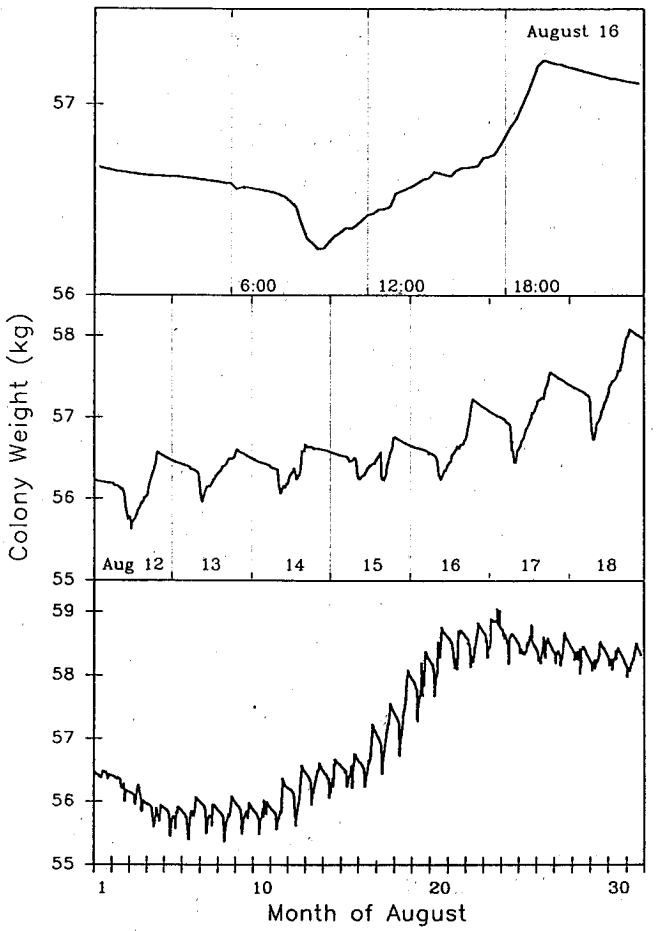
Special Feature

Proceedings of the American Bee Research Conference

The 1990 American Bee Research Conference was held on October 1 and 2 in Tucson, Arizona. Meetings were in the Meats Auditorium at the Campus Agricultural Center of the University of Arizona. The sixth American Bee Research Conference will be held in Tucson on October 7 and 8, 1991. The following are abstracts from the 1990 conference.

1. Buchmann, S. L.[a] – ELECTRONIC SCALE COLONY INTERFACED WITH A DATALOGGER[qq] – Routinely weighing colonies on mechanical scales has been used for decades to monitor honey flows. Knowing colony weights on a weekly or daily basis is a powerful research tool for studying population dynamics, transient pulses of harvested nectar and pollen, swarming behavior, general health, and a management device for honey extraction. An automated method is now presented which interfaces an industrial scale (Sartorius model F330S industrial balance) to a modern data logger (Polycorder from Omnidata, Logan, Utah). A custom Polycode program was written that prompts the electronic balance then stores the downloaded data at any user-defined time interval. Several months of data can be stored in tabular format inside the Polycorder memory until it is downloaded to a floppy or hard disk on a host PC. A sampling interval every 15 minutes around the clock is advantageous and data on behavioral phenomena such as nocturnal weight loss due to honey ripening or the number of foragers are easily obtained. This sensitivity is achieved since the scale can accommodate hives up to 300 kilograms with a resolution of 1 gram (the weight of 8-10 bees). Data for two colonies at different Sonoran desert sites has been collected for two years and provides an invaluable database for understanding colony population and foraging dynamics. The accompanying figure is a plot of the raw data for a large colony during the month of August, 1989 and illustrates daily patterns of nectar collection.

The Sartorius industrial balance is a rugged unit intended for dusty or wet warehouse applications for counting parts or in quality control during assembly lines. As such it has a rugged stainless steel base and sealed electronic components, including a built-in calibration weight and tare function, and is ideal for outside biological weighing applications when an AC power source is available. Our scale has now operated for a two-year period on a cement slab and under a shade screen during rainy and hot conditions (often exceeding 45 degrees Centigrade) without malfunctioning. Such a device is ideal for studying swarming and colony foraging ergonomics in honey bees and other central place foraging insects. Other temperate and tropical eusocial bees, such as *Bombus*, *Melipona* and *Trigona* spp. would be ideal candidates for long-term dynamical research using smaller Sartorius models. Perhaps the best feature of the electronic scale/datalogger interface is the ability to acquire vast amounts of error-free data, and the ability to estimate the number of bees out foraging at any time.



2. Buchmann, S. L.,[a] M. K. O'Rourke[b] and C. W. Shipman[a] – POLLEN PREFERENCES AND DIETARY BREADTH OF MANAGED AND FERAL SONORAN HONEY BEES[qq] – Since September 1980 an OAC pollen trap apiary of three colonies has been maintained near Pima

Canyon, north of Tucson. Trapped pollen was collected weekly and its weight recorded. A 100 g subsample was frozen until year's end when the annual diet was reconstituted by proportionally mixing portions of the 52 samples according to the total mean weight harvested weekly. Pollen samples were rehydrated, homogenized, acetolyzed and prepared for microscopic identification and counts according to methods given elsewhere (see O'Rourke and Buchmann, *J. Environ. Entomol.* in press). Palynological results indicate that from September 1980 to December 1989 the colonies collected pollen from 55 species of angiosperms in 40 genera and 25 families. Numerically, the dominant pollen types present during this 10-year period were: cf. *Aster* (22.7%), *Prosopis* (17.1%), Liliaceae (9.5%), *Eucalyptus* (7.0%), *Larrea* (6.6%), *Simmondsia* (6.6%), *Ambrosia* (6.4%), *Phoradendron* (4.8%), *Rhus* (3.1%), and Cruciferae (1.6%) with thse taxa accounting for 85.4% of the annual dietary pollen representation. Colonies harvested pollen from a total of 35-55 flowering plant species annually which represents about 18-28% of the species within their flight range.

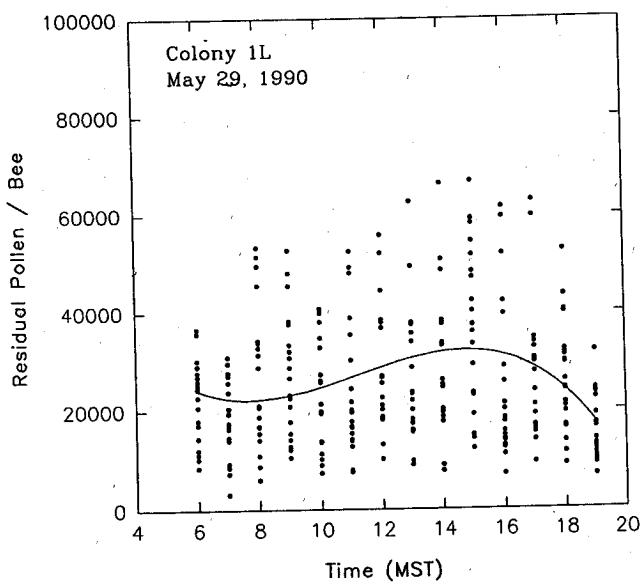
With their stored honey energy reserves *Apis* colonies are able to exploit pollen from anemophilous sources (eg. *Ambrosia, Ephedra, Rhus, Simmondsia*) early in the year when brood rearing is near maximum. During the period from 1981-1989 from 5 to 28% of the contribution to the annual pollen diet came from wind-pollinated plants. Unexpectedly, dominant plants in terms of vegetative or floral biomass (eg. *Cereus giganteus* and *Cercidium* spp.) represented only 0.8 ± 0.4 (SD) and 1.1 ± 0.7 (SD) of the mean annual diet. Although pollen is usually harvested proportionally to its community floral biomass, *A. mellifera* has distinctive preferences for certain plants, year after year. One example of a plant with minute flowers blooming in earliest Spring (Jan/February) and highly attractive to bee colonies is the parasitic mistletoe, *Phoradendron*, which occurs abundantly on host trees of mesquite (*Prosopis velutina*) and palo verde (*Cercidium microphyllum*). *Phoradendron* pollen was highly preferred (grand mean of 4.8% during the decade) by the bee colonies.

Although the site contains a largely undisturbed upper bajada Sonoran desert plant community, there are houses with ornamental plantings within flight range. From 1981-1989, pollen from exotic cultivated plants (eg. *Citrus, Eucalyptus, Morus, Olea, Rhus,* Tamarisk) constituted from 9-22% of the total pollen taxa harvested. Elsewhere (see Buchmann and O'Rourke, Grana, in press) we present data and caveats for quantitative assessment and understanding the importance of individual taxa (as numerical counts and by pollen volume) in pollen dietary assemblages from honey bees and other bee species.

Pollen diets can be quantified by processing dark *Apis* brood combs since these contain vast quantities of pollen harvested by the colony and consumed by larvae. As combs age, every 21 day brood cycle adds another layer of dark pollen-rich larval feces beneath silk cocoons. Little of this fecal pollen leaves via housecleaning bees. Solvent extraction methods for recovering and quantifying these comb samples from managed and feral colonies will be given elsewhere. Feral colonies living in Sonoran desert protected dry sites, produce unique debris middens rich in pollen. These can be exploited to determine foraging activity and pollen preferences over multiyear time spans. Such hardened, black, asphalt-like agglomerates of dead bees, wax, feces, dropped pollen and other materials are sometimes found below very old feral colonies in Sonoran rock outcrops. These bee middens can be processed using modified palynological techniques to yield a unique quantitative assessment of past pollen meals. One example of a multiyear (@5-15 yrs old) pollen diet from a feral colony located at Picacho Peak, Arizona is given below. Pollen from 37 species in 36 genera and 25 families were found. The dominant pollen types included; *Ambrosia* (25.7%), *Cercidium* (12.2%), Cheno-Am (8.1%), cf. *Aster* (7.9%), *Prosopis* (7,7%), *Larrea* (5.9%), *Trixis* (4.3%). Gramineae (4.1%), *Celtis* (3.2%), *Artemisia* (2.9%). Much older *Apis* middens were recently discovered in Organ Pipe Cactus National Monument and are being analyzed for their pollen content. Together, these data from managed and feral colonies constitute an invaluable database for bee diets prior to impending Africanization, and a means to assess intraspecific competition for floral resources.

3. Buchmann, S. L.,[a] C. W. Shipman[a] and H. M. Hansen[c] — POLLEN RESIDING IN SAFE SITES ON HONEY BEE FORAGERS — Pollen that increases male fitness by donation to stigmas, therefore pollination, represents a small fraction of the total pollen harvested by colonies. Honey bees are not sympathetic to plant reproductive needs, but are efficient floral herbivores of pollen and nectar for their own nutritional needs. *Apis mellifera* carry two corbicular payloads from 8.0 to 23.4 mg containing about 250,000 to 4,000,000 pollen grains, depending upon grain size. As a by-product of their sloppy harvest and grooming behavior on flowers and in flight, much pollen is lost to the bees and from pollination. Because of their plumose setae, large surface area and biophysical factors such as electrostatic charge and pollen characteristics (exine ornamentation, pollenkitt lipids) some pollen sticks to bees. Often, less than 0.007% of the pollen harvested by a forager gets lodged in "safe sites" where it cannot easily be groomed off for ingestion or transport. Safe sites for pollen grains occur in body regions including the occiput, thoracic notum, proboscideal fossa, between coxae and hind tibial pollen combs. For plants, some ungroomed residual pollen is donated to stigmas between floral visits. This diffuse coevolution between bees and flowers has directed the evolution of anther and stigmatic placement (*i.e.* noto- and sternotriby). Half-lives for residual pollen are unknown, but much is **not** donated to flowers or other bees. Many grains die, and often remain on bees for their entire lifetimes (Buchmann, in prep.).

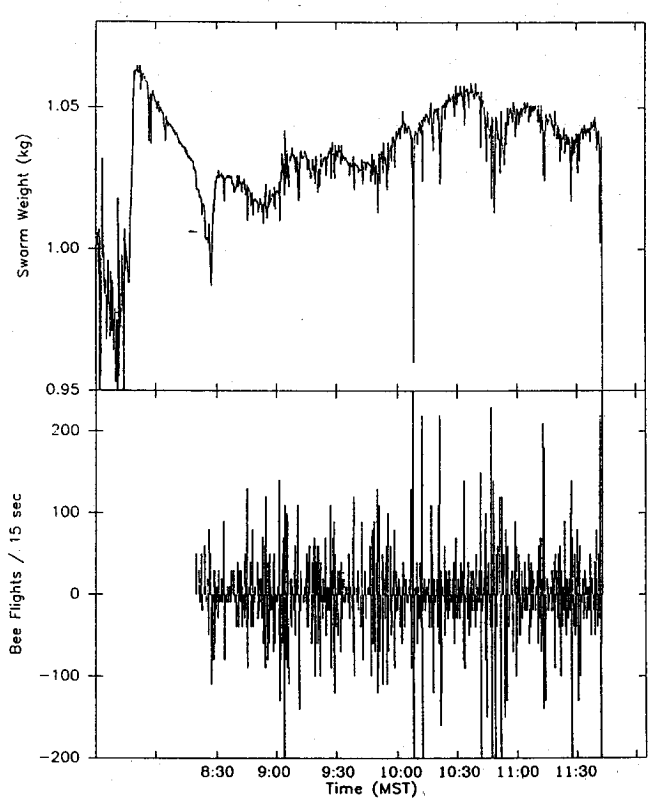
Experiments conducted in Tucson on full-sized colonies of Italian bees quantified residual pollen on outbound workers, drones and incoming nectar and pollen foragers. Additionally, newly emerged workers were marked and released into colonies to assess if any in-hive pollen transfer had taken place. Outbound foragers carried an average of 26,393 ± 3,952 (SD) pollen grains. Returning pollen foragers carried the most safe site pollen. The figure illustrates variable residual pollen on exiting foragers, but demonstrates a weak temporal pattern in pollen amount. Newly emerged bees acquired 6,780 ± 4,146 (SD) grains after 65 hours from nestmates, cell contacts, and feeding on bee bread. One sur-



prising result for newly emerged bees was the finding that bees could acquire up to 4,778 dead grains one hour post emergence from feeding on bee bread. If not ingested, this pollen was rapidly packed by young bees into the inner tibial pollen combs where it is not likely to be transferred to other nestmates. We conclude that in-hive pollen transfer from bee-to-bee is statistically unlikely for pollination compared with the predominant flower-to-bee-to-flower mode before grooming occurs.

4. Buchmann, S. L.[a] and S. C. Thoenes[a] – SCOUTING AND FORAGING BEHAVIOR BY BEES IN NATURAL SWARMS – From April 13 to May 15, 1990 a total of nine natural swarms were captured in Tucson, AZ and brought to the research center to study the scouting and foraging dynamics of unrestrained free-flying swarms. At capture these sugar-engorged swarm bees weighed on average 126.9 ± 18.9 mg. Within one hour of their collection, each swarm was installed on a screen cone suspended from a metal stand resting upon a Sartorius electronic balance linked to a Polycorder datalogger. The scale rested upon a concrete platform and the colony was shaded on three sides with dark green shadecloth which also provided protection from wind gusts. The support was tared out of the system and swarm mass was recorded every 15 seconds from installation until the swarms took flight to their new nest site usually on the first or second morning following collection. Since the swarm bees averaged 127 mg each, and the Sartorius balance is accurate to ± 1 gram, we have a weight resolution of ± 7.9 scouting/foraging bees for each time interval measured. No swarm traps or other artificial nest cavities were provided for the bees. Scouts were allowed to fly freely, come to a natural consensus, then move to unknown nest sites. Observations were also conducted on the number of waggle and DVAV dancers during certain days for some swarms. In addition to nocturnal measurements from the scale, swarm workers were randomly collected when found and at departure along with their weight and crop contents (volume and % TDS) to estimate the amount of nectar harvested during the scouting phase of nest establishment.

The figure illustrates the dynamic changes in weight for Swarm No. 8, May 3, 1990 plus estimated number of flights in lower panel. First bee flights began at 0615 MST and reached their peak at 1000 hrs. During maximum flight activity there were 400 to 1,000 bees away scouting or foraging. Pollen foragers were observed at a very low level (<0.01%) and no combs were constructed. During its entire stay prior to departure this swarm harvested 57 g of nectar, and made an estimated 15,000 scouting flights, or about 6 trips each by 2,798 bees. This is the first time that scouting/foraging dynamics from natural swarms has been studied. Our results indicate that about 80% of the bees are scouts, while only 20% are foragers. We estimate that even without foragers a swarm of this size (16.787 bees) could remain in a scouting mode for up to 5 days existing entirely on carbohydrate reserves in their honey crops.



5. Clark, K. J.[d] – 1990 FIELD TRIALS COMPARING VEGETABLE OIL AND MENTHOL AS A CONTROL FOR TRACHEAL MITES – Honey bee colonies infested with tracheal mites were treated with: 1) 250 g of a 1:3.5 canola oil:sugar mix applied as a patty in the brood nest, 2) 2 packets, each containing 25 g of menthol pellets, or 3) 2 plastic foam strips, each containing 10 g of re-solidified menthol, wrapped in perforated polyethylene.

