

# Proceedings of the American Bee Research Conference

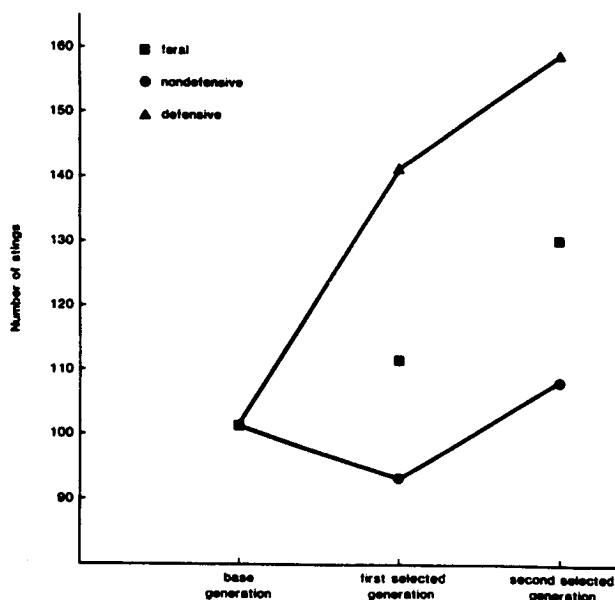
The 1986 American Bee Research Conference was held at the Agricultural Center of Louisiana State University on October 7 and 8. A second conference will be held at the same place on October 6 and 7, 1987. Abstracts of the proceedings follow.

1. Collins, A. M.<sup>2</sup> — **BIDIRECTIONAL SELECTION FOR COLONY DEFENSE IN AFRICANIZED HONEY BEES** — The initial direction of this research was to determine the feasibility of a genetic selection program to produce less defensive bees, and to carry out such a program using Africanized stocks. A field test of colony defensive behavior had been developed by Collins and Kubasek (*Ann. Entomol. Soc. Amer.* 4:355) to quantify aspects of the complex of behaviors that collectively constitute colony defense. Using this standard test, an array of colonies with appropriate genetic relationships was assayed to estimate heritability ( $h^2$ ), the proportion of the existing variation that can be attributed to genetic causes and is amenable to change by selection. Estimates of  $h^2$  for several aspects of defensive behavior (*J. Hered.* 1984, 75:135-140) indicated that a sufficient portion of the variation was genetic and that a selection program would be feasible. In addition, the trait was very variable in the population of bees on which the selection would be practiced, a necessary condition for success.

Selection was practiced for three generations beginning with a base population of only Africanized honey bees, 80 colonies established from caught swarms in a highly Africanized area. The 10 most defensive and the 10 least defensive were chosen as parentals for the next generation using the standard field test. The values from the field test were combined into a single value, or selection index. In subsequent generations, more feral colonies were established and tested as controls, and then added to the selected population to increase the available colonies and to reduce inbreeding.

After two generations of selection, significant differences existed between the two lines for time to respond to target, number of bees responding at 90 s and number of stings (see

figure). Therefore, the selection program using the standard test to measure colony defense was successful in modifying the undesirable defensiveness. The extent of the success was



The mean number of stings in two 2 cm x 2 cm suede leather targets after 30 s of attack by a defending colony for two selected lines and the feral population controls.

measured by estimating realized heritability; values in the more defensive line ranged from 0.59 to 1.34, in the less defensive line from 0.10 to 0.79. The difference in the magnitude of these estimates indicated that the program was more successful in selecting for more defensive bees than for less defensive bees.

**2. Cox, R.L.,<sup>b</sup> W.T. Wilson, D.L. Maki, and A. Stoner.—CHEMICAL CONTROL OF THE HONEY BEE TRACHEAL MITE, *ACARAPIS WOODI*.—**Acephate (Orthene<sup>®</sup>) and dimethoate (Cygon<sup>®</sup>) were fed at 3ppm a.i. in sugar syrup to field size honey bee colonies for 6 weeks. Colonies were fed *ad libitum* and the old syrup was replaced each week with freshly prepared treatment syrup. Neither compound reduced the mite infestation during the treatment period nor in the 8-week period following treatment. Coumaphos (Perizin<sup>®</sup>), a chemical used to treat the *Varroa* mite in Europe, was tested in the laboratory and field tests for the control of the tracheal mite. Coumaphos did not reduce significantly the mite population density or infestation level when administered to bees topically or *per os* as a food additive fed *ad libitum* in sucrose syrup.

In two tests, six mite-infested colonies were treated with 50 gram packets of menthol crystals and six colonies left as untreated controls. The crystals vaporized and acted as a fumigant within a bee hive. New menthol packets were placed on the bottom board of each hive every 2 weeks for 6 weeks of continuous exposure. Samples of live worker bees were dissected to remove the prothoracic trachea, identify and count various life stages of the tracheal mite and to determine mite mortality inside the trachea. After two weeks of exposure to menthol vapors, 98% of the adult mites were dead and after three weeks 100% of the mites were dead in the tracheal tubes.

Colony infestation level decreased during both tests regardless of the treatment. We offer no explanation for this phenomenon, but seasonal factors do not account for all of the decrease. A difference in colony infestation level begins to show at 2 weeks after starting menthol treatment and the difference increased until the end of the test. The difference between treated and untreated would be even greater if only bees with live mites were used in calculations.

The population density of mites also decreased in all colonies. However, mite populations from treated colonies decreased more rapidly than controls and eventually reached zero. For example, after 2 weeks of menthol exposure there were no live adult mites found in the trachea but the untreated samples averaged 3.8 live adult mites/bee. The adult mites were affected first, followed by a decrease in the immature mite and egg populations.

Honey bee populations were sometimes adversely affected by exposure to menthol vapors. Dead bee trap counts were about twice as high in the menthol group as in the untreated colonies (197 vs. 107 dead bees/colony/week), yet would fall within the normal range. The data indicate that possibly smaller colonies and higher ambient temperatures are conditions that lead to increased brood and adult mortality.

**3. Cox, R. L.,<sup>b</sup> W. T. Wilson and J. O. Moffett—RESIDUES ON FOLIAGE, HONEY BEES AND BEE PRODUCTS FOLLOWING E.C. APPLICATIONS OF ETHYL PARATHION TO COMMERCIAL SUNFLOWERS—**An emulsifiable concentrate of ethyl parathion was applied by aircraft two times to a 40 ha field of commercial sunflowers (*Helianthus annuus*) that was in bloom near Lubbock, Texas in July 1982. The insecticide was applied at 1.1 kg in 28 liters of water per ha. Six standard-size colonies of honey bees (*Apis mellifera*) were located within 50 meters of the edge of the field prior to application. Six additional colonies were placed adjacent to a field of sunflowers (ca. 1 ha) that remained untreated. A Todd-dead-bee trap was attached to the entrance of each hive. A modified OAC pollen trap was placed under one-half (3) of the colonies at each location.

The insecticide applications caused serious mortality in

adult worker bees. The number of dead bees collected from the dead bee traps next to the treated field were more than 50 times larger than in unexposed control colonies during the first 2 days after the spray was applied. Between the third and fifth days the number of dead bees dropped rapidly. On July 16, the 5th day after the first application, the mortality rate was comparable in exposed and unexposed colonies (45 vs. 46, respectively). In late July, the colonies were transported to northern Colorado and placed in a rural area where few or no insecticides are utilized. Without further pesticide exposure the colonies recovered in adult population and brood production. The colonies stored sufficient honey to winter well.

Parathion residues in dead bees averaged 3.6 ppm the first day and 1.5 ppm the second day after insecticide application. Then, residue levels in dead bees dropped rapidly to only 0.1 ppm by the fifth day.

In bee-collected pollen, the pellets contained 3.7 ppm parathion 3-days after the first application. In all other daily collections the quantity was always below 1 ppm.

The ethyl parathion sprays caused a 96 to 98% reduction in the collection of sunflower pollen and a 73 to 97% reduction in the collection of other species of pollen pellets the first full day after the sprays were applied. Pollen collection was slow to increase because of drastic loss of foraging bees.

