Longevity of Laboratory-Reared Boll Weevils (Coleoptera: Curculionidae) Offered Honey Bee-Collected Pollen and Plants Unrelated to Cotton[1]

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ABSTRACT Understanding the ability of the boll weevil to survive on plants other than cotton is important in understanding how to control or eradicate this pest. Laboratory-reared adult boll weevils, *Anthonomus grandis* Boheman, were given a variety of foods. When honey bee-collected pollen and water was offered, 78.9% survived for 10 days, 56.7% survived for 15 days, and 13.5% survived for 35 days. When weevils were fed a diet of 1.0% pollen + 1.0% sucrose, 76.7% survived for 10 days and 20% survived for 15 days. Due to high mortality this test was discontinued after 15 days. Decreasing the concentration of sugar and pollen in the diet to 1.0% or less resulted in significantly increased mortality. Boll weevils offered nine plant species common to northeast Mississippi lived as long as 8-16 days. Weevils survived longest on primrose, *Oenothera speciosa* Nuttall; sow thistle, *Sonchus asper* L.; and dandelion, *Taraxacum officinale* Weber because of pollen and seed heads present in the flowers which were not found in the other species tested. Weevils survived twice as long on unadulterated pollen plus water compared with the best plant species tested on low doses (1.0%) of pollen plus sucrose.

KEY WORDS *Anthonomus grandis* Boheman, pollen, sucrose, non-cotton plants, survival, feeding.

The boll weevil, *Anthonomus grandis* Boheman (Coleoptera: Curculionidae), was once considered monophagous on cotton (Riley 1885) feeding on flower buds, bolls, and terminal growth. The number of malvaceous plants found to be suitable hosts has increased considerably since then. The four genera closely related to each other within Malvacea (*Gossypium, Cienfuegosia, Thespesia,* and *Hampea*) include all the principal reproductive hosts of the boll weevil (Cross et al. 1975). Other Malvacea hosts which are used for food only include: *Sphaeralcea lindhindheimeri* Gray, *S. phaeralcae emoryi* Torr., *S. phaeralcea coulteri* (Wats.) Gray, *Callirhoe involucrata* (Nutt. ex Torr. and Gray) Gray; *Althea rosea* (L.) Cav.; *Hibiscus lasiocarpus* Cav.; (Stoner 1968) (Gaines 1933).

This research was conducted to determine boll weevil survivability on plants or plant products unrelated to cotton. McKibben et al. (1989) found that boll weevils have a decided preference for the fruit of the plant, feeding very little on leaves, stalk, or petioles when cotton is squaring. Later, Haynes (unpublished data) found that if squares are not available on the plant they can survive on cotton leaves for 2 weeks. In another study related to weevil survivability, Hardee (1970) demonstrated that laboratory boll weevils can live for several

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weeks on one of the following diets: bananas, peaches, string beans, okra, and squash. Adult male weevils were even able to produce some pheromone while feeding on these plants unrelated to cotton.

Generally, it has been considered that feral boll weevils emerging from overwintering sites during April and May may not live long enough to infest the new cotton crop (Bariola et al. 1984) beginning in the middle of June, so little concern has been given to these weevils. However, the literature is not conclusive as to whether boll weevils could survive a few weeks on wild plants found growing in early spring until cotton is fruiting. This study was conducted to investigate the ability of laboratory boll weevils to survive on one or more wild plants, sugars, and/or pollens common to the north Mississippi area. If mass-reared laboratory weevils could survive on these foods available in the spring, feral weevils emerging two to five weeks before cotton squaring may also survive on these foods and later infest the crop.

Materials and Methods

Three experiments were conducted with boll weevils by offering them various plant products, other than cotton, and determining their length of survival. Feeding was not quantitatively determined, but extensive consumption of flower heads and lesser amounts of feeding on leaves was evident when fresh plants were provided daily. Laboratory weevils were used in these studies because their age was known unlike that of feral weevils which vary in the field. The age of the weevil had to be known to collect meaningful mortality data.

In the first experiment, three groups of 10 unsexed, newly-emerged boll weevils, obtained from the Robert T. Gast Rearing Laboratory at Mississippi State, MS, were held in 500 ml beakers with plastic screen covers. One group of weevils was offered 100% honey bee-collected pollen once a day in a 1 × 1 cm container. Each container held approximately 0.15 gm of pollen. Water was provided twice a day in another 1 × 1 cm container. A second group of weevils was offered only water, in a bottle cap, twice a day. The third group of weevils received 2-3 standard diet plugs once a day. Each plug containing ca 6-7% protein was coated with wax (Lindig et al. 1979). Since water was the primary ingredient in the artificial diet, no extra water was provided. Mortality in each of the three groups was recorded every morning for 45 days after the test began or all the weevils died. The test was replicated six times.