Weather during the treatment period (July 6-21) was close to the warmest of the year for the region, with mean daily temperatures about 17°C and maximum daily temperatures generally above 25°C, occasionally reaching above 30°C. The mean amount of menthol vaporized in treatment 2 was 35 g per colony, and in treatment 3 was 12 g per colony. Menthol remaining at the end of the 15 days was removed. The oil patties were left on the colonies, and lasted 4 to 7 weeks.

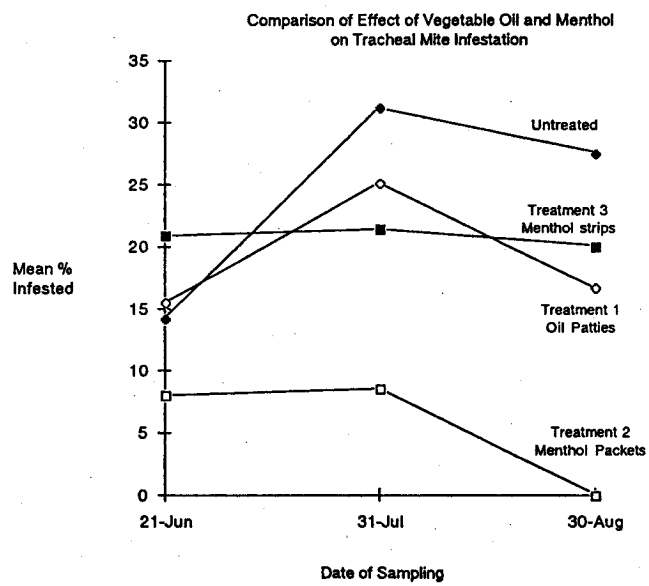
The mean tracheal mite infestation in untreated colonies increased from about 14% to about 30% during the 2 month trial (figure).

Eight weeks after the vegetable oil patties were installed, the mean mite infestation in that group of colonies was 40% below ($p < .05$) the infestation in the untreated colonies.

No change in infestation was indicated 25 days after installation of the menthol, although the thoracic disc examination method used, did not distinguish between live and dead mites.

Eight weeks after the menthol had been applied, fewer than 1% of bees in samples from treatment 2 had mites, a reduction of over 99% from the untreated group.

Perforations in the polyethylene wrappers around the menthol strips in treatment 3, became propolized enough to



reduce vaporization in that formulation. Samples indicated that the mite population in treatment 3 did not change over the period of the trial, but since the infestation in the untreated colonies had increased, the treatment 3 infestation at week 8 was lower than that in the untreated colonies.

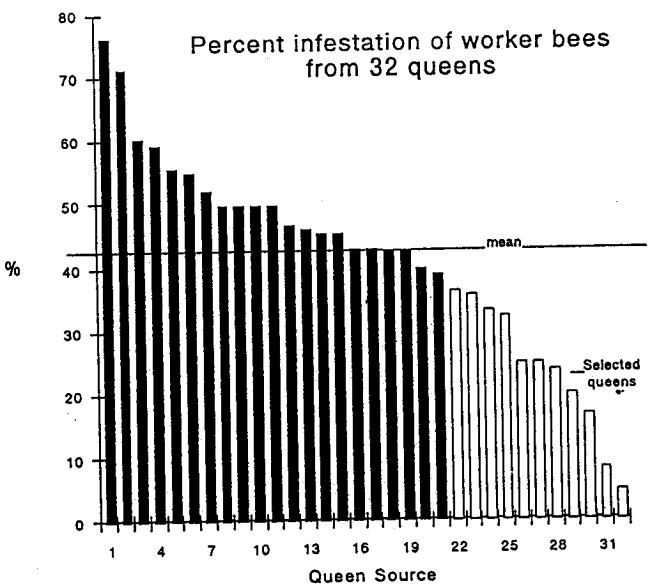
6. Clark, K. J.,[d] E. Huxter,[e] N. J. Gates[f] and T. I. Szabo[g] – SCREENING BREEDER HONEY BEE STOCK FOR RESISTANCE TO TRACHEAL MITES – Worker honey bees of 35 breeder queens from 11 commercial queen rearing operations in British Columbia were assessed to determine their relative tendency to become infested by tracheal mites in infested bee colonies. Workers from an additional 12 queens representing families of Alberta bee stock were assessed simultaneously. Results for the latter group are still being processed.

Newly emerged bees from each queen were marked with a unique 2 color combination. For each of 9 replicates of the assessment, 25 marked bees from each of the queens were introduced within 20 hours of emergence, into an infested colony. The bees were retrieved 2 weeks after introduction, sorted by color mark, and dissected (thoracic disc method) to determine the presence of tracheal mites. Three infested colonies were used on each of 3 dates, 1 week apart, providing 9 replicates with a maximum total of 225 marked bees per queen.

About 36% of the nearly 5,000 marked bees were retrieved with their marks intact. In 5 of the 9 replicates, less than 10% of the marked bees became infested, owing to low mite populations in the host colonies. Data from these 5 replicates were not included in the analysis. Marked bees from the other 4 replicates had a mean infestation of 43% (range 40-49%) resulting from host bee colonies with a mean infestation of 63% (range 53-83%).

The infestation of groups of bees from individual queens ranged from 4.8% (0.11 of the mean of all the marked bees) to 76% (1.8 of the mean) (figure). From the 35 breeder queens, 11 whose retrieved workers had a mean infestation of 23% (0.55 of the mean) were selected for production of a second generation. Ten daughters were grafted from each of 9 of the selected queens. The resulting queens were mated in an isolated location with drones from the same 9 queens. The project currently has about 70 queens which will be reassessed in the spring of 1991.

We intend further selection within the lines, inclusion of other apparently resistant stock, exchange with other projects, and distribution of stock to project cooperators.



7. DeGrandi-Hoffman, G.[a] and J. Bromenshenk[h] – AN UPDATE ON THE BEEPOP HONEY BEE COLONY POPULATION DYNAMICS MODEL – Two years ago a group of scientists from the Carl Hayden Bee Research Center (CHBRC) created a computer simulation model of honey bee colony population dynamics (BEEPOP) (DeGrandi-Hoffman *et al. Ecol. Modelling* 45:133-150). BEEPOP uses parameters known to influence population dynamics including: weather conditions, daylength, queen age, egg laying potential, the amount of sperm in the queen's spermatheca, and the size of the adult worker population.

BEEPOP is an interactive, menu driven, mainframe computer program. Default values obtained from the literature are provided for all parameters. By entering climate along with colony parameters, users can simulate population growth for very specific sets of conditions, times of year, and geographic locations. Users can test parameters for their effects on population size and identify those with the greatest influence. From simulations conducted under U.S. southwestern desert and midwestern weather conditions, we determined that the queen's egg laying potential is the most important parameter influencing population growth, because it limits the colony's ability to replace adult workers even when all other factors are optimized.

We constructed BEEPOP on a mainframe computer to take advantage of the virtually unlimited memory and rapid mathematical computations. However, many people do not have access to a mainframe computer and program portability is limited.

The problem of BEEPOP program portability was resolved at the University of Montana. At U.M. we developed PC-BEEPOP, a software program for IBM-compatible personal computers (Bromenshenk *et al. Environ. Tox. & Chem.* in press). Conceptually, PC-BEEPOP is similar to BEEPOP and retains all the options present in the original model. To facilitate use of the model, we added pull down menus, extensive on-line help, and graphics. We were interested in simulating colony responses to stress, including disease and exposure to toxic chemicals such as pesticides and hazardous wastes. Consequently new features were added to PC-BEEPOP. These include the ability to: vary development time, longevity, and mortality rates due to pesticides, predation, or diseases for specific lifestages and periods of time; randomize or manually initialize the population's age structure, control ratios of adults to brood, induce swarming, limit space for brood rearing and food storage, account for winter losses, and profile food gathering and food consumption rates, as well as entering the percentage of foragers that collect water, nectar, pollen, resin, or act as scouts.

PC-BEEPOP was designed for use in applied research and to assess bee population responses to environmental variables and exposures to toxic chemicals. We believe that PC-BEEPOP can be particularly useful as a teaching tool for courses in apiculture and social insects, population ecology, and general biology. Extension agents can use the program in beekeeping courses to illustrate the repercussions of various management practices. Beekeepers also may be interested in using PC-BEEPOP to identify the best management strategies for their particular geographic region. Regulatory agencies could better educate applicators about the effects of various pesticides using PC-BEEPOP.

PC-BEEPOP requires an IBM-compatible machine with a hard disk, 520K of memory, and a graphics adapter card. A 286 or 386 processor and a color monitor are preferred for ease of use and optimal performance.

8. Eischen, F. A.,[i] E. D. Akre,[j] and R. L. Hellmich[k] – AGONISTIC INTERACTIONS BETWEEN ANTS AND HONEY BEES IN THE TROPICS – Colonies of African-

ized and European honey bees were presented with living and freshly killed ants [*Camponotus sericeiventris* (Guerin)] at their entrances. Africanized colonies responded more quickly and with greater numbers of defending workers than did European colonies.

We speculate that because of their prevalence and incessant predatory behavior, ants have played an important role in the evolution of honey bees in the tropics. We suggest that ant predation prevented extensive utilization of the neotropics by European bees, but that effective defenses by Africanized honey bees allowed population growth and migration.

9. Ferrari, T. E.[l] – "ENPOLLINATION" OF HONEY BEES WITH PRECOLLECTED POLLEN IMPROVES POLLINATION OF ALMOND FLOWERS – Many crops have strongly self incompatible flowers and require cross pollination for fruit, nut or seed set. Poor environmental conditions, however, often interfere with optimal dispersion of pollen. Procedures that improve transfer of compatible pollen to flowers by bees are useful when undesirable situations threaten to limit crop production.

Dispersal of hand- or machine-collected pollen onto bees is termed enpollination. The procedure is fast, safe and easily implemented for many crop pollination situations. Enpollination of bees at the hive entrance improved pollination of cherry and apple flowers (Mayer & Johansen, *Goodfruit Grower* 38:32-33).

Tests with almonds support two components of pollen dissemination (near vs far) in orchards depending on kinetics of in-hive, bee-to-bee pollen transfer and orientation of tree rows. Three hours after almond pollen was applied to colonies, the number of grains on exiting bees peaked. At that time, transfer of viable pollens to flower pistils by bee bodies was improved 1.6- to 2.9-fold. Thus, an additional nut set would manifest itself where bees are foraging in an orchard when the pulse of increased pollination efficiency occurred.

Enpollinated colonies – placed so that bee flight was perpendicular to tree rows – produced significantly more nuts (table) within 300 feet of hives (near). When bee flight was parallel to rows, more nuts were produced beginning about 500 feet (far) from hives. No such changes were measured in orchards which did not receive supplemental pollen (-P). Results confirm known preference of bees to forage down, rather than across tree rows.

Table – Improved almond yields after enpollination of colonies with precollected pollen – based on two independent foraging patterns.

Orchard +/-Pollen	Nuts/Tree Diff	Chance	Student T-Test
Perpendicular	Near-Far	%	Level
1 + P	2415	+56.3	0.01
2 - P	-225	- 4.4	NS#
3 + P	1867	+44.4	0.01
4 - P	-291	- 3.2	NS
Parallel	Far-Near		
5 + P	1168	+25.8	0.05
6 - P	-556	- 11.4	NS
7 + P	1640	+17.8	0.1
8 - P	9	+ 0.1	NS

#: NS = not significant at 0.2 confidence level

10. Garza-Q.,[m] C., J. H. Dustmann,[m] W. T. Wilson[n] and R. Rivera[n] – CONTROL OF THE HONEY BEE TRACHEAL MITE *(ACARAPIS WOODI)* WITH FORMIC ACID IN MEXICO[pp] – One of the most important parasites affecting honey bees, *Apis mellifera*, is the tracheal mite, *Acarapis woodi*. Since first being reported in Mexico in 1980 (Wilson & Nunamaker, *Am. Bee J.* 122:503-505, 508), the parasite has spread rapidly and is now endemic in bee colonies in areas such as northeastern Mexico (Eischen, *et al., J. Kan. Entomol. Soc.* 63:56-73). Eischen *et al. (Apidologie* 20:1-8) reported that heavy mite infestations in Mexico caused serious economic damage to colonies and Garza-Q. (unpublished) found that the level of infestation increased during winter. Although non-chemical and management methods exist in Europe for mite control (Dustmann, *Allgemeine Deutsche Imkerzeitung* 21:2-8), chemical control is currently the method of choice in Mexico. Although several acaricides have been used by Mexican beekeepers, most chemicals have not been successful for reasons such as difficulty in dispensing, toxicity to bees or excessive cost.

Since formic acid is a naturally occurring compound and has been used effectively as an acaricide in Europe, it was decided to test formic acid fumes in 27 mite-infested honey bee colonies near Linares (N. L.) Mexico in 1988 for the control of *A. woodi*. Each of 9 colonies was given 4 applications of formic acid at intervals of 4 days. The chemical was dispensed on a cardboard sheet in the top of each colony (1 brood chamber & 1 super per colony). There were 3 colonies in each of 3 groups: I) 5 ml per colony per application (total 20 ml), II) 10 ml per colony per application (total 40 ml), III) 20 ml per colony per application (total 80 ml). Adult worker bees were collected from the colonies and dissected to determine the number of dead adult mites per bee on days 0, 4, 8, 12 & 16. The mite infestation level in the bee population was 30% or more at the beginning of the study. The entire test series was repeated three times. Therefore, the summary data is an average of the 3 replications.

Formic acid fumes gave good control of the tracheal mite in autumn field tests in northeastern Mexico. The 5 ml and 10 ml treatments killed about 40% of the adult mites after the 1st treatment and 61 and 76% of the mites, respectively, following the 4th treatment with the final mite counts made on day 16. The 20 ml treatment produced excellent control with 56% of the mites dead after the 1st, 71% after the 2nd, 90% after the 3rd and 96% after the 4th treatment (in 4 colonies 100% mite control was achieved). The normal adult mite mortality in the tracheal tubes prior to chemical treatment was approximately 6%.

The data showed that 4 treatments were necessary and that a 4-day period between treatments was suitable to achieve effective mite control. Although the bees did a lot of fanning when the treatments were applied, no bee mortality or abnormal bee behavior was observed in any of the treated colonies. Consequently, formic acid was not only efficacious in mite control, but also it was not damaging to the bees. The use of formic acid fumes shows much promise in Mexico as a cost-effective control for *A. woodi*.

11. Gilliam, M.[a] and S. Taber III[o] – DISEASES, PESTS, AND NORMAL MICROFLORA OF HONEY BEES, *APIS MELLIFERA*, FROM FERAL COLONIES – The opinion that feral colonies of honey bees are a menace to beekeeping because they harbor and spread diseases and pests is not expressed as frequently now as it was in the past. A review of the limited available literature revealed that the incidence of diseases in feral colonies has been found to be lower than that in managed colonies.

Data on wax moths in feral colonies are lacking. Since abandoned combs are often destroyed by wax moth larvae, these insects have been thought to play a role in slowing or preventing the spread of pathogens, particularly *Bacillus larvae*. However, an often overlooked, early study (Phillips, USDA Bull. 75) concluded that wax moths do not eat scales formed from honey bee larvae that have died from American foulbrood.

Recent interest in feral honey bee colonies, limited information available on surveys of feral colonies for diseases and pests, and lack of data on microflora of feral colonies prompted this work which was conducted before the mites, *Acarapis woodi* and *Varroa jacobsoni*, were reported in the United States. Our purposes were to survey feral colonies for disease and pests, to determine intestinal microflora of worker bees from feral colonies, and to compare the intestinal microflora of bees from feral colonies to that of bees from managed colonies.

Examinations and collections were made from 7 colonies located in rock caves, overhangs, or holes south of Cottonwood in central Arizona. Access to both colonies and brood combs within the colonies prevented examination of additional feral colonies in the area. Colonies were inspected and tested for diseases, pests, and parasites according to Shimanuki and Cantwell (USDA ARS-NE-87). Microflora was determined by isolating intestinal bacteria, yeasts, and molds from 34 foraging worker bees from 5 colonies.

Nosema apis, the only pathogen found, was observed in the intestinal tracts of 9 of 21 bees which were unable to fly and were crawling on the ground below one of the colonies. Only 1-5 spores of *N. apis* per bee were found after thoroughly searching numerous slides prepared from each intestinal tract.

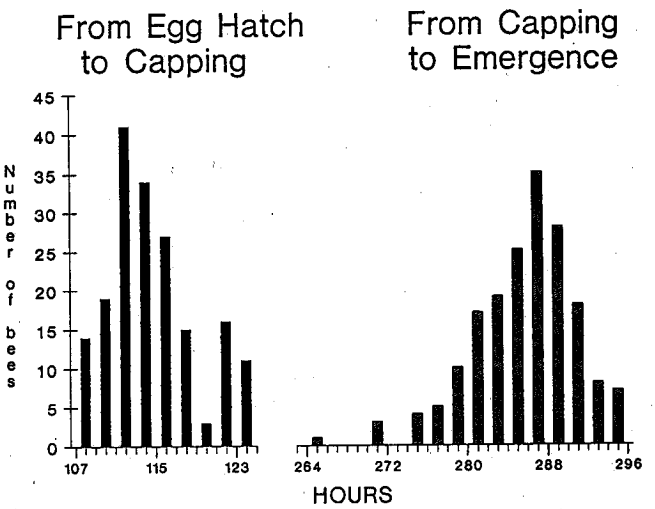
Frass and larvae of the greater wax moth, *Galleria mellonella*, were present in 2 colonies. One colony, below which the crawling workers with *N. apis* were found, had combs that were disintegrated as a result of attack by wax moth larvae. The other had no queen; but egg-laying workers, honey, and pollen were present.