Parathion residues on the sunflower leaves varied from 41 to 107 ppm on the first day after spray application to a low of 12 to 20 ppm on the fifth day. These residues were high over several days. There were no honey bees or other species of insects in the field or on the plants for several days. The residue was lower on the sunflower heads, probably because of the greater thickness between the two exposed surfaces when compared to "thin" leaves. This resulted in a dilution due to the greater mass of plant tissue.

No parathion residues were detected in newly stored honey, in recently capped honey, in beeswax or in samples of air collected in the sunflower fields ca. 2 meters above the ground.

#### **4. Danka, R. G.<sup>a,c</sup> — RESPONSES OF AFRICANIZED HONEY BEES TO POLLINATION MANAGEMENT —**

The rigors of commercial, migratory pollination practices may increase the frequency and severity of the objectionable traits of Africanized honey bees (AHB). Examining these effects is essential to assess the potential impact of AHB on pollination in the United States. This study was conducted to evaluate likely problem areas by comparing AHB to European honey bees (EHB).

Fifteen AHB and 15 EHB colonies were moved (at night, with hive entrances screened and queens left uncaged) six times to different sites during a 2-month test in Venezuela. Colonies remained at the sites (commercial sesame fields, commercial mango and citrus groves, or tracts of tropical dry forest) for periods ranging from three to 14 days. Hot, dry conditions during the test contributed to colony stress. Colonies were inspected thoroughly at each location to determine the status of the queen, worker population, disease and pest problems, and colony handling characteristics (i.e., excessive running, festooning or stinging). A standardized defense test (*Ann. Entomol. Soc. Amer.* 75: 383-387) was used to evaluate defensive responses of each colony on the day following each move. Nectar storage was estimated by colony weight changes at each site. Adult mortality in five colonies of each bee type was monitored with dead bee traps.

More AHB colonies (n=12) than EHB colonies (n=5) were debilitated by moderate to severe population losses. These losses were not classical abscondings, as the queen and some workers typically remained. The colonies which experienced losses were probably unacceptable as pollination units during at least some portion of the test. Population losses variously affected the other responses which were measured.

Differences in defensive responses of the two bee types were less than has been found when colonies were not managed for pollination, but sufficient stinging problems

could be expected in a labor-intensive agricultural setting to warrant considerable concern. Compared to the pretest baseline, stinging after movement was often increased in EHB and reduced in AHB. Overall, AHB colonies stung targets 33% more than EHB colonies stung targets. AHB colonies also responded with more flying, harassing bees, while EHB colonies had more crawling bees on the hives.

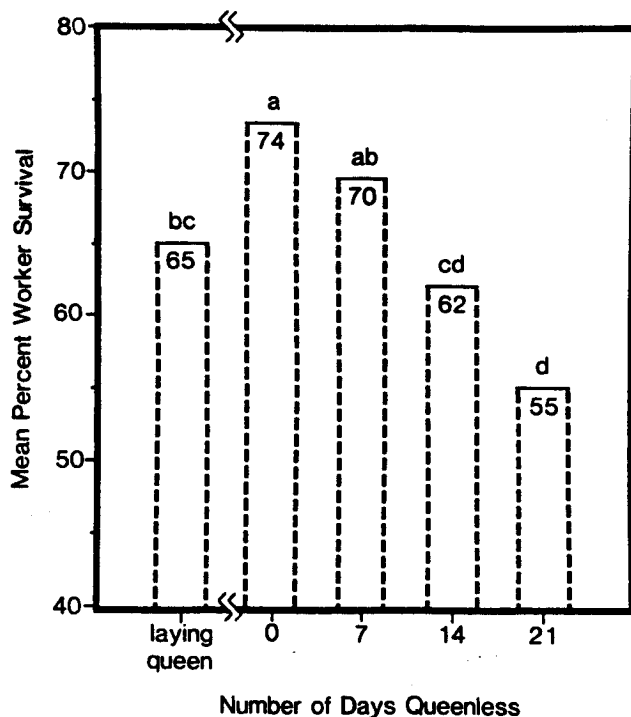
EHB colonies had greater weight gains than AHB colonies at four of the sites. The bee types lost similar amounts of weight at the other two locations.

Running, festooning, or stinging bees hampered inspections of AHB colonies three times as frequently as inspections of EHB colonies. No differences were found in the number of times requeening was required among the groups of bees ( $n_{\text{AHB}}=8, n_{\text{EHB}}=7$ ). Locating AHB queens during colony inspections was often difficult and time consuming. There were no significant pest or disease problems, and swarming was never initiated in any of the colonies. Adult mortality was usually higher among the EHB colonies.

Generally, the simulated pollination program resulted in smaller bee-type differences than expected for most potential problem areas. However, it is likely that under less harsh conditions response differences would be greater. The tendencies of AHB colonies to suffer population losses, to defend the nest excessively, to be difficult to inspect, and to store honey poorly make managing these bees for commercial pollination an unattractive prospect.

5. Delaplane, K. S.<sup>c</sup> and J. R. Harbo — EFFECT OF QUEENLESSNESS ON WORKER SURVIVAL, HONEY GAIN AND DEFENSE BEHAVIOR — The effect of queenlessness on worker honey bees was tested with 50 colonies in groups of 10 (5 treatments and 2 replicates) in August, October, December 1984, February, and April 1985.

#### WORKER SURVIVAL



Effect of queenlessness on the survival of adult worker bees in newly established colonies. Colonies started with no brood and the experiment ended before any adults emerged from the laying queen treatment. Percent worker survival was the number of workers in the final population (after 28 days) divided by the number in the initial population. Means with different letters are different at the 0.05 level.

in Baton Rouge, Louisiana. The 10 colonies in each group were all from a single heterogeneous mixture of bees, and each colony began with a known population size (about 6,000 workers) and no brood. Colonies were placed 20-50 meters apart and about 1/2 kilometer from the nearest apiary. The 5 treatments were each 28 days long and consisted of (1) queen caged for 9 days; queen laying for 19 days (control); (2) queen caged for 28 days, queenless for 0 days; (3) queen caged for 21 days, queenless for 7 days; (4) queen caged for 14 days, queenless for 14 days; and (5) queen caged for 7 days, queenless for 21 days.

At the end of the 28-day period, colonies were checked for the number of bees, the weight gain of the combs, stinging behavior, amount of brood, and worker drift. Worker drift was checked to confirm results for survival. A paint color was assigned to each colony on day 5 (all colonies still had caged queens at this point), and 300 bees from each colony were marked. During the final examinations, bees of nonresident color were noted.

Among treatments 2-5 that never had a laying queen or worker brood, prolonged queenlessness caused decreases in worker survival (see figure), colony weight gain, and defense behavior (number of stings). Few workers (36/15,000 marked bees) changed their residence to other colonies. This low incidence of drifting showed that the results depended on treatments and were not affected by workers being attracted away from queenless colonies.

6. Dietz, A.<sup>d</sup> and R. Krell — SURVEY FOR HONEY BEES AT DIFFERENT ALTITUDES IN KENYA— The introduction of *Apis mellifera scutellata* into South America has seriously affected not only beekeeping, but also the general public. On the continent of its origin, *A. m. scutellata* shares East Africa with several other subspecies in more or less overlapping populations. *Apis mellifera monticola* is one of the subspecies which is separated from *A. m. scutellata* by ecological rather than geographical barriers. *A. m. monticola* has been collected in the Tanzanian mountains at 2,400-3,100 m altitude in forest regions with night frost. Ruttner (1981) reports the presence of *A. m. monticola* also for the lower altitude regions of Kenya. An intermediate type of bees, in appearance similar to hybrids of *A. m. monticola* with *A. m. scutellata*, was found at an altitude of 1,500-2,400 m (Rinderer, per comm.).

*A. m. monticola*, a gentle, large bee, and perhaps a good honey producer (Rinderer, per comm.), appears to have more desirable traits for beekeeping than its temperamental neighbor, *Apis mellifera scutellata*. It is assumed that *A. m. monticola* has maintained its purity, except for some hybridization in the immediate contact zone, and has prevented the invasion of aggressive *A. m. scutellata* into its territory. Therefore, it may provide important clues for breeding European bees resistant to hybridization with Africanized bees in Central and North America. The purpose of this survey was to determine the distribution of *A. m. monticola* and to identify suitable breeding stock.

