal plant tissues without causing harm to their hosts[1,2]. In the last decade, major attention was focused on studying the plant interactions with rhizobia and vesicular–arbuscular mycorrhizae (VAM). A few years ago it was understood that a wide range of plants was infected with endophytic fungi. Endophytic fungi have been reported from different plants such as mosses and ferns[3], conifers[4,5], palms[6], and monocots[7]. To date, the ecological role of endophytic fungi is poorly understood. The purpose of this note is to emphasize the gaining importance of endophytes other than rhizobia and VAM.

Endophytes occupy a unique ecological niche and have major influences on plant distribution, ecology, physiology and biochemistry. The studies on the endophytes of grasses, conifers and other woody perennials indicated several beneficial effects. Endophytic infection enhances the resistance of host plants against insects[8]. It was hypothesized that endophytes of conifers and woody perennials decrease palatability for grazing insects and antagonize pathogens[5,9,10]. Thus, to improve their fitness in a given environment, plants might have acquired/accommodated the endophytes.

Endophytes so far isolated were either ascomycetes or their anamorphs and zygomycetes, whereas those belonging to basidiomycetes or their anamorphs or other fungi were rarely reported[3,11]. Several fungi adapted endophytic lifestyle possibly because of the competition of different fungi on suitable substrates. Endophytes are in an advantageous position to colonize the plant parts starting from the initiation of senescence. Endophytes usually bear fruit after the host has died, hence, senescent or dead twigs might be excellent materials to establish anamorph–teleomorph connections.

There is a notion that endophytes have evolved from plant pathogenic fungi. Endophytes may often cause pathological symptoms when the host is under stress[12,13]. These may also behave as latent pathogens, under situations which disrupt the endophyte–plant association (for instance, modern agricultural practices), where endophyte-intolerant host selection will be favoured and transition of endophyte to pathogen might take place[9]. Endophytic, pathogenic and saprophytic behaviour of fungi might be host/environment-dependent. To derive maximum benefits from fungi, plants have to cope with the changing environment to maintain fungi in endophytic rather than pathogenic state, but during senescence of plant parts naturally endophytes switch over to saprophytic phase. Several readjustments have to be made to decide the nature of microorganisms as and when we explore more about endophyte–plant interactions. Some endophytes might behave as pathogens under specific environmental conditions. The decisions taken on microorganisms as plant pathogens or seed pathogens have to be reconsidered with caution. The bacterial or fungal appearance on surface-sterilized excised plant parts in tissue culture can be strongly suspected as endophytes. Plant–endophyte association is an excellent model system which facilitates to understand evolution of plant–microbe symbioses.

Endophytes are known to infect different plant parts either by vertical transmission via host seeds/vegetative propagules or by horizontal transmission. It is now known that climatic conditions greatly influence fungal spore germination and ultimate infection. The increase in rainfall increases the level of endophytic infection. The deposition of surface runoff along the midrib/lamina of leaves favour fungal spores to collect and subsequently to infect heavily[14]. It is also known that aquatic roots of riparian vegetation are colonized by aquatic hyphomycetes, and it is suspected that the selection pressure might have been induced by scarcity of substrates[15,16].

Many plant secondary metabolites have structural and qualitative similarities with endophytic allelochemicals and fungal toxins[17]. The possibility of endophytes acting as vehicles of horizontal gene transfer between the genomes of fungi and plants cannot be ruled out, if the endophytes are not the allelochemical producer. Interestingly, many grass endophytic fungi are known to produce alkaloids which act as insect repellents. Several grasses which possess endophytes (infected by *Acremonium* spp.) are toxic to livestock. Surprisingly, on grazing some grasses cattle, horse and sheep get intoxicated and that is why animals avoid grazing such stuff[8]. It is now known that the intoxicating effect is due to the metabolites of endophytic fungi[18]. The properties of plant parts in curing human/animal ailments and as intoxicants and toxins might also be influenced by the endophytic partner. Endophytic fungi are now recognized as a potential source of new secondary metabolites[19]. Endophytes are known to produce compounds active against human and plant pathogenic bacteria[20–23]. Besides these, endophytes including VAM produce hormones such as indole-3-acetic acid (IAA) and cytokinins which stimulate growth and flowering of plants[24,25]. Endophytic niche is considered as the potential source of microbes which produce a wide variety of bioactive metabolites. It has become a new source of biochemicals like those from soil, freshwater and marine ecosystems.