Intestinal microorganisms were isolated from 79% of the foraging worker bees. Gram-variable pleomorphic bacteria were the most frequent isolates. Species of *Bacillus* were the second most common organisms; only *B. alvei* and *B. megaterium* were found. Some bees from all colonies contained Gram-variable pleomorphic bacteria and *B. megaterium*. Actinomycetes, Gram-negative bacterial rods, Gram-positive cocci, molds and yeasts were present in less than 10% of the bees. Thus, the honey bees from feral colonies in central Arizona contained the same kinds of intestinal microorganisms as honey bees from managed colonies in southern Arizona.

Ten samples of wax moth frass from each of the two colonies were stained and examined microscopically for bee pathogens and were also plated to test for *B. larvae*. Results were negative. The microflora of the frass was determined and found to be comprised of Gram-variable pleomorphic bacteria, *Bacillus* spp. including *B. alvei* and *B. megaterium*, Gram-positive cocci, actinomycetes, and molds. Thus, there are similarities in the kinds of microorganisms in bees and in wax moth frass from feral colonies.

12. Harbo, J. R.[k] — BREEDING FOR A SHORT CAPPED PERIOD IN WORKER BROOD — A capped period of about 240 hours is required for a female mite, *Varroa jacobsoni*, to produce 1 mature female in the cell of a worker bee, and additional females are produced at 30 h intervals (Rehm & Rittner, *Apidologie* 20:339-343). Moritz (*J. Hered.* 76:267-270) found that the capped period of worker brood differed by more than 48 h between European and African races of bees, and he reported a high heritability (0.8) for this trait. Therefore, it should be possible to acquire resistance to *Varroa* by selecting bees for a short capped period.

I surveyed bees in Baton Rouge to measure variability and heritability of development time. Newly hatched larvae were obtained from 26 different colonies by placing brood combs in an incubator without adult workers. Larvae from eggs that had hatched in the incubator were identified by their not having brood food in their cells. These larvae (0-3 h old) were then transferred to a small patch of worker cells



Development times for 180 worker bees from 26 different colonies. The mean ± SD was 114.5 ± 4.3 hours for the uncapped period and 285 ± 5.1 h for the capped period. Combined times ranged from 379 — 417 hours, so by adding 71 hours for the egg stage (Harbo & Bolten, *Ann. Entomol. Soc. Am.* 74:504-506), total development times ranged from 450 — 488 h (18.8 — 20.3 days) with a mean of 19.6 days.

and put into a strong colony to be reared. This equalized the ages of the larvae and placed larvae from different stocks into a uniform environment for comparison. Development time was established for each worker by checking the comb at 2 hour intervals during the capping and emergence periods (see figure). Heritability was 0.56 for the capped and 0.40 for the uncapped period. Stocks with rapidly developing workers did not always produce rapidly developing queens (worker-queen phenotypic correlation = 0.4), so one must evaluate workers rather than queens. With standard breeding methods, it should be possible to select within th. Baton Rouge population to produce a stock with a capped period <270 h (probably some resistance to *Varroa*), but a higher level of resistance (<240 h) may be difficult to achieve.

13. Houck, M. A.[c] — BEE MORPHOMETRICS AND THE INFLUENCE OF SIZE ON THE DISCRIMINATION OF AFRICANIZED AND NON-AFRICANIZED BEES — In any multivariate analysis, change in morphological characters must be evaluated within the context of some allometric model. Variation (due to such factors as ontogeny, nutrition, and phenotypic plasticity) that effects general size can contribute significantly to the variance structure of discriminant function analyses. Such influences must be considered as separate from conclusions concerning evolutionary or populational differences. In the past, discriminant function analyses on *Apis* have been accomplished without consideration of the allometric effect of size on discriminatory characters.

I present the first of a series of analyses that will examine the discrimination of Africanized bees from non-Africanized bees in an allometric context. This work represents an extended collaboration with R. Strauss, E. Dyreson, H. Daly, and E. Erickson. It investigates discrimination due to forewing and hindwing characters of worker bees as related to 4 measures of head and thorax size. Later reports will focus on similar analyses applied to the stinger, leg III, mouth parts, and antennae of workers.

Bees were collected from 14 geographic localities representing 4 groups: African bees, Africanized bees, non-Africanized North and Central American bees, and European bees. Data were entered into the discriminant function analysis with geographic location as the categorical variable. The condition of Africanization was not a categorical variable.

When size was retained in the 14-locality analysis, meaningful discrimination by degree of Africanization was not evident in the structure of the data. When size was partitioned from the data set, using the method of residual analysis, a clear two-group separation occurred that discriminated African/Africanized bees from European/Europeanized bees. A regional subset of 7 localities (feral bees from Arizona, managed bees from Arizona, feral Californian bees, and 3 Africanized localities: Brazil, Costa Rica and Colombia) resulted in the discrimination of 3 groups: Africanized bees, CA/European bees, and AZ feral/AZ managed bees.

Results from these analyses are encouraging, and size-independant discriminant procedures may be very helpful in distinguishing Africanized from non-Africanized bees, especially on a regional level where within-group variances are low as compared to among-locality variation.

14. Kitto, G. B.,[p] F. Davidson,[p] E. Broussard,[p] J. Lemburg,[p] and W. Rubink[n] — DEVELOPMENT OF BIOCHEMICAL DETECTION METHODS FOR AFRICANIZED BEES — Africanized Bees are now approaching the southern border of the United States, and it is imperative that rapid and reliable means of detecting and monitoring the spread of these bees be available so that effective control measures can be implemented. Electrophoretic and immunological techniques offer great potential for identifying Africanized Honey Bees (AHB). We have identified three proteins (termed A-1, A-2, and B-1) which are unique to AHB (Davidson *et al, Am. Bee J.* 129:813) using narrow range non-denaturing isoelectric-focusing (IEF). Such AHB specific proteins have subsequently been confirmed (Hung, *Am. Bee Jour.* 130:49), also using such IEF procedures.

Africanized honey bees from 16 different sources in Mexico, Honduras, Costa Rica, Venezuela, and Brazil, have been screened by IEF (more than 800 individuals). Only 7% of these samples lack the AHB-specific proteins. Tests using the three AHB-specific proteins should make it possible to have a 93% accuracy of AHB detection. Trials using USDA Mexican trapline samples have been consistent with this figure, and correlate with other methods of AHB detection.

AHB-specific proteins have been purified by a combination of IEF and SDS-gel electrophoresis for structural studies and antibody preparation. Rabbit polyclonal antibodies directed against the A-1 and A-2 proteins cross react not only with these proteins in AHB samples, but also with the other AHB-specific protein, B-1, and, to a lesser extent, with a protein termed B-2 which is found in all European bee populations studies and in approximately 50% of AHB populations. This cross-reactivity is indicative of a degree of structural relatedness of the 4 proteins. Preliminary trials indicate that absorption of these antisera and an EHB extract provides antibodies that are AHB specific. The availability of such antibodies allows for the development of ELISA assays for AHB detection and the development of dipstick-type immunoassays for rapid and economical detection of AHB. The ELISA approach should provide a means for quantitative estimation, in a laboratory setting, of the degree of Africanization of large scale samples from swarms and traplines. The ready availability of automated equipment for this type of assay makes its use attractive for tests at centralized facilities. The dipstick, or test-strip, type of assay has proven very reliable in clinical analysis and this approach is well suited for rapid, low cost analyses in the field. Potential uses include hive sampling and rapid field identification of Africanized swarms.

Analysis of malate dehydrogenases (MDH) of honey bees has shown the presence of 3 alleles for the cytoplasmic form of this enzyme. Previous studies (Nunamaker, PhD Dissertation, Univ. Wyoming) on *Apis mellifera scutellata* from African populations showed that the "fast" or "5" allele was present in 100% of these colonies, but was only present in low frequencies in other *Apis mellifera* subspecies. These findings suggested that the MDH "5" allele might be a useful marker for assaying the degree of Africanization of bee colonies in North and South America. In order to assess the usefulness of this approach, we have determined the MDH allele frequencies of a number of Africanized bee samples from Central and South America, and have carried out a brood survey of European Bees (EHB) across the United States. The AHB samples from Central and South America have high MDH-5 allele frequencies, but certainly not 100%. More importantly, allele frequencies of EHB samples show a very broad range of variation (3%-65% MDH-5). Even different colonies of European Bees from the same apiary can have very different MDH allele frequencies (13%-65% MDH-5). We conclude that MDH allele frequency analysis is an inappropriate tool for assessing the degree of Africanization of honey bees in the U.S.

These studies were supported in part by a grant from The Texas Advanced Technology Program.

15. Loper, G. M.[a] and M. M. Fierro[q] — USE OF DRONE TRAPPING AND DRONE RELEASES TO INFLUENCE MATINGS OF EUROPEAN QUEENS IN AN AFRICANIZED HONEY BEE AREA; TAPACHULA, CHIAPAS, MEXICO — This study was very similar to that reported by Hellmich, *et al. (J. Econ. Entomol.* 81:796-799) which had been conducted in Venezuela. However, instead of supplying European drone source colonies located in the central queen nuc apiary, the drone colonies were placed 1 km away from the queen nucs in each of 4 cardinal directions (Taylor and Rowell In *Africanized Bees and Bee Mites*, Chap. 21, pp. 173-192. 1988). Additionally, modified Taylor aerial net traps (*J. Apic. Res.* 23:18-20) were used to eliminate many of the Africanized drones before the release of the second batch of sister Cordovan virgin queens. The drone colonies supplied about 6,400 yellow or cordovan colored drones whereas the drone trapping eliminated about 6,400 "feral" Africanized drones. Some of the drones may have come from some managed colonies, but over 80% of the trapped drones were black (Table) and highly Africanized and only 2% were yellow or Cordovan.

The progeny of 12 queens from the pre-drone control mating and 8 queens from the post-drone control mating were rated in terms of the number of yellow bands on their abdomens. There seemed to be a "break point" at 1½ yellow bands; *ie.* 52.6% of the progeny from the first mating (with the feral drone population) had 1½ or fewer yellow bands whereas only 6.4% of the progeny from the controlled mating had 1½ or fewer yellow bands.

It is obvious that drone populations, and therefore mating results, can be influenced with current technologies. But only in very isolated situations would total drone control be possible. Some introgression of African genes may be desirable in producing genetic lines for the future (Hellmich and Waller, *Am. Bee J.*, 130:537-542.)

Table — Drone trapping, color sorting results. Ejido Joaquin M. Gutierrez, Chiapas, Mexico, 1989.

Date	Color Sort				TOTAL
	% Black		% Yellow		
Nov. 17	85.7		14.3		63
	% Banded Black	% Black	% Semi-Yellow	% Yellow + Cordovan	
Nov. 30-Dec. 7	64.5 ± 7.8*	15.8 ± 6.0	18.5 ± 8.2	1.2 ± 0.8	6,036
	% Black		% Semi-Yellow	% Yellow + Cordovan	
Dec. 8	39.9		9.3	50.8	801
Dec. 9, 14, 19	66.7 ± 11.7		28.0 ± 10.1	5.2 ± 4.4	803

* ± Standard deviation

16. Loper, G. M.[a] W. W. Wolf[r] and O. R. Taylor, Jr.[s] – SUMMARY OF STUDIES ATTEMPTING TO INFLUENCE HONEY BEE DRONE FLIGHT DIRECTION – RADAR OBSERVATIONS – The use of a portable X-band radar has documented that drones orient to tree-lines and other structural features and form broad (80-100 m wide) flyways to the side (60-100 m) of such features. For example, in a flat desert area west of Tucson, AZ, drones from an apiary formed flyways on either side of a line of short mesquite trees growing in a dry wash. The drone flyway curved with the tree line and extended in excess of 4 km along the wash. At various places, the flyway branched and congregation areas formed apparently in relation to other features encountered along the way. Beginning in 1989, some efforts were made to attempt to influence drone flight direction by providing new lines of visual cues. In 1989, the studies were conducted west of Tucson on an old air field where there were only a few small (<3 m) trees and low (<1 m) shrubs, but where drone flyways were known to exist (*i.e.* "natural" conditions). In 1990 the artificial lines of cues were established on the flat, barren bed of a large 15 x 15 km (roughly heart-shaped) dry lake – the Wilcox Playa near Willcox, AZ (*i.e.* "unnatural" conditions). The reason for going to the Playa in 1990 was that even the low shrubs on the airfield interfered with the radar viewing. In both areas a line of "artificial trees" up to 1,200 m long was created. A "tree" consisted of a 2 m steel fence post (placed at 3-5 m intervals) to which a triangular piece of plywood was wired (cut from 4' x 8' plywood sheets, 2/sheet). The first tree line (1989) was essentially straight with a slight curve "dog leg" at the end. Another was a straight line and another formed a semi-circular curve intersecting a known flyway. The one straight line also had a width of mosquito netting (Army green, 28 cm wide) which was weighed down with fence posts. In 1990, we used 1 straight line of the "artificial trees" (1,200 m) and another line (curved near one end) of the netting (850 m long). Additionally, on the lake bed, any vehicle track was also an obvious cue and care was taken to establish long straight sets of tracks in a rectangular pattern near the central apiary.

In 1989, the radar viewing was interfered with – at the lower levels (10-15 m above ground) by the shrubs, but occasionally, drones appeared to be diverted to new directions by the artificial cues. The curved tree line that crossed a known flyway was installed in one morning and as the drones began to fly, they "piled up" in the curve. However, later in the day they were crossing it reforming their normal flyway. (This was not documented by radar, but from the sound of drones flying (or not flying) on either side of the tree line).

On the Playa, there were very few other insects and most of the workers were diverted to a source of sugar-water. However, both workers and drones were flying low (½-5 m) in the experimental area and the radar could not tell worker from drone targets. Only by comparing pictures before and during drone flight time and by using queen pheromone could some deductions of drone flight be surmised. Since the bees flew so close to the ground visual observations were made to complement the radar.

Unfortunately, the "tree line" was a strong reflector of radar energy and since the bees flew so low, bee activity near it was obliterated by radar "clutter." However, bee activity near the netting and tracks was obvious. In addition to the scatter of bees in the general radar viewing area (800 m radius, 360°) the radar pictures show insects flying over and alongside all straight line and curved features in greater numbers than in the rest of the viewing area (except to the sugar-water). Only during drone flight time, a DCA-like feature developed at the end of a set of tracks: drones flew away from the apiary along these tracks for approximately 800 m until they reached the end of the road. About 50 m beyond this point, a separate group of targets formed from which they dispersed in all directions, but this grouping continued for many minutes.

We feel that we have sufficiently documented that drones use (even seek out) visual orientation cues and form flyways along them using them in both outward and returning flight.

17. Loper, G. M.[a] and E. A. Sugden[n] – USE OF AVERMECTIN-TYPE INSECTICIDE APPLIED TO DRONE HONEY BEES TO CONTROL FERAL COLONY POPULATIONS[pp] – A large population of feral colonies exists in the United States especially in locales where the African honey bee (AHB) is expected to become endemic. In most cases, these feral populations are sufficiently isolated such that they pose no threat to humans and they provide a beneficial source of pollinators for wild plants. However, in some locales, urban, recreational and queen mating areas, especially, feral AHB may become a socioeconomic problem. In these areas, periodic elimination of feral colonies may become necessary. Most feral colonies, especially AHB colonies, produce a large number of drones, and when flying they can be attracted in large numbers (using queen pheromones) and caught in aerial net (Taylor) traps.

The Avermectins are a class of compounds derived from *Streptomyces avermitilis* produced by fermentation. Commercial preparations of these compounds: Avermectin ("Avid") and Ivermectin ("Zimectrin") have been formulated to use against the "fire ant" and numerous internal parasities in animals, respectively. Drones escaping from the top of a modified Taylor drone trap were forced to contact either Ivermectin or a mixture of Avermectin and Ivermectin (A + I). This resulted in the death of the drones in less than 24 h, but their nest mates survived (Loper, unpubl.). A procedure of manually dosing drones with 5 mg of A + I (≈ 70 μg active ingredient) was developed and this paper describes the experiments and results of tests conducted in 1989 and 1990.

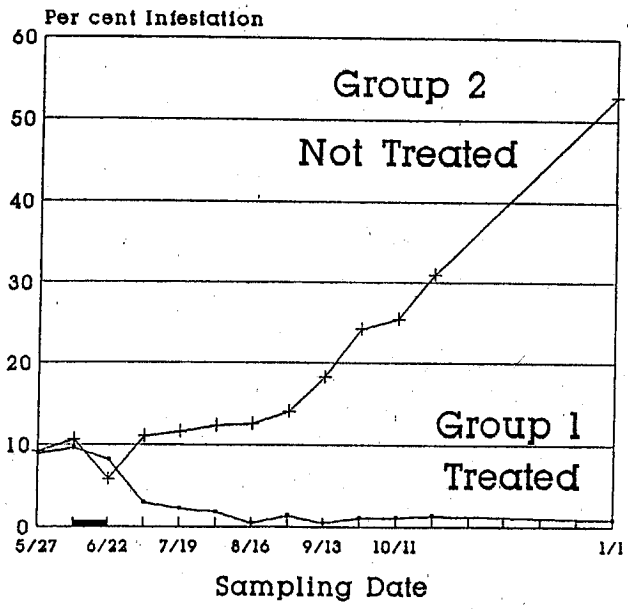
In Arizona (1989) 60 drones returning to a feral colony were caught at the nest entrance and treated with 41 μg/drone of A + I and released 100 m from the nest. Treated drones were observed (but not counted) returning to the nest. Within 13 h, the colony was severely affected (many dead drones and bees at the entrance) but it took approximately 10 weeks for it to die. Apparently, the sealed brood (worker and drones) survived after emergence, but with no queen the colony was doomed.

