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Research Article

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The Preference of Butterflies for Nectarine Food Plants

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ABSTRACT

Objectives: *This study surveys the nectarine food plants (NFPs) available at the butterfly sanctuary of the La Union Botanical Garden (LUBG) and evaluate their interaction with butterflies acting as pollinators.* ***Methodology:*** *A total of 158 butterfly species in 8 families were identified as to their preference for specific families of NFPs. The 77 NFPs were assessed in terms of abundance, diversity, butterfly visits, nectar production and its sugar compositions. Lengths of proboscis and pistils were correlated to nectar production as well.* ***Results:*** *In terms of abundance, diversity and density of butterfly visits, the families Rubiaceae and Asteraceae were the most predominant NFPs. This could be explained by high nectar productions in these families with sucrose being the most concentrated sugar. Among the pollinators, the families Danaidae, Nymphalidae and Papilionidae are the common denominators of all the NFPs of plants from the families Rubiaceae and Asteraceae. The plants Ixora sp., Cosmos sulphurreius and Chromolaena odorata are all pollinated by butterfly species distributed in 9 families. There appears to be a correlation between proboscis length (but not pistil length) and nectar production.* ***Conclusions:*** *This study was able to provide evidence on the preference of butterflies at LUBG for Rubiaceae and Asteraceae flowering NFPs.*

Key words: *butterfly, Nectar, NFPs, Asteraceae.*

INTRODUCTION

One of the primary factors influencing the surivival of butterflies are the relative territorial abundance of nectarine flowering plants. A study by Nacua *et al.*[1] shows that certain families of butterflies at the La Union Botanical Garden (LUBG) are highly dependent on specific nectarine plants. However, there was no report on the significant correlation between frequency or density of butterfly visits and the predominant families of nectarine plants found in 6 vegetation areas of LUBG, including the butterfly sanctuary. In a subsequent report, Nacua et al.[1a] reported that butterfly and nectarine food plant (NFP) species in LUBG are well correlated to their diversity and areal density and that these NFPs were highly represented by the families Rubiaceae and Asteraceae. This study seeks to gather evidence on the preference of butterflies for Rubiaceae and Asteraceae NFPs at LUBG.

MATERIALS AND METHODS

Plant and Butterfly Identification

A total of 77 plants, consisting of trees, shrubs herbs and woody vines, was collected at the butterfly sanctuary of LUBG from January to December of 2013. These flowering plants were identified as NFPs based on the average hourly butterfly visits within the observation period of 0800 to 1800 hours in both shaded and sunny areas of the butterfly sanctuary. There were 400 butterflies consisting of 158 species and sub species found. At any time of the day, the hourly butterfly visits were counted for each of the 77 NFPs.

The butterflies were identified based on the atlas of Baltazar[2]. Proboscis and pistil lengths were measured using a digital Vernier caliper of 0.01 mm accuracy.

Plant Identification

Herbarium specimens and photographs of the 77 plants in their natural habits were identified at the Philippine National Herbarium. The herbariums with official label were prepared according to the method of Lavoie[3]. Some of the plants were identified based on the gross morphological atlas of Quisumbing[4] and Madulid[5].

Nectar Collection and Sampling

Daily cumulative nectar production of the 77 NFPs was at the end of 1800 hours. Flowers were bagged in mosquito netting at bud stage to prevent visits from pollinators and mites. A set of at least 5 flowers were sampled and measured for nectar volume per flower by graduated Hamilton microliter syringes. Nectar sugar concentration per flower was quantified using an Atago refractometer[6].

Statistical Treatment

Replicate measurements are stated as mean ± standard error of the mean. Means were compared by 2-way analysis of variance (ANOVA) and the 90% confidence interval (CI). Correlation of data was carried out by linear regression analysis, Kruskal-Walis and chi-square.

RESULTS AND DISCUSSIONS

Plant Species Richness

The 77 NFPs were dominantly represented by the families Rubiaceae (n = 28; 36.4%), which includes several species of the genera *Morinda* and *Ixora,* and Asteraceae (n = 20; 26%). These were followed by Verbenaceae (n = 8; 10.4%), Apocynaceae (n = 8; 10.4%), Moraceae (n = 6, 7.8%), Anacardiaceae (n = 4; 5.2%) and Myrtaceae (n = 3; 3.9%).

Table 1 compares relative abundance of NFPs with diversity indices in both shaded and sunny areas of the butterfly sanctuary of LUBG. There is a higher correspondence in the plot between relative abundance and diversity indices of NFPs in the sunny area (r = 0.9543) than in the shaded area (r = 0.9324), although these do not yet reflect the actual quantity of butterfly visits. On the other hand, there is a high linearity between each pair of the 3 diversity indices (r > 0.95). These data indicates that diversity correlates well plant abundance and that the families Rubiaceae and Asteraceae are the most predominant in terms of species richness and diversity.