In the second experiment, 10 groups of weevils were offered various levels and combinations of protein and carbohydrate to determine survivability. Two groups of weevils were offered agar pellets containing 0.25% or 1.0% protein. The protein content of this pollen may have been as high as 25.0%. Sucrose, which in nature is a readily available carbohydrate source, was offered in agar pellets to two groups of weevils at concentrations of 0.25% or 1.0%. An aqueous solution containing 3.0% of agar (alone) was provided to one group of weevils. Another group of weevils was given the usual artificial boll weevil diet containing 5.0-6.0% sucrose (Lindig et al. 1979), and served as the control. Agar pellets containing 0.25% or 1.0% protein plus 0.25% or 1.0% sugar were offered to four groups of weevils. An aqueous solution containing 3.0% agar was used in formulating the pollen and sucrose diets in this test. The agar was dissolved in boiling water for 1 to 2 min. Pollen and/or sucrose was added to the slightly cooled mixture and poured into a mold forming the pellets. After cooling, the pellets were coated with hot wax to prevent desiccation. Each of the 10 groups of 10 unsexed weevils were held in 7.3 × 7.3 × 2.9 cm plastic boxes provided with a screen air hole. Fresh diet was provided daily, and old unused diet pellets were removed. Mortality counts were mated daily for 15 days after initiation or until all weevils died. The test, including the control, was replicated eight times.

In the third experiment, plant cuttings from nine species were tested to determine the boll weevil's ability to survive on commonly occurring non-cotton species. Those plant species selected were: Bermuda-grass, *Cynodon dactylon* (L.); crabgrass, *Digitaria sanguinalis* (L.); Johnson grass, *Sorghum halepense* (L.); white Dutch clover, *Trifolium repens* (L.); wild garlic, *Allium vineale* (L.); wild carrot, *Daucus carota* (L.); dandelion, *Taraxacum officinale* Weber; primrose, *Oenothera speciosa* Nuttall; and sow thistle, *Sonchus asper* (L.). Individual cuttings from these species were collected at random in north Mississippi in April and May, which is a period of time when fruiting cotton is unavailable to the weevil.

Eight replicates of each host plant were exposed to 10 unsexed weevils in 1,000 ml beakers provided with screen tops. The host plant included flower and/or seed heads as well as leaves and stems. The grasses collected were not mature at the time, and only leaves and stems were provided. The plant cutting was held in a 5.5 cm (high) × 1.5 cm (diam) bottle filled with water to keep the plants fresh. Dry "rolled" cotton fiber was stuffed around each plant to keep the weevils from getting inside the bottle and drowning. The bottle containing the plant cutting was placed inside the 1,000 ml beaker. Fresh plant cuttings were added every 2-3 days. A 1 × 1 cm (diam.) container of water was placed inside each beaker and refilled twice daily. Mortality was recorded each morning until all weevils had died.

Data were statistically analyzed as a three factorial design using an analysis of variance (ANOVA) (Cochran and Cox 1957). The mean mortalities of weevils offered all the various types of diets in these three experiments were compared with each other and with means of the controls using the least significant differences test (LSD; $P = 0.05$).

Results

First Experiment (Table 1). After five days, boll weevils offered only water had significantly greater mortality (66.6%) as compared with weevils offered 100% bee-collected pollen (10.0%) or the normal adult diet pellets (3.3%). In a similar study, Hardee (1970) found that most of the laboratory weevils only lived 3 days when offered only water while feral boll weevils lived 40% longer. Weevils provided 100% pollen plus water after 15 days had less mortality than weevils offered only water for 5 days. On a diet of pollen and water, a gradual increase in weevil mortality was noted by day 15; after 25 days, only one-third of the weevils remained, and by 45 days all the weevils were dead. Weevils provided the dry pollen diet ate very little for several days but then ate as much as one-third

Table 1. Percent mortality of boll weevils offered 100% honey-bee collected pollen and water, artificial diet pellets, or water*.

