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VISITATION RATE, EFFECTIVENESS AND EFFICIENCY OF POLLINATORS TO *CADABA FRUITICOSA* (LINN) DRUCE

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ABSTRACT
Abundance and flower visitation rate of the pollinators of *Cadaba fruiticosa* (Linn) Druce (Capparidaceae), a butterfly pollinated shrub was studied over a 3-year period. The objective was to elucidate interspecific differences in the "quantity" component of the plant-pollinator interaction. The plant was solely visited by three butterfly species of the family Pieridae. These 3 pollinator species differed in flower visitation rate (0.046 – 0.113 flowers/ min). This variation was explained by differences in flower handling time (HT) *i.e.* TF/NF. Though the proboscis length of *Colotis eucharis* and *C.danae* were equal (17mm), the HT was differed. *Anapheis aurota* had longer proboscis (20mm) than the other two species and HT were also high. The total no. of visits that each pollinator contributed to the plant (NFV) was estimated as the product of abundance and visitation rate. The results revealed that *C.eucharis* was more effective pollinator to *C.fruiticosa* and the pollinator effectiveness influenced by foraging behavior.

INTRODUCTION

The pollination of flowering plants by animals represents a critical ecosystem. Pollinator behavior in plants affects the mating outcomes of animal pollinated plants. Plants may regulate the pollinator behavior by controlling floral design and display to maximize pollination efficiency. Pollinator communities vary in their visitation rate and in the effectiveness of each taxon at transferring pollen (Spears, 1983; Schenske and Horvitz 1984; Armbruster *at al.,* 1989; Fishbein and Venable, 1996). Pollinators often have considerable spatial and temporal variation in their visitation rates to a single plant species (Herrera, 1989; Horvitz and Scheuiske, 1990; Traveset and Saez, 1997; Fenster and Dudash, 2001; Ivey *et al.,* 2003). Although pollinators differed in effectiveness and visitation rates, pollinator importance was primarily determined by visitation rates (Sahli and Conner, 2007). Differences in visit duration among pollinators have been implicated in influencing pollinator effectiveness with visit duration being positively related to both pollinator efficiency and effectiveness (Fishbein and venable, 1996; Ivey *et al.,* 2003) and negatively related to effectiveness (Boyd, 2004). Morphological aspects of pollinators such as tongue length (Schenske and Horvitz, 1984) and body size (Kandori, 2002) can also contribute to differences in efficiency. Regarding this, I examined quantity and quality of the floral visitors to *Cadaba frutticosa* (Linn) Druce of the family Capparidaceae. The quality and quantity of the visitor contribute to their "pollinator importance" (Olsen, 1997). In plant-pollinator systems, interspecific differences in quality component depend on number of pollen grains carried and deposited on stigmas and the quantity component depend on variation in pollinator abundance and flower visitation rates. Even within a pollinator taxon, the pollen removal deposition dynamics may vary with pollinator behavior at flowers (Goodell and Thomson, 1996; Frietas and Paxton, 1998; Williams and Thomson, 2003). It reflects the complexity of ecological interactions and animal behavior (Young *et al.,* 2007). Recently most investigations focus on single species or specialized pollinators. To understand plant reproduction and floral evolution in generalist plant species, a thorough understanding of each pollinator taxon, effectiveness, visitation rate and variation in visitation rates overtime is essential. Significant variation in visit duration is also uncommon among insects foraging on a single taxon. Vazquez *et al.,* 2005 suggested that the rates of visitation may be sufficient as estimates of the strength of interaction. The paper deals with effectiveness of pollinators.

MATERIALS AND METHODS

The study was conducted and collected the data on *Cadaba fruiticosa* (Linn) Druce population growing near Panyam (vi.) which is situated between eastern latitudes of 76°58′ to 78°56′and northern latitudes of 14°54′ to 16°14′ latitude of Kurnool district for about 3 years. Plants grow there in a scrub forest. These flowers were solely visited by Pieridae butterflies, *Colotis eucharis, C.danae* and *Anapheis aurota*.

Cadaba fruiticosa is a species of plant in the Capparaceae family. It is endemic on Indian Subcontinent. The abundance of pollinators was assessed by conducting counts of floral visitors along a track of 60m. Specimens of butterflies recorded were collected at the start of the study for determination. Every year, pollinator counts were performed during the period July – November, when the flowers and pollinators were abundant. Counts were evenly distributed from sunrise to sunset and count dates were spaced as evenly as possible between the start and the end of the census period. An average abundance in terms of individuals recorded per count was obtained during the study period.

