Eva Crane Trust

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On the scientific front

Sugars poisonous to bees

The report about dead bees under lime trees in 1977 *Bee World* (pages 129-130) created much interest and comment. Several readers have sent publications that provide further evidence on the toxicity of various sugars to bees; I am especially indebted to Dr. R. J. Barker, some of whose work is referred to below.

The explanation given by Sols[7], of the mechanism by which mannose poisons bees, has been refuted by two other authors. Van Handel[18] found that worker honeybees metabolized mannose much more slowly (not more quickly) than glucose, and that mannose did not inhibit the metabolism of glucose, or vice versa. (Honeybees paralysed by mannose continued to metabolize until almost all the mannose was oxidized.) Arnold and his colleagues[10] explained the toxic effect of mannose by the reduction of the concentration of adenosine triphosphate which results from the failure of mannose-6-phosphate to inhibit the hexokinase, an inability which seems to be due to the bees' strictly carbohydrate-adapted metabolism. But Zucoloto[19], who fed various mixtures of mannose and glucose to live bees, agrees with Sols[7] that the toxicity of mannose to the honeybee is due to an enzymic competition for phospho-glucoseisomerase between mannose-6-phosphate and glucose-6-phosphate.

In a study of 13 sugars from the view points of acceptability, nutritive value, and toxicity to bees, Barker and Lehner[13] obtained some complex results; "acceptance was correlated with survival, but whether low acceptance is a consequence or a cause of mortality was not established". Mannose, galactose and arabinose, which show similarities in chemical structure, were all toxic: bees fed on them died more quickly than bees fed similar amounts of other sugars. Galactose (but not mannose) was identified in the exudate of stigmas of Darwin tulips, flowers in which dead bees had been found, although their death had previously been attributed to mannose[2].

In experiments[12] on carbohydrates that occur in pollen substitutes, Barker found that a number of sugars were toxic when fed to caged bees, but that these sugars could be diluted to a safe level with sucrose. He suggests that the other sugars in nectar may well dilute the toxic sugars that occur in pollens. The toxic sugars were galactose, lactose, raffinose and stachyose; other toxic carbohydrates were glucuronic, galacturonic and polygalacturonic acids and pectin.

In commercial sugar used for feeding to bees, also, a small percentage of toxic sugars can be tolerated (by the bees, and thus by the beekeeper buying the sugar) if they are sufficiently diluted with sucrose[13]. These sugars include melibiose and xylose. Melezitose is not toxic to bees in normal circumstances.

The above comments relate to the toxicology of sugars. Botanical problems are also raised: which of the *Tilia* species do upon occasion kill bees, and to what extent can the species even be distinguished? A recent study on their pollination biology in North America[9] makes the point that the flower characteristics are so similar in some species of limes that they cannot be used for identification purposes; moreover the difficulty that students of botany have in recognizing species may well be shared by the pollinating insects, and the resultant inconsistency of the pollinators can explain in part the blurring of species boundaries. Bees were the commonest day-time visitors and pollinators of the species studied—*T. americana* (basswood), *T. cordata* and *T.*

platyphyllos—but 43 species in 23 non-bee families were also recorded. Night was as busy as daytime, and in Nebraska (although not in Connecticut) the nocturnal pollinators were the more effective ones—inflorescences accessible to insects only at night set more seed than those accessible only by day. Each tree produces a quantity of flowers, and nectar and pollen are abundant and easily available. Most nectar is produced during the second and third days a flower is open, and droplets of nectar are produced in the sepal bases in quantities large enough to be seen and tasted.

C. I. Carter, a Forestry Commission Entomologist in the south of England[15], has now started to collect records of incidents of apparent poisoning of bees by limes. He asks readers to send details, including a sample of dead bees, to him at the Forestry Commission Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, England.

It seems important that the *Tilia* species and hybrids should be reassessed from the point of view of their desirability as bee forage, so that better guidance can be given about what to plant. The species offered for sale in the future may be partly influenced by their ease of propagation, which is being investigated at East Malling Research Station[16] (see their 1977 Annual Report).

The *Pharmaceutical Journal*[17] raises a query of a different sort in response to the *Bee World* article: why is it that there seems to be no record of bee poisoning by limes in the fairly extensive beekeeping literature of classical times? "Pliny tells us that the Italian vineyards north of the Po were planted with lime, generally taken to have been *T. tomentosa*, among other kinds of tree. He says further that "the best kind [of honey] and that least stained with the foliage, is sucked from the leaves of the oak and lime, and of reeds". Both he and Threophrastus assert that the lime is remarkable in that no animal will eat its fruit, although its leaves are enjoyed by many. Virgil, in his *Eclogues*, remarks that the yews of Corsica are particularly injurious to bees, but even his fourth *Georgic*, almost given over to bee lore, contains no mention of ill effects from lime trees."

References

References 1-8 are detailed in *Bee World* 1977 (p. 130).

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