BROOD REARING AND FOOD CONSUMPTION BY HONEYBEE COLONIES FED POLLEN SUBSTITUTES SUPPLEMENTED WITH STARCH-ENCAPSULATED POLLEN EXTRACTS

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Summary

The whole lipid fraction of fresh bee-collected pollen was encapsulated in a starch polymer and added to a whey-yeast pollen substitute. Honeybee colonies fed pollen substitute supplemented with 2, 4, 6 or 8% (dry weight) of the lipid reared significantly more brood to the sealed stage than did colonies fed the substitute without lipid. Colonies fed 2 or 4% lipid reared as much brood as colonies fed pollen. Addition of the starch-coated pollen lipid to the pollen substitute also improved its consumption, but not in proportion to the improvement in brood production; thus the pollen lipid may have influenced brood production directly as well as by increasing protein intake.

Introduction

One of the current possibilities of improving the efficiency of beekeeping may lie in the development of an effective pollen substitute with which to feed colonies during periods of pollen dearth when much is needed, such as the early spring when colonies rear brood well before natural pollen is available. Honeybees (Apis mellifera) usually prefer pollen to pollen substitutes, probably more because of attractant substances in the pollen than because it contains more nutrients than the substitutes do.

Many people have tried to isolate and identify the attractants in fresh pollen. Classes of compounds identified, and sometimes apparently shown to be attractive, include sterols, vitamins (inositol), growth regulators, plant pigments and long-chain fatty acids.

Most of these substances have been isolated from fractions extracted with lipid solvents, or from the whole lipid fraction of pollen (Taber, 1963; Robinson & Nation, 1966, 1968; Doull, 1974). Particular substances that have been identified and claimed to be attractive include 24-methylene cholesterol (Hugel, 1962), a carotenoid ester and (2E, 9Z, 12Z), 2,9,12-octadec trienoic acid (Lepage & Boch, 1968; Hopkins et al., 1969; Starratt & Boch, 1971), and gibberellic acid (Nation & Robinson, 1966, 1968).

Pollen substitutes are often made attractive by adding bee-collected pollen to them, but this may perhaps carry some risk of transmitting pathogens from the collecting bees to the recipient ones. The possibility could be avoided by using attractive extracts of pollen instead of whole pollen; we now report our efforts to do this successfully.

Many pesticides have been successfully encapsulated in a starch matrix (Shasha et al., 1976; Doane et al., 1977; Shasha, 1978). Encapsulating a pesticide retards its loss or degradation in the field, and the same principles may apply to encapsulated pollen fractions, so we have made and tested some.

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Materials and Methods

Fresh bee-collected pollen (50 g) was homogenized in a Virtis 45R blender with methanol (40 ml) for 5 min. The methanol extract was added to a separating funnel with 80 ml of chloroform, and the separation was completed by the addition of an equal volume of water (120 ml). The chloroform layer was then collected and air dried.

The starch encapsulation of pollen lipid was by a modification of procedures used by Shasha (1978) for the encapsulation of pesticide. Corn starch was slurried in water and mixed with carbon disulphide followed by sodium hydroxide dissolved in water. Gelation occurred immediately, and the mixture was allowed to stand for 2 h, after which 20 g of dry pollen lipid was added to 100 g of it. The pH was adjusted with 4·25 ml of acetic acid, and 2·25 ml of 30% hydrogen peroxide was added to cross-link xanthate to xanthide by oxidation. After air drying for 24 h the mixture was homogenized in a WaringR Blender and added to a whey-yeast pollen substitute.

The final mixtures were made to contain 0, 2, 4, 6 or 8% dry weight of lipid. Each mixture was adjusted to 23% protein by adding 69·7 g of it to 130·3 g of sucrose. Enough water was then added to make a moist patty. For each of the five mixtures and one similar mixture of fresh bee-collected pollen, we used 4 colonies of bees; 50 g of each mixture was placed in a plastic petri-dish lid (15 x 100 mm) that was inverted over the top-bars of a hive. Each test colony comprised 400 g of newly emerged ‘Italian’ bees (ca. 4000 bees) and a mated, laying queen, and was in a small hive with 5 empty combs, each 3 x 16 x 24 cm. Each colony was placed in a separate screen flight cage 2 x 2 x 2 m. Both protein food and 50% w/v sucrose solution were offered ad libitum, and after successive intervals of one week the protein food was weighed and replaced with fresh material. When the first sealed brood appeared the number of sealed cells was estimated weekly with a squared grid.

