

Preliminary Studies of the Composition of Some Indiana Nectars¹

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According to Bailey, Fieger and Oertel (1954), Bonnier (1878) was the first worker to make any extensive study of the influence of external factors upon nectar secretion. However, Park (1929) indicates that Planta (1886), in Switzerland, made the first accurate analyses of the composition of nectar when he determined the sugar content of fresh nectar from the flowers of four plants, all greenhouse or garden ornamentals:

<i>Fritillaria imperialis</i> (Crown imperial)	6.6%
<i>Tecoma radicans</i> (Trumpet creeper)	15.3%
<i>Protea mellifera</i>	17.1%
<i>Hoya carnosa</i> (Wax plant)	40.6%

Investigations by many workers indicate that the nectar of different flowers varies in the content of water, sugars, minerals, proteins and other substances (Eckert and Allinger, 1939). However, sugars comprise about 99 per cent of the solids in nectar (Caillas, 1926; Beutler, 1930), and the chief variation in the composition of nectar involves the relative amounts of sugars and water. Shuel and Pedersen (1952) have summarized the literature, showing that nectar yield and composition varies not only from plant species to species but also with such environmental factors as atmospheric pressure, sunlight, moisture, physical and chemical properties of the soil and temperature.

The influence of this variation in nectar yield and composition upon flower visitation by bees with the concomitant pollination resulting in seed or fruit production, was indicated by Vansell (1942): "bees shift their activities from blossoms of low concentrations to those with higher sugar concentrations, even within the course of a day." However, these shifts are tempered by the fidelity of bees to plant species and limited area, even to a single bush or an area of a few square yards, (Park 1949) and probably by preference for various sugars which occur in nectar (Wykes 1952) or for a particular type of flower structure.

The potential honey production within any area is determined by the composition of the nectar available and may be influenced by the habits of bees in their preference and constancy to a particular kind of flower, when because of inherent characteristic or environmental factors the sugar content of its nectar is low. Park (1949) has shown that it requires 262 calories of heat to evaporate one pound of water at 95° F., the approximate temperature of the bee hive, and that if all this energy were supplied by the colony 1/6 of a pound of honey would be consumed. However, Ribbands (1953) found "by feeding large quantities of concentrated and dilute syrup, that the evaporation of each

¹ Purdue University Agricultural Experiment Station Journal Paper No. 1365.

1 lb. surplus water involved the wastage of 4-5 oz. sugar." As honey is approximately $\frac{4}{5}$ sugar, this is the equivalent of $\frac{1}{3}$ or more of a pound of honey. Thus, the production of honey from nectar of 20 per cent sugar would require the bees to gather four pounds of nectar for each pound of honey produced. From this amount of nectar three pounds of water must be removed, requiring the use of a pound of honey for this process alone! The production of a pound of honey from nectar of 30 per cent sugar content requires the energy equivalent of $\frac{5}{9}$ of a pound of honey for the evaporation of water only, rendering it necessary for the bees to handle six pounds of nectar. It appears likely that the extra labor involved in the gathering of such a quantity requires enough extra energy that the bees are wasting their time and labor in gathering nectar of 30 per cent sugar content for honey production, and that the collection of nectar with less sugar consumes honey already in the hive or being produced from richer nectar coming into the hive simultaneously.

Because of the importance of the quantity and quality of available nectar both to honey production and the pollination of plant crops, research on nectar available for honey production in Indiana has been initiated. This research involves the study of the quantity and quality of nectar and the variation due to plant species and clone and environmental factors. Preliminary studies during the past summer have been confined to the determination of total sugar content of the nectar gathered by bees from plants in the open.

Comparatively few investigations of the sugar content of the nectar of plants comprising the honey flora have been reported. Vansell (1942) gave the average sugar concentrations of the nectar of 96 California and Oregon plants, "collected during a number of seasons and from many locations." These data are widely quoted, but the known variations in nectar composition due to environmental factors render them somewhat invalid for other areas.

The data summarized here were obtained from the examination of 2023 bees of which 1093 had gathered enough nectar to analyze by the use of a low range hand refractometer. Thirty-eight species of plants are included, with from one to 153 nectar samples. The bees were taken directly from flowers by means of a vacuum bottle, usually as part of a collection of all insects working the flowers. The insects were killed when the collection was completed by the substitution of a cork containing a vial loaded with sodium cyanide for the vacuum apparatus. The honey bees were separated from the other anthophilous insects and dissected for nectar analysis, either immediately or within a few hours. It was determined that no change occurred in the nectar carried by the bees for a considerable time (42 hours), by analyzing portions of collections over a period up to 24 hours, and finally after 18 and 42 hours. The collection from *Eupatorium altissimum* was divided and analyzed after 18 hours, showing a range of 34.5 to 50.0 with an average of 44.37 per cent sugar, and after 42 hours, with a range of 35.8 to 55.8, and an average of 44.94 per cent.