Our survey included the collection of honey bee samples from feral and managed colonies, as well as composite bee samples from roadside flowers. The bees were obtained from 30 roadside locations, 42 Kenya Topbar hives (KT), 21 rustic log hives (RL), and 4 feral colonies (1 in the ground and 3 in trees).

The locations surveyed ranged from 3,500' to 11,000' in altitude and dry acacia savanna to mountain rain forest. It is very difficult to find colonies at high elevations (8,000' to 11,000'). Most colonies were sampled between 5,000' to 7,000'. There was a wide variation of behavior in response to disturbance, ranging from very gentle to extremely aggressive. Most colonies sampled were aggressive to very aggressive, especially those located at the lower elevations (5,000' to 7,000'). Black and yellow bees were encountered at all elevations.

The bees in the Kimbo Research Apiary (GK), near Meru

at 8,500', were fairly aggressive when collected from the entrance of KT hives without smoke. When inspected with smoke at sunset on another day, we encountered a greater variation in behavior. Some colonies were rather gentle, while others were very aggressive; however, population sizes varied considerably.

All other colonies surveyed at Mt. Elgon (4,000'-6,000'), Elgon and Kimilili district, were aggressive to very aggressive and persistent in pursuing us after colony inspections. The bees collected near Mt. Kenya had a wider range of behavior and fluctuated from almost gentle to very aggressive. In both areas (at lower elevations), the temperatures were considerably higher and some bees near Mt. Kenya were working on a slight nectar flow.

The defensive behavior of bees from a training apiary near Nairobi, and from very aggressive colonies encountered near Mt. Elgon and Mt. Kenya, was very pronounced and very similar to that of many aggressive colonies examined by us during our research in Brazil and Argentina.

Colonies examined at more than 8,000' elevation appeared gentler than most bees at lower elevations. However, a number of factors such as temperature, colony size, etc., may have had a strong influence on this behavior. Therefore it may not be prudent at this time to generalize about any change in aggressiveness in bees following an elevation incline, or a change of habitat. Once the identity of the samples is known, the correlation may become stronger.

As far as the correlation between elevation and the type of bee is concerned, the 30 composite bee samples obtained from roadside flowers, 11 of which were collected above 7,000', should further clarify the situation. Additional conclusions can then be formulated about behavior, distribution, interbreeding, and possible reasons for interbreeding or failure to interbreed.

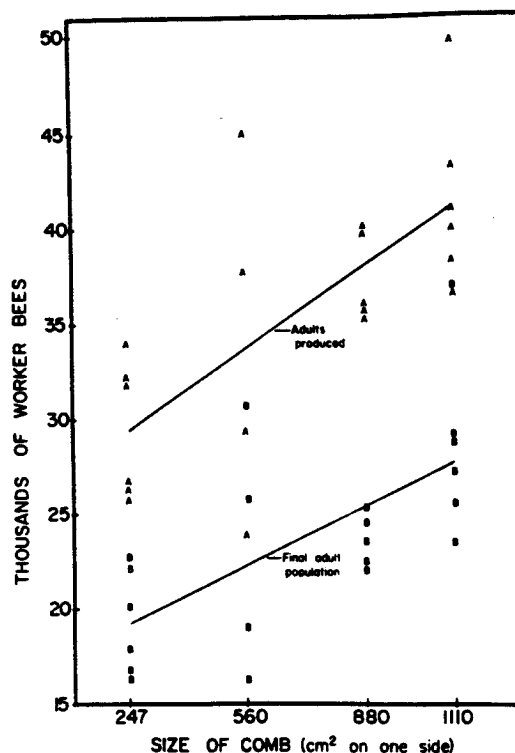
7. Eischen, F.A.,<sup>d</sup> C. Vergara, and A. Dietz. — **APITOL, A NEW SYSTEMIC ACARICIDE FOR THE CONTROL OF ACARAPIS WOODI.** — The epidemic of *Acarapis Woodi* in northeastern Mexico is expanding and adverse effects are indicated. Preliminary results with Apitol® (Ciba-Geigy) show good control when it is fed in sucrose solutions. Bee longevity and hoarding were normal at effective doses.

#### 8. Harbo, J. R.<sup>a</sup> — **MANAGEMENT OF FIELD COLONIES FOR GENETIC SELECTION OF HONEY BEES**

— The purpose of this work was to design field colonies that would be well suited for comparing stocks and for selecting genetic characters in honey bees. Previous work showed that the number of bees, the amount of comb, and the volume of the hive are all variables that affect population growth and honey production and thus must be controlled. When comparing colonies with 2300, 4500, 9000, 17000, and 35000 bees; a population of 9000 bees was best overall (*J. Apic. Res.* 25:22-29). Populations of 9000 bees were then compared at different degrees of crowding (100, 200, 300, or 500 bees per liter of hive space). The most crowded bees produced the most honey and had the shortest life span; those at 200 bees per liter produced the most brood.

This report presents data on the effect of comb size. Colonies with the largest combs produced more brood and had more adult workers at the end of the 59 day experiment than colonies with the two smallest-sized combs ( $P < 0.05$ ) (see figure). Moreover, studies using instrumentally inseminated or naturally mated queens in colonies with small or large combs showed that small combs diminished differences in the rate of egg laying, differences that were present when large combs were used. Therefore, it is not only important for combs in all colonies to be the same size during testing, it is important for them to be large.

The study of comb size completed the work to develop a field colony for genetic selection of honey bees. Based on all the data, field tests began with Langstroth-sized hives, each with 9,000 bees, 7 combs (each 21 x 43 cm), and a queen to be tested.



Effect of comb size on the population growth of honey bees. All colonies started with no brood, 9000 workers, and a naturally mated queen. Colonies differed in comb size (13 X 19, 13 X 43, 21 X 43, or 26 X 43 cm) but had the same comb surface area and hive space. The test period was March 15 — May 13, a period of maximum colony growth in Louisiana. A = the number of adult bees produced during the 59-day test period. No adults emerged during the first 20 days, so the values represent adults emerging from day 20 to day 59. Equation for line A:  $Y = 25961 = 13.6X$ ,  $r = 0.71$ ,  $n = 21$ . B = the number of adults in the colonies at the end of the experiment (day 59). Equation for line B:  $Y = 16794 = 9.7X$ ,  $r = 0.86$ ,  $n = 21$ .

#### 9. Hellmich, R. L.<sup>a</sup> — **MATING EUROPEAN HONEY-BEE QUEENS TO EUROPEAN DRONES IN AREAS WITH AFRICANIZED BEES.**

— Beekeepers in Africanized areas need a reliable, inexpensive source of European queens in order to requeen Africanized colonies. European queens that are produced in these areas usually are not acceptable because they mate predominantly with Africanized drones. The objective of this research is to provide information on drone saturation technology. This technology, combined with semi-isolated mating apiaries, can be used to produce European queens that mate predominantly with European drones in Africanized areas.

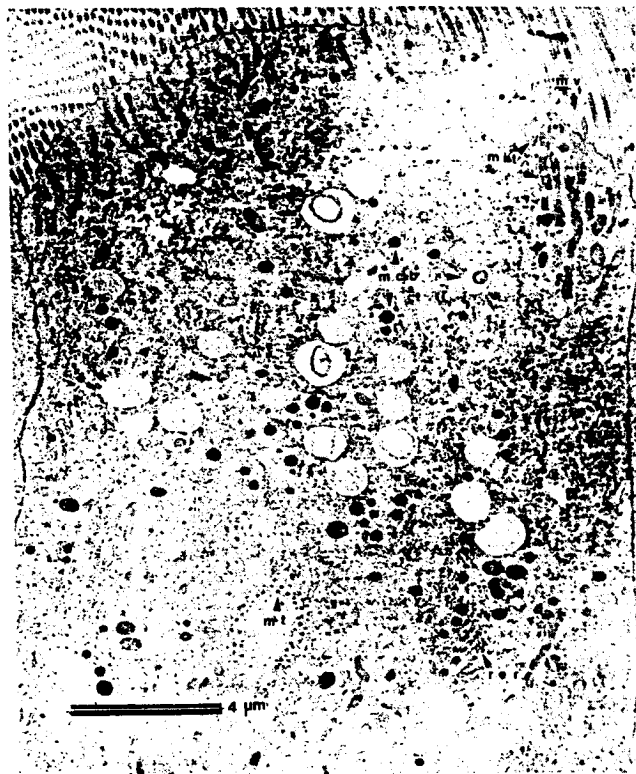
In Venezuela, 30-40% of European queen matings were controlled in an apiary which had only four to seven European drone colonies. Workers produced by the mated queens were compared to hybrid and European workers. These standards were produced by instrumentally inseminating European queens with semen from either Africanized or European drones. The number of Africanized drones which potentially had access to the queens from the experimental apiary was equivalent to the number of drones flying from approximately ten European drone colonies (drone-colony equivalents;  $DCE = P_h/P_e \times D$  where  $P_h$  = average percentage of hybrid progeny,  $P_e$  = average percentage of European progeny, and  $D$  = number of European drone colonies). If the DCE measure of feral drones for an apiary is known, then matings can be controlled at predictable levels. Control is accomplished by supplying a mating apiary with a sufficient number of European drone colonies (see Table 1). Clearly some of the colony numbers shown in the table are not operationally realistic; however, others are. Relatively few European drone colonies are required in an apiary to attain