In Texas (1990) a series of domesticated colonies were similarly treated (58-81 μg/drone). The number of treated drones allowed to return to a colony were: 25, 35, 45 and 55. All colonies were severely affected; colonies treated with 45-55 drones died quickly. In the sub-lethal treatments, each treated drone resulted in the death of approximately 250 nest mates. Some drones flew at least 2 km after treatment to return to their colony. Feral drones were caught during the experiment, but no feral colony was located. On one afternoon, 128 feral drones were dosed and no more drones could be caught at that location on subsequent days. However, virgin Cordovan queen successfully mated with wild-type drones after this treatment. These drones could have come from: (1) newly emerged and matured drones from the treated feral colony(s); (2) drones from untreated (or under-treated) feral colonies within flight range of the queen.

Samples of dead bees, honey and wax from treated colonies were analyzed by Paul Rivera for residues of A and I, but no detectable levels (less than 0.1 μg/bee) of residues were found, even with samples of 30 dead bees.

18. Macdonald, J.[t] and K. J. Clark[d] – 1989 FIELD TRIALS OF MENTHOL AS A CONTROL FOR TRACHEAL MITES – Honey bee colonies in an apiary infested with tracheal mites were divided into 4 groups:

1) Infested colonies to be treated with menthol,



2) Infested colonies to receive no treatment,
3) Non-infested colonies to be treated with menthol, and
4) Non-infested colonies to receive no treatment.

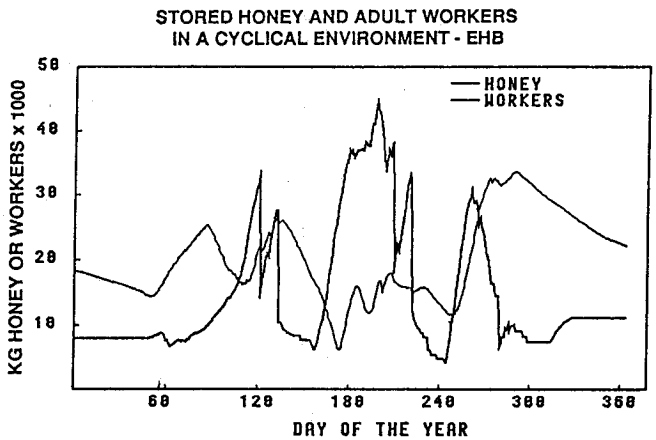
The menthol treatment applied was 50 g of pellets in a 13 x 19 cm polyethylene bag with 18 perforations per square cm., placed on top bars of the bottom box of the hive, for 2 weeks starting June 7. Weather during the application period was warm for the region, with daily mean temperatures about 14°C and daily maximum temperatures over 20°C. The mean amount of menthol vaporized during the 2 week application was 21.4 g per colony. Menthol was re-applied to the treated colonies from August 29 until October 11.

The June menthol application was effective in reducing the mite infestation. The infestation in the treated colonies (group 1) was significantly lower ($p < .05$) than that in the untreated colonies, from 4 weeks after the menthol was applied, to the conclusion of the trial over 5 months later (figure). The infestation decreased from about 9% to less than 2%. No change in infestation was indicated following the fall applications of menthol.

From the end of the application period, the mean tracheal mite infestation in untreated colonies (group 2) increased continuously from about 9% in June to about 31% in the middle of August. Untreated colonies alive in January 1990 had a mean infestation of over 50%.

The June menthol application to colonies in which mites were absent or undetectable, resulted in lower incidence of mite infestation, compared to similar colonies left untreated. Over the study period, mites were detected in all 7 untreated colonies, while only 2 of 6 treated colonies were found to have infested bees.

19. Makela, M. E.,[u] W. J. Sames IV,[u] and G. A. Rowell[u] – POPULATION DYNAMICS OF AFRICANIZED, EUROPEAN AND HYBRID HONEY BEES: SIMULATIONS BASED ON INHERITED BEHAVIORAL CHARACTERISTICS – A honey bee population dynamics model called BeeDyn has been implemented in the object-oriented flavor system of Symbolics Common LISP™ on a Symbolics 3640 computer. In object-oriented models of biological systems, key organisms are represented as separate objects and their programmed behaviors dictates how they change over time. BeeDyn Simulates day to day growth, reproduction and migration of multiple colonies of Africanized, European and hybrid honey bees. the major features of the model include: 1) Genetics: nine independent loci code for 27 behavioral phenotypes influencing foraging, swarming, and absconding behavior, cavity preference, energy usage, larval development rates, life span and others. Inheritance is strictly modeled with random mate selection within a drone congregation area (DCA). 2) Energetics: for each colony, daily energy balance depends on the amount of nectar and pollen in the environment and the number of workers available for foraging. Consumption depends on the number and age of brood and on the number of workers and drones, with busy workers and flying drones consuming more than idle ones. 3) Reproduction: a colony produces a swarm when it runs out of room for brood and storage or, if Africanized, when it exceeds 25,000 adult workers. The swarm consists of the old queen and a majority of young workers. It settles in an empty hive site, if one is available and large enough, or is lost to the simulation by migrating out of bounds. 4) Migration: a colony migrates after reproduction or when absconding. The direction of movement is random, and the distance traveled each day is assumed to be genetically determined. Migration terminates when a suitable hive is found or when the swarm migrates out of bounds. 5) Study area; the study area is rectangular with dimensions in kilometers. Plants with variable flowering cycles constitute the available nectar and pollen resources which are assumed to be spatially uniform. Hive sites and DCAs have fixed locations. For a typical simulation, the figure shows the number of workers (x 1000) in an EHB colony and the amount of stored honey in kilograms. Nectar and pollen were available in varying amounts for 8.5 months during the middle of the year.



20. Mamood, A. N.[v] and J. O. Schmidt[a] – HONEY BEE POLLINATION AND SEED SET IN PEARL MILLET – Pearl millet (*Pennisetum americanum* L. K. Schum.), is an annual warm season bunchgrass that is used for both forage and grain. It is grown extensively in the arid and semi-arid tropics as a dry-land crop and considered one of the most important grain crops on the Indian sub-continent and Africa. As one of the most drought tolerant crops, pearl millet has important economic potential for grain and forage production in the semi-arid regions of southwest United States.

The pearl millet flower is protogynous, a characteristic that seems to favor a very high level of natural out-crossing. Because of the nature of flower and the long-time interval between the exertion of the stigma and first anther, extensive cross-pollination occurs. Although insects may cross-pollinate millet, wind is the major pollinating agent. Honey bees (*Apis mellifera* L.) do, however, readily visit millet flowers in bloom to collect pollen. For this reason, a field study was conducted in Tucson, Arizona in 1989 to evaluate the impact of honey bee pollination on the seed quantity and quality in pearl millet.

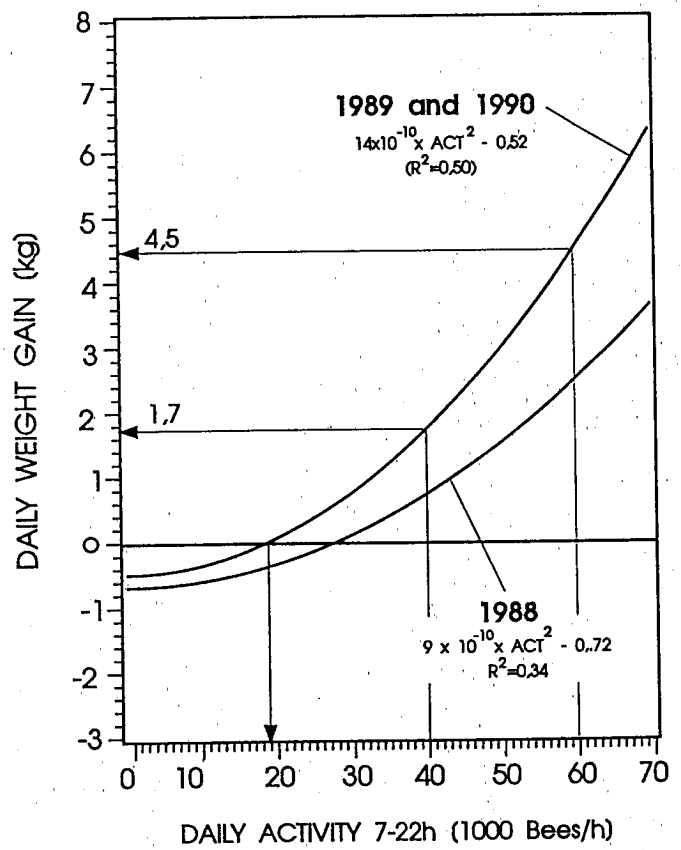
Two pearl millet parents, a male-sterile and a male-fertile chosen, and two pollination treatments – plants

caged with bees and plants caged without bees — were established.

Both male sterile and male fertile flowers responded positively to honey bee pollination. The relative attractiveness of male fertile flowers to honey bees was significantly higher than that of male sterile flowers. Cages with bees produced significantly more seeds than cages from which bees were excluded. However, there were no qualitative differences in the percent seed germination between the treatments. This study demonstrated that honey bees can increase overall seed yield in pearl millet.

21. Marceau, J.,[v] and J. M. Perron[w] — A STUDY OF THE RELATION BETWEEN PRODUCTION AND FLIGHT BEHAVIOR OF BEEHIVES IN QUEBEC — In 1988, 1989, and 1990, some hives (3 or 4 per year) were continuously monitored during June, July and August at Deschambault, Quebec, Canada. Bee flight activity (in and out-going bees), hive weight and meteorological data were measured with electronic sensors. The components were collected to a data logging system that cumulated hourly data. Daily activity was considered as the mean reading between 7:00 a.m. and 10:00 p.m. while daily production was considered as the hive weight difference between midnight and midnight the day before.

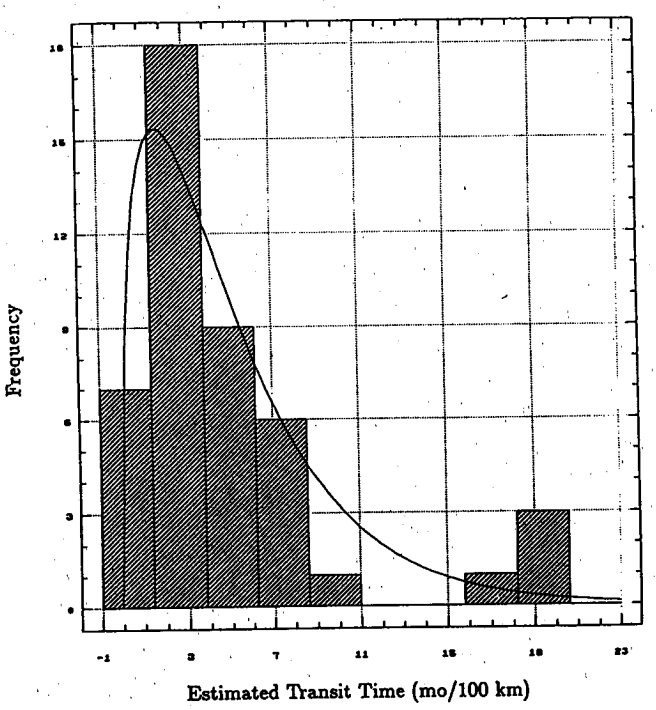
The mean seasonal activity remained quite the same throughout the 3 observation years. However, the production was very different. In 1988, the production in Quebec was very low while in 1989 and 1990 the production was relatively good. A reduced quadratic equation best expresses the relation between the daily production and the colony activity. In the same year, the relations are usually not different between hives, but the relations are different throughout the years except for the combination 1989-90. In fact, one model can represent the 1988 situation and a different model represents the situation encountered in 1989-90. The intercepts of the two relations are relatively close. However, the slopes are different and represent the main differentiation between the two models. Considering the 1989-90 model, if the daily activity remains below 20,000 bees/h, hive weight decreases. On these days, bees consumed stored food (around 500 g) and the activity was not sufficient to cover the weight lost. Activity over 20,000 bees/h covers the daily weight loss of the colony. From this value, a slight increase in activity caused a great increase in production. At 40,000 bees/h, the daily gain was 1.7 kg, and when activity reached 60,000 bees/h the production increased to 4.5 kg. A 50% increase in activity involved a 260% increase in daily production.



Descriptive relations of the daily colony production vs activity. The models are from observed data at Deschambault, Quebec, Canada in 1988, 1989 and 1990.

22. Matis, J. H.,[x] W. L. Rubink,[n] and M. Makela[u] — SOME STATISTICAL MODELS FOR PREDICTING ARRIVAL TIMES AND SUBSEQUENT DENSITIES OF THE AFRICANIZED HONEY BEE — Classical insect dispersal models (Southwood, *Ecological Methods* 2ed, 1978) and previous studies predicting arrival times of the AHB (Taylor *et al. Am. Bee. J.* 128:809; Villa & Labougle, *Am. Bee J.* 128:810) are based on the mean distance travelled per time period or on the mean rate of spread for various environmental conditions. An alternative approach (Matis *et al., Tech Report 109,* Texas A&M U.) is based on the "transit time" variable, *i.e.* time required to cover some specified distance. This study assumes the gamma transit time model.

A histogram of 45 transit times, standardized to months/100 km, is given in the figure. The fitted gamma distribution (with parameters α = 1.49 and β = 0.293), which is regarded as adequate, is also illustrated. Assuming that the transit time between the Mexican (in Tamaulipas) and Texas (at U.S. border) transects comes from the same population, the transit time for the 215 km distance would also be gamma (with α = 3.20 and β = 0.293). This model has a mean of 10.9 mo with upper and lower 2.5% tiles of 25.7 and 2.4 mo. Therefore, given the Sept. 1989 arrival time of AHB in Tamaulipas, the predicted arrival time at the Texas transect is Aug. 90 with a 95% prediction interval of Nov. 89 to Nov. 91. The width of the interval reflects the



Histogram of 45 estimated transit times (months/100 km) of the spread of Africanized honey bees through Mexico — fitted to a gamma distribution (parameters α = 1.49, β = 0.293) model.

large uncertainty in predicting transit times, and research is in progress to narrow the interval by using concomitant environmental variables.

The gamma transit times may also be incorporated into a stochastic model (semi-Markov process) to predict the relative density of AHB at specified locations of interest. Such models are presently used to simulate relative densities over time based on assumed parameter values. These models may also be fitted to observed data on trapline density as they become available.

Postscript: Since the conference, first capture of the AHB occurred in Texas on October 15, 1990, which gives a 13 month transit time. The 2-month difference between the actual and the predicted times is not surprising in light of the prediction interval. In fact, it demonstrated the practical utility of interval estimation.

23. Mayer, D. F.[y] and J. D. Lunden[y] – OXAMYL INSECTICIDES AND HONEY BEES (*APIS MELLIFERA* L.) – The topical drop for LD_{50} for honey bees was 0.251 μg/bee (confidence interval 0.161, 0.392 and slope value 1.354). The LC_{50} using a microsprayer was 0.644 μg of insecticide (confidence interval 0.442, 0.939 and slope value 1.568). Johansen & Mayer (Pollinator Protection. Wicwas Press, Cheshire, CT.) indicate insecticides with an LD_{50} of less than 2.0 are highly toxic to honey bees.

In residue bioassay studies, the residual degradation time in hours (RT) to bring honey bee mortality down to 25% in cage test exposures to field-weathered deposits was less than 2 hours for the 0.25 lb (AI)/acre rate, less than 8 hours for the 0.5 lb (AI)/acre rate and about 8 hours for the 1.0 lb (AI)/acre rate. Oxamyl applied in the late evening at less than 1.0 lb (AI)/acre is probably not hazardous to honey bees though the 1.0 lb (AI)/acre rate may be somewhat hazardous.

Syrup feeders containing oxamyl were set out in an apiary and free flying honey bees allowed to choose between the different treatments. Oxamyl in syrup feeders at 50, 100, and 500 ppm reduced honey bee visitation. At 2 and 10 ppm there was some (non-significant) reduction in honey bee visitation. These results suggest oxamyl applied to blooming crops may cause reduced bee visitation.

In a field test, oxamyl (0.5 lb (AI)/acre) applied to blooming red raspberry reduced bee visitation 44%, 51% and 45% at 15, 20 and 65 hours after application. Foraging honey bees can detect oxamyl in red raspberry nectar. Honey bees captured while foraging red raspberry bloom in oxamyl treated plots 15 hours after application had 50% mortality. Foraging bees captured in the plots 20 hours after application had 5% mortality.

Oxamyl (0.5 lb (AI)/acre) applied to apples at 5% open bloom reduced honey bee visitation 31% at 5 hours after application. There was no reduction of bees visiting the apple bloom at 29 and 53 hours after application. Oxamyl applied to blooming apples will cause some reduced bee visitation.

