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Foraging Strategies of Honeybees and Solitary Bees as Determined by Nectar Sugar Components*

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Nectar sugar composition of some subtropical cultivated crop plants revealed sucrose, glucose and fructose as the main components except in *Parkinsonia aculeata* L. and *Pongamia glabra* L. which contained traces of maltose also. Depending upon the main sugar constituents, nectars were categorised into sucrose-dominated, glucose-dominated and equi-proportioned sugars. Pollinating bees, *Apis dorsata* F., *Megachile cephalotes* Smith, *M. Lanata* Lepel and *Xylocopa fenesterata* F. visited sucrose-dominated nectars more frequently, while *Pithitis samaragdula* F. and *Apis florea* F. heavily relied on glucose-dominated flowers. The possible origin of maltose in *P. aculeata* and *P. glabra* as a contaminant of nectar was also traced.

Key Words: Nectar-sugar components, Sugar preferences, Pollinators

Introduction

Nectar is the chief source of energy and a major attractant for pollinators like bees, bumble bees and butterflies (Harborne 1982). Though the relevance of nectar-sugar constituents influencing bee-flower relationship has extensively been studied in the past (Wyke 1952, Sihag & Kapil 1983, Percival 1961), the studies are mainly concerned with honeybees. Sihag and Kapil (1983) found that *A. dorsata* with higher energy requirements visited sucrose-dominated flowers more frequently than did *A. florea* which mostly relied on glucose-dominated ones. Wyke (1952) reported that honeybees prefer equi-proportioned sugars. Waller (1972) and Abrol (1985) disputed Wyke's claim and stated that bees prefer nectar with one dominant sugar than the equi-proportioned sugars. But how far these nectar constituents influence the visit of solitary bees not been studied. The present investigation was conducted to assess the role of sugar constituents in nectar on the foraging preferences of both honeybees and wild solitary bees, and to trace the possible origin of maltose in nectars of *P. aculeata* and *P. glabra*.

Materials and Methods

Qualitative and Quantitative Analysis of Nectar Sugars

Samples of nectars were collected from the flowers with the help of fine glass capillary pipettes and immediately loaded on the chromatographic sheet (Whatmann No. 1. 55 × 45 cm) for qualitative analysis, as described by Partridge (1948), using

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n-Butanol, acetic acid and water (4:5:1) as the running solvent. The quantitative estimation of different sugars was done according to Johnson et al. (1964). The different components of sugar separated on the chromatograph were eluted by dissolving the spots in 80% ethanol. The extract of the respecttive sugars thus obtained was analysed quantitatively by the colorimetric method of Yamm and Wills (1954), using 0.2% anthrone dissolved in 70% sulphuric acid and recording O D at 620nm for sucrose and fructose land at 540nm for glucose with Spectronic 20.

Sampling of Bee Populations

The relative abundance of bees was assessed by the method of Kapil and Brar (1971) on different crops right from the commencement of flowering, till their population declined. For this purpose, five plots of 1 m size each were selected and the total number of bees of a species visiting such plots each hour was calculated. The data are based on the mean of five observations. The recorded data were analysed following Snedecor and Cochran (1967).

Results and Discussion

Sugar Composition of Nectars

Determination of sugar constituents in 12 cultivated crops revealed that sucrose, glucose and fructose were the main components except for traces of maltose in *P. aculeata* and *P. glabra*. The ratio of glucose/fructose was more than one in all the nectars. On the basis of sugar constituents present and their proportion, crop nectars may be grouped into three categories:

(i) Sucrose-dominated nectars e.g. *Cajanus cajan* L. and *Pongamia glabra* Vent.

(ii) Glucose-dominated nectars e.g. *Brassica* species, *C. sativum, F. vulgare, T. alexandrium, P. aculeata* and *M. sativa*.

(iii) Equi-proportioned glucose, fructose, sucrose nectars, e.g. *Luffa cylindrica*.