Observations were carried out on the foraging behavior of pollinators to determine their flower visitation rates. Individuals of each species were followed continuously at close range to a maximum of one minute *i.e.* 60 seconds while they were actively foraging at flowers. For each observation sequence, total time spent on flowers (TF) and total observation time (TT) which included time in flowers plus time in flight between consecutive flowers were noted in separate stopwatches. The total number of flowers visited over the entire observation period (NF) was also recorded for each sequence. From the resulting figures, (a) Visitation rate, the average number of flowers visited per time unit (NF/TT); (b) Average time spent in each visited flower / handling time (TF/NF) and (c) Average time spent in flight between consecutive flower visits of "flight time" (TT-TF)/NF. The total number of visits that each pollinator contributed to the plant (NFV) was estimated as the product of abundance and visitation rate i.e. abundance x visitation rate (Herrera, 1989).

Using fine forceps, the proboscis was gently uncoiled on a ruler and its length were measured. Nectar tube length of *Cadaba fruiticosa* flowers was also measured. The number of pollen grains adhered to different parts of butterflies was counted by observing under the microscope. Because nectar distribution within flowers can be a strategy for efficient pollination by manipulating pollinator behavior (Hirabayashi *et al.,* 2006), nectar characteristics were studied. The nectar accumulated in the flowers covered with butter paper bags was measured with graduated micropipettes. Sugar concentration was determined by using Refractometer. Analysis of nectar for the type of sugars present was done by Paper Chromatography (Horborne, 1973). The presence and the relative amount of amino acids in nectars were determined by the method of Baker and Baker (1973).

RESULTS

Flowers of *C.fruiticosa* set fruits either by geitonogamy or xenogamy. Flowers avoided from butterfly visits were not developed into fruits (Meerabai and Subbareddi, 1984). The pollinators have shown short flights. Details of proboscis lengths of the pollinators, their average abundance, number of plants visited, total number of flowers visited, total time spent in flowers, total observation time were provided in Table 1. On the basis of the data, flower visitation rates, handling time (forage time) and flight time were determined (Table 2). Number of pollen grains adhered to different parts of the pollinator species were also provided in Table 2.

The nectar of *C.fruiticosa* was relatively concentrated and individual flowers contain very small volumes. The nectar was deeply concealed at the base of the narrow specialized 7 mm. long nectorial tube. The average nectar concentrations was 19% and mean daily production was 2.2μL/flower. Sucrose was the predominant sugar. Histidine scale was 5.5 and shown that the nectars were rich in amino acids.

Table 2: Flower visitation rate (NF/TT) and total no. of visits contributed by each pollinator to the plant (NFV), Average time spent in flower/handling time (TF/NF), Average flight time (TT- TF)/NF and the number of pollen grains adhered to different parts of the pollinator

Name of the pollinator	NF/TT	NFV	TF/NF (Sec.)	(TT-TF)/NF(Sec.)	No. of pollen grains adhered to P*	H*	W*	L*	A*
Colotis eucharis	0.113	0.1356	0.027	8.715	10	5	2	2	1
Colotis danae	0.056	0.0504	0.035	17.47	8	4	1	1	1
Anapheis aurota	0.046	0.0276	0.044	21.20	6	3	-	2	2