low levels of mismatching in areas that are semi-isolated (i.e. areas with low DCE values). Queens produced from such a management scheme should be marketable in many areas of South and Central America where European queens are not available.

**Table—Approximate Number of European drone colonies necessary to control matings of European queens when Africanized drone-colony equivalents (DCE) range from 0.01 to 20.0. The estimated DCE for a mating apiary in Venezuela was 10.**

Percentage of Matings Controlled	DCE							
	0.01	0.1	0.5	1.0	5.0	10.0	20.0	
10						1	2	
20					1	3	5	
30					2	4	9	
40					3	7	13	
50				1	5	10	20	
60				2	8	15	30	
70			1	2	12	23	47	
80			2	4	20	40	80	
90			5	9	45	90	180	
95		2	10	19	95	190	380	
99		10	50	99	495	990	1980	
99.9	10	100	500	999	4995	9990	19,980	

**10. Jimenez, D. R.<sup>c</sup> and M. Gilliam. — ULTRASTRUCTURE AND CYTOCHEMICAL LOCALIZATION OF CATALASE AND L-(ALPHA)-HYDROXY ACID OXIDASE IN MICROBODIES OF HONEY BEE MIDGUT** — The ultrastructural location of catalase and L-(alpha)-hydroxy acid oxidase (HAO) was determined in the ventricular epithelium of 5-day-old worker honey bees. Catalase-positive reaction product occurred in apical supra-nuclear cytoplasm of mature columnar epithelial cells and



**Mature columnar epithelial cell showing catalase-positive reaction product as small dense microbodies and as diffuse matrix within larger mature bodies (rer = rough endoplasmic reticulum, mit = mitochondria, mv = microvilli, mcb = microbodies, mt = microtubules.).**

was evenly distributed throughout the ventriculus but decreased in the immature cells of the regenerative nidus. It was localized in spherical to ovoid bodies, 0.2-2.0  $\mu\text{m}$  in diameter. The smaller bodies (0.2-0.8  $\mu\text{m}$ ) exhibited a dense outer ring surrounding an electron lucid core. Development of the mature microbody resulted in enlargement to the full diameter of 1.5-2.0  $\mu\text{m}$  and the dispersion of catalase reaction product as a diffuse granular matrix or as a concentric ring within the limiting tripartite membrane. HAO occurred within the same cellular organelle and had a similar developmental sequence. The enzyme complex appeared to be intimately associated with the interior wall of the microbody as a small (0.2-0.4  $\mu\text{m}$ ) multilaminar sphere, or when the microbody expanded, as an intricate part of the membrane. Oxidase activity resulted in reaction product deposition when intact tissue was supplied with glycolic, lactic, isobutyric, or isocaproic acid. Early cytochemical work by other researchers demonstrated high concentrations of divalent cations within similar particles and suggested a secretory function. We hypothesize that the microbodies are microperoxisomes involved in intracellular catabolism in the midgut. This is the first ultrastructural demonstration of microperoxisomes in honey bee midgut, although they have been intensively studied in mammals and some invertebrates.

**11. Krell, R.<sup>d</sup> — A MODEL FOR ESTIMATING POLLINATOR EFFICIENCY AND POLLINATION REQUIREMENTS** — A study of honey bees on Gallberry (*Ilex glabra*) showed a characteristic correlation between certain foraging behavior and the size of nectar rewards encountered by the foragers. A weak positive correlation existed between reward size and number of flowers visited per minute. A stronger negative correlation was found between reward size and the FFC (Krell and Dietz 1985). The FFC (forage flight coefficient) is calculated by dividing the largest possible distance between any two points of a forager's path by the length of time for which this foraging flight has been observed.

The FFC will allow an estimate of reward size without having to measure nectar content of flowers. The number of flowers visited per minute can either be deduced from the reward size or from actual counts in the field. If the average crop load of a returning forager is known, the length of a forage flight can be calculated. To calculate the total possible number of forage flights per day and per forager with the above information, one has to assume that rewards remain the same all day and that a forager will collect all day at the same rate. If one assumes that each flower will be visited only once, one can deduct the maximum number of flowers that can be visited by one forager per day. After counting the number of flowers to be pollinated in a certain area, a total need of pollinating foragers can be assessed.

Once this basic relationship is established, modifications can be introduced in order to increase the accuracy of this model. For example, there will be a certain percentage of flower revisits which will be influenced by forager density and by the nectar secretion characteristics of the flowering species. These influences also affect the FFC and are partially deductible from it. The percentage of flower revisits and other factors will increase the number of foragers needed for pollination (i.e., honey bees do not forage at the same rate all day, rewards change during the day, certain species need revisits for optimum seed set and fruit development etc.). Most of these influences can be corrected for by measuring the FFC at various times over the course of a day. The number of foragers needed in this model for nectar foragers is reduced by the number of pollen foragers and other pollinators in the field and the life time of a flower, if longer than one day. However, the presence of pollen foragers and other pollinators may often be negligible. The distance between colony and flowers and the reward size will influence crop load in a predictable manner. Weather and flower shape and accessibility will also predictably influence the need for foragers.

After estimating the number of foragers needed to pollinate all flowers, we need to determine the number of colonies necessary. This is easy to calculate if the number of foragers is known which will be available per colony to forage on the target plants. However, this number depends on a variety of factors such as strength, health, and developmental status of the colony, the amount of brood, food stored, season of the year, swarm, package or established colony, stimulation inside the colony by space, comb, need and recruiting, competition by other flowering species, etc.. While some of these conditions are easier assessed, and their influences are better known than others, their accuracy can be readily checked if the number of colonies in the area is known. Estimates should closely agree with counts derived from density measurements (bees/m<sup>2</sup>, or bees/flower).

Although it seems to be a workable model, or method, for determining pollinator requirements, its accuracy has not yet been tested. The FFC makes the use of this model feasible without extensive laboratory measurements. With minor modifications, it should also allow the prediction of available resources and ultimately the capacity for honey production. Its advantage is the adaptability to very special and local conditions, particularly when compared to experimentally derived density recommendations (bees/m<sup>2</sup>). It is assumed that the extra effort required for this method will be offset by higher accuracy.

**12. Loper, G. M.<sup>c</sup> and W. W. Wolf — USING THE USDA-ARS INSECT RADAR UNIT TO MONITOR HONEY BEE DRONE ACTIVITY** — Honey bee drones establish localized congregation areas for the purpose of mating with virgin queens. These areas, extensively studied in Europe by the Ruttner brothers, and in this country by Gary, Morse, and O. R. Taylor at their respective institutions, have been called "Drone Congregation Areas" (DCA's). Although we have rather limited experience, we believe DCA's exist, but there is very little good data or hard evidence documenting their existence or the biology of drone flight activities.

For 4 days in 1985 and 8 days in 1986, the USDA-ARS Insect Radar unit from the Insect Biology & Population Mgmt. Res. Lab. in Tifton, GA was brought to southeast Kansas and operated by W. W. Wolf. We worked in cooperation with O. R. Taylor, Jr. of the Univ. of Kansas, Lawrence, KS.