Table 1 *Sugar composition of nectars*

Species	Flowering period	Percentage of total sugars*				C-F Ratio	
		Gulcose	Fructose	Sucrose	Maltose	G/F ratio	F/G ratio
Compositae	Apr-Nay	42.75	31.50	25.75	0	1.35	0.73
Helianthus annuus L.							
Cucurbitaceae	Jul-Aug	33.30 ± 1.83	32.50 ± 2.41	34.20 ± 3.15	0	1.02	0.96
Luffa cylindrica L.							
Cruciferae	Nov-Dec	58.80	41.20	0	0	1.42	0.70
Brassica Campestris War toria							
B. Juncea	Dec-Jan	64.50 ± 1.75	35.50 ± 1.89	0	0	1.81	0.55
B. carinata	Feb-Mar	62.30 ± 1.95	37.20 ± 3.77	0	0	1.68	0.59
Leguminosae	Sept-Nov	27.16 ± 1.76	20.71 ± 3.50	51.53 ± 1.98	0	1.34	0.74
Cajanus cajan							
Trifolium alexandrium	Apr-May	43.50 ± 1.15	20.73 ± 1.83	35.80 ± 2.50	0	2.10	0.47
Parkinsonia aculeata	Apr-May	41.30 ± 1.81	31.40 ± 1.20	16.20 ± 2.10	8.12 ± 1.12	1.41	0.70
Pongamia glabra	May-Jun	31.60 ± 1.35	21.40 ± 1.74	38.50 ± 2.24	8.50 ± 0.51	1.47	0.67
Medicago sativa	Apr-Mat	38.76 ± 1.76	27.24 ± 2.89	34.00 ± 1.53	0	1.42	0.70
Umbelliferae	Jan-Feb	58.20 ± 3.55	31.50 ± 1.79	18.10 ± 1.09	0	2.45	0.54
Coriandrum sativum							
Foeniculum	Feb-Mar	54.50 ± 2.80	29.10 ± 1.89	16.40 ± 2.20	0	1.87	0.53

Table 2 *Relative attractiveness of bee pollinators to different crops blooming during different parts of the year*

Plant species	Flowering period	Dominant sugar	Bee Population/m² (x + S.E. n = 5)					
			Apis florea	A. dorsata	M. cephalotes	M. lanata	Xfene sterata	P.smarag dula
Cajanus Cajan	*Oct-Nov*	*S*	7.80±0.24	11.40±0.60	8.60±0.25	10.20±0.11	8.10±0.27	3.20±0.16
Brassica campestris	Nov-Dec	G	70.40±0.40	4.30±0.22	0	0	0	0
Var toria B. Juncea	Dec-Jan	G	25.40±0.80	2.20±0.42	0	0	0	0
Coriandrum satuium	Jan-Feb	G	25.40±0.84	2.20±0.15	0	0	0.60±0.01	0
Brassica carinata	Feb-Mar	G	13.80±0.27	3.40±0.11	0	0	0	0
Foeniculum vulgare	Feb-Mar	G	20.60±0.60	1.80±0.02	0	0	0.40±0.001	0
Cajanus cajan (Spring variety)	Mar-Apr	S	2.20±0.11	6.60±.28	7.40±0.80	11.80±0.24	5.80±0.11	1.20±0.03
Medicago sativa	Mar-Apr	G	15.20±0.44	12.20±0.30	6.40±0.22	4.20±0.10	2.20±0.10	5.70±0.12
Trifolium alexandrium	Apr-May	G	17.80±0.48	10.40±0.38	0	0.80±0.10	0.60±0.02	0
Parkin sonia aculeata	April	G	15.00±0.20	1.56±0.20	5.80±0.40	4.40±0.16	2.40±0.24	0.20±0.01
Helianthus annuus	May	G	22.80±0.84	15.40±0.46	10.40±0.30	15.20±0.40	18.20±0.82	17.80±0.60
Pongamia glabra	May	S	3.20±0 10	7.80±0.20	10.40±0.20	7.20±0.30	6.20±0.04	1.20±0.02
Luffa cylindrica	Jul-Aug	E	8.20±0.30	11.20±0.34	0	0	5.80±0.05	3.80±0.32

S, Sucrose dominated; G, Glucose dominate; E, Equi-proportioned

The glucose/fructose ratio was maximum in *C. sativum* and minimum in *L. cylindrica* whereas fructose/glucose ratio was maximum in *L. cylindrica* and minimum in *F. vulgare*. The percentage of sucrose was highest in *C. cajan* and lowest in *P. glabra*. In case of *Brassica* sp. sucrose was not detected. *B. Juncea* had maximum and *C. cajan* minimum glucose in their nectars. Similar results have earlier been reported by Jain and Kapil (1980), Sihag and Kapil (1983) and Abrol (1985). The presence of maltose would remain in doubt until evidence is available of the existence of a biochemical pathway for the synthesis of maltose in nectar yielding plants (Rowley 1976). Rowley (1976) believes that maltose is possibly synthesized in nectar itself.