	Number of days offered					
Diet	5	10	15	25	35	45
Pollen and water	10.0 b ± 7.3†	21.1 b ± 5.5	43.3 b ± 7.6	69.9 b ± 11.0	86.5 ab ± 2.6	100.0 a ± 0.0
Artificial diet pellets	3.3 b ± 2.8	3.3 c ± 2.8	3.3 c ± 0.0	13.3 c ± 4.8	76.6 b ± 13.6	88.3 a ± 5.7
Water (only)	66.6 a ± 21.4	85.4 a ± 6.3	100.0 a ± 0.0‡			

* Data are means ± SD of six replicates of 10 weevils for each diet.
† Means in columns followed by the same letter are not significantly different ($P = 0.05$; LSD test; [Cochran and Cox 1971]).
‡ All weevils dead by day 11.

of the diet available each day. Pollen was often seen adhering to the weevil's proboscis. Although the pure pollen diet was probably not a balanced diet, some weevils were able to survive on it for more than six weeks. Boll weevils given artificial diet pellets demonstrated low mortality for 25 days; by 45 days most of the weevils were dead. The small inverted bottle cap proved to be a suitable drinking container; if the weevil fell into the water it could escape without drowning.

Second Experiment (Table 2). A 0.25% or 1.0% pollen diet or a 3.0% agar diet alone did not sustain weevils for more than a few days; mortality was 100% by 5 days. There was a significantly higher survival rate for boll weevils after 5 days on a 1.0% sucrose diet than on a 0.5% sucrose diet. After 10 days, mortality of weevils offered the 1.0% sugar diet was 25% lower than those given the 0.25% sugar diet, but the differences were not significant. After 5 and 10 days, weevils offered 0.25% or 1.0% pollen plus 1.0% sucrose diets had significantly lower mortalities than those given 0.25% or 1.0% pollen plus 0.25% sucrose diets. When the concentration of sucrose in the diet remained at 1.0% and pollen was decreased from 1.0% to 0.25%, weevil mortalities after 10 days increased by a factor of ≥ 2.5. About 15-20% of the boll weevils survived after 15 days when fed 1.0% sucrose; adding 0.25% or 1.0% pollen did not increase longevity.

Third Experiment (Table 3). All boll weevils offered a diet of Bermuda grass, dandelion, primrose, or sow thistle survived for two days; control weevils or weevils offered other plants in this study had significantly greater mortality during the same period. Boll weevils provided white Dutch Clover, dandelion, primrose, or sow thistle for 4 days had less mortality than weevils given Bermuda grass, crabgrass, wild garlic, and wild carrot. After 6 days, only those test weevils provided primrose and sow thistle had significantly lower mortality compared with weevils offered other plants. After 8 days, weevils offered sow thistle had less mortality than those provided all the other plants. Dandelion also sustained boll weevils for 8-10 days. A few boll weevils ($\leq 10\%$) survived on a diet of white Dutch clover, wild garlic, primrose, and sow thistle for 12-22 days. After 4 days, mortality of boll weevils offered wild carrot, crabgrass, or Bermuda grass was as high as that of the control which was only offered water. These plants sustained the weevils for significantly fewer days than all the other plants tested.

Discussion

Insects eat a wide variety of organic materials. A knowledge of what they are able to assimilate, even foods not usually eaten, furthers our understanding of fundamental nutritional physiology. Many insects, such as boll weevils, are so highly specialized that they develop only on a diet of one particular portion of a particular plant or animal. When new foods are presented as in this study, we found that initial acceptance or rejection of a nutrient material is no indication of its nutritive value. An insect is guided to its natural foods by the tastes and odors of various chemical substances present. When their natural food is unavailable their willingness to accept somewhat different or even totally new plants or animals is a test of its survivability. The boll weevil primarily feeds on immature pollen and petals of young flower buds; temporarily switching to other plant pollens may not have been such a great nutritional change for them.

Table 2. Percent mortality of boll weevils offered agar pellets, artificial diet pellets, or various concentrations of pollen and sucrose pellets alone or in combination*.

Diet†	No. days offered		
	5	10	15
0.25% Pollen	100.0 a ± 0.0‡		
1.0 % Pollen	100.0 a ± 0.0		
0.25% Sucrose	100.0 a ± 0.0		
1.0 % Sucrose	27.5 c ± 8.8	75.0 a ± 13.2	100.0 a ± 0.0
3.0 % Agar	98.8 a ± 3.3	100.0 a ± 0.0	
Artificial diet pellets (Standard)	2.5 d ± 1.9	10.0 c ± 2.6	16.3 b ± 4.9
0.25% Pollen + 0.25% Sucrose	86.6 a ± 7.1	100.0 a ± 0.0	
0.25% Pollen + 1.0% Sucrose	6.6 d ± 5.7	56.6 b ± 11.5	86.6 a ± 5.8
1.0 % Pollen + 0.25% Sucrose	46.6 b ± 10.3	100.0 a ± 0.0	
1.0 % Pollen + 1.0% Sucrose	0.0 d ± 0.0	23.3 c ± 7.7	80.0 a ± 20.0

* Data are means ± SD of eight replications of 10 weevils for each diet.

