Generalized relationship among Indian ornithophilous plants and their flower visitors: What can we look for?

Pollination by animal vectors has been a little studied area in India. A study of this aspect of pollination ecology of plants would aid in understanding an important facet of reproductive strategies of plants, especially in the tropics. Though a vast potential is available for studying the role of birds in pollination in India, except for a few studies[1-7], the subject has received very little attention. A review of Indian literature on ornithophily indicates that nearly 60 species of birds are reported to be visiting the flowers of 93 plant species. Further, over 80 per cent of these plant species are frequented by more than one bird species and an equal percentage of bird species frequent more than one plant species[8]. While a majority of the ornithophilous plant species attract only a few bird pollinators, certain other species attract up to 50 different bird species for nectar. In addition, most of the ornithophilous plants are also visited by insects and bats. This suggests that a generalized relationship exists among ornithophilous plants and their flower visitors[8]. However, it appears that all visitors to the flowers of a plant species may not contribute equally to pollination. For instance, in a recent study, Santharam[7] grouped the flower visitors to a clump of *Helicteres isora* Linn. into legitimate pollinators, thieves and robbers. By evaluating the role of each species, he has shown that among several animal visitors, only a few bird species contributed towards pollination of *H. isora*.

Considering this scenario, we feel that there is a need for a deeper understanding of the nature and consequences of such a generalized relationship between flowering plants and their flower visitors[9,10]. In the light of our review[8], we assume that: (i) The generalized relationship could clearly be a strategy among plants to exploit opportunistically, a variety of potential pollinating agents; (ii) For such a strategy to operate, the generalized relationship should result in the development of certain associated patterns like nectar-reward patterns, floral trait patterns and variations in the pollinator contribution to the benefit (e.g. seed set) derived by plants.

Though a variety of animal taxa visit the flowers of ornithophilous plant species[1,8], only a few of the visitors appear to aid in pollination[7]. Thus, it would be interesting to know: (i) Types of flower visitors (pollinators, thieves and robbers[7]) harvesting nectar in different plant species. (ii) Whether each plant species selectively attracts different animal species (insects and mammals) in addition to birds to effect pollination. (iii) Whether it is possible to categorize plants based on the nature and type of their flower visitors into different groups (Table 1), whereby a specific plant species could be classified, for example, into a predominantly ornithophilous plant but visited by insects and/or mammals or predominantly entomophilous plant, but visited by birds and/or bat, etc. (iv) The proportion of flowers that are lost due to the visitation of thieves and robbers (v) What is the specific role of thieves and robbers in the ecology of a plant? Do plants get any benefit from them? If not, do plants regulate the visitation of thieves and robbers and encourage legitimate pollinators at the same time, to maximize pollination efficiency?

Plants gain benefits from visiting avian pollinators and offer nectar as a reward. Preliminary work of Bahadur and his associates[11] indicates that nectar composition (sugars and amino acids) is useful in predicting the type of flower visitors. It is shown that ornithophilous flowers offer amino acid-poor but sugar-rich nectar, while entomophilous flower nectar is rich in amino acids[8,11,12]. Under a generalized situation, the nectar type (sucrose-rich, hexose-rich, amino acid-rich, with or without other minor constituents[11-16]) and presentation pattern of different plant species may vary depending on the types of pollinating agents visiting the flowers of a specific plant species. Considering this, it would be interesting to examine: (i) The association between patterns of nectar rewards (nectar type and quantity) and the number of pollinators visiting the flowers of a particular plant species; (ii) Whether the nectar reward pattern in a plant species can be used to predict the type and number of visiting pollinators; (iii) Whether the temporal variation in reward presentation patterns among different plant species is aimed at attracting specific pollinating agents; (iv) Possible effect of pollen reward in addition to nectar reward.

Since nectar secreted by plants is concealed within the flower, a pollinator is unable to determine definitely the type of nectar (i.e. quality) offered by plants until it visits the flower. But several floral traits (flower size, shape, type, etc.) could well serve to indicate to potential pollinators, the type of nectar reward offered by the flower. Among Indian ornithophilous plants, considering the generalized relationship with flower visitors, it is not yet clear whether there is an association between floral traits and nectar reward among plant species and whether an understanding of specific floral cues can provide insight to the type of nectar reward offered by plants and thus the pollinator types.