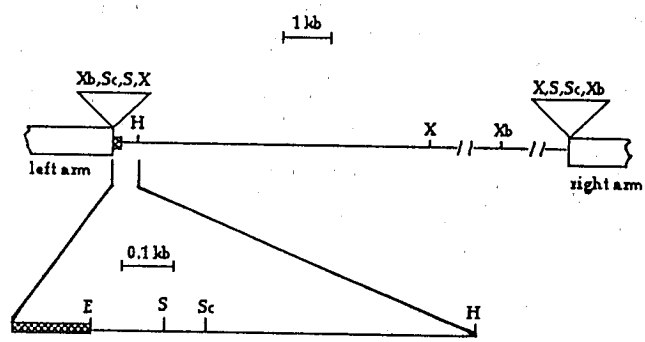
Three field tests were conducted on apples to determine if oxamyl applied at late pink reduced honey bee visitation to apple flowers. In the first test, oxamyl (0.5 lb (AI)/acre) caused no reduced honey bee visitation 36 hours later when there was 5% open bloom. In the second test oxamyl (0.5 lb (AI)/acre) caused no reduced honey bee visitation 72 hours later when there was 5% open bloom. In the third test oxamyl (0.5 lb (AI)/acre) or oxamyl (0.75 lb (AI)/acre) caused no reduced bee visitation 36 hours later when there was 5% open bloom. In the third test, flowers from the oxamyl treated plots were picked 36 hours after the application and analyzed for oxamyl. No oxamyl residues were found. Oxamyl applied to apples at the pink stage does not reduce bee visitation.

A 20 acre orchard was treated with oxamyl (0.5 lb (AI)/acre) at pink. Four colonies with Todd dead bee traps were placed in the orchard and dead bees in the traps were counted daily until the orchard was at 100% open bloom. The oxamyl application caused no abnormal adult bee mortality.

24. Miao, G. G.[z] and W. W. Doane[aa] – A GENOMIC HONEY-BEE CLONE WITH HOMOLOGY TO DROSOPHILA ALPHA-AMYLASE cDNA – Biochemical and molecular analyses of the alpha-Amylase gene-enzyme system in *Apis mellifera* L. were performed. Southern analysis of genomic DNA from a European strain was carried out using a Drosophila alpha-amylase cDNA clone as the probe. Results indicate the coding region of the structural gene *(Amy)* for this amylase is highly conserved between honey bees and *Drosophila mellanogaster*. They also suggest that the functional *Amy* locus in honey bees contains a single active gene copy. However, the possibility exists that there may be an *Amy* pseudogene, or remnant of one, in the bee genome.

A genomic library was constructed from the above bee strain in lambda Fix (Stratagene) replacement vectors and screened with the Drosophila amylase cDNA probe. The library consists of 2.2×10^5 independent clones and contains about 4.5 times the number of clones theoretically required for a "complete" library. Putative *Amy* clone isolates were verified for homology to the probe on Southern transfers. The inserted sequence in confirmed clones was characterized for restriction endonuclease cleavage sites, and a composite restriction map was constructed (see figure). Sequences homologous to the Drosophila cDNA probe span a small region less than 150 bp located at the left end of the composite map and are insufficient in length to code for a full *Amy* transcript. Efforts to isolate DNA for the entire *Amy* gene and related sequences will continue.

Evidence for a functional *Amy* gene in the honey bee comes from biochemical studies: alpha-amylase in extracts of whole larvae was inhibited by specific wheat germ alpha-amylase inhibitors. Spectrophotometric assays of larval extracts indicate amylolytic activity is optimal at about pH 5.0 when assayed at 25° C. Bee food gland amylase is reported to display optimal activity at pH 5.6-5.9 and 45° C (Rinaudo *et al.*, *Comp. Biochem. Physiol.* 46B:253-256).

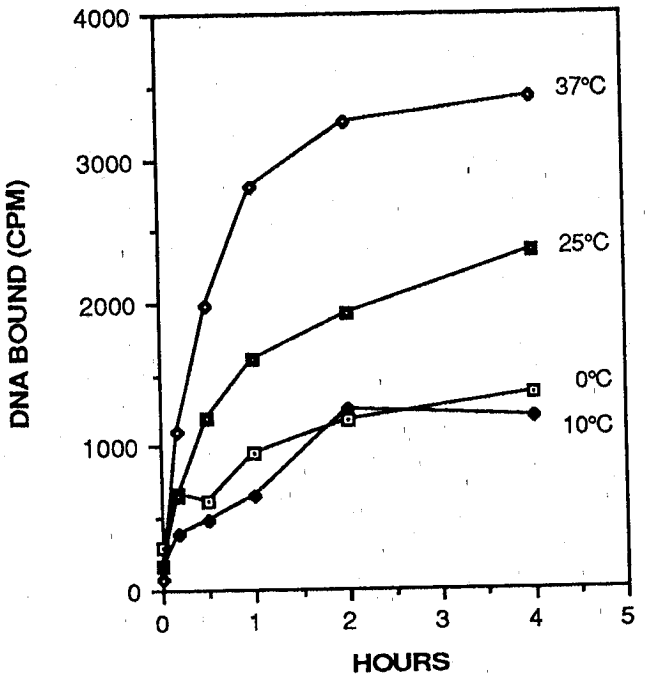


Partial endonuclease restriction map of the inserted sequence in the recombinant honey-bee clone Am 2.5. *Amy*-homologous sequences are shown at the left end by the checkered bar. Portions of the right and left lambda vector arms are included. Restriction sites include those for: *Eco*RI (E), *Hin*dIII (H), *Sac*I (Sc), *Sal*I (S), *Xba*I (Xb), and *Xho*I (X). The distance between *Xho*I and *Xba*I restriction sites within the insert is 8.7 kb, and the distance between *Xba*I and the cloning site at the right arm is 5 kb.

25. Milne, C. P., Jr.,[j] and K. J. Pries[bb] – DNA BINDING BY HONEY BEE SPERM – Recent, as yet unconfirmed, reports indicated that sperm incubated with DNA can vector genes into the genome of the mouse and sea urchin. In order to determine the suitability of honey bee sperm to transfer genes, we examined the binding of DNA by honey bee sperm. Semen was collected from drones and incubated with a 971 base pair linear DNA fragment of a commercially

available plasmid. The DNA was labelled with ^{32}P by either 5' end labelling with T4 polynucleotide kinase, or 'nick translation' with DNase I and polymerase I, which labels DNA uniformly along its length. DNA and sperm were mixed in a Kiev's sperm diluent to allow binding. The amount of DNA bound by the sperm was determined by either pelleting or filtering the sperm to separate the sperm from the unbound DNA, and counted in a scintillation counter.

DNA was rapidly bound to honey bee sperm (see Figure), and binding was more rapid at 37°C than 25°C. Significant binding occurred at 0°C and 10°C after 12-16 hours. There was some exonuclease or kinase activity that removed the 5' end label from bound DNA. Honey bee sperm binds a large amount of DNA, an average of 6,700 molecules per sperm after 2-4 hours at 25°C or 37°C. This amount of DNA is larger than the DNA contained in the smallest honey bee chromosome. Greater than 98% of the bound DNA appears to be on the outside of the sperm and is degradable by DNase I. The DNase resistant DNA is in an undetermined form, but it was shown that these counts were not due to reincorporation of degraded DNA fragments. Honey bee sperm tightly binds DNA, and after 15 hours, more than 80% of the initially bound DNA remains bound. These results are entirely consistent with honey bee sperm being able to transfer genes into the honey bee genome after fertilization.



Samples of sperm (2.5 μl), Kiev's sperm diluent (2.5 μl) and DNA (2.0 μl, 14.3 ng) were incubated for the times and the temperatures indicated. The DNA was 'nick translated' to uniformly label it with ^{32}P using a BRL kit and α-^{32}P dCTP. Unincorporated label was removed by a Millipore spin column and ethanol precipitation. After incubation of the sperm with the DNA, the 7 μl samples were diluted into 1 ml of cold Kiev's sperm diluent, and filtered through a 0.45 μm filter to retain sperm but not unbound DNA. The filters were then counted in a scintillation counter.

26. Petersen, L. E.,[cc] R. E. Campbell,[cc] J. O. Moffett,[dd] and D. L. Maki[dd] — HONEY BEES INCREASED YIELDS OF CARDINAL STRAWBERRIES IN OKLAHOMA — In a 1983 experiment in Oklahoma, marketable yields of "Cardinal" strawberries, *Fragaria ananassa* Duch., were 30% higher for the entire season and 115% higher in the earlier pickings in plots caged with honey bees than in plots caged to exclude bees. The no-bee plots produced 244% more deformed fruit than the plots caged with bees (10.0% vs. 4.1%). For the entire three week picking season, fruit size of the individual strawberries averaged 39% heavier in the bee plots than in no-bee plots. All differences were statistically significant.

In the open plots, marketable yields of strawberries were intermediate between the bee and the no-bee plots. The percentage of deformed fruit was similar in the open plots and in the plots caged with bees. The size of the individual fruit was almost identical in both the open plots and the caged plots where bees had been excluded. There were several colonies within a mile of the plots. Apparently, these bees helped increase the yields in the open plots above the yields in plots caged without bees.

Although strawberries are partially both self-pollinated and wind-pollinated, honey bee visits resulted in more marketable fruit by weight, in less deformed fruit, and in larger individual fruits.

Table — Comparisons of marketable yields of strawberries among plants caged with bees, caged to exclude bees, and left uncaged. Perkins, OK, 1983.

	Marketable Yield (g)		
Harvest Date	Bee Plot	Open Plots	No Bees
1. May 17	1081.4a	757.2b	418.7c
2. May 20	958.4a	804.8a	533.1a
3. May 23	1431.9ab	1585.5a	955.0b
4. May 25	1006.2a	1040.2a	1033.5a
5. May 27	775.9a	792.8a	811.4a
6. May 31	886.1a	808.8a	798.8a
7. June 3	408.4a	262.9a	382.1a
8. June 6	360.2a	268.6a	333.9a
Total	6908.5a	6320.8ab	5266.5b

[1]Treatment means followed by the same letter within rows are not significantly different at the .05 level, according to Duncan's multiple range test.

27. Pettis, J. S.,[u] W. T. Wilson,[n] and W. J. Sames IV[u] — EFFECTS OF TEMPERATURE, DOSE, AND RACE ON THE TOXICITY OF FLUVALINATE TO HONEY BEES[qq pp] — The use of Apistan Queen Tabs® (AQT) (1% a.i. fluvalinate) to kill *Varroa jacobsoni* on the honey bee *Apis mellifera*, has become routine practice for many queen breeders in the United States. Herbert *et al.* (1988 *Amer. Bee J.* 128:289-292) demonstrated control of "Varroa" with fluvalinate. Pettis *et al.* (*Apidologie*, in press) found little effects on queen acceptance and supersedure rates following treatment with AQT. Henderson (1988. in: *Africanized Bees and Bee Mites*, Ellis Horwood Ltd.) found fluvalinate to be toxic to newly emerged bees. Three experiments were conducted to further examine the effects of fluvalinate. Commercially available 2.5x1.3 cm fluvalinate impregnated strips, AQT (1% a.i.), were used in all experiments, along with 2.5% a.i. strips in experiment #2. Strips were placed below the screen wire, opposite the candy end. All wooden queen cages (Benton type, 3x8x2 cm) contained queen candy, seven worker bees, and were supplied with drops of water twice daily.

Experiment 1. Worker bees were collected from one colony and placed in cages (120) with either a 1% fluvalinate strip or no strip. Cages were held in incubators at 22, 32 or 38°C, and inspected daily for mortality. After nine days, worker mortality was 3:7, 1:4, and 67:67 for the treated:untreated groups held at 22, 32, and 38°C, respectively. No statistical differences in mortality were detected within temperature treatments. At 38°C, bee mortality in both treatments increased beginning on day 7.

Experiment 2. Twenty-seven laying queens of unknown ages were removed from active colonies on May 17, 1989, and placed in Benton cages with seven worker bees. Cages were held in the laboratory at 26 ± 3°C and monitored daily

for mortality. Cages were randomly assigned to one of three treatment groups; Untreated (no strip), 1% AQT, or a 2.5% fluvalinate strip. After 14 days the total mortality for the worker:queens were 19:1, 28:4 and 37:6 for the untreated, 1%, and 2.5% groups, respectively. Queen mortality in the 2.5% group was significantly different when compared with controls after 14 days, but not after five days (4:0, 8:0, and 4:1, 5 day mortality figures as above).

Experiment 3. Worker bees from Carniolan, Italian, and Cordovan stock were placed either in cages with an AQT or no strip. The resultant 180 cages were held at 32 ± 1°C and monitored daily for mortality. After nine days, mortality counts were 35:32, 3:9, and 15:52 for the (untreated:treated) Carniolan, italian, and Cordovan groups. The treated Cordovan stock suffered significantly higher mortality than controls.

The toxicity of fluvalinate did not differ with the temperatures tested in these studies. Increasing dose and exposure time did increase the toxicity of fluvalinate to workers and queens in Benton cages in our studies, also potential racial differences need further testing. However, the label recommendation of a three-day exposure period with 1% a.i. strips appears to cause no significant mortality to honey bees and queens shipped in this manner. The benefits gained by the use of such products in slowing the spread of *Varroa jacobsoni* to new areas cannot be understated.

28. Rebolledo, M.,[ee] S. Tolentino,[ee] J. J. Gonzalez,[ee] and S. Cajero[ee] — A BAITING SYSTEM FOR AFRICANIZED BEE CONTROL BY USING ACEPHATE: PRELIMINARY FIELD TESTS IN MEXICAN AFRICANIZED AREAS — In order to protect the commercial beekeeping industry as well as public and animal health from the stinging of Africanized bees, several methods have been implemented for the control of Africanized bees in Latin America. In Louisiana, an acephate baiting system was evaluated in a simulated feral bee eradication program. In five replications, after foragers collected sucrose-honey solution containing 500 ppm acephate, 33 of 41 European feral colonies (85%) were killed (Danka *et al.*, *Am. Bee J.* 129: 813).

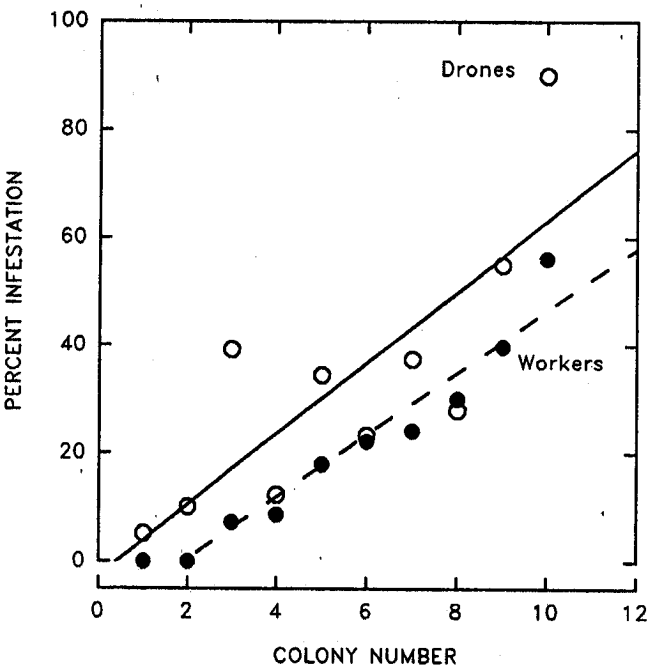
In the summer of 1990, three field tests were conducted to assess an acephate-baiting system for the control of Africanized bees. Tests were conducted in the Pacific coast area, at the town of Santiago Astata, State of Oaxaca. In each test, in early morning, a feeding station was placed to expose and deliver a 50% sugar syrup containing lemon essence as attractant and 250 ppm acephate. Locations consisting of four colonies (2 European colonies and 2 Africanized swarm/colonies) were established at 50 meter intervals from the feeding station. In the first 2 replications, the entrances of the European colonies remained closed during the treatment. Colonies were inspected at 24 h intervals after treatment. 67% (6 of 8) and 82% (9 of 11) of the Africanized swarms and colonies were destroyed in the first 2 replications when the colonies were within 200 and 300 meters of the feeding station, respectively, and no European colony was apparently affected. In the third replication, the entrances of the European colonies remained open and 58% of the Africanized swarms/colonies and 39% of the European colonies were destroyed at distances < 300 and 500 meters, respectively, from the feeding station (see table).

Table — Honey bee colony mortality in three replications conducted in an africanized area in Santiago Astata, Oaxaca, Mexico, after exposing a 50% sugar syrup containing lemon essence and 250 ppm acephate. These field tests are part of a baiting system project for control of Africanized honey bees.