Insects, including drones and workers, are detected by the radar beam; it is not necessary to add any reflective material to the insects. The radar display screen is photographed during each revolution of the radar dish using a black and white movie camera. Thus, insect activity is documented as a timelapse 16 mm movie. Terrain features and buildings can interfere with viewing the drones, but in satisfactory areas, drones can be located as far as 1 km away.

In 1985, on 3 days, the radar documented drones flying in the same limited space; an aerial area about 100 m in diameter and extending from 12 to 40 m above ground. "Ground truth" observations were made to make sure the insects seen on the radar were drones: (1) the sound of drones was heard in the area only, (2) a caged queen was lofted in and outside the area and drone comets were observed only in the DCA, (3) an aerial trap was lofted in the area and as many as 450 drones in one 5 min. period were caught.

Using computer image analysis techniques, the number of drones in the area and information on trajectories can be obtained from the time-lapse film. (a 16 min. video film was shown documenting the use of the radar in southeast Kansas in 1986 where we used it to locate DCA's in a cooperative study with Dr. Taylor).

**13. Maki, D. L.<sup>b</sup>, W. T. Wilson, & R. L. Cox. — INFESTATION BY ACARAPIS WOODI AND ITS EFFECT ON HONEY BEE LONGEVITY IN LABORATORY CAGE STUDIES.** — In this experiment, 10 cages, each with ca. 50 newly emerged bees from a colony heavily infested with mites

(*Acarapis woodi*) were placed in an incubator at 30° C. After preparation of a thin transverse section from the anterior portion of the thorax, the prothoracic tracheae were examined for mite infestation. Seventy percent of all the bees were infested with mites. During the first 10-day period, 83% were infested. The second 10-day period yielded 65%, and the third 10-day period was 74% mite infested. The percentage of moderate to heavy infestation as opposed to light infestation per individual bee followed the same trend for the three periods, being 68, 42, and 46%. Of the bees examined that were infested with mites during the first period, 50% were infested in both trachea. Second-period bees were down to 37% infestations on both sides. The last period rose to 43% in both sides. Data showed that bees with highest infestation levels died earliest. A slight decrease in percent bee infestation during the third period suggests reinfestation.

In the second part of the study, 6 cages, each with ca. 50 randomly-selected adult bees from the same highly infested colony were utilized. Three of these cages were placed at 30° C, and the other 3 at 25° C. Control cages of uninfested bees from another colony were prepared at the same time and placed in the incubators at the two temperatures. Seventy-four percent of the bees at 30° C were mite-infested, most of which contained heavy infestations in at least one side. In these 3 cages with infested bees, the average bee lived 13.7 days, as compared to 22.5 days for bees in the uninfested cages. At 25° C, in which 81% of the bees were infested, the average life-span was 9.5 days, compared to 11.5 days in the controls. At 30° C, the bees' longevity was reduced by 39%. At 25° C, it was reduced by only 17%. The authors feel that the discrepancy was due to the colder temperatures overriding all other stress factors. With such small numbers of caged bees, they were not capable of appropriate clustering behavior and appeared somewhat 'listless' during the experiment. On the other hand, at 30° C, the bees were able to cluster and were seen more active, thus the reduced life-span was probably greatly affected by high mite infestations. Further testing at various temperatures will be done, with larger populations used for lower temperature settings.

Table—Average number of days bees lived in infested and uninfested cages at 30° and 25° C.\*

	Cage 1	Cage 2	Cage 3	Cage 4	Cage 5	Cage 6
Infested Cages	13.1	14.2	13.9	8.9	9.2	10.3
Uninfested Cages	24.8	22.2	20.8	12.4	10.8	11.1

\* cages 1-3 at 30° C, and Cages 4-6 at 25° C.

**14. D. F. Mayer,<sup>f</sup> J. D. Lunden, and L. W. Weinstein — EVALUATION OF FLUORIDE LEVELS AND EFFECTS ON HONEY BEES** — Honey bees are subject to diseases, pests, pesticide poisoning and industrial pollutants which may result in bee mortality. Fluoride gases and particulates are released as by-products at low levels from aluminum smelters. Reports concerning fluoride levels in honey bees and their response to airborne fluoride emission are few. In 1984, we began a three year study on fluoride levels in honey bee colonies and the biological response of colonies exposed to different levels of airborne fluoride emissions.

The field study was conducted in the Puyallup Valley, WA. Honey bee colonies were placed in locations which provided for high (FH location), medium (VRF location), low (REC location) exposure of bees to fluoride. Other colonies located at Prosser, 200 miles from Puyallup, served as checks. Live, dead, and teneral adults, stored pollen, and honey obtained from each colony at each location were analyzed for fluoride content periodically during the study. Each year, from April to October, colonies were carefully inspected every 10 to 14 days. Data on number of adult bees, number of dead adults, amount of brood, brood survival, brood population dynamics, and honey production were evaluated.

Mean fluoride concentration of live adult bees was different between locations. Highest amounts of fluoride were found at the FH location (219 ppm) and lowest at Prosser (11 ppm) with the REC and VRF locations intermediate. Mean fluoride concentration of dead bees was significantly different between locations though there were no differences between live and dead bees at the four locations. Fluoride was found in stored pollen in the lowest level at Prosser (8 ppm) and the highest at FH (37 ppm). Fluoride levels in honey varied from 0.3 ppm (Prosser) to 1.2 ppm (FH).

The average adult bee and brood population data were summed to a monthly mean. In general, all colonies developed normal-sized adult and brood populations with no striking consistent differences detected between locations. The number of dead bees found appeared normal and there were no significant differences between locations. In 1984, significant differences were detected in brood survival between locations though the differences were not related to areas of fluoride concentration. No differences were detected in 1985 or 1986. Brood population dynamics indicated the percent of individuals in different stages of development approximated a bell-shaped curve and no consistent differences were evident between locations or time of year of sampling. In 1984, no significant differences were evident between locations in honey production and the colonies at VRF produced the most honey. In 1985 and 1986, the colonies at Prosser produced the most honey followed by those at FH, REC, and VRF.

Data collected during this study show fluoride is present in honey bees, stored pollen and honey at different levels, depending on location of the colonies in relation to a fluoride point source. Our data show that these concentrations of fluoride are not a factor in bee mortality, colony vigor, or honey production.

15. Moffett, J.O.,<sup>b</sup> D.J. Banks, and R.M. Pittman — **FLORAL VISITS BY HONEY BEES TO THREE CAGED PEANUT GENOTYPES AND THE RESULTING INCREASE IN HYBRID SEED** — In 1982, three peanut genotypes, *Arachis hypogea* L., were grown under 6 Saran® cages at the Oklahoma Agricultural Experiment Farm at Perkins to determine how honey bees, *Apis mellifera* L., would visit peanut flowers in cages. The increase in hybrid seed resulting from these floral visits also was determined.

Twenty-one plants (7/genotype) were planted as a double 3 x 3 Latin Square with the last 3 plants added on the end of each of the 3.66 x 7.32 x 2.44 meter cages. Identical plantings were made in 6 uncaged field (check) plots which were interspersed among the caged plots. Each genotype, "Krinkleleaf" (P151), "Narrowleaf" (P105Y), and "Yellowflower" (US 98Y), contained a dominant genetic marker so that the 6 possible crosses could be separated visually when plants were grown from this seed.

A strong nucleus containing at least 3 frames of brood was kept in each cage continuously from the onset of bloom until it was too late in the year for mature seed to be produced by the flowers that opened.

Inside the cages, more than 3 times as many bees made floral visits to the "Yellowflower" genotype as to either the "Narrowleaf" or "Krinkleleaf" genotype (904, 284, and 252 visits respectively). The bees averaged moving between genotypes every 5th (19.8%) floral visit and flew to different plants of the same genotype on 6.8% of their visits. This amount of bee movement among genotypes should be adequate to effectively transfer peanut pollen among cultivars if it can be successfully transferred by honey bees.

