NECTAR CHARACTERISTICS AND PHENOLOGY OF SPRING BEE PLANTS IN NORTHWESTERN NEW YORK

E.E. SOUTHWICK and A.K. SOUTHWICK

Department of Biological Sciences, State University of New York, College at Brockport, Brockport, NY 14420 (U.S.A.)

(Accepted for publication 15 January 1986)

ABSTRACT


The sequence of blooming of nectar- and pollen-yielding spring plants in northwestern New York is reported. Seasonal progression and the importance of these species to honey bees (Apis mellifera), whether for nectar and/or pollen, is indicated and discussed. The nectar standing crop volume, sugar concentration and total sugar are reported for representatives of 9 plant families. The data show an average standing crop of nectar per flower of 0.7 µl at a concentration of 41% (g sugar 100 g nectar⁻¹) containing 0.33 mg sugar and providing 1.3 cal of energy.

INTRODUCTION

Honey bees (Apis mellifera L.) differ from wasps and other insects in their food habits because of their complete dependence on flowering plants for energy and protein foods. Bee plants have always interested hobby and commercial honey producers, and are an important consideration in pollination programs. Honey bees collect nectar and/or pollen from about 3,000 different plant species in the United States and Canada (Robinson and Oertel, 1975). Ninety percent of the honey comes from fewer than 100 plant species, and in any local region, most surplus honey is derived from fewer than a dozen species upon which bees forage most extensively (Morse, 1974; Robinson and Oertel, 1975).

The foraging activity of honey bees ultimately provides more than US$ 45 million in honey production annually in the United States. Their pollination activity contributes to the annual US$ 6 billion in agricultural crop production, and there are extensive but unknown pollination benefits to the natural flora (Southwick and Pimentel, 1981).

Several authors have identified the more important nectar and pollen plants utilized by bees (Mitchener, 1948; Free, 1970; Crane, 1975; Robinson...
and Oertel, 1975; McGregor, 1976; Lovell, 1977; Pellet, 1977). However, most of these references are general treatments and do not discuss local geographical regions where the plant species may be found, their flowering times, or their attractiveness and importance to honey bees. Pellet (1977) states that much work remains to be done before nectar resources of the country can be mapped with accuracy. Yet, nectar and pollen plants are being eliminated as land use pressures increase (Coleman, 1982).

Plant life is diversified and especially affected by regional climate and soil types (Barbour et al., 1976). As a result of this, sequence of blooming, nectar production and pollen presentation may be noticeably affected by local climatic conditions (Demuth, 1923; Shuel, 1975; Southwick and Southwick, 1983).

This paper describes the phenology and some characteristics of the nectar in spring blooming bee plants of western Monroe County in northwestern New York.
Fig. 1. Phenology of nectar- and pollen-yielding plants in northwestern New York (Monroe County). Start of flowering (left end of each horizontal bar) indicates the full opening (anthesis) of the first few buds, and end of flowering (right end of bar) marks the ceasing of the flowering process for that species.

MATERIALS AND METHODS

Plants flowering or about to flower during the months of March–June were located at sites on or near the Brockport College campus of the State University of New York (western Monroe County, 43°N 78°W). More than 3000 individual nectar samples were taken with 1–5 µl calibrated glass micro-pipettes using a mouth aspirator. Samples were analyzed in the field for volumes and sugar concentrations (sucrose equivalents). Volumes were taken from the columnar lengths within the constant bore micro-pipettes. Concentrations were determined on hand-held light refractometers that...
read directly in weight percent \((g\text{ sugar} \ 100\text{ g solution}^{-1})\). Sugar composition (sucrose, fructose and glucose) and other characteristics of nectar in some species, were determined and reported elsewhere (Southwick et al., 1981; Southwick, 1982, 1983; Southwick and Southwick, 1983). To determine the standing crop (the amount of nectar available in a flower), nectar was sampled from plants that were open to insects (i.e., not bagged to exclude nectar feeders).

From our direct observations and published data, we developed a species list for spring flowering plants yielding nectar and pollen, following the nomenclature of Gleason and Cronquist (1963). A key to spring flowering plants was used for a general check on flowering times (Muenscher and Petry, 1976).

RESULTS

Figure 1 indicates seasonal progression of flowering spring plants of northwestern New York yielding nectar and pollen and utilized by bees \((Apis mellifera)\). Hodges' (1978) calendar of the bee plants of the United Kingdom and the phenology list developed for bee plants in Finland by Ranta et al. (1981) served as models for this figure.

Most plants followed a near normal distribution of flowering and nectar and pollen production. Those plant species showing a normal distribution show a gradual rise to the peak production, followed by a gradual fall extending the blossoming time (e.g. \textit{Melilotus alba}, sweet clover). Another normally distributed blossoming pattern shows a sharper peak with a shorter season (\textit{Tilia} spp., basswood). Some species such as \textit{Taraxacum officinale} (dandelion), serve as major nectar and pollen resources early during their flowering seasons and quickly decrease to minor yield status after that (i.e., they show a left skewed frequency distribution). \textit{Medicago sativa} (alfalfa) and \textit{Trifolium pratense} (red clover), however, are of minor importance early in their blooming period, and only later do they become major nectar-yielding plants (i.e., show right skewed frequency distributions).