In making the analysis, a bee was dissected by grasping the thorax between the thumb and a finger of the left hand and the posterior

half of the abdomen between the thumb and finger of the right hand and pulling gently but steadily. The abdomen usually separated between two of the three anterior segments, exposing the honey sac attached to the anterior portion of the bee. The digestive tract usually broke just posterior to the proventriculus leaving the honey sac intact. The honey sac with its contents still undisturbed was removed and transferred to the surface of the prism of the refractometer by seizing the oesophagus just in front of the sac with a pair of forceps. After it was in place the sac was ruptured with a point of the forceps, or a dissecting needle. This permitted the nectar to flow onto the surface of the prism, after which the crumpled tissue of the honey sac and adhering oesophagus were removed, the cover of the refractometer closed and the reading taken immediately. Although the reading of the refractometer indicates total solids, the only corrections made were for temperature (taken directly from a correction thermometer mounted on the instrument), since sugar makes up almost 99 per cent of the solids in nectar.

Some of the bees collected from the flowers of all plant species sampled, except *Salix discolor* ("Pussy" willow), *Cucumis sativus* (Cucumber) and most collections from *Citrullus vulgaris* (Watermelon), contained enough nectar for analysis. However, the number without nectar varied from all in these collections to none in one collection from *Melilotus officinalis* (yellow sweet clover). No correlation between these numbers and the percentage of sugar, pollen collecting or other observed factor can be found.

For each collection the date, county, number of bees—collected and without nectar, and the range and average of the sugar content of nectar are given. The range within each collection may be due to inherent differences in clumps or individual plants, age of flowers, and other real factors rather than random variation. Individual samples obviously out of range, or of differently colored nectar, were not included in the calculations, but are indicated by footnotes. Four collections analyzed in 1957 are indicated by an asterisk (*) following the date.

TABLE I
Sugar concentrations of the nectars of some Indiana plants

Plant Species	Date	County	No. of bees total without nectar		Sugar content (percentages)		
					Low	High	Ave.
<i>Polygonum</i>							
<i>virginianum</i>	Oct. 3	Posey	48	18	45.3	56.3	51.3
<i>Polygonum</i> spp.	Aug. 27	Tippecanoe	16	11	37.1	46.6	42.0
	Sep. 4	"	20	4	44.2	61.7	55.9
	Sep. 7	"	11	4	53.7	64.7	59.9
	Sep. 9	Gibson	12	2	52.7	57.7	55.8
<i>Medicago sativa</i>	June 12	Marshall	32	2	20.6	30.1	25.2
	July 14	Gibson	23	12	16.8	22.3	20.0
<i>Melilotus alba</i>	June 7	Gibson	52	28	26.7	40.7	30.8
	June 18	"	58	30	15.0	22.0	18.8
	July 22	Marshall	50	5	18.7	27.2	22.5
	"	"	30	7 ¹	22.2	28.7	25.2
	Aug. 11	Vigo	53	33	11.5	19.5	14.2