The bees started visiting the flowers when they opened, or about 7:30 a.m. on sunny days. Bee visits peaked between 8:30 and 9:30 a.m., and then gradually declined on the 6 warm days

of the 9 days between August 2 and September 3 when observations were made. During these hot days the flowers closed by mid-afternoon. During the 3 cool damp days, the bee visits peaked at 11:00 a.m., 1:00 p.m., and 4:00 p.m. On the cool days the flowers both opened later and stayed open later than on the warm days. Overall, the honey bees visited the peanut flowers moderately well.

The time the bees spent visiting a peanut flower ranged from 1-165 seconds, the average time was 16.1 seconds, the median time 11.0 seconds, the most frequent times 4 and 5 seconds. The bees appeared to collect nectar only. No bees were observed collecting pollen.

All the seeds from the experimental plants were collected in the fall and planted the following spring to determine the percent of hybridization. Because flowers of the genotypes studied are highly cleistogamous (self-fertilizing before the flower opens), hybridization was low. Sixty-two of the 7540 plants (0.82%) grown from the seed collected from plants grown under the cages with bees were hybrids. This was 3 times more than from the check plots where 20 of the 7171 plants that grew were hybrids (0.28%).

Pollen from the "Yellowflower" genotype was the male parent for more than three times as much seed as the other two genotypes (35 vs 12 for "Krinkleleaf" and 22 for "Narrowleaf" pollen).

Normally, bee visits to peanut flowers at the Perkins Farm are low. During this study no bees were observed visiting the flowers in the uncaged (check) plots. However, megachilid and halactid bees have sometimes been seen visiting other peanut flowers on this farm.

Honey bees could be used as pollen vectors, at least in cages, in the production of hybrid peanut seed if male sterility can be achieved in peanuts by the use of cytoplasmic male sterility, genetics, chemicals, or other methods.

16. Moffett, J.O.,<sup>b</sup> J. Harvey, & R. Cox — **PENNCAP—M TOXIC TO HONEY BEES FIVE HOURS AFTER APPLICATION** — Adding an experimental sticker did not markedly reduce the toxicity of either Furadan® (carbofuran) or PennCap-M® (a microencapsulated formulation of methyl parathion) to honey bees. These insecticides were sprayed before 9:30 a.m. by air to fields of flowering alfalfa on both July 28 and Aug. 4, 1983. The insecticides were applied at a rate of 1.1 kg AI/ha in 18.7 liters of spray mixture per application to fields located in Southwestern Oklahoma. All these colonies survived, but most were reduced to 2-3 frames of bees and brood.

In a related study all 5 of the colonies moved to the edge of a field 5 hours after the last application of PennCap-M died. During the 1st week after the bees were moved to the field, an average of 13,836 dead bees per colony were collected from the dead bee traps and bottom boards. Almost all the bees in the colonies were killed. Five colonies were also moved next to the field sprayed with both PennCap-M and the sticker 5 hours after the last spray application. These colonies suffered moderate damage. An average of 1,544 dead bees/colony were collected the 1st week after their exposure to the combined sticker-PennCap-M spray. This was only 11% as many dead bees as were lost by the colonies exposed to the PennCap-M spray that did not contain the sticker. Dead bees collected the morning after the bees had been moved into the PennCap-M sprayed fields contained 3x as much parathion residue (2.50 ppm) as dead bees collected from colonies exposed to the combined sticker-PennCap-M spray (0.76 ppm).

Overall residues of carbofuran from the colonies and fields exposed to 2 sprays of Furadan in declining order of magnitude were alfalfa foliage 873, pollen 15, dead bees 6, and honey 1. Residues of parathion from the PennCap-M exposed colonies and fields in declining order of magnitude were alfalfa foliage 356, pollen 21, dead bees 1, and honey 0.

Details of this study are documented in an article by the authors. (*J. Entomol. Sci.* 21:294-300,1986)



**17. Rinderer, T. E.<sup>2</sup> — RECENT DEVELOPMENTS IN THE MORPHOMETRIC IDENTIFICATION OF HONEY BEES** — In the last 2 years the morphometric analysis of honey bees has been further tested and expanded. In a cross fostering experiment, changes in morphology caused by nutrition (nurse-bee type) and comb cell-size were sufficiently trivial that identification procedures still correctly identified Africanized and European bees.

Novel discriminant analysis comparing Africanized and African bees showed that the two groups were completely separate. Africanized bees were more similar to African bees than they were to European bees but were distinctly different from either parental type. Thus, the name "Africanized" is the best term for this population of bees.

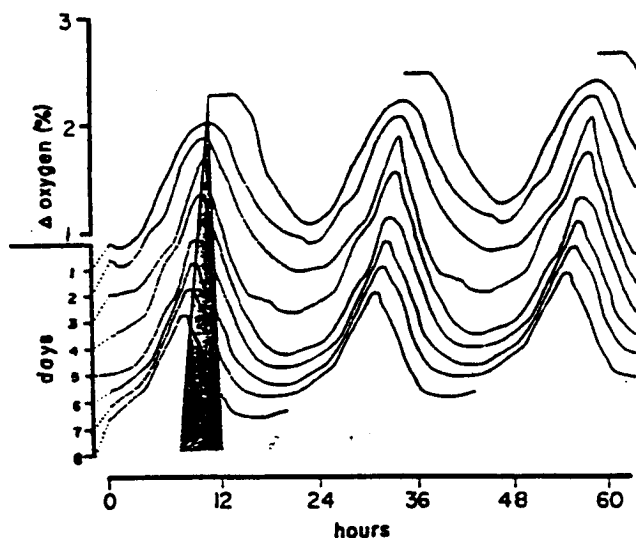
A new analysis has been developed which distinguishes between Africanized, European, and F<sub>1</sub> hybrids.

**18. Southwick, E. E.<sup>5</sup> — COLONIAL SYNERGISM OF RHYTHMS IN HONEY BEES** — Honey bees are highly social organisms with many physiological and behavioral functions that occur only when they are in the colony or a group. They show daily rhythms in behavior (*Apidologie* 15:278-280) and oxidative metabolism (*Comp. Biochem. Physiol.* 71A:277-281). Therefore, I investigated how honey bee workers in a group synchronize individual circadian rhythms.

Nucleus colonies consisting of a fertile queen, brood and about 2500 workers were housed outdoors or in a flight room with a light cycle 12 hr out of phase. All bees were free to fly. Indoor bees were provided milled pollen and 50% sugar *ad libitum*. After six weeks, tests were run on group metabolic rhythms by placing groups of 100 workers in metabolic chambers in constant dark, and monitoring their group metabolism continuously for ten consecutive days.

Test groups from outdoor and indoor colonies showed typical circadian rhythms of oxygen consumption in the dark (Fig.). The figure shows peaks of metabolism corresponding to subjective "day" time, and troughs during the "night." When successive days are lined up vertically, the shaded triangle indicates a phase advance of about three hours over nine days, giving a free-running rhythm in metabolism of 23 hr. 40 min.

Test groups from the indoor (DL) colonies had metabolic rhythms about 12 hr. out of phase with those housed outdoors (LD). Yet when indoor and outdoor groups were mixed, they showed a coordinated group rhythm with peaks and troughs falling inbetween those of the "pure" groups. This suggests



Circadian rhythm of oxygen consumption (Y-axis) of a group of honey bees in constant dark (X-axis = time in hours) monitored over 10 consecutive days.

that the clocks of the individuals were re-entrained and synergistically synchronized. When groups were tested with a double screen separating them, preventing physical contact, there was no group rhythm.

The results reported here demonstrate that honey bees synchronize their individual cycles in an overall group cycle, an endogenous synergistic circadian rhythm. Re-entrainment to an overall group rhythm takes place by physical social interactions such as tactile and trophallactic behaviors known to be important in colonial communication (*Insectes Soc.* 29:209-211). This, then, serves as the likely mechanism in the synergistic control of group metabolic rhythm in honey bees.

**19. Spivak, M.<sup>h</sup> — RELATIVE SURVIVORSHIP OF AFRICANIZED AND EUROPEAN HONEY BEES IN THE HIGHLANDS OF COSTA RICA** — This study was designed to determine the relative survivorship and reproductive success of Africanized and European honey bees over an elevational gradient in Costa Rica. My observations in Perú (13° S) in 1980 and 1982 showed that neither feral nor hived Africanized colonies were found above 2300m. Whereas below that elevation, the area was saturated with Africanized bees. In contrast, hived European colonies were relatively common above 2300m (determinations confirmed morphometrically by Dr. H. Daly). These results seemed to indicate that there may be climatic or resource factors limiting the survival or movement of Africanized bees at higher elevations.