P* = Proboscis; H* = Head; W* = Wings; L* = Legs; A* = Antenna

DISCUSSION

The present study was shown that, though the length of proboscis of *C.eucharis* and *C.danae* were same, flower visitation rate, abundance, foraging time, their flight times were different. The number of pollen grains adhered to various parts of the body was also different. Differences in flower visitation rates (NF/TT) were due to differences in flight time (TT-TF/NF) and in handling time (TF/NF). This study has supported the previous investigations which were shown variation between interspecific pollinators in foraging rates (Hopper, 1980; Ratna, 1983; Schmitt, 1983; Bocher and Philip, 1985; Sugdan, 1986; Herrera, 1989 etc.). Studies of Sahli and Conner (2007) indicated that pollinator effectiveness and efficiency were functions of both behavior and morphology. But in this study though the energetic supplied by the floral nectar and the size of proboscis for both the pollinator species *C.eucharis* and *C.danae* were similar, the visitation rates were different. Other pollinator *A. aurota* had longer proboscis, but flower visitation rates were lesser (Table 2). While studying the abundance and flower visitation rate of the pollinators of *Lavandula latifolia* (Labiatae), Herrera (1989) was explained that the differences in flower visitation rate was by differences in flower handling time (HT) and HT decreased with increasing proboscis length, where he attributed the interspecific variation in flower handling time should be mainly related to differential efficiency in nectar extraction. In case of *C.fruiticosa* all the 3 pollinators received same energetic resources from the flowers. Thus this study does not support the view of Herrera (1989). According to the studies of Pivnick and Mc Neil (1985) on mechanics and energetics of nectar feeding by butterflies, nectar intake rate would be negatively related to proboscis length *i.e.* the nectar intake rate should be inversely related to proboscis length. In this study the nectar intake was assumed by the number of plants visited, total number of flowers visited over the observation period and by the total time spent in flowers (Table 1). Results of this study do agree with this prediction, as long-tongued butterfly species *A.aurota* have more

Table 1: Average abundance of pollinators, their proboscis size (mm), and number of plants visited, total number of flowers visited over the observation period (NF), total time spent in flowers (TF) and the total observation time (TT)

S.No.	Name of the pollinator	Average abundance of pollinators	Length of proboscis (mm)	No. of plants visited	NF	TF(SEC.)	TT(Min.)
1.	*Colotis eucharis*	1.2	17	11	34	3.67	5
2.	*Colotis danae*	0.9	17	09	17	3.0	5
3.	*Anapheis aurota*	0.6	20	09	14	3.1	5

handling time than short tongued butterfly species *C.eucharis* and *C.danae* (Table 2). It means, the nectar intake rate by *A.aurota* was less though their proboscis length was high. But the number of flowers visited during the observation period was less in the case of *A.aurota* (Table 1) and the average time spent in flowers was less than *C.eucharis*, but it was almost equivalent to *C.danae*. The efficiency was assessed on basis of their mobility *i.e.* on visitation rates and on pollen carried by the pollinators (Table 2). It was confirmed that *C.eucharis* was more efficient pollinator to *C.fruiticosa* than *C.danae* and *A.aurota*. Number of plants visited during the observation time by *C.eucharis* was also more. In this case, selection favoring specialization on particular pollinator species was observed. It would provide a useful mechanism for the evolution of "pollination syndromes". This might explain why some plants have traits that appear to restrict the suite of visitors and pollinators (Mitchell *et al.,* 2009). This study helps to renew interest in how ecological interactions between plants and pollinators affect evolutionary patterns.

REFERENCES

Armbruster, W. S., Keller, S., Matsuke, M. and Clausen, T. P. 1989. Pollination of Dalechampia magnolifolia (Euphorbiaceae) by maleeuglossine bees. *American J. of Botany.* **76:** 1279-1285.

Baker, H. G. and Baker, I. 1973. Amino acids in nectar and their evolutionary significance. *Nature (Lond.).* **241:** 543-545.

Bocher, J. and Philipp, M.1985. Aspects of the reproductive biology of *Mimulus repens* (Scrophulariaceae) at Lake Ellesmere, Canterbury, New Zealand. *New Zealand J. of Botany.* **23:** 141-149.

Boyd, E. 2004. Breeding system of Macromeria viridifolia (Boraginaceae) and geographic variation in pollinator assemblages. *American J. of Botany.* **91:** 1809-1813.

Fenster, C. B. and Dudash, M. R. 2001. Spatio temporal variation in the role of hummingbirds as pollinators of Silene virginica. Ecology. **82:** 844-851.

Fishbein, M. and Venable, D. L. 1996. Diversity and temporal change in the effective pollinators of *Asclepias tuberose*. *Ecology.* **77:** 1061-1073.

Freitas, B. M. and Paxton, R. J. 1998. A comparison of two pollinators: the introduced honey bee Apis mellifera and an indigenous bee Centris tarsata on cashew *Anacardium occidentale* in its native range of N. E. Brazil. *J.Applied Ecology.* **35:** 109-121.