Rep. / Distance in meters	EHB Col. Total	AHB Col. Total	Number of colonies found dead when inspected 1-5 days after tmt. 1 EHB	1 AHB	2 EHB	2 AHB	3 EHB	3 AHB	4 EHB	4 AHB	5 EHB	5 AHB	Colony Mortality EHB	Colony Mortality AHB
I (Jun-90)	9	9											0%	67%
50			0	0	0	0	0	2	0	0	0	1		
100			0	0	0	0	0	0	0	2	0	0		
150			0	0	0	0	0	0	0	0	0	0		
200			0	0	0	0	0	0	0	0	0	1		
II (Jul-90)	12	11											0%	82%
50			0	0	0	1	0	0	0	0	0	0		
100			0	2	0	0	0	0	0	0	0	0		
150			0	1	0	1	0	0	0	0	0	0		
200			0	0	0	1	0	0	0	0	0	0		
250			0	0	0	0	0	1	0	0	0	0		
300			0	0	0	1	0	0	0	1	0	0		
III (Aug-90)	18	12											39%	58%
50			0	1	1	0	0	0	0	1	1	0		
100			0	0	1	1	0	0	0	0	0	0		
150			0	0	0	0	0	1	0	0	0	0		
200			0	0	1	0	0	0	0	0	0	0		
250			0	1	0	0	0	0	0	0	0	1		
300			0	0	0	0	0	0	0	0	0	1		
350			0	0	0	0	0	0	0	0	1	0		
400			0	0	0	0	0	1	0	0	0	0		
450			0	0	0	0	0	0	0	0	0	0		
500			0	0	0	0	0	0	0	0	1	0		

The use of acephate can become a very useful tool in control of feral honey bee populations in Africanized areas. However, we need to determine its impact on the environment as well as the most effective way to use it.

29. Royce, L. A.[ff] and P. A. Rossignol[ff] — SEX BIAS IN TRACHEAL MITE INFESTATION OF HONEY BEES — Prevalence of tracheal mites showed a significant bias towards drones in contrast to workers. In ten hives sampled, both managed and feral, drones had a 50% higher prevalence of infestation (33.5 ± 8 vs. 21 ± 6 percent infestation per colony ± SD; arcsin transfomation). Mite load also was correlated with sex, being twice as high in drones as in workers (8 ± 9 vs. 3 ± 5 mites per honey bee). Because drones tend to drift from colony to colony much more than workers, they may represent as a major route for colony to colony transmission, in addition to serving as a reservoir within a hive. In certain instances, however, it may also be that drones act as a sink, and dampen transmission, particularly at the end of the active season when drones are driven out of the colony. This expulsion might dramatically lower mite load of the colony.



Infestation of tracheal mites in samples of drones (open circles, solid regression line) and workers (closed circles, broken regression line) from 10 different colonies in northwest Oregon.

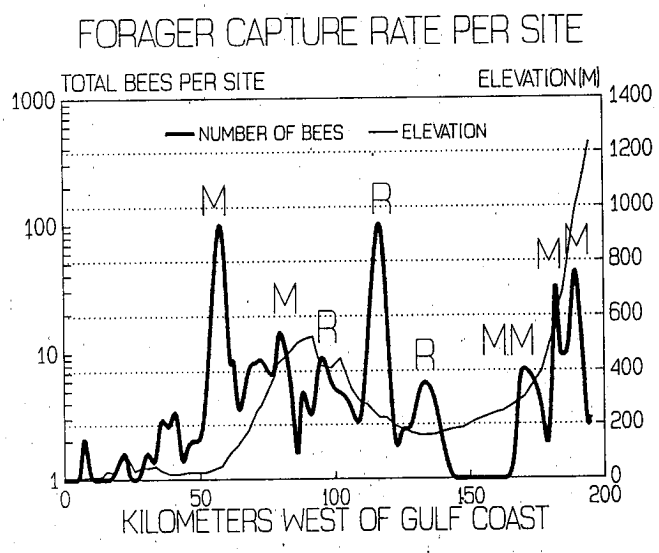
30. Rubink, W. L.,[n] K. R. Williams,[n] E. S. Sugden,[n] J. H. Zavala-M.,[gg] P. Luévano-M.[gg] — COMPARISON OF TWO TECHNIQUES FOR MONITORING HONEY BEE POPULATIONS — Since 1988 we have maintained two extensive transects of bait-hives in Tamaulipas, Mexico and southern Texas to characterize existing regional honey bee populations in advance of Africanization (Rubink *et al*, 1990, J. Kans. Entomol. Soc. 63:288-97). These transects utilize pulp-pot bait-hives (Schmidt and Thoenes; *Am. Bee*

J. 127:435-438), deployed with two duplex traps per site. In this study a 'scout' bee trap, which captures forager bees, was also used (Sugden *et al*, *Am. Bee J.*, 129:824). Our results provide comparisons of the relative capture rates of honey bees from the two trap types in diverse habitats.

The study was done from September, 1989 to September 1990 on the 200 mile long transect traversing central Tamaulipas state, Mexico. Sixty-three equidistantly-spaced bait-hive stations (252 bait-hives) and 75 superimposed, independent scout trap stations (141 traps) were sampled monthly for 12 months.

Mountainous areas exhibited low swarm capture rates while coastal and intermontane valley areas registered higher swarming activity. Some of the highest levels of swarming activity were from areas with no known apicultural activity. Honey bee capture rates in scout traps showed contrasting patterns of activity, roughly inverse to those indicated by bait-hive swarm captures during the same period. This was especially apparent in the mountain area (80-100 km) and in the intermontane area (140-170 km). Activity levels were also indicators of moderately sized (20-50 colonies) rustic (R) or modern (M) apiaries. Other peaks of activity may represent foci of high feral honey bee colony density. (see Figure)

Scout traps thus provide alternative relative population estimates to existing swarm-capture techniques. They detect large apiaries and imply the existence of large local feral honey bee aggregations. We suggest that population estimates from bait-hive capture rates from montane areas containing a high density of natural nest sites are low-biased and do not reflect actual population levels. Estimates from lowland Mesquite/Scrub may be (high) biased.



31. Sames, W. J. IV,[u] W. T. Wilson,[n] J. W. Smith, Jr.,[u] and H. D. Petersen[x] — KILLING HONEY BEE SWARMS, FERAL AND MANAGED COLONIES[pp qq] — Controlling Africanized honey bees (*Apis mellifera* L.) will be a major concern of U.S. beekeepers, civil authorities and pest control operators as Africanized honey bees spread into rural and urban environments. In this study, methods of killing honey bee populations were chosen in part on their availability to the general public, the safety of the various chemicals and methods, ease of application, cost, and their potential impact on the environment.

The swarms for this experiment were made by placing a queen honey bee in a wooden queen cage. The cage was taped to the center of a wooden cross. Honey bees from the same colony clustered around the caged queen after being dislodged from the frames of the hive. The swarms were killed using ETOC (1%), diesel fuel, resmethrin (0.25%), or a soap and water solution (1:16). ETOC, an experimental compound produced by the McLaughlin, Gormley, King Corp. (MGK), provided the best kill with no flare-up. Flare-up describes the sudden outburst of flying honey bees leaving a clustered swarm during application of a treatment. The soap and water solution provided an adequate kill with no flare-up. The diesel and the resmethrin provided adequate kills, but mean flare-up of 3.7% and 26.7%, respectively, was experienced. Since ETOC is an experimental compound (still undergoing testing for registration), it is currently not available for public use; therefore, the soap and water solution should be used in areas where flare-up and possible contact with honey bees needs to be avoided. The ETOC, the soap and water solution, and the diesel fuel were applied with a hand sprayer. The resmethrin was applied with an aerosol can.

Feral colonies were established in wooden structures designed to simulate the wall of a house. The colonies were destroyed using resmethrin (1%), ETOC (1%), permethrin (0.225%), or potassium nitrate (28 cc). The resmethrin, ETOC, and potassium nitrate provided the fastest kill. The permethrin was slow acting but killed most of the honey bees within 30 minutes. The combs and honey may become contaminated with these methods and should be destroyed. The potassium nitrate is the least preferred method because of the smell, excessive smoke, and the potential danger of starting a fire. The resmethrin and the permethrin were applied using aerosol cans; the ETOC was applied with a hand sprayer, and the potassium nitrate was burned in a honey bee smoker.

Managed colonies, represented by four-frame nucs, were killed using potassium nitrate (28 cc), pyrethrum (0.25%), and suffocating/overheating in a plastic bag. These methods were selected to avoid contaminating the combs. The potassium nitrate provided an adequate kill, but it is not recommended because of the disadvantages mentioned in the discussion of feral colonies. The plastic bag method worked within a 2 hour time period, but larger, more durable bags will have to be manufactured for use in killing full sized Langstroth type hives. Placing the colonies into the plastic bags is labor intensive, and this should be taken into consideration before implementing. The pyrethrum, applied with a spray bottle, was inadequate. A formulation of 1% pyrethrum placed in a aerosol formulation may enhance its killing effectiveness. Overall, the search for faster methods of killing managed colonies without contaminating the combs or other bee equipment should be continued.

Recent work at USDA-ARS Honey Bee Laboratory in Weslaco, TX shows a rapid knockdown of honey bees in four frame nucs with a 1-5 second blast of ETOC in an aerosol formulation. MGK is evaluating the residue levels of the ETOC in the comb. At Texas A&M University, researchers are evaluating the reusability of honey bee comb after being sprayed with a soap and water solution.

32. Schmidt, J. O.[a] — AFRICANIZED AND EUROPEAN HONEY BEE VENOMS: IMPLICATIONS FOR BEEKEEPERS AND THE PUBLIC — The lethalities of Africanized and European honey bee venoms are statistically identical — about 2.8 mg/kg in mice (Schumacher *et al. Nature* 337: 413). Interestingly, however, Africanized bees produce only about 75% as much venom.

Bee stings pose two potential health threats: allergy and toxic envenomation. The two differ dramatically and must be treated differently. In (hyper)sensitive individuals, allergic reactions often occur following a single sting and the reaction typically tends to be an "anaphylactic" reaction. Hypersensitive reactions are caused by an inappropriate immunological reaction mounted by the body in defense against the venom proteins. Although these reactions can cause death, death is a very rare event with only about 15-20

deaths per year in the U.S. This is in spite of an estimated 2.5-10 million people who are hypersensitive and hundreds of thousands of individuals have anaphylactic reactions each year. Currently the danger of dying as a result of smoking is 10,000 times that of a bee-sting; of a penicillin injection – 15 times; of lightning or horseback riding – 5 times; and playing high school football and overexertion are both greater killers than beestings. In toxic envenomations, the large amount of venom injected directly poisons the body. In this case literally hundreds or thousands of stings are received and the result is analogous to being bitten by a large rattlesnake. Deaths due to toxic envenomation typically occur after many hours to several days, and frequently are associated with kidney failure.

Several discoveries relative to Africanized bees and envenomations are relevant to beekeepers and the general public. First, Africanized bees tend to sting much more readily than European bees, with the consequent result that moderate to massive envenomations will be more common. This is important both from an allergic and a toxic envenomation standpoint. In the case of allergy, conventional wisdom held that there were no differences in the rates of reactions between one sting and 10 or more. Recent analysis reveals that this is not the case – reactions, especially severe reactions, are more frequent in individuals stung 10+ times than in those stung only once. Moreover, the reason that many beekeepers are "immune" to bee sting reactions is because they contain high levels of "blocking" antibodies (IgG) in their blood and that these prevent venom components from reaching the allergy-producing anti-bodies (IgE) and thereby inducing a reaction. A problem can occur if a beekeeper receives so many stings (probably 50-200) that his blocking antibodies are overwhelmed and he can go into anaphylactic shock. A few examples of this occurring are known; but more importantly, the frequency of such events is likely to dramatically increase among beekeepers after the arrival of Africanized bees. The other major problem for both beekeepers and the general public will be increased incidence of toxic envenomations. Since the cause of death in these cases is different from that of allergic reactions, the "protection" against stings developed by beekeepers is not likely to be of much benefit from toxic poisoning. Based on calculations derived from mouse studies, the average number of stings to give equal odds of living versus dying is 1120 stings for a 130 pound adult. Epidemiological studies suggest that this figure is realistic (Schmidt in "The Hive and the Honey Bee," in press). Although beekeepers might be able to withstand a few more stings than non-beekeepers, the risks of anaphylactic reactions subsequent to massive envenomation are probably greater in beekeepers than the general public. These findings suggest that beekeepers and researchers will need to exercise good judgment and caution when working with potentially Africanized bees and might wish to work with another person for safety.

33. Schmidt, J. O.,[a] H. G. Spangler,[a] and S. C. Thoenes[a] – BIRDS AS SELECTIVE PREDATORS OF DRONES – Many birds including, house sparrows *(Passer domesticus)*, are generalists that opportunistically feed on a variety of insects. A few birds, such as western kingbirds *(Tyrannus verticalis)* are specialist predators of stinging insects including honey bees. Most reports of bird predation on bees are anecdotal in nature and assume that the birds are preying on workers, though some suggest that kingbirds prefer drones.

From May 2 to June 1 western kingbirds were observed at a distance of 5-6 m with the aid of binoculars to be feeding on bees from a feral colony in Tucson, AZ. Regurgitated pellets from the stomach of the kingbirds were analyzed to provide a record of prey. Time-lapse photographs were made of sparrows near the landing boards of three honey bee colonies in Tucson. The cinecamera automatically exposed one frame every 2 minutes from daybreak to sundown during a period from May 19 to June 11. Visual and frame-by-frame analysis of the photographs were used to determine bird activities.

We observed a pair of kingbirds perched on small branches near the flight path and about 2-3 m from a colony in a tree. The birds actively watched individual bees flying past and periodically flew to quickly capture a bee, then return to the branch to consume it. Although in most instances we could not identify the captured bees, in several cases we could clearly see that drones were prey. In no case did we identify workers as the prey. The birds regularly returned to their perches, so regurgitated stomach pellets that fell onto plastic sheeting under the perches provided a record of what they had eaten. Analysis of these pellets showed that the most contained only fragments of drones. We also observed a synchronism of drones on the outer combs and in flight with the periods of kingbird presence and feeding.

During 17 days of photographics, a total of 633 sparrows were recorded near the landing boards of the three colonies. The daily average was 37.2 ± 23.8, with a range of 3 to 91 birds/day. The camera only sampled the bird activity by photographing one frame every two min, so the record can only estimate the rhythm of sparrow activity. The most active period occurred from 11:00 to 17:00 MST when an average of 3.32 ± .54 birds/hr were recorded. After 17:00 the number decreased. From sunrise until 11:00 activity was significantly lower ($\bar{X}$ + 1.75 ± .59 birds/hr.). The maximum incidence of sparrow activity corresponded with the period of maximum drone activity. Also, some photographs appeared to show sparrow predation on drones. We suspect that at other times the sparrows were consuming mainly dead or dying bees in front of the colonies.

Although the loss of drones and dying bees to sparrows might have little impact on colonies, western kingbirds are active predators of drones and appear able to severely deplete the drone population of a colony. They appear to distinguish drones from workers based on the differences in their sizes and flight behaviors and likely reject workers not only because they can sting, but also because they have a noisome taste due to defensive chemicals in their mandibular, venom, and Nasonov glands. Workers might also be avoided because they contain a lower nutrient density than drones. The impact of kingbirds on beekeepers concerned primarily with honey production is probably negligible; but their effects on queen breeders, or on potential genetic barriers via drone saturation to Africanized honey bees could be severe.

34. Schmidt, J. O.[a] and S. C. Thoenes.[a] – THE EFFICIENCY OF SWARM TRAPS: WHAT PERCENT OF SWARMS ARE CAPTURED AND AT WHAT DISTANCE FROM THE HIVE – Swarm traps are likely to become one of the most powerful tools available for controlling Africanized or unwanted European honey bees. Control is often feasible by "mass trapping" for species having low reproductive potentials. Honey bees are, thus, ideal candidates for mass trapping because colonies appear to generate on average only 1-3 viable reproductive swarms per year and we have highly attractive wood pulp swarm traps for capturing them. A major remaining question concerns the efficiency with which traps attract swarms. By efficiency, we mean the percentage of available swarms in the environment that will be attracted to swarm traps. To determine this we established an apiary of 38 colonies in a remote, mostly bee-free area of Arizona, marked queens, and encouraged them to swarm. Surrounding the apiary were concentric rings of 12 swarm traps at six directions each at distances of 100 and 250 m, and at 12 directions each at 500 and 1000 m. The traps were examined weekly and colonies

inspected for presence of a marked queen. Captured swarms were dissected to determine the identity of the queen.

In 1989 seven swarms were captured at respective distances of: 100 m – 2; 250 m – 3; 500 m – 2; 1000 m – 0. In 1990 the 21 swarms were captured at distances of: 100 m – 3; 250 m – 8; 500 m – 5; 1000 m – 5. The mean ± SD distances traveled were 278 ± 165 m in 1989 and 467 ± 332 m in 1990, for a combined mean of 420 ± 308 m. Both the median and mode distances traveled each year and overall were 250 m. These data indicate that European swarms typically travel about 250 to 500 m from the parent colony with shorter distances (eg. 100 m) and longer distances (eg. 1000 m) being relatively less common. These patterns further suggest that a trapping grid surrounding colonies to a distance of 1000 m probably captures 90 percent of the emitted swarms.