A comparative study was initiated in Costa Rica in 1984, when Africanized bees were just moving into the area. Queens were reared from either Costa Rican-European breeders, or from Africanized swarms recently entering the area. The virgins were taken to be mated in areas either predominantly Africanized or not yet Africanized. In this way, all daughter queens were approximately the same age, and displayed characteristics as far towards the extremes of the Africanized-European continuum as possible.

The first half of the study extended from July through November, 1985 (wet season). Three apiaries were established at 900m, 1800m, and 2300m, each with 10 Africanized and 10 European colonies. In the second half of the study, all colonies were relocated into two apiaries, situated in an agricultural area at 900m and in a cloud forest at 2800m, from December 1985 to July 1986 (dry season) and first two months of the wet season) to test the effects of more extreme climatic and resource conditions on colony survivorship.

Every two weeks over the year, all colonies were weighed, and measured for pollen, nectar, honey, worker and drone brood areas, using 3 and 5 cm<sup>2</sup> grids as needed. Reproductive swarms, supersedures and absconding colonies were recorded.

Data show that Africanized colonies maintain large brood areas, and have high incidences of swarming at all elevations, even at 2800m where resource conditions are poor, and climatic conditions are unfavorable. Africanized colonies also rear drones and issue swarms earlier in the season than European colonies, which increases their reproductive potential. While European colonies performed poorly at lower elevations relative to Africanized colonies, the differences between Africanized and European colonies were not so pronounced at higher elevations. Further analyses and discussion of these results will be published at a later date.

The most important implication of these findings is that Africanized bees may not tend to swarm up to higher elevations, but when moved there in man-made "nests" are able to survive. Distinguishing between feral and manipulated movements may help explain the seemingly contradictory observations on the distribution and survivorship of Africanized bee populations in different areas. Since a large part of the beekeeping industry in the United States is based on migratory practices, it is important to consider that under these circumstances, Africanized bees may become established in areas where previously they were not expected to survive.



20. Sylvester, H. A.<sup>2</sup>— **CORRELATIONS BETWEEN HOARDING AND HONEY PRODUCTION** — Scientists at this Laboratory have been examining hoarding tests as one measure of a behavior related to honey production and possibly closely enough correlated to it to be useful in breeding for improved honey production. It has generally been observed in hoarding tests run at this lab that newly emerged adult worker bees remove very little sucrose syrup the first two days that they are caged, remove a greatly increased amount the next three days, and then remove decreasing amounts on following days. Days 3, 4 and 5 also have been the days when the differences between cages were most noticeable. This did not agree with the findings of Milne (*J. Apic. Res.* 19: 122-126) who reported that data from days 3-5 "... will not produce results which are correlated with honey production." However, he reported that hoarding on days 7-9 was highly correlated with honey production, based on 14 colonies.

I conducted sugar syrup hoarding tests on 25 colonies in one location and 26 in another, near Baton Rouge, LA during March or June, 1980. These colonies were weighed on April 28 and May 29, 1980, and the change in colony weight was calculated, as a measure of honey production during the major nectar-flow period in this area. Correlations between change in colony weight and daily hoarding rate were calculated by the SAS<sup>®</sup> General Linear Models procedure.

The correlation coefficients at the two locations were: day 3, 0.440\* and 0.386; day 4, 0.429\* and 0.452\*; day 5, 0.361 and 0.455\*; day 6, 0.320 and 0.357; day 7, 0.258 and 0.194; day 8, 0.264 and 0.126; day 9, 0.361 and 0.044; and (days 3 & 4 & 5)/3 -0.455\* and 0.470\* (\* indicates  $P < 0.05$ ).

Thus, under our conditions, the hoarding rates on days 3 and 4 (location 1), 4 and 5 (location 2) and, especially, both means for days 3 + 4 + 5, are significantly correlated with changes in colony weight. However, none of the correlations for days 7, 8 or 9 is significant.

The mean hoarding rate for days 3-5 should therefore be a useful correlated measure to use as a laboratory test to breed for improved honey production. The lack of significant correlation for days 7-9 may explain why Milne later found a significant correlation between hoarding on days 7-9 and honey production in only one of six years (*J. Apic. Res.* 24: 237-242.)

21. Villa, J. D.<sup>3c</sup> — **PERFORMANCE OF AFRICANIZED COLONIES AT HIGH ELEVATIONS IN COLOMBIA** — The potential distribution of Africanized bees in tropical highlands and their possible impact to beekeeping in cold climates were evaluated. Tests 1 and 2 were conducted under conditions where daily foraging was possible (latitude 6° N, elevations between 2000 and 3000 m, temperatures above 10°C). Tests 3 and 4 were conducted where foraging was minimal (latitude 6°N, elevations over 4000 m, temperatures below freezing every night and below 10°C during the day).

Test 1- The performance of 9 colonies of Africanized honey bees (AHB) was compared to that of 9 colonies of European honey bees (EHB) at 2450 meters by measuring the weekly changes in conditions over a period of one month. The average total weight of the AHB colonies remained constant while all the EHB colonies lost weight. Most of this divergence in weights could be explained by AHB colonies producing significantly more unsealed brood than EHB colonies. Significant differences did not appear in adult population nor in amount of sealed brood. Honey and pollen stores decreased equally in both types of colonies.

Test 2- A two-year survey was conducted on the occupation by AHBs of hollow cores of concrete electrical poles in an area between 2000 and 3000 m: AHB colonies were found from 2000 to 2750 m, yet the densities were much lower than reported for tropical lowlands. EHBs did not colonize these poles even though they had been in the region for decades. The number of AHB colonies increased during the dry seasons and decreased during the rainy seasons. Swarming and absconding were more frequent than those reported for feral European bees in temperate regions.

Test 3- The consumption of honey stores during ten days by 5 AHB and 5 EHB colonies was compared at 4250 m. Honey consumption varied widely, but the range for both types of colonies was similar (70 to 110 g honey/kg adults each day). These estimates were comparable to those made by other researchers with EHBs at similar temperatures.

Test 4- The survival of 14 AHB and 15 EHB colonies was measured by establishing sets of packages ranging from ½ to 2½ kg on preweighed combs and hives at 4100 m. Brood production was initiated in all colonies despite lack of forage and maximum daily temperatures below 7°C. Adult mortality caused a marked drop in the survival of colonies after one month. After 4 months only one weak Africanized colony remained while 11 European colonies survived.

Therefore, managed AHB colonies are more successful than EHB colonies at elevations where foraging is not interrupted for long periods of time. In these areas, AHBs have more feral colonies if nesting sites are available. In areas where temperatures are more extreme, honey consumption of AHBs and EHBs is similar, but the survival of AHB colonies over a long period of confinement could be limited by reduced adult longevity.

22. Waller, G. D.<sup>c</sup>, G. M. Loper and S. L. Buchmann — **POLLINATION RESEARCH ON HYBRID COTTON SEED PRODUCTION** — Research on the honey bee as a pollinator of male-sterile (cms or A-line) cotton (*Gossypium* spp.) has provided an opportunity to develop new techniques to evaluate the degree of pollination and factors affecting pollination. The large cotton flowers are open for only one day from sunrise until sunset and can be easily examined for bee visits, stigmatic pollen deposition, boll retention or abscission, and production of seed and lint.

Research by Moffett *et al.* [*Handbook of experimental Pollination biology*, Jones, C. E. and R. J. Little (Eds.), 508-514] indicates that honey bees often effectively pollinate male-sterile cotton under both experimental conditions and those of commercial seed production. They characterized the nectar reward available to floral visitors and, using the percentage of flowers with bees visiting, determined the threshold for adequate bee activity. Moffett's research also revealed that cotton pollen was generally rejected by the honey bee forager, resulting in avoidance of the pollen-bearing B-or R-line flowers and the collection of pollen from many other plant species.