If the type of flower visitor frequenting the flower of a specific plant species can vary based on the nectar reward offered by that plant, the contribution to seed set by different pollinating agents should also vary. In other words, based on the composition of nectar, a specific type of pollinating agent may frequent the flowers of a particular plant species more often than others. As a consequence, its contribution to seed set should be greater than other agents. Though insects and bats frequent ornithophilous plants[8], their relative contribution to seed set may vary in different plants.

Thus, from the foregoing discussion, it

Table 1. Possible patterns of flower visitor syndromes in plants

	Birds	Insects	Mammals	Birds + insects + mammals
Birds	+	+	+	
Insects		+	+	+
Mammals			+	

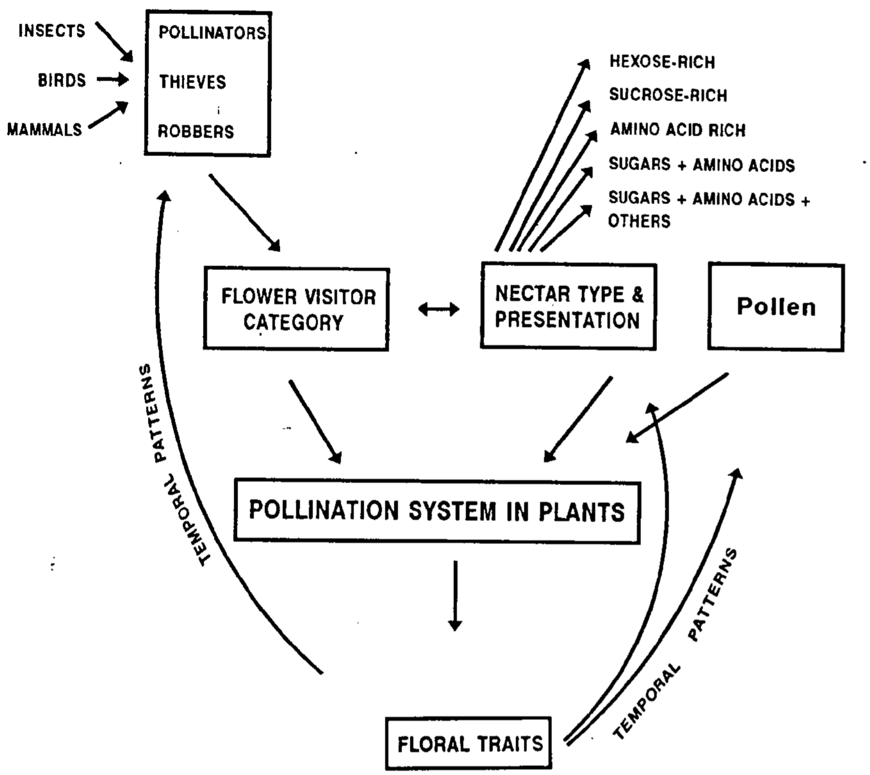

Figure 1. Possible interaction of factors shaping the pollination system due to animal vectors in ornithophilous plants.

can be summarized that the pollination system (i.e. due to animal vectors) in plants could be chiefly governed by (i) type and quality of flower visitors and (ii) quality, quantity and presentation patterns of nectar (Figure 1). This relationship may possibly be reflected in floral traits of a specific plant species. Taking this scenario into account, it would be interesting, if studies could be centred on understanding the following aspects of Indian ornithophilous plants.

1. To evaluate the nature and type of flower visitors to different ornithophilous plants.
2. (i) To analyse the components of nectar that favour visitation by birds and other pollinating agents; (ii) To study the relationships among temporal patterns in nectar presentation, especially the volume of nectar secreted and pollinator visitation rates among predominantly ornithophilous plants.
3. To identify floral syndromes in ornithophily based on the types of visiting pollinating agents.
4. To analyse the relative contribution of ornithophily in otherwise generalized ornithophilous plants to seed and fruit set and to compare this with contributions from other flower visitors.

The method described by Santharam[7] can be followed for obtaining details on different taxa visiting the flowers of different plant species and also for evaluating the visitation pattern and elucidating the relative importance of the visitors to flowers. Specific analytical and field methods, as and when necessary, can be found in Kearns and Inouye[17] and Davidar[2].

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