In 1989 all queens in the swarm traps were relatively small and "fuzzy," indicating that young newly mated or virgin queens were heading the swarms. In 1990 we pursued the idea that mother queens were remaining in the colonies and young queens were frequently leaving with the swarm by individually marking and monitoring the fates of all queens in the apiary with the aid of dead bee traps. At the end of the swarming season, the results were: marked queen still in colony – 24 (63%); superseded (in dead bee trap) – 7 (18%); colony died – 5 (13%); left with a captured swarm – 1 (3%); never located – 1 (3%). When examining colonies still possessing their original queen we found three cases in which the queen and only a few bees remained (because the previous week the colonies contained large populations, we assume most of the population left with a young queen) and two examples of the mother queen plus a young queen. These data when considered with the capture of 21 mostly small fuzzy queens suggest that most swarms captured in 1990 came from the apiary and were headed by young queens. Since the mother queens did not frequently leave with a swarm, our marking technique could not provide absolute measures of the efficiency of capture by the swarm traps. However, our weekly monitoring of colony condition generally allowed us to detect when a swarm left. By this indirect measure it appears that the trap design captured most, probably about 90 percent of the swarms that emerged. The fact that the outermost ring of traps captured fewer swarms than the inner rings suggests that few, if any, swarms from feral colonies were captured. Overall, these tests indicate that mass trapping ("trapout") of swarms from Africanized bees has potential for control and that the ultimate effectiveness of such a program will depend more on the numbers and modes of swarm trap deployment than possible limitations of the pulp-based trap design or of mass trapping theory.

35. Schmidt, J. O.[a] and Thoenes, S. C.[a] – HIERARCHIAL PREFERENCE OF HONEY BEE SWARMS FOR CAVITIES THAT CONTAIN PHEROMONE, OLD COMB, AND/OR WERE PREVIOUSLY INHABITED – Although we understand some of the criteria used by bees in selecting a nest site (Seeley *Sci. Amer.* 247: 158-68; Schmidt & Thoenes *Ann. Ent. Soc. Amer.* 82: 271-74), the relative importance of various factors used by bees in that selection process is poorly understood. Our objective in this study was to determine the hierarchy of importance of Nasonov pheromone, previous habitation by bees, and presence of old dark brood comb.

To compare the three factors, we established 21 stations of three artificial cavities (swarm traps) made of wood pulp (Schmidt *et al. ABJ* 129: 468-71) during the spring of 1990 in Tucson, AZ. The treatments were: a cavity never previously inhabited by bees; a cavity that had been previously inhabited, but without comb; and a previously inhabited cavity that also contained half a full depth frame of empty black brood comb. To determine the effects of pheromone, we established a rotating experimental design in which each week the artificial cavities in half of the stations contained pheromone; the next week the pheromone-containing stations were reversed, and so forth throughout experiment 1. In experiment 2, pheromone was removed from all stations.

The results of experiment 1 (see table) revealed that cavities containing pheromone were preferred significantly ($P < .05$) to those lacking pheromone. When pheromone was present, previously inhabited cavities were highly significantly preferred ($P < .01$) to those not previously inhabited; there was, however, no preference between previously inhabited cavities with, or without, black comb. Experiment 2 showed ($P < .001$) that in the absence of pheromone, cavities containing old brood comb were preferred to cavities without comb. From these results, we conclude that the following overall hierarchy of preference for nest sites exists: pheromone is clearly the primary factor of importance; when pheromone is present previous habitation is a secondary factor; and presence of comb is not an important factor if pheromone is present. In the absence of pheromone, dark comb can serve as a secondary attracting factor.

Table – Effect of pheromone, previous habitation, and old dark comb on attractiveness of swarm traps.

EXPERIMENT 1: PHEROMONE VS. NO PHEROMONE

	Pheromone	No Pheromone	Total
Not Previously Inhabited	0	0	0
Previously Inhabited	5	0	5
Prev. Inhab. plus Comb	8	3	11
Total	13	3	16

EXPERIMENT 2: PREVIOUSLY INHABITED VS NOT PREVIOUSLY INHABITED TRAPS AND COMB VS NO COMB IN TRAPS WITHOUT PHEROMONE

	No Pheromone
Not Prev. Inhab.	0
Prev. Inhab.	0
Prev. Inhab. plus Comb	11

36. Smith, D. R.,[hh] B. R. Taylor,[hh] M. F. Palopoli,[hh] L. Garney,[ii] and J.-M. Cornuet[ii] – MITOCHONDRIAL DNA OF SPANISH HONEY BEES – Studies of honey bee mitochondrial DNA (mtDNA) have shed light on the biogeography of honey bees in the Old World, and polymorphisms in honey bee mtDNA have been used to study genetic interactions between European, Africanized and feral Neotropical African bees in the Americas (Smith, pp. 303-312 in Needham, *et al., Africanized honey bees and bee mites*, 1988; Smith, *et al., Nature* 339:213-215; Smith and Brown, *Ann. Entomol. Soc. Am.* 83:81-88; Smith, *Trends in Ecology and Evolution*, in press). We examined the mitochondrial DNA (mtDNA) of Spanish honey bees, *Apis mellifera iberica*, because *iberica* is one of the subspecies introduced to the Americas by early European colonists.

We sampled bees from northern Spain (Oviedo: 18 hives; Lugo: 2 hives), southern Spain (Cordoba: 10 hives) and 8 locations along the eastern coast of Spain (16 hives) (Smith *et al., J. Hered.* in review). MtDNA from each sample was prepared and surveyed with the 6-base restriction enzymes

AccI, BclI, BglII, EcoRI, EcoRV, Eco0109, HindII, HindIII, NdeI, PstI, PvuII, SpeI and XbaI using methods described in Smith and Brown (*Ann. Entomol. Soc. Am.* 83:81-88). The resulting restriction fragments were compared with previously constructed maps of the mtDNA of European and African honey bee subspecies (e.g., Smith, pp. 303-312 in Needham, *et al., Africanized honey bees and bee mites*, 1988).

We found two types of mtDNA in this population: 25 hives had a west European type like that of *A. m. mellifera* and 21 had an African type like that of *A. m. intermissa*. The *mellifera* mtDNA was most common in northern Spanish samples, and *intermissa* mtDNA was most common in southern Spanish samples. This suggests that the west European and African honey bee lineages come into secondary contact and hybridize in the Iberian peninsula. The mtDNA of *A. m. intermissa* and *A. m. iberica* with *intermissa*-like mtDNA is very similar to that of South African *A. m. scutellata*, the subspecies which was introduced to Brazil and which is the ancestor of the Africanized bee populations in the Americas. When studying Africanized and Neotropical African bees in the Americas, it is important to be able to distinguish the mtDNA of relictual populations of Spanish bees from that of the more recently introduced *A. m. scutellata*. So, we carried out a more detailed comparison of these mtDNAs.

We surveyed the mtDNAs of 11 hives of Spanish bees with *intermissa*-like mtDNA (for convenience, simply referred to as "*intermissa*" from now on) and 10 hives of South African *A. m. scutellata* with 3 additional 6-base restriction enzymes (AflII, AvaI, XhoI) and a 4-base restriction enzyme (HinfI). We found no single 6-base restriction enzyme that could be used to distinguish all *intermissa* mtDNAs from all *scutellata* mtDNAs. However, we found many polymorphic restriction sites that differed between *scutellata* and *intermissa*. Most *A. m. iberica* samples with *intermissa* mtDNA could be differentiated from *A. m. scutellata* by one or a combination of 6-base restriction enzymes. All our iberian samples could be distinguished from *scutellata* by the 4-base restrictions enzyme HinfI.

37. Smith, R.-K.[rr] and O. R. Taylor, Jr.[s] — CHEMICAL STUDIES ON HONEY BEE DRONES — Past work of Smith resulted in very accurate methods, based on assay of cuticular olefins, to identify Africanization in worker and queen honey bees. To complete this work, a method for drones needed to be developed. Over 2 years ago, Taylor supplied Smith with a number of drones of varied African and European inheritance as a blind test. The initial impression from examination of the drone chromatograms was that this was going to be a tough problem, not readily solved. These data have recently been examined in detail and the results of the blind test tabulated. In general, the initial impressions have been confirmed and drones are indeed difficult to identify.

Comparison of related European workers and drones indicates that drones display 2 to 3 times as many individual compounds as workers, and compounds which the castes exhibit in common, there is only a general similarity. This can be quantified through use of the genetic distance function of Nye (*Amer. Nat.*, 106:282-292) on 31 unsaturated hydrocarbons common to workers and drones. Brother drones are found to be very similar (0.03) as are sister workers (0.03), but a much greater difference exists between the drones and related workers (0.14). It has been proposed that hydrocarbons may serve a role in nest-mate recognition in social insects. The presence of the many extra hydrocarbons on the cuticle of the drones may serve to mask the chemical clues of nest-mate recognition and thus allow the observed drifting of drones from one colony to another.

The analysis of drones for Africanization begins with a known group of Africanized drones (French Guiana) and European drones (Florida and Georgia). Analysis of the drone olefin patterns using the worker models previously developed, resulted in partial separation of the test drones. Most of the test drones were then assigned as European, Africanized or Unknown. The tentative European and Africanized drones were used to prepare drone models and the whole set re-analysed. Some of the Unknown drones could now be classified as European or Africanized, however, six still remained as Unknown. Of the 36 drones assigned as Africanized, 31 were correct (86%) and the other 5 were actually European. There were 15 European drones in the test, only four were correctly assigned (27%). The six Unknowns should have all been European. Overall, 35 of 46 drones were correctly identified (76%).

It was felt that part of the problem could be arising from a very limited database for European characterization. The idea was tested by sorting the bees into their correct categories, either European or Africanized and then recalculating the population means and standard deviations. The whole set of drones was then analysed on the basis of the correct assignment means and the results plotted. Now what is achieved is complete separation of the European and Africanized drones. The resulting decision line has a zone of uncertainty around it, the width of which must be determined through analysis of a wider selection of drones.

Overall, the method has considerable promise in line with the success rates achieved for queens and workers. Difficulties are to be expected in the correct peak assignment due to complexity of the hydrocarbon chromatogram. Again a much greater size database is needed before the method is usable.

38. Spangler H. G.[a] — A MECHANISM THAT MAY TRANSMIT DISTANCE INFORMATION DURING THE WAGGLE DANCE OF HONEY BEES — Wing vibration frequency of honey bees performing waggle dances after they returned from a feeding station at a series of distances was detected and recorded using an optical technique. The experimental colony was kept in an observation hive covered with glass side panes, so that the bees' ability to thermoregulate could be preserved. The optical technique resulted in precise recording of vibrations from only the waggling bees. Other bee sounds and noise were effectively excluded. The bees visited feeding stations 50, 100, 200, 400, 800, and 1600m from the hive on subsequent days.

It was found that the bees vibrated their wings more rapidly after they had visited nearby stations than when they foraged at more distant stations. Mean vibration frequency was 317 Hz at 50m compared to 207Hz at 1600m. Thus, wing vibration frequently appears to be another element of the waggle dance known to indicate the distance that bees must fly to reach food sources. Other known elements indicating distance include the duration of the straight run, the number of wagtail movements in the run and the duration of the entire dance. The return time and the length of the wagtail run are probably not correlated with distance.

39. Spangler, H. G.,[a] S. L. Buchmann[a] and S. C. Thoenes[a] — ACOUSTICAL MONITORING OF HONEY BEE SWARMS TAKING FLIGHT — We monitored swarms of honey bees primarily to study the occurrence of the buzz-run *(Schwirrlauf)* associated with the act of swarming. Esch Z. *vergl. Physiol.* 56:408-411) described how the workers produce the buzz-run and attempt to contact other workers while buzzing their wings at 180-250 Hz every 0.5-3 seconds. At the moment of contact with another bee, the frequency of the buzz increases very quickly to 400-500 Hz and stays at this level until the bees separate. The bee receiving the buzz signal in turn passes the signal to another bee, who in turn passes it along until all bees in the colony become aroused enough to take flight. Because the buzz-run is

thought to be the "command to leave" we are exploring the possibility that swarms can be controlled by manipulating them acoustically.

Four naturally occurring honey bee swarms were captured and placed on a screen cone measuring 24 cm long, 13 cm in diameter at the top and 5 cm in diameter at the bottom. The bottom of the cone was sealed with screen, and the top attached to a 17 cm diameter wood disk. A three-wire harness hung the cone from an electronic scale which provided a continuous analog voltage level indicating weight. A microphone was inserted through a hole in the disk into the center of the cone. An accelerometer detected vibration of the substrate while an optical detector monitored vibrations in a circular area 10 cm in diameter on the surface of the swarm. An instrumentation tape recorder recorded the scale signal on an FM channel and the 3 acoustical signal inputs on 3 DR channels.

The weight data showed that once the bees began to leave the cone all detectable bees were airborne within a mean of 35.5 seconds. Two swarms made a smooth transition while becoming airborne while large chunks of bees fell from the other two swarms as they began to leave.

The buzz-run was recorded by the optical detector which produced clearly identifiable recordings. There was a mean of 4.5 buzzes produced during the period 90-60 seconds before the bees began to take flight; 7 occurred between 60 and 30 seconds, and 14.5 occurred from 30 to 0 seconds. After the bees began to lift off, bees flying between the detector and the swarm obscured the detection of the buzzes enough to make their detection unreliable. Less frequent buzzes usually occurred earlier than 90 seconds before the bees took flight. However, one swarm produced 9 buzzes during a 14.5 second period starting at 140 seconds.

The wing beat frequency of bees flying near the swarm taking flight was also analyzed. The mean wing beat frequency was 233.8 Hz. The data from both the microphone and the accelerometer showed an increase in amplitude and continuity of the sounds and vibrations of the swarm as it began to take flight; however neither transducer isolated the buzz-run satisfactorily. This suggests that most of the sound and vibration energy of a swarm occurs on the surface where it can be detected optically. Knowledge of when and where the signals occur is vital to efforts aimed at controlling swarms acoustically.

40. Spivak, M.[i] Zeltzer, A.,[a] DeGrandi-Hoffman, G.,[a] Martin, J. H.[a] – THE INFLUENCE OF PUPATION TEMPERATURE ON THE COLOR PATTERNS AND DEVELOPMENT TIME OF QUEEN HONEY BEES – Environmental factors induce the expression of polyphenisms (multiple phenotypes) in many organisms. In this study, we measured the effect of temperature on the color patterns and rate of development of queen honey bees. Queens were reared from either a yellow or black parental line between November 1989 and July 1990. Both black and yellow parental queens were inseminated with the semen of all black, brother drones from a third, unrelated colony. The pupae were placed in incubators at 35.5°C, 33.5°C (ca. brood nest temperature) and 30.5°C (± 1.5°C in each incubator). Development time was recorded approximately every 12 hours while the queens emerged. The color of the 3rd tergite (T3), 4th tergite (T4), 4th sternite (St4) and right hind-leg was ranked after full pigmentation was attained. The individual ranks were summed (T3 + T4 + St4 + Hind-leg) to give a total color rank for each queen.

The results (in Table) clearly indicate that increasing temperature during pupation significantly decreases development time and increases color rank. The range of development times for both lines was 14.5 days at 35.5°C to 20.0 days at 30.5°C; above 36°C and below 30°C, queens did not emerge. The total color rank for both lines ranged from 4 (black) to 18 (yellow).

Further studies on the effect of temperature during pupation among different queen lines within and between colonies in the field are in progress.

– Effect of temperature during pupation on the development time and color patterns of queen honey bees.

DEVELOPMENT TIME (days)[1]

	Black Line			*Yellow Line*		
Temp °C.	# Queens	Mean Devt. time	std. dev.	# Queens	Mean Devt. time	std. dev.
30.5	60	18.1[a]	0.797	71	18.4[a]	1.114
33.5	58	16.4[b]	1.034	94	16.9[b]	1.331
35.5	61	15.1[c]	0.668	71	15.7[c]	0.870

[1] Results of a 2-way ANOVA showed significant differences between queen lines ($F = 25.15$, $p<0.001$) and between temperatures ($F = 255.24$, $p<0.001$). Means within a column with different letters are significantly different ($P<0.001$; Tukey's Studentized Range test)

COLOR PATTERNS[4]

	Black Line			*Yellow Line*		
Temp °C	# Queens	Mean Color Rank	std. dev.	# Queens	Mean Color Rank	std. dev.
30.5	55	4.3	0.64	69	8.6	3.45
33.5	57	6.2	2.08	94	11.0	4.35
35.5	48	9.2	3.12	53	15.7	3.23

[2]Results of Kruskal-Wallis between temperatures within the black line: H(adj) = 73.80, $p<0.0001$; and within the yellow line: H(adj) = 69.93, $p<0.0001$.

41. Sugden, E. A.[n] and A. M. Collins[n] – BURGLAR BARS EXCLUDE VERTEBRATES, MINIMIZE BAIT HIVE LOSS – Rats have proven the most frequent cause of bait hive loss during three years of collecting honey bee *(Apis mellifera)* swarms in south Texas with the Schmidt/Thoenes pulp pot bait hive (Schmidt & Thoenes, *Bull. Entomol. Soc. Am.* 35:155-158). Rats usually enter hives through the single provided port and gnaw passageways through the lid in the course of nesting. This makes the hive difficult to use in swarm handling and may affect its attractiveness to swarms. Rats also foul hives with excrement, may occlude them with nest material, and sometimes destroy pheromone baits. In one month in 1989, nearly 10% of all hives along the Texas/Mexico border USDA-ARS trap line were damaged or destroyed by rats. Bird nests (probably House Sparrow, *Passer domesticus* and Boat-tail Grackle, *Cassidix mexicanus*, latter protected, neither threatened or endangered) have been found in at least seven out of ca. 5,000 hive servicing events. Bait hives may endanger other protected bird species by presenting unintentional nest cavities.