Goodell, K. and Thomson, J. D.1996. Comparisons of pollen removal and deposition by honey bees and bumble bees visiting apple. Acta Horticulture. 437: 103-107.

Herrera, C. M. 1989. Pollinator abundance, morphology, and flower visitation rate: Analysis of the quantity component in a plant-pollinator system. *Oecologia.* **80:** 241- 248.

Hirabayashi, Y., Ishil, H. S. and Kudo, G. 2006. Significance of nectar distribution for bumble bee behavior within inflorescences; with reference to inflorescence architecture and display size. *Eco Science.* **13(3):** 351-359.

Hoppers'. 1980. Pollination of the rain-forest tree Syzygium tierneyanum (Myrtaceae) at Kuranda, Northern Queensland. *Australian J. of Botany.* **28:** 223-237.

Horborne, J. B. 1973. Phytochemical methods. Chapman and Hall, London. Ivey, C.T., Martinez, P.And Wyatt. R.2003.Variation in pollinator effectiveness in Swamp milkweed, *Asclepias incarnata* (Apocynaceae). *American J Botany.* **90:** 214-225.

Kandori, I. 2002. Diverse visitors with various pollinator importance and temporal change in the important pollinators of Geranium thunbergii (Geraniaceae). *Ecological Research.* **17:** 283-294.

Meerabai, G. and Subba Reddi, C. 1984. Butterfly pollination in *Cadaba fruiticosa* (Capparidaceae). S.IV-05; Fourth Indian Palynological Conference. Department of Environ mental Sciences, Andhra University, Waltair-530003.

Mitchell, R. J., Irwin, R. E., Flanagan, R. J. and Karron, J. D. 2009. Ecology and evolution of plant- pollinator interactions. Annals of Botany. **103:** 1355-1363.

Morris, W. F., Hufbauer, R. A., Agrawal, A. A., Bever, J. D., Borowicz, V. A. and Olsen, K. M. 1997. Pollination effectiveness and pollinator importance in a population of *Heterotheca subaxillaris* (Asteraceae). *Oecologia.***109:** 114-121.

Pivnick, K. A. and Mc Neil, J. N. 1985. Effects of nectar concentrations on butterfly feeding; measured feeding rates for *Thymelicus lineola* (Lepidoptera: Hesperidae) and a general feeding model for adult Lepidoptera. *Oecologia.* **66:** 226-237.

Ratna, E. 1983. Foraging differences in bumble bees. *Annal's of Entomological Fenn.* **49:** 17-22.

Sahli, H. F. and Conner, J. K. 2007. Visitation, Effectiveness and Efficiency of 15 Genera of visitors to wild Radish, *Raphanus raphanistrum* (Brassicaceae). *American J. Botany.* **94(2):** 203-209.

Schemske, D. W. and Horvitz, C. C. 1984. Variation among floral visitors in pollination ability: a precondition for mutualism specialization. *Science.* **225:** 519-521.

Schmitt, J.1983. Flowering plant density and pollinator visitation in Senecio. *Oecologia.* **60:** 97-102.

Spears, E. E.1983. A direct measure of pollinator effectiveness. *Oecologia.* **57:** 196-199.

Sugden, E. A. 1986. Anthecology and pollinator efficacy of *Styrax officinale* subsp.*redivivum* (Styracaceae). *Am. J. Botany.* **73:** 919-930.

Traveset, A. and Saez, E. 1997. Pollination of *Euphorbia dendroides* by lizards and insects: Spatiotemporal variation in patterns of flower visitation. *Oecologia.* **111:** 241-248.

Vazquez, D. P., Morris, W. F. and Jordano, P. 2005. Interaction frequency as a surrogate for the total effect of animal mutualists on plants. *Ecology Letters.* **9:** 1088-1094.

Williams, N. M. and Thomson, J. D. 2003. Comparing pollinator quality of honey bees (Hymenoptera: Apidae) and native bees using pollen removal and deposition measures. In K. Stickler and J. H. Cane (Eds.) For nominative crops, whence pollinators of the futurel. Entomological Soc.of America, Lanham, Maryland, USA. pp.163-179.

Young, H. J., Duming Dan, W. and Von nasseln, K. W. 2007. Foraging behavior affects Pollen removal and deposition in *Impatiens capensis* (Balsaminaceae). *American J. of Botany.* **94(7):** 1267-1271.