Figure 1, designates major and minor plants and portions of bloom periods by bar shading, but does not directly show frequency distributions or times of peak production. Most species, however, would have a peak near the midpoints of their bars. Major plants (indicated by solid bars) are important nectar sources for surplus honey production by honey bees. Minor plants (dotted bars) often provide nectar in small amounts when major plants are not in flower. Those plants providing pollen, but little or no nectar are indicated by dashed bars.

Samples of nectar were obtained from flowers open to nectar feeders, from which the standing crop for 9 plant species early in their flowering periods was determined. Data obtained from individual flowers actually containing nectar (i.e., excluding zero readings in the analyses) are summarized in Table I. Most open blossoms contained < 1.0 \(\mu L\) of nectar. The
TABLE I
Standing crop of nectar in spring flowers in northwestern New York

<table>
<thead>
<tr>
<th>Common name</th>
<th>Family</th>
<th>Species</th>
<th>Sample size</th>
<th>Volume flower⁻¹</th>
<th>Nectar concentration g sugar 100 g soln.⁻¹</th>
<th>Total sugar mg flower⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Rosaceae</td>
<td>Pyrus malus</td>
<td>311</td>
<td>1.1 ± 0.05⁺</td>
<td>19 ± 1.7⁺</td>
<td>0.23</td>
</tr>
<tr>
<td>Gill-over-the ground</td>
<td>Labiatae</td>
<td>Glecoma hederacea</td>
<td>805</td>
<td>0.3 ± 0.01</td>
<td>43 ± 0.9</td>
<td>0.16</td>
</tr>
<tr>
<td>White clover</td>
<td>Leguminosae</td>
<td>Trifolium repens</td>
<td>21</td>
<td>0.7 ± 0.09</td>
<td>35 ± 3.3</td>
<td>0.28</td>
</tr>
<tr>
<td>Mock orange</td>
<td>Saxifragaceae</td>
<td>Philadelphus spp.</td>
<td>289</td>
<td>1.2 ± 0.21</td>
<td>68 ± 1.7</td>
<td>1.09</td>
</tr>
<tr>
<td>Honeysuckle</td>
<td>Caprifoliaceae</td>
<td>Lonicera maackii</td>
<td>140</td>
<td>0.5 ± 0.04</td>
<td>35 ± 0.8</td>
<td>0.19</td>
</tr>
<tr>
<td>Milkweed</td>
<td>Asclepiadaceae</td>
<td>Asclepias syriaca</td>
<td>63</td>
<td>1.9 ± 0.20</td>
<td>32 ± 1.9</td>
<td>0.70</td>
</tr>
<tr>
<td>Vipers bugloss</td>
<td>Boraginaceae</td>
<td>Echium vulgare</td>
<td>31</td>
<td>0.2 ± 0.04</td>
<td>33 ± 2.4</td>
<td>0.07</td>
</tr>
<tr>
<td>Basswood</td>
<td>Tiliaceae</td>
<td>Tilia cordata</td>
<td>33</td>
<td>0.1 ± 0.02</td>
<td>61 ± 2.9</td>
<td>0.08</td>
</tr>
<tr>
<td>Butter and eggs</td>
<td>Scrophulariaceae</td>
<td>Linaria vulgaris</td>
<td>28</td>
<td>0.4 ± 0.05</td>
<td>39 ± 4.0</td>
<td>0.18</td>
</tr>
<tr>
<td>Overall unweighted mean</td>
<td></td>
<td></td>
<td></td>
<td>0.7 μl</td>
<td>41%</td>
<td>0.33 mg</td>
</tr>
</tbody>
</table>

⁺ Data presented as mean with standard error.

The greatest standing crop per blossom was found in *Philadelphus*, in which the large individual flowers averaged 1.2 μl nectar at a mean concentration of 68%, containing 1.09 mg sugar (4.3 cal of energy). The smallest mean volume available for nectar feeders was 0.1 μl containing only 0.08 mg sugar (0.3 cal) μl. Average volume, concentration and total sugar are shown in the table.

DISCUSSION

**Nectar standing crop**

Normally, nectar secretion begins at about anthesis and ceases after pollination (Shuel, 1975). Duration of flow is variable, even within a single species, and is affected by local climate, genetic and edaphic factors (Robinson and Oertel, 1975; Southwick et al., 1981; Southwick and Southwick, 1983). It is quite variable among species, with a single flower of one species producing nectar for only a day or less (e.g. cucumber *Cucumis sativus* (Collinson, 1973), or continuing for as long as 5–7 days in blossoms of alfalfa (*Medicago sativa*) (Pankiw and Boitlen, 1965).

