GENERAL DISCUSSION

The environmental significance of a particular species can be in three ways.

1. The contribution of the species to normal and altered environmental quality.

2. The influence of the species on other forms of life in the environment.

3. The influence of the quality of the environment on the species itself.

In the present investigation all these aspects are explored to understand the environmental significance of fern spores. Since very little background information regarding fern spores was available it was preferred to undertake preliminary, nevertheless original studies on the periphery on each of the aspects rather than detailed investigation on one facet only. As such the findings have focussed attention on all possible environmental relevance of fern spores, and has opened several new lines for further research.

The idea that the fern spores could pose problems as air pollutants, came from the detection of spores of several species in air samples from different regions of the country. As to be expected, the natural habitats like Assam, showed higher counts, indicating that spores could be important
topics for further aerobiological studies in such regions. Long patches of terrestrial ferns are a common sight in the tropical locations such as in Kerala. Mud walls running along several kilometers of the road tracks are completely covered with different species of ferns such as *Hemionitis*, *Cheilanthus*, *Pteris*, *Pseudodrynaria* and *Selaginella*. Tufts of epiphytic ferns sporulating profusely can be observed on trees over large patches of areas. *Drymaria*, *Pyrrosia* and *Drymoglossum* are very common as epiphytes on almost every tree at certain areas. Slopes of hills at Assam and Kerala are also full of ferns. These areas are generally thickly populated and the species come in common human contact. The profuse spore production and the dense fern vegetation in such areas, make it imperative on the part of aerobiologist to list fern spores also among viable particulate pollutants. The detailed studies on the spore morphology will greatly help in the authentic identification of the causative species. Also since the biological effects vary with each species the relating incidence of hazardous ones rather than total spore counts, will be needed to forewarn the potential victims of allergy and to develop immunoprophylactic measures. The varied extents, in degree and magnitude of allergy as revealed in the present study, clearly advocates the morphological identification of the spore type. It may be pointed out that unlike fungal and algal spores, growth pattern in synthetic media, cannot help in identification of fern spores in air. Expertise
in morphology and taxonomy is vital in all environmental and ecological studies to supplement experimental and field monitoring efforts. Since spore morphological studies (Devi, 1977a, 1981a; Nayar and Devi, 1964, 1965, 1966, 1967, 1968; Tardeu Blot, 1965; Lugardon, 1963; Er̈ẗm̈an and Sorsa, 1971) have been confused as keys to identification, of fern taxa, modern techniques such as SEM are also adopted to supplement information. Several minute characteristics which are missed by the LM can be identified by SEM. Spore morphology of all the species dealt with in different chapters has been studied. Even though the aerospora trapped in a slide could be studied by LM, addition information was available by collecting the spores of these from the corresponding localities and viewed through SEM. It is evident from the LM studies that the spore characters are specific in the case of Asplenium, Tectaria and some polystichums with the typical perispore folded into various characteristic patterns. These species also have a supralaesural folds. In the case of Cyrtomium the perispore is folded into semicircular folds, Polystichum aculeatum has a typical areolate pattern resembling soap bubbles, while Bolbitis has the less folded loose perispore. All the Pteris species has an equatorial collar separating the proximal and distal surfaces, while Ceratopteris and Anemia have costate ornamentation of the sporoderm. Adiantum have a verrucate perine, while Cheilanthus has a rugulate reticulate one. The incidence of fern spores in air is not confined to wild habitat only.
In many an urban garden from the big organised parts to individual houses ferns form a green background in major ways. Fern has also become commonly accepted as indoor plants as well as floral displays. This could be another way of exposure to allergenic fern species. As such their spores could be in urban and indoor air also eventually reaching susceptible individuals through inhalation or skin contact. The pilot level data with monitoring in the fern house, closely support this contention.

Further, the basic processes involved in the release of spores and their transport in air as influenced by morphological characters have been elucidated from the present study. Regarding the second aspect how fern spores affect other species, by a multidisciplinary approach, it has been established that spores of several ferns are powerful allergens. By a systematic study of the effect of several spores and extracts therefrom the incidence of dermal allergy in patients of the allergy clinic, has been thoroughly studied. It may be pointed out that apart from the work in this laboratory there have been only two isolated reports, one on a German florist by leather leaf fern fronds and the other on a Japanese dentist by *Lycopodium* powder, on this area (Hausen and Schulz 1978; Koboyashi 1980). The allergenic principles were found to be both on the spore coat as well as in the protoplasm, also the isolated lipids as well
as free solutions, presumably proteins were found to elicit allergy. It is also interesting that apart from these clinical tests toxicity of fern spores has been established by experimental animal models. The data from dermal patch tests in rats clearly showed adverse effects on skin. This explains the possibility of dermal allergy as occupational or environmental exposure to fern spores. The clues offered from the present results and the protocols developed, will be helpful in further studies on fern spore allergy. In the characterization of the allergens and the forewarning potential victims and protecting them through desensitization. Another significant outcome of the present study is the detected natural association between fern spore and fungal spores. The implications of this in ecological inter relations especially allelopathy (Whittaker and Feeny, 1971) and on the spreading of each are unknown and could prove vital frontiers for further study. Its significance could be even more in the case of human health effects, since exposure to multiple stress factors can be more complex than individual exposure. If both fern and fungal spores are hazardous, synergistic or additive effects can be more severe (Devi and Wadhwani, 1983). Also one may potentiate the effect of the other. In such case the combined effects have to be studied and prophylactic measures developed accordingly. Thus apart from poisoning of live stock by acute effects of bracken fern, chronic effects of spore inhalation also account for the undesirable environmental effects of ferns.
The third aspect that is whether environmental quality can influence or not is also partially answered by the present results. Synthetic detergents in very low concentrations inhibit spore germination. Since detergents are used in herbicide formulations they could be useful in controlling unwanted flora. Also detergent pollution of water is very common and could account for changes in ecology of aquatic ferns. Sensitive ones will be outnumbered by resistant ones and the quality of environment is important. It has been possible to arrive at, through experiments, a possible safe limit of detergent in water. If the experimental data is extrapolated to field conditions detergent levels below 0.001 ppm may be considered safe for ferns. Such studies are useful in fixing environmental quality standards which will not allow ecological balance. The fern spore germination inhibition could also serve as a toxicology evaluation model, for assessing the risk of environmental chemicals.

Thus the potential significance of fern spores in environmental biology has emerged from the above studies. Since pteridophytes generally received much less attention than other classes of plant kingdom, by the environmentalists, it is hoped that the present results will revive interest. Due to their peculiar position in the evolutionary ladder as vascular cryptogams no study of ecotoxicology of
environmental pollution will be complete without assessing the effects of ferns and preserving the species from damage through environmental degradation. Apart from this applied significance the detailed studies on ultrastructural morphology could be of considerable interest in basic botany. The importance of ornamentation features and the ultrastructural organization of the perispore are important in this respect.