Results and Discussion

Bees fed the whey-yeast food mixed with starch-encapsulated pollen lipids produced significantly more sealed brood than bees fed the same food without pollen lipids (Table 1). Bees fed either 2% or 4% pollen lipids reared as much sealed brood as bees fed pollen, and 2-3 times as much as bees fed food without pollen lipids. Bees fed 8% pollen lipids reared only twice as much brood as bees fed without pollen lipids.

Table 1. Amount of sealed brood produced (cm²) and consumption of protein food (g/week) by caged honeybees fed whey-yeast pollen substitutes to which various proportions of pollen lipid were added.

<table>
<thead>
<tr>
<th>Pollen given</th>
<th>Sealed brood</th>
<th>Food consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollen substitute plus:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% pollen lipid</td>
<td>776 ± 176 c</td>
<td>550 ± 45 e</td>
</tr>
<tr>
<td>2% pollen lipid</td>
<td>1833 ± 66 a</td>
<td>808 ± 39 b</td>
</tr>
<tr>
<td>4% pollen lipid</td>
<td>1795 ± 24 a</td>
<td>805 ± 31 bc</td>
</tr>
<tr>
<td>6% pollen lipid</td>
<td>1363 ± 31 b</td>
<td>676 ± 37 d</td>
</tr>
<tr>
<td>8% pollen lipid</td>
<td>1479 ± 121 b</td>
<td>715 ± 47 cd</td>
</tr>
<tr>
<td>Pollen</td>
<td>1922 ± 68 a</td>
<td>909 ± 30 a</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter do not differ significantly (Duncan’s multiple range test).
As in the previous experiment with colonies in flight cages (Herbert & Shimanuki, 1978b), brood production peaked early in the experiment and then gradually declined. Sealed brood at the first measurement was highest for bees fed 2% lipid. The area of sealed brood increased steadily and peaked at week 9 and then gradually declined; at the end of the test (week 12), however, the mean brood area was still 95 cm², which was second only to the area for colonies fed pollen. For bees with 0, 4, 6, 8% lipid, brood area was highest during week 6, and then declined gradually. Only bees fed 0% lipid had produced no sealed brood by the first week when the others had it; their brood averaged only 32 cm² one week later. Bees fed pollen had produced only a few sealed cells by the first week when other colonies had some, but these colonies contained the most brood (mean of 169 cm²) at the end of the experiment.

Consumption of protein food was generally high early in the experiment and then declined gradually. Pollen was most eaten, followed in order by 2, 4, 6, 8, 0% pollen lipid. Lipid levels of 2 and 4% are similar to those in fresh bee-collected pollen (Herbert & Shimanuki, 1978a), so 6 and 8% may have been distasteful because they were excessive. Free bees, however, do collect pollens that vary widely in fat content (Standifer, 1966).

The amount of brood reared with the pollen substitute without pollen lipid was proportionately less relative to consumption than the amount reared with pollen lipid added or contained in pollen. This suggests that the pollen lipid directly increased brood rearing to some extent, either by sensory stimulation or by meeting a nutritional requirement.

Starch is a good raw material for encapsulation because it is harmless, readily available and costs relatively little; it is thus gratifying that the addition of starch-encapsulated attractants to pollen substitutes shows much promise. The unlikelihood that this method will transmit fungal pathogens from pollen-collecting to recipient bees was verified by showing that chloroform extracts of pollen containing chalkbrood mummies did not produce colonies of *Ascospaera apis* on potato-dextrose agar containing 0-1% yeast extract.

The method of encapsulation could be modified to increase or decrease the release rate if either would be useful. This might be done by varying the amount of water in the mixture, since the attractant is released as moisture penetrates the starch coating. The release rate could also be lowered by adding latex or polyvinyl chloride to the starch xanthate.

We hope to compare the effects of optimum levels of lipid in encapsulated and un-encapsulated form. It may be possible to find ways of making attractive some pollen substitutes that have hitherto proved unattractive. It may even be possible to make some substitutes as attractive as fresh pollen, and so perhaps as nutritive.

References


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