Dreyfuss and Chapela[26] estimated that over 1.3 million endophytes are awaiting discovery. The study of endophyte distribution, biodiversity and their biochemical characteristics are of immense importance in plant biology to understand and to improve plant fitness; to develop safe biocontrol chemicals; to produce environment-friendly chemicals in industrial scale. The distribution and fitness of plants in a given environment; physiological performance of plants and biochemical features of plant tissues have been greatly influenced by endophytes. There are many benefits to be derived and several questions yet to be answered regarding endophyte–plant interactions.

1. Petrini, O. and Carroll, G. C., *Can. J. Bot*, 1981, 59, 629–636.
2. Petrini, O., in *Microbial Ecology of Leaves* (eds Andrews, J. and Hirano, S.), Springer, New York, 1991, pp 179–197.
3. Petrini, O., in *Microbiology of the Phyllosphere* (eds Fokkema, N. J. and Van den Heuvel, J.), Cambridge University Press, Cambridge, 1986, pp. 175–187.
4. Bernstein, M E. and Carroll, G. C., *Can. J Bot.*, 1977, 55, 644–653.
5. Carroll, G. C. and Carroll, F. E, *Can. J. Bot.*, 1978, 56, 3034–3043
6. Rodrigues, K. F. and Samuels, G. J., *Mycol. Res.*, 1990, 94, 827–830
7. Fisher, P. J. and Petrini, O., *New Phytol.*, 1992, 120, 137–143.
8. Clay, K., *Ecology*, 1988, 69, 10–16.
9. Carroll, G. C., *Ecology*, 1988, 69, 2–9.
10. Clark, C. L., Miller, J. D. and Whitney, N J., *Mycol. Res.*, 1989, 93, 508–512.
11. Petrini, O., Fisher, P. J. and Petrini, L. E., *Sydowia*, 1992, 44, 282–293.
12. Miller, C. S., in *Microbial Ecology of the Phylloplane* (ed. Blackman, J. P.), Academic Press, London, 1980, pp. 185–209.
13. Andrews, J. H., Hecht, E. P. and Bashirian, S., *Can. J. Bot.*, 1985, 60, 1216–1221.
14. Wilson, D. and Carroll, G. C., *Mycologia*, 1994, 86, 635–647.
15. Fisher, P. J, Petrini, O. and Webster, J., *Mycol. Res.*, 1991, 95, 543–547.
16. Sridhar, K R. and Baerlocher, F., *Mycol. Res*, 1992, 96, 305–308.
17. Wilson, D., *Oikos*, 1993, 68, 379–384.
18. Bruchl, G. W., Kaiser, W. J. and Klein, R. E., *Mycologia*, 1994, 86, 773–776.
19. Bills, G. F. and Polishook, J. D., *Sydowia*, 1992, 44, 1–12.
20. Dreyfuss, M. M., *Sydowia*, 1986, 39, 22–36.
21. Fisher, P. J., Anson, A. E. and Petrini, O., *Bot. Helv.*, 1984, 94, 249–253.
22. Fisher, P. J., Anson, A. E. and Petrini, O., *Trans. Br. Mycol. Soc.*, 1984, 83, 145–148.
23. Fisher, P. J., Anson, A. E. and Petrini, O, *Trans. Br. Mycol. Soc.*, 1986, 86, 153–156.
24. Pugh, G. J. F., in *Seed Ecology* (ed. Heydecker, W.), Butterworth, London, 1972, pp. 337–345.
25. Allen, M. R., Moore, T. S. and Christensen, M., *Can. J. Bot*, 1980, 58, 371–374.
26. Dreyfuss, M. M. and Chapela, I. H, in *Discovery of Novel Natural Products with Therapeutic Potential*, Butterworth, London, 1992, Biotechnology Series.

K. R. Sridhar
N. S. Raviraja

Department of Biosciences,
Mangalore University,
Mangalagangotri,
Mangalore 574 199, India.