Sugar Components and Caloric Rewards in Relation to Bee Flower Interaction

Occurrence of sucrose or glucose-dominant nectars indicates that the total caloric reward is an important factor for the foragers and determines their populations on a particular crop (table 2). We find that *A. dorsata, X. fenesterata, M. cephalotes* and *M. lanata* with higher energy requirements visited sucrose-dominated flowers, providing more caloric rewards, more frequently than *A. florea* and *Pithitis smaragdula*. The latter with relatively low energy (Abrol 1985) visited glucose-dominated crops like *Brassica* sp., *C. sativum, F. Vulgare, M. sativa, T. alexandrium* which provide low-caloric rewards. Wyke (1952) suggested that bees prefer more equiproportioned

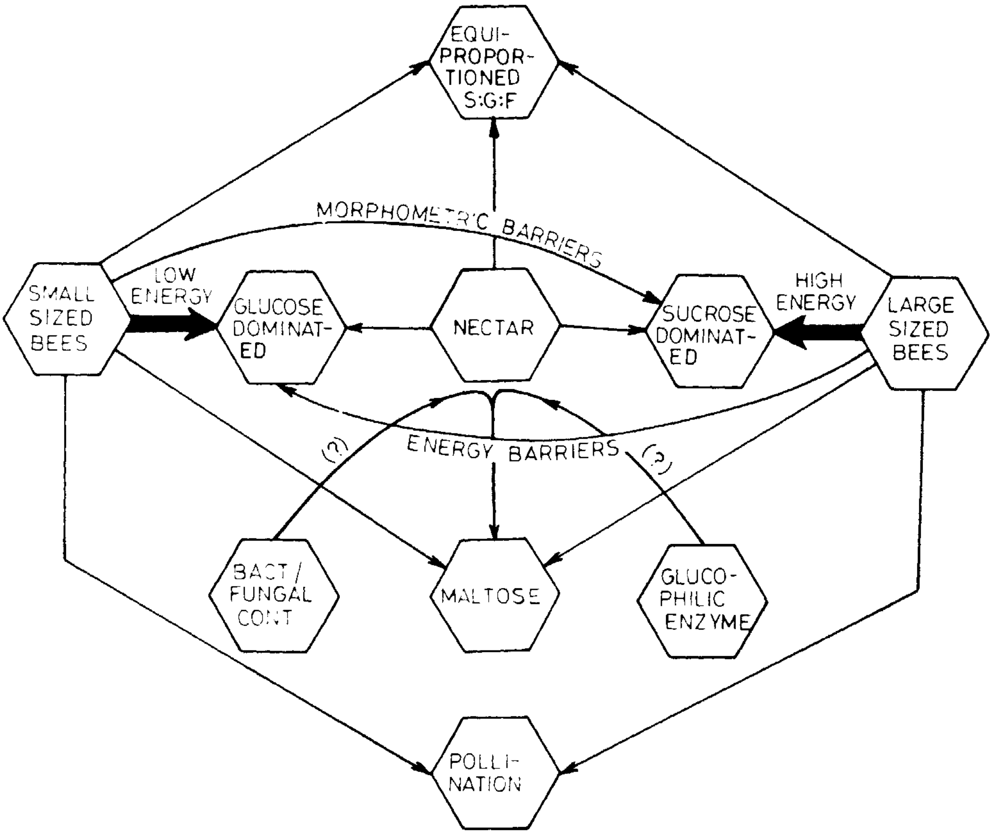

Figure 1 Schematic model exhibiting attractiveness of bees to different nectar-sugar components and the possible pathways for the synthesis of maltose

sugars, viz., glucose, fructose and sucrose than any other combination but neither Waller (1972) using behavioural responses, nor Whitehead and Larsen (1976) with their electrophsiological studies supported Wyke's results. Bachmann and Waller (1977) also did not support her contention. Our own results support the findings of Sihag and Kapil (1983) in which attraction of bees to nectars with one dominant sugar has been reported. In summary, the attractiveness of bees to nectar sugar components and possible origin of maltose may be represented by a schematic model (figure 1). Thus, the nectar offers great potential for further work and *Carbet* (1978) had pointed out "the dynamic complexity of nectar can be seen as just another technical obstacle to the assessment of the caloric rewards available for flower visitors, or it can be seen as a phenomenon worth studying in its own right, as a rich source of unanswered questions for zoologists and micrometrologists as well as for botanists and beekeepers".

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