† 3.0% agar added to solidify the diet (except for the 3.0% agar control).

‡ Means in columns followed by the same letter are not significantly different (P = 0.05; LSD test [Cochran and Cox 1957]).

Table 3. Percent mortality of boll weevils offered plants other than cotton found growing in North Mississippi in April and May*.

Plant offered	Number of days offered 2	4	6	8	10	12	14	16
Bermuda grass	0.0 a ± 0.0†	74.0 b ± 15.1	100.0 b ± 0.0					
Crabgrass	7.1 b ± 4.8	75.0 b ± 7.1	96.3 b ± 3.7	100.0 b ± 0.0				
Johnson grass	5.0 b ± 5.3	47.1 ab ± 9.8	98.8 b ± 3.5	100.0 b ± 0.0 b				
White Dutch clover	2.5 b ± 3.7	38.8 a ± 5.4	88.8 b ± 10.1	90.0 b ± 5.3	95.0 a ± 5.0	100.0 a ± 0.0		
Wild garlic	3.8 b ± 5.1	63.8 b ± 14.5	90.0 b ± 10.0	91.2 b ± 4.5	91.2 a ± 4.5	91.2 a ± 4.5	95.0 a ± 5.3	100.0 a ± 0.0
Wild carrot	2.5 b ± 3.4	62.5 b ± 13.1	97.5 b ± 4.7b	100.0 b ± 0.0				
Dandelion	0.0a ± 0.0	33.8 a ± 6.8	78.7 ab ± 15.9	95.0 b ± 5.0	100.0 a ± 0.0			
Primrose	0.0 a ± 0.0	22.5a ± 7.5	60.0 a ± 11.3	93.8 b ± 6.2	95.0 a ± 5.0	95.0 a ± 5.0	95.0 a ± 5.0	95.0 a ± 5.0‡
Sow thistle	0.0 a ± 0.0	28.8a ± 8.9	66.2 a ± 14.1	78.3 a ± 10.2	93.3 a ± 5.4	95.0 a ± 5.0	95.0 a ± 5.0	100.0 a ± 0.0
Water control	7.5 b ± 5.9	68.8 b ± 11.3	98.8 b ± 3.6	100.0 b ± 0.0				

* Data are means ± SD of six replicates of 10 weevils for each diet.
† Means in columns followed by the same letter are not significantly different (P = 0.05; LSD test; [Cochran and Cox 1957).
‡ 100% of weevils dead by day 22.

For the relatively few species of insects which have sufficiently studied it has been found they require much the same nutrients required from other types of animals from protozoa to man. These include water and certain minerals; carbohydrates, fats or protein as an energy source, protein as a source of essential amino acids; and accessory growth factors (sterols and vitamins of the B complex. Kitzes et al. (1943) found in an analysis of pollen that, in addition to its high protein content, it contains vitamin B complex. Pollen, if it is dried properly and remains dry, can maintain its nutritive value for years.

Vansell (1942) reported that the sugar content of nectar secreted by plants varies from 2.1% to 65.0%, depending on the species, type of flowers, air circulation, and relative humidity. Consequently, the concentrations of sugar available in nature are much higher than the 0.25-1.0% concentrations that we found necessary for minimal boll weevil survival. Many plants in northeast Mississippi have abundant sources of sugars and pollens available to insects during early spring (Pellett 1947). Hardee (1970) reported that boll weevils fed apples, bananas, or peaches for 5 days had 15.0-23.3% mortality, which was about half that observed when they were fed only water. In another feeding study, Haynes (1985) demonstrated that boll weevils given 100 ppm of dimilin in the diet plus 10 krads acute gamma irradiation had no mortality after 4 days, if their diet contained 10.0% sucrose or 10.0% maltose; this compared with 35.0% mortality when their diets contained 2.5% of these sugars.

The conclusion from the literature as well as these studies is that the longevity of adult boll weevils can be extended by diet supplementation with sucrose or pollen. We found some laboratory weevils were able to survive for 2-3 weeks when offered one of the following diets: 1.0% pollen and 1.0% sugar, primrose, or sow thistle. Some boll weevils lived for ≥ 5 weeks on a diet of unadulterated honey bee-collected pollen plus water. Feral boll weevils emerging 2-5 weeks prior to cotton squaring may be able to survive and infest the crop.

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