Table 1: Abundance of Nectarine Food Plants and Diversity in Two Vegetation Types of the Butterfly Sanctuary at the La Union Botanical Garden

Family	*Relative Abundance	Diversity Indices in the Shaded Area			Diversity Indices in the Sunny Area		
		Shannon	Dominance	Simpson	Shannon	Dominance	Simpson
Rubiaceae	32.30%	3.18	1.18	0.76	4.12	1.32	0.67
Asteraceae	27.40%	3.03	1.09	0.75	3.88	1.11	0.58
Verbenaceae	16.20%	2.88	0.96	0.58	3.39	1.01	0.51
Apocynaceae	11.70%	2.11	0.88	0.49	3.11	0.91	0.38
Moraceae	8.90%	1.97	0.76	0.37	2.87	0.79	0.27

*Percentage of the 372 plants inside the butterfly sanctuary

Table 2 compares hourly butterfly visits with mean cumulative nectar volume production among 7 families. The families Rubiaceae and Asteraceae contain the greatest concentrations of nectars. Nectarine volume is linearly correlated to the hourly density of butterfly visits (r = 0.98), reflecting plant - pollinator relationships and confirming the preference of butterflies for Rubiaceae and Asteraceae NFPs.

Table 2: Comparison of Butterfly Visits, Nectar Production and Sugar Composition Among 5 Families of Nectarine Food Plants

Family	No. of Butterfly Visits Per Hour	Mean Cumulative Nectar Volume	Nectar Sugar Concentration (% w/v)		
			Sucrose	Glucose	Fructose
Rubiaceae	98.7 ± 13.4*	134.6 ± 23.2 mcL*	47.3 ± 5.4	19.7 ± 3.3	13.2 ± 1.8*
Asteraceae	85.4 ± 11.2*	124.9 ± 18.7 mcL *	51.3 ± 6.5	15.3 ± 4.1	11.1 ± 2.1*
Verbenaceae	54.3 ± 8.8	67.4 ± 14.1 mcL	44.8 ± 4.9	15.8 ± 5.3	6.2 ± 3.2
Apocynaceae	47.9 ± 7.6	43.5 ± 8.7 mcL	41.2 ± 7.7	21.3 ± 2.7	3.8 ± 0.9
Moraceae	28.5 ± 8.1	33.2 ± 9.1 mcL	38.6 ± 8.3	20.1 ± 4.4	2.1 ± 0.7

*$p < 0.001$ vs. Verbenaceae, Apocynaceae and Moraceae by 2-way ANOVA and 2-tailed t-test; $p > 0.05$ between Rubiaceae and Asteraceae

The nectarine levels of sucrose and glucose are comparable among the 5 families ($p > 0.05$). Chi-squre analysis reveals that sucrose and glucose levels are not positively correlated with butterfly preferences for specific families of NFPs ($r < 0.5$). In contrast, there is a high correspondence between fructose levels and butterfly preference for NFPs ($r > 0.95$). The levels of fructose, being the sweetest sugar, are greatly concentrated only in Rubiaceae and Asteraceae NFPs which may explain for the high preference of butterflies for these 2 families[7]. The nectarine sugar levels in Rubiaceae and Asteraceae are even significantly higher ($p < 0.001$) than the sugar levels in *Hibiscus rosa-sinensis* L. which are abundantly found at LUBG. Previously, the foraging and phylogenetic experiments of Wolff and Liede-Schumann[8] and Baker and Baker[9] revealed the abundance of nectars in Rubiaceae and Asteraceae plants, respectively, with sucrose being cited as the most abundant sugar.

Table 3 shows the predominant NFPs in the families Rubiaceae and Asteraceae and the specific butterfly families which serve as pollinators. Two of these plants are endemic to the Philippines, namely: *Hedyotis apoensis* Elmer. and *Psychotria luzoniensis* F. Vill. (Figure 1)

Table 3: Checklist of Associated Butterfly Families for Dominant Rubiaceae and Asteraceae Nectarine Food Plants

Family	Most Abundant Species	Associated Butterfly Families (Initials*)							
		Dan.	Lib.	Lyc.	Nym.	Pap.	Pie.	Rio.	Sat.
Rubiaceae	*Morinda citrifolia* L.	+	-	-	+	+	-	-	-
	Ixora sp.	+	+	+	+	+	+	+	+
	Carphalea kirondon Bail.	+	+	-	+	+	+	+	-
	Pentas lanceolata Deflers	+	+	-	+	+	+	+	-
	Hedyotis apoensis Elmer.	+	+	-	+	+	+	+	-
	Psychotria luzoniensis F. Vill.	+	-	-	+	+	-	+	-
Asteraceae	*Cosmos sulphurreus* L.	+	+	-	+	+	+	+	+
	Helinathus annus L.	+	+	+	+	+	+	+	+
	Chromolaena odorata King	+	+	+	+	+	+	+	+
	Zinia elegans Jacq.	+	-	+	+	+	+	-	-
	Synedrella nodiflora Gaertn.	+	-	-	+	+	+	-	-