"Burglar bars" made of ½ inch hardware cloth were tested in bait hives between February and July of 1990 for their ability to exclude vertebrates while not deterring honey bee swarm colonization. Semicircles of ca. 4 in. diameter were cut and fastened to the hive interior over the entry port with staples and construction adhesive. A space was cut through several cross pieces to allow insertion of the pheromone clip. A total of 60 hives were used in two separate series utilizing back-to-back bait hive duplexes baited with 1:1, citral:geraniol. In the first series, a choice test, only 1 hive of a pair was meshed with burglar bars. Five pairs were hung in each of two sites. In the second series, a no-choice test, hives were placed in groups of two duplexes each and hung in trees at 10 stations, pairs ca. 20 meters apart, stations 1.5 to 3 miles apart. All four hives at alternating stations received burglar bars.

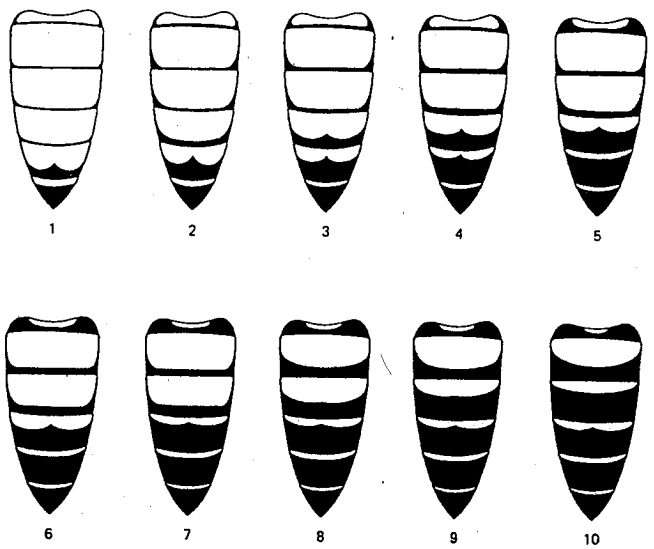
Results were compiled in August. Out of 388 bait hive

service events, 59 swarms were captured, 28 of them in hives with burglar bars, not significantly different from the non-meshed hive catch, 31. There were no significant differences in number of swarms collected in meshed vs. non-meshed hives in either the choice (14 vs. 15) or no-choice (14 vs. 16) series. There were 17 records of rodents or rodent nests present in individual hives resulting from 12 separate incursions. In all cases but one (a no-choice double-meshed bait hive pair) rats appeared to enter through non-meshed bait hives. No bird nests were found in hives.

Burglar bars were put on all USDA-ARS bait hives in south Texas in August, 1990. Data collected from 246 hives during September were compared to pre-burglar bar data from August, 1990. Based on swarm capture from August and September, 1989, swarm capture by burglar-bar equipped hives was greater than expected (11 expected vs. 6) but not significantly so. Both rat or rat nest presence (8 vs. 23) and individual incursions (6 vs. 16) were significantly fewer than expected, despite heavier rainfall and probably higher rat populations in 1990.

In conclusion, damage to duplex pulp pot bait hives from rodents can be minimized by covering the entrances of new hives with ½ inch hardware cloth. The resultant "burglar bar" effect will not alter the attractiveness of the hives to honey bee swarms. Bird nesting may also be prevented. The cost of materials for burglar bar outfitting is ca. 10 cents per bait hive.

42. Szabo, T. I.[g] – MORPHOMETRIC CHARACTERISTICS OF *APIS CERANA* FROM SRI LANKA – Worker bees from 11 colonies of A. *cerana* collected from different geographical regions of Sri Lanka were examined. The coefficients of variability of 19 morphological characteristics were calculated and a tergite color classification was made (see figure). The body parts from the right side of each of 291 specimens were measured. The following characteristics were recorded: proboscis length, forewing length, forewing width, cubital vein a, cubital vein b, cubital index a/b, number of discodial cell hairs in 0.4 mm area, hindwing length, hindwing width, number of hamuli, femur length, tibia length, metatarsus length, metatarsus width, third sternite length, wax mirror length, wax mirror width, distance between wax mirrors, and tergite color patterns. The greatest mean coefficient of variability was 24.41% for targite color, and 7.94% for proboscis length, while the least variable was 1% for forewing length. The possibility of using highly variable simple characteristics in tandem selection is suggested.



Color classes of *Apis cerana* worker bees

43. Szabo, T. I.,[g] and L. P. Lefkovitch[kk] – DEVELOPMENT OF OVERWINTERED HONEY BEE COLONIES WITH ONE- AND TWO-YEAR-OLD QUEENS – The development of the population and of the brood area of 29 overwintered honey bee *(Apis mellifera)* colonies were recorded, and honey production measured at the end of the season. Colonies with one- and two-year-old queens, representing the eighth and seventh generations, respectively, from a closed population breeding program, were investigated. The bees were in standard Langstroth hives in two yards separated by 1 km. One yard contained 15 colonies with 1-year-old and 2 colonies with 2-year-old queens, while in the other, there were six colonies with 1-year-old and six with 2-year-old queens. On April 2, May 6, June 2, June 23 and July 17, 1987, the number of combs covered by bees, the area of worker and drone brood of all stages, and during the two censuses, the weight and number of workers and drones, together with the honey produced, were determined as described by Szabo and Lefkovitch (*Apidologie* 20:157-163).

The area of worker brood, measured in cm^2, and the population size, determined by the number of combs covered by bees, were respectively 1060:3.98 on April 2, 3760:6.52 on May 6, and 6610:13.4 on June 2. On June 23, the worker brood area measured 8380 cm^2 and the number of workers was estimated as 26,524. On July 17 the average number of workers was 39,669 and the number of drones 1779. The only significant yard difference was found in worker brood area for April 2. On May 6, colonies with 2-year-old queens had significantly more combs occupied by workers and larger areas of drone brood than those with 1-year-old queens. Later in the season no differences in brood area, population or honey production of the colonies were found. The mean honey production was 88.4 kg per colony, ranging from 38.7 to 139.9 kg. The average length of productive life of workers ranged from 25.4 to 27.7 days, and unit honey production from 2023-2311 g honey per 1000 workers. These findings are similar to previous results of Szabo and Lefkovitch (cited above), and demonstrate that, in certain environmental conditions, overwintered colonies with one- or two-year-old queens cannot be distinguished in their ability to recover from their winter population loss, and both are able to produce surplus honey in a relatively short time period.

44. Szabo, T. I.,[g] and L. P. Lefkovitch[kk] – EFFECTS OF HONEY REMOVAL AND SUPERING ON HONEY BEE COLONY GAIN – Eight honey bee *(Apis mellifera)* colonies, divided into two groups of four, were individually placed on platform scales and their weights were monitored daily. During six honey removal treatments, honeycombs were removed and replaced with empty combs alternately from the two groups of colonies, so that honey was removed three times from each group. During the four days following honey comb removal, the mean gain per day for each of the removal-treated colonies was 2.41 kg, significantly less than the 3.37 kg for the undisturbed colonies.

The present study has reached a conclusion in conflict with the theory that frequent honey removal increases honey production. The average loss in gain caused by honey removal was 3.84 kg per colony for the combined first four days after disturbance. If we consider an apiary with 1000 colonies, the loss in gain because of a single honey removal could be 3840 kg. Moreover, honey is usually removed from 4 to 6 times during the nectar flow. If the honey removal processes could be reduced by half, using our previous example, the production could be increased by approximately 7600 to 11,500 kg of honey. Since early harvested honey can have an unacceptable high water content, and since artificially drying the honey does not provide the essential enzymes important in honey quality, a less frequent honey removal not only may increase production but also its quality.

Also, the present study indicates that frequent honey removal followed by the addition of empty combs causes extra stress and work for the bees. The newly extracted combs are covered with honey and many of the cells are damaged during extraction. These must be cleaned and repaired by the bees and this time consuming procedure is repeated with each honey removal and subsequent supering. This explains why colonies with no honey removal gained more than those which had their honey removed and had been provided with empty comb space. The presence of empty combs may increase honey production (Rinderer *et al.*, *Am. Bee J.* 119:40-43; Rinderer *J. Apic. Res.* 21:74-87), however, as indicated by our results, during intense flow conditions, the repeated colony disturbances associated with frequent honey removal and supering reduced the productivity of the bees. Less frequent honey removal demands that more empty combs be added to the colonies at a time, thus reducing the repetition of cleaning, repairing and other disturbances, therefore allowing the bees to concentrate on honey production.

45. Taylor, O. R.[s] and G. Rowell[u] — MATING AND GENE FLOW WITHIN AND AMONG HONEY BEE POPULATIONS. — Spatial aspects of the honey bee mating system are not well known primarily because matings occur in mid-air at a height and speed which make direct observations extremely difficult. Owing to the highly dynamic nature of queen and drone flight, the genetic consequences of natural matings have also remained unpredictable. Neutral or null models, based on assumptions and conditions similar to those of mixed mating models for plant populations may help us better understand the relationships between the mating system and genetics in honey bees.

Two primary assumptions of a neutral mating model are (1) that reproductives (drones and queens) of various genotypes do not differ in characteristics which affect mating success (for example, flight performance, copulatory behavior, or fertility), and (2) mating is random with respect to genotype.

With these simplifying assumptions, the honey bee mating system is simulated as a surface topography of relative frequencies of drones and queens over a given area. Field studies, using aerial drone traps and mark-and-recapture techniques indicated that drones occur about their home colonies in patterns which approximate a bivariate normal distribution with standard deviations ranging from 800 to 1500 meters. By modelling distributions of drones from two or more sources, the expected frequencies of drones, encountering queens at any point in space, is calculated. These expected values provide a null hypothesis against which observed frequencies may be tested.

A hypothetical queen flight distribution is modelled with a peak frequency at a distance (ranging from 0 to 5 km) away from the queen source location. Because the mode of this queen distribution occurs at a distance away from the origin, flight distributions of queens could be described as hyper-dispersed.

Tests of the model show that it is possible to obtain predetermined frequencies of drones of two or more types at specified distances by altering the distance between drone sources and the number of drones at each source. Matings by genetically marked queens within linearly structured drone populations indicated that most queens mate at distances of 1-1.5 km from their colony. Frequency distributions for mating flights of both queens and drones provide a basis for measuring gene flow among honey bee populations via the mating system. When combined with information on the dispersal distances of swarms, we should be able to establish the conditions that lead to genetic heterogeneity among isolated and semi-isolated feral and managed honey bee populations.

The models suggest that gene-flow increases 1) with increasing population density, 2) with increasing vagility of swarms, and 3) with increasing flight distance of queens. Indirect evidence from the literature seems to indicate that queen flight distances are inversely related to the density of the drone populations.

Because European and Neo-tropical African bee populations appear to differ significantly in distributions, density and vagility, we hypothesize greater variation within and among European than African bee populations. Thus far, allozyme data from Mexico are consistent with this hypothesis. Considerable variability occurs within and among apiary populations of European bees within a region. In contrast, allelomorph frequencies in African bees for MDH and HK show little variation throughout Mexico.

46. Thoenes, S. C.[a] and S. L. Buchmann[a] — TRACHEAL MITE INDUCED COLONY MORTALITY MONITORED BY AN ELECTRONIC SCALE[qq] — Tracheal mite (*Acarapis woodi*) infestation of honey bee colonies in Arizona has been increasing since 1988. Typical signs of mite-induced colony mortality include 1) fecal spots at the colony entrance, 2) disjointed wings ("k-wing") on bees both outside and inside the colony, 3) hives with abandoned brood and honey, and 4) rare occurrence of large numbers of dead bees in front of the hive. The usual time of year that the colony mortality due to mites occurs is January or February.

We have several colonies placed on electronic scales in various Sonoran Desert plant communities. The colony in this study was located in Pinal County, 57 km north of Tucson, AZ and had a hive volume of 100 liters. The colony was placed on a Sartorius electronic scale (model F 330S) which recorded weights every 15 minutes and was located inside a louvered wooden housing for wind protection. Tracheal mites were not purposefully introduced, and their origin remains unknown.

Over the course of a typical late winter day near Tucson, the normal colony weight remains constant or drops a few grams as stored honey is consumed. In contrast to this normal pattern, on February 13, 1990, after several days of losing more than 100g per day, the hive weight dropped from 73.0kg to 71.6kg. The drop did not occur abruptly, but was a gradual, constantly declining pattern over a five hour period from 1300 to 1800 MST. The hive remained undisturbed on the scale for several additional days during which the weight changed only slightly indicating no bee foraging. Most of the normal signs of tracheal mite induced colony mortality were present *i.e.* fecal spots, a few K-wing workers, and an abandoned hive. The colony contents were analyzed. Honey, pollen, and brood were present in quantities of 18,666.3, 3121.8, and 141.9 $cm,^2$ respectively. Approximately 150 newly emerged worker bees were present in the colony. These bees were examined for tracheal mite infestation and were found to be positive.

Our calculations reveal that ca. 15,000 bees exited the colony over a 5-hour period. The most interesting fact revealed by the scale data is that the drop was not precipitous, but occurred as a gradual decline. Using the raw data, and assuming that any weight loss was from bees leaving, the rate of tracheal mite-induced absconding occurred at an average of 800 bees every 15 minutes. Also of interest is that the entire adult population was affected eventually leaving the hive abandoned, even though both sealed brood and honey were present. The ultimate reason why the tracheal mite-infested bees abandon their colony at this time of year is not known, but this study helps elucidate how it occurs. This behavior might be an adaptation to heavy mite infestation, since the queen usually does not abscond and the worker caste is slowly replaced by newly emerged, mite-free individuals. The colony is very vulnerable at this stage with survival possible only with ambient temperatures at or near 34° C.

47. Thoenes, S. C.,[a] S. L. Buchmann,[a] and J. O. Schmidt[a] – REPRODUCTIVE SWARMING PHENOLOGIES AND THE EFFECTS OF CLIMATE, LATITUDE, AND FOOD SOURCE – Almost no research exists on the effect of extrinsic factors on reproductive swarming by honey bees *(Apis mellifera)*. A main difficulty encountered in such studies is assembling large long-term data sets that are necessary to demonstrate correlative trends.

Our swarming phenology study is based on a 16 year record (from 1975 through 1990) of swarm occurrence and location in Tucson, AZ. The quantity of pollen entering the hives was based on weekly pollen collections from OAC pollen traps over 10 years (from 1981 through 1990). Pollen protein and nutritional quality was assayed by Kjehldahl nitrogen analyses of those weekly samples. Daily temperature maxima and minima, as well as precipitation records were derived from weather stations for 1975 through 1990. Daily weights for unmanaged colonies in Tucson from 1973 through 1978 (Moffett *et al. ABJ* 121:329-331, 335) and from 1988 through 1990 (Buchmann and Thoenes, unpubl. data) reflect incoming nectar flows. Percentage of swarms each month for all states (excluding Hawaii and Alaska) were recorded by the Bureau of Crop Estimates for 1914 through 1981. Swarm phenologies for individual cities reported in the recent literature were also compiled.

The Tucson swarming phenology record totals 3069 swarms. The earliest swarm occurred on 24 January and the latest on 15 November. Most swarming occurred during March, April, and May with the bell-shaped distribution peaking in mid April. Low numbers of swarms occurred from June through mid November with no evidence of a minor peak in the Fall. The timing of the Spring peak varied between years. This variation was somewhat correlated with climatic factors including rainfall and temperature, but was highly correlated with pollen and nectar availability. The peak occurrence of swarms was related very closely with the quantity of spring pollen available; *i.e.* a shift in the spring peak of pollen resulted in a corresponding shift in swarm occurrence. Nectar availability had the opposite effect, with increasing colony weight corresponding to fewer swarms. We conclude that climatic conditions affect shifts in blooming phenologies to which the bees, in turn, respond. The timing of reproductive swarming occurs simultaneously with the section of the year yielding the highest pollen quality; a time when pollen consumption by young adult bees or developing larvae yields longer-lived individuals. Thus, peak swarming occurs each year at the time where food source availability maximizes the likelihood that swarms will survive.

Increasing latitude had two affects on swarming. First, it shortened the season in which swarming occurred, with 10 to 12 month seasons in the southern U. S. and 3 to 5 month seasons in the far north. Secondly, it shifted peak occurrences from April in the southern states to June in the northern states. An unexpected factor was maritime influence, with earlier swarm occurrence near the coasts and later swarming in the interior states. Elevation also affected swarming, with higher elevation delaying swarm occurrence. In general, swarming each year begins along the Gulf Coast, moves north along the coasts, moves inward toward the Rockie Mountains, and ends in the high elevations of Colorado and Wyoming.

48. Thoenes, S. C.[a] and J. O. Schmidt[a] – A RAPID, NON-INJURIOUS METHOD FOR REMOVING LARVAL HONEY BEES FROM CELLS – The increased biochemical research on honey bees requires newer and easier methods for obtaining needed material. For example, our research involves purification and characterization of the hemolymph proteins of honey bees. The adults were easy to collect, but the various immature stages created a problem: large numbers of each particular larval stage were needed and this required a technique that not only was fast and non-injurious, but was also specific enough to pick out larvae of the desired age.

A new method was developed in which large numbers of each specific larval stage were obtained by "washing" the cells with a thin stream of water. A 500 ml plastic laboratory wash