Singh *et al.* (*Indian J. Agric. Sci.* 38: 528-535.) showed that floral anthesis and pollen shedding are nearly simultaneous in cotton and that stigma receptivity precedes anthesis and continues for at least six hours beyond anthesis. Our observations and experimental results concur with Singh's, but *in vitro* pollen germination in Arizona dropped off to less than 20% within 8 hours, whereas Singh *et al.* showed similar reductions only after 18 hours. Our results confirmed Singh's earlier work that pollen of Pima cotton (*G. barbadense*) has lower germination *in vitro* than pollen of upland cotton (*G. hirsutum*).

Using a technique modified after Vaissiere *et al.* (*Proc. Beltwide Cotton Prod. Res. Conf.*, 1982) for collecting stigmas and dislodging and counting pollen grains, we now have a method to measure precisely the degree of pollination success, *viz.* the number of pollen grains on each stigma. We have used this technique to evaluate the diurnal rhythm of cotton pollination and identify factors responsible for varying levels of pollination success.

First, we determined that the primary period of cotton pollination under climatic conditions of southern Arizona is between 0900 and 1200 hr MST. When bees were excluded from male-sterile cotton flowers prior to 1200 hr, they were still pollinated well until 1400 hr, but there was no improvement in pollination when previously exposed flowers were left exposed beyond 1200 hr. With least squares regression equations using pollen grains per stigma as the independent variable and seeds per boll as the dependent

variable, we demonstrated that 100 pollen grains per stigma should be accepted as an adequate level of pollination and that more than 160 is superfluous.

Spears pollination efficiency index (*Oecologia* 57: 196-199.) was used to determine the number of floral visits by various bee species needed to produce a boll with seed-set equal to open pollination. The results show that it took from 5.2 to 19.6 bee visits to equal the seed-set of flowers having unlimited visits. Since 80 to 90 bee visits per flower were observed during a flower's receptive life, full seed set was assumed for the open-pollinated flowers. Earlier work by Waller (unpublished) indicated that eight honey bee visits were nearly enough to approximate "full pollination."

Finally, we have been assessing the Pima pollen "parent problem" which has nearly caused abandonment of efforts to produce an interspecific (Pima X upland) hybrid cotton. Early results showed relatively few pollen grains on stigmas of male-sterile seed parents (upland) planted next to a Pima pollen parent and that only 20% of the few resulting seeds produced hybrid plants. Lack of bloom synchrony, cleistogamy of early-season Pima flowers, and ethological isolation by honey bees visiting only the cream-colored upland flowers or the yellow-flowered Pima all contributed to low seed production when using a Pima pollinator.

### 23. Waller, G. D.<sup>c</sup> and K. S. Taylor — SYNTHETIC PYRETHROIDS AND HONEY BEES

— The partial replacement of organophosphate and carbamate insecticides with synthetic pyrethroids has greatly improved the safety of bees near many agricultural crops, e.g. cotton in Arizona, sunflowers in North Dakota, rape in Europe. First synthesized only during the past decade, the pyrethroids registered and marketed today are, except for fluvalinate, highly toxic to honey bees exposed to contact or topical applications. Questions are being raised pertaining to behavioral changes induced in foraging bees by pyrethroids applied to crops which are being heavily visited by honey bees. Some researchers have described pyrethroids as bee-repellent compounds. This may be a simplistic explanation for a complex behavioral phenomenon. When methomyl alone was applied to sorghum we counted more than 1000 dead bees per colony, but applying a combination of methomyl plus permethrin (a pyrethroid highly toxic to honey bees) resulted in less than 100 dead bees per colony. In the latter case foragers arrived in the treated field at sunrise, but appeared not to return to the field and flight activity at colony entrances was suppressed only temporarily.

We have also observed an almost complete absence of honey bee foragers on cotton flowers following treatment of cotton fields with either permethrin or fenvalerate. Serious mortality from fenvalerate resulted when cotton fields were treated during daylight hours. No observable bee loss occurred when permethrin was applied during the night. Leaves of pyrethroid-treated cotton plants were used to test residual toxicity to honey bees. Most (but not all) pyrethroids were highly toxic to bees confined continually with freshly-treated leaves, and one (cyfluthrin = Baythroid® 2 EC) killed more bees that were exposed to day-old residues than to freshly-treated leaves.

We subjected honey bees to one of six pyrethroids at an LC50 dosage in a series of laboratory tests and compared the learning ability of the survivors with that of untreated bees. Ninety per cent of untreated bees responded to a test odor with positive responses after four training bouts, while only 50-60% of bees that survived pyrethroid exposure responded. Whether this impairment of conditioned response resulted from the inability to respond to the scent or sugar water stimuli or from a malfunction of the central nervous system, including memory storage or retrieval, is unknown. That we showed a depression of both rate of learning and degree of learning from pyrethroid exposure suggests that bee foragers visiting pyrethroid-treated crops might also suffer from impairment of olfactory learning. Additional research is planned to

elucidate the complex way in which forager inhibition occurs and the rate and extent to which individual bees recover.

**24. Williams, J. L.<sup>a</sup> — EVALUATION OF PHEROMONE TRAPS FOR DRONE HONEY BEES** — A portable wind-directed pheromone trap was designed in 1985 for monitoring drone honey-bee populations. The system includes a white nylon net (modified from Taylor, *J. Apic. Res.* 23: 18-20), pheromone lure (porous polyethylene rod treated with synthetic E-9-oxo-2-decenoic acid [9-ODA]), 6.1 m fiberglass pipe (3.81 cm OD by 0.7 cm wall), a base of steel pipe screwed into a steel plate bolted to a 0.61 m<sup>2</sup> piece of plywood, a collection bag holder, and ca. 25 m of 60#-test nylon monofilament line. Dimensions of the net are 50 cm (mouth diam.) by 100 cm (length) by 22.5 cm (top diam.).

From May to early July 1985, traps routinely captured 150 to 300 drones per 3 min. during peak flight (Table), both at extra-apiary sites and along the edge of a large apiary. For unknown reasons, capture rates at the same apiary were much lower in 1986. Smaller funnel-type traps (all plastic or combinations of netting and plastic) were much less effective than the nets. Initial field tests in 1985 indicated that drone flight over flat terrain with few trees is restricted to specific routes; traps at some locations consistently caught marked drones while others 100 to 160 m away caught very few or none.

The pheromone trap described here appears to have considerable potential as a survey and management tool for wide-area Africanized honey-bee suppression programs if trapping efficiency can be improved. The author is now working on the development of a system for selective control of feral Africanized honey bee colonies in which a delayed-action toxicant is applied to drones by pheromone traps.

Table — Number of drones captured per 3 min in pheromone traps within flight range of 4 apiaries, 9 July 1985. Wind-directed traps baited with 5 mg 9-ODA each were located along a 1,600-m lane bisecting a cultivated area and on line with two apiaries. Trap stations were 800 m (trap 1), 1200 m (trap 2), 1700 m (trap 3) and 2100 m (trap 4) from a large apiary (ca. 60 Langstroth colonies and 100 nuclei); traps 3 and 4 also were 500 and 100 m, respectively, from apiary 2 (15 Langstroth colonies and ca. 20 nuclei). Apiaries 3 and 4 were located ca. 966 m W and 1600 m NW, respectively, of trap 1. Drones were counted and released between catches.

Starting time (h CST)	Trap*			
	1	2	3	4
1550	267	—†	—	—
1600	289	—	191	—
1614	225	287	36	46
1624	210	289	132	6
1634	324	96	134	42
1644	231	74	52	18
1654	68	118	82	11

\*Weather data means for trapping periods: air temp (°C), 34.3; wind speed (m/sec), 1.5; light intensity (lux x 10<sup>-3</sup>), 11.9.

† Trap not operated.

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## CORRECTIONS

These corrections are for the Proceedings of the American Bee Research Conference published in the December *American Bee Journal*.

Page 830 — column 2 — line 9,

$Y = 25961 - 13.6X$  change to  $Y = 25961 + 13.6X$

Page 830 — column 2 — line 11,

$Y = 16794 - 9.7X$  change to  $Y = 16794 + 9.7X$

Page 832 — column 2 — line 15,

a slight decrease in percentage . . . change to a slight increase . . .

Page 833 — column 2 — line 24,

and 22 for "Narrowleaf" change to and 11 for "Narrowleaf" . . .

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