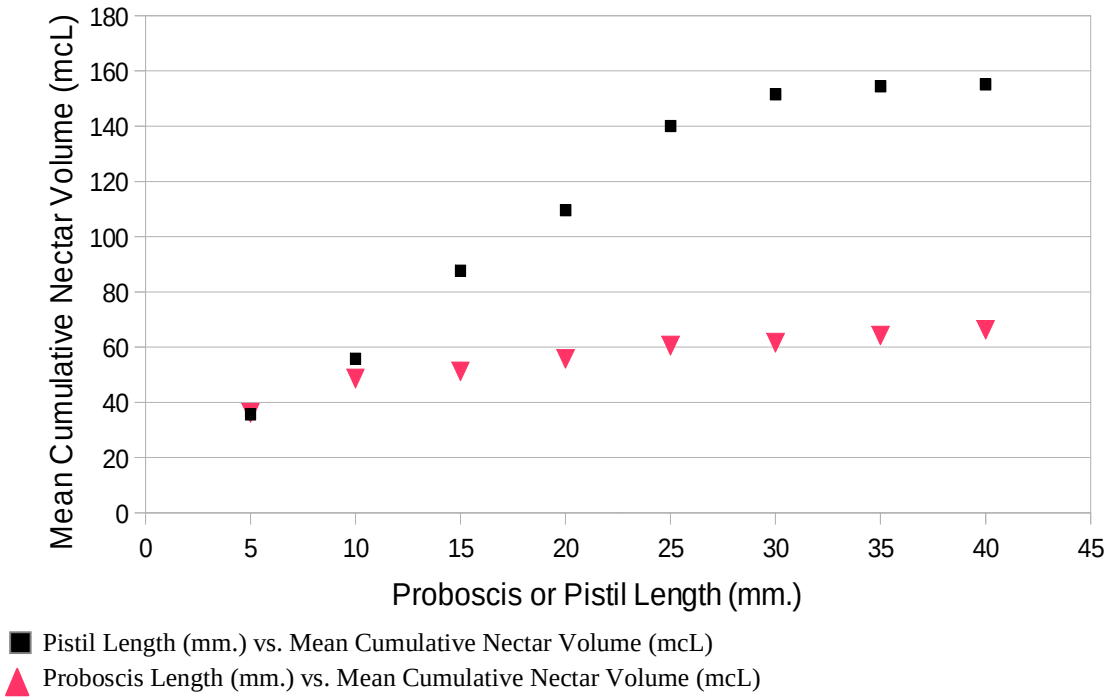
*D = Danaidae; LI = Libythidae; LY = Lycenidae; NYM = Nymphalidae; PA = Papilionidae; PI = Pieridae; R = Riodinidae; S = Satyridae

Fig.1: Endemic Rubiaceae Nectarine Food Plants: Hedyotis apoensis Elmer. (Left) and Psychotria luzoniensis F. Vill. (Right)

The predominance of butterflies from the families Danaidae, Nymphalidae and Papilionidae (as the common denominators of all the NFPs listed) at LUBG are due to their great mobility and speed which allows for their high survival rate as they are not easily attacked by predators and their adaptability to both forest and urban vegetations and even pollution[10]. At LUBG, it was observed that the abundance of nutritious host plants for their larva, the high humidity, warm climate and the presence of rotten fruits of *Mangifera indica* L. and *Diospyros philippinensis* Rolfe. highly attract these butterflies.

Ixora sp., *Cosmos sulphurreius* and *Chromolaena odorata* are all pollinated by species from the 8 butterfly families. This could be due not only to their abundnace but also to the high concentration of sugars in their nectars. Among the Rubiaceae plants, *Morinda citrifolia* is the least pollinated because of the characteristic noxious odor, taste and smell of the ripe fruits which attract the common fruit fly *Drosophila sechellia*[11]. Figure 2 shows the relationship between pistil/proboscis lengths against nectar production.

Fig. 2: Correlation Between Pistil/Proboscis Size to Nectar Production



There is a high correspondence ($r > 0.97$) between proboscis length and nectar production regardless of the species of NFPs or butterfly. However, pistil length do not correlate well with nectar production ($r < 0.5$). Convolution of Figure 1 does not show linear relationships between pistil and proboscis length in terms of nectar production. Similar to the findings of Stang *et al*.[12], this study shows that proboscis length greatly influences high nectar production which may be due to long-term adaptation in the interaction of NFPs and their pollinators.

CONCLUSIONS

This study proved that the 158 species of butterflies belonging to 8 families at LUBG prefer to pollinate NFPs belonging to the families Rubiaceae and Asteraceae on the basis of relative abundance, density of butterfly visits, diversity indices and nectar production.

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