Plant Species	Date	County	No. of bees total without nectar		Sugar content (percentages)		
					Low	High	Ave.
<i>Melilotus officinalis</i>	June 5	Posey	51	0	31.6	55.6	47.2
	June 7	Gibson	50	25	34.2	55.2	48.5
	June 12	Fulton	43	14	24.7	32.7	27.8
	"	Pulaski	51	31 ²	21.6	31.6	27.3
<i>Trifolium repens</i>	June 6	Gibson	16	11	39.4	50.4	45.2
	June 18	Vigo	55	21	39.0	50.0	45.6
	July 16	Greene	26	9 ³	30.1	36.6	34.5
	Aug. 11	Vigo	27	18 ⁴	37.0	43.0	39.6
	Sep. 9	Posey	29	13	49.3	59.8	55.1
<i>Trifolium hybridum</i>	Aug. 13	Sullivan	36	25	28.8	42.8	37.7
<i>Lotus corniculatus</i>	July 14	Gibson	54	16	11.3	19.3	13.8
		"	49	24 ⁵	12.3	22.8	14.9
		"	53	15	11.8	18.8	14.9
		"	63	11	14.3	23.8	17.2
<i>Lespedeza bicolor</i>	Sep. 23	Tippecanoe	2	1			49.0
<i>Althaea rosea</i>	Aug. 11	Parke	2	1			11.0
<i>Malva sylvestris</i>	Aug. 27	Tippecanoe	47	15	18.7	25.2	22.8
		"	4	3			32.7
<i>Hibiscus syriaca</i>	July 23	Tippecanoe	7	3	24.7	28.7	27.0
<i>Jussiaea diffusa</i>	Aug. 11	Vigo	52	35	29.5	40.5	34.9
	Aug. 13	"	8	6	27.3	31.8	29.6
<i>Asclepias tuberosa</i>	July 16	Greene	20	13	17.6	22.1	19.5
	July 22	Marshall	48	14	21.7	31.7	27.1
<i>Asclepias syriaca</i>	July 14	Parke	13	10	12.8	15.8	14.5
	July 16	Owen	16	8	13.6	22.1	18.9
	July 22	Marshall	8	6	21.6	29.6	25.6
	July 23	Tippecanoe	16	9 ⁶	18.6	23.1	20.7
	Aug. 11	Vigo	6	4	17.0	18.5	17.8
<i>Verbena stricta</i>	July 15	Gibson	27	15	19.2	22.7	21.6
<i>Marrubium vulgare</i>	July 23	Tippecanoe	3	2			21.1
<i>Nepeta cataria</i>	July 22	Marshall	6	4	26.6	29.1	27.9
<i>Pycnanthemum pilosum</i>	Aug. 27	Tippecanoe	7	0	19.1	24.6	21.7
	Sep. 7	"	3	0	42.2	47.2	45.2
<i>Mentha rotundifolia</i>	Aug. 27	Tippecanoe	44	23 ⁷	17.6	31.1	26.5
	Sep. 7	"	11	0 ⁸	43.2	56.2	49.9
	Sep. 24	"	32	9	13.7	35.2	23.7
<i>Cephalanthus occidentalis</i>	July 22	Marshall	16	8 ⁹	31.1	35.1	33.0
<i>Lonicera fragrantissima</i>	April 17	Tippecanoe	24	21	48.5	52.0	50.0
<i>Citrullus vulgaris</i>	June 18	Gibson	5	4			26.6
<i>Cucumis melo</i>	June 18	Gibson	19	5	28.4	41.4	32.7
	July 24*	Tippecanoe	12	8	31.0	34.5	32.3
	Aug. 13	Gibson	70	40 ¹⁰	23.8	37.8	31.6
<i>Eupatorium altissimum</i>	Sep. 8	Montgomery	89	52	34.5	50.8	44.6
<i>Solidago unilugulata</i>	Oct. 2	Putnam	12	4	37.8	43.8	40.9
<i>Solidago</i> sp.	Sep. 23	Tippecanoe	51	13	20.8	35.3	28.2
<i>Aster novae-angliae</i>	Sep. 23	Tippecanoe	37	22	17.8	22.8	20.3
	Oct. 1*	Allen	14	13			36.5
	Oct. 3	Posey	3	1	31.6	37.6	34.6

Plant Species	Date	County	No. of bees total without nectar		Sugar content (percentages)		
					Low	High	Ave.
<i>Aster ericoides</i>	Oct. 2	Daviess	5	2	34.6	40.6	38.1
	Oct. 3	Posey	29	14	41.3	51.3	47.5
		"	26	11	43.8	51.3	48.1
	Oct. 4	"	11	5	33.3	47.8	41.5
		"	7	5	40.3	52.3	46.3
<i>Aster</i> sp.	Oct. 1*	Allen	23	7	46.5	54.5	50.6
<i>Rudbeckia laciniata</i>	July 16	Greene	35	12 ¹¹	33.6	51.1	40.6
<i>Helianthus annuus</i>	Sep. 8	Knox	7	4	48.5	57.5	53.5
<i>Bidens ceruina</i>	Oct. 3	Posey	32	14	48.4	59.4	53.2
<i>Bidens coronata</i>	Sep. 8	Greene	24	3	44.4	61.9	55.7
<i>Centaurea cyanus</i>	June 6	Gibson	17	7	32.0	38.0	33.9
<i>Taraxacum</i> sp.	April 21	Tippecanoe	11	6	43.5	54.0	50.1
<i>Zinnia</i> sp.	July 23	Tippecanoe	14	10	16.5	19.5	18.0
	July 24*	"	12	8	20.5	26.0	22.5
	Aug. 5	"	11	4	18.5	25.5	21.3
<i>Tagetes</i> sp.	Sep. 22	Tippecanoe	2	1			26.5

Notes: Identifications of some plants were made by Professor A. T. Guard of the Department of Biological Sciences, Purdue University.

* Analyses made in 1957.

¹⁻¹¹ Excluded samples. ¹37.2%; ²16.1%; ³23.6%; ⁴19.5%, 22%, 23%, 61%; ⁵44.3%; ⁶32.6%; ⁷15.6%; ⁸6.2%, 7.7%; ⁹24.1%; ¹⁰21.8%, 48.3%; ¹¹17.6%, 24.6%.

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* Original paper not seen; quoted in another reference as indicated in text.