For a plant to become valuable as an energy source or source of surplus food for pollinators, it must first be abundant in the vicinity of the latters' home ranges i.e., within about 2 km for honey bees, Southwick and Pimentel (1981). Secondly, the sugar concentration of the nectar must be high enough to provide the required energy; for example, the small standing crop found in *Tilia* (0.1 μl blossom⁻¹) provided little energy (0.3 cal) for bee flight to and from a nest site. Bee flight requires about 1.1 cal km⁻¹ (Southwick and Pimentel, 1981), so a bee could fly only about 0.3 km on the energy gained from a single flower. Assuming no other source of energy, it would...
need to visit at least 15 blossoms just to obtain enough flight energy for one round trip to a nest 2 km away. Thirdly, a good bee plant must display a large number of open blossoms that are accessible. Fourthly, nectar and/or pollen must be consistently available to the forager. This is particularly important for honey bees and other species of nectar feeders that show constancy in foraging activity. A fifth requirement for a good bee plant is that the sugar concentration of the nectar must be high enough to provide the required energy. Finally, the food supply must be coordinated with the dietary need and preferences of the feeders. Feeding preference has been shown to vary in honey bees according to colony needs. On hot days, for example, when the colony needs water for evaporative cooling of the hive, the colony only accepts diluted nectar or water from returning foragers. Those field bees with concentrated nectar loads must wait until the colony preference changes (Vansell, 1952). Any plant species fulfilling all of these requirements would be considered a major honey plant.

This classification of major and minor nectar and pollen plants cannot be rigid, because the relative roles of plants change under different conditions. Many investigators have found great variations among the first dates of flowering from year to year (Taylor, 1969; Hodges, 1978; Macior, 1978; Käpylä and Niemala, 1979). We found that cool weather conditions seemed to extend or delay the blooming periods of vernal herbaceous flowering plants, with hot weather shortening the period. However, each year, plants flowered and produced nectar and pollen in the same sequential order. This has also been found in other phenological studies by Hodges (1978) in the United Kingdom, and Macior (1978) and Taylor (1969) in the United States. In addition, the skewness of the distribution of flowering and nectar presentation was characteristic of individual species. Such temporal flowering curves provide for overlapping resource availability that may be adaptive to both the plant and the pollinator. A discussion of this aspect of flowering phenology is found in Ranta et al. (1981), Schemske et al. (1978) and Thomson (1980).

**Phenology**

Monroe county, is located approximately mid-way along the southern shore of Lake Ontario in western New York State. The lake, being deep and remaining unfrozen most winters, plays an important role in determining the climate of this area. As a result of the effect of the nearby large, cold lake, spring temperatures remain low and postpone vegetative development, giving protection to early bloomers from frost damage. This lake effect not only affects the wildflowers, but makes the area ideal for growing apples, pears, peaches, sweet and sour cherries and vegetables, as well as many shrubs and ornamentals. Although it is not the best region of the state for honey production, several commercial beekeepers and numerous amateurs maintain over 4,000 colonies of honey bees in the area.

The flowering sequence was found to be similar to the seasonal progres-
sion of pollen collection by *Apis mellifera* reported in southern Ontario, Canada by Adams et al. (1979).

The minor nectar plants such as *Fragaria virginiana*, *Robina pseusoacacia* and *Linaria vulgaris*, often supplement the pollen and nectar needs of pollinators during off periods of the major sources. These plants may be good producers but are rare in the area. Minor plants enable pollinators, like *A. mellifera*, to maintain themselves and their larvae by stimulating brood rearing, thus providing stronger bee colonies that gather more surplus honey (Morse, 1974; Pellet, 1977).

Many of the plants that serve as major nectar and pollen sources for honey bees are introduced species. Morse (1974) states that over half of the nectar plants in the United States utilized by honey bees are exotic species. The changing patterns of agriculture have increased the importance of introduced and native weed species for providing nectar and pollen to foraging insects. Today, about half of the honey produced is from weed plants or plants growing in fallow fields in early stages of succession (Morse, 1975). The remaining half comes from bees pollinating commercial crops.

The nectar available in any patch containing several species of flowering plants is maintained by the temporal distribution of flowering between and within species (Southwick and Southwick, 1983). A number of plant species with blossoming peaks occurring close together provide great reward with a dearth of nectar between peaks. The attractiveness of a patch with many plants bearing small blossoms each yielding a small volume of nectar can be as great or greater than that of a patch with few blossoms containing copious amounts of nectar. However, a reasonably sustained presentation of nectar is required by many nectar seekers. In North Temperate regions, for example, *Apis mellifera*, needs adequate forage over extended periods in order to hoard enough to carry it over the flowerless, cold winters. Only the surplus of stored honey can be harvested by man.

ACKNOWLEDGEMENTS

We are grateful for financial support from the Research Foundation of the State University of New York and the Andrew W. Mellon Foundation. We thank H.D. Hammond of the New York Botanical garden for reading and commenting on the manuscript and N. Frisch of SUNY Brockport for composing the figure.

NOTE ADDED IN PROOF

A simplified phenology and management recommendation chart for beekeeping in upstate New York is available on request from the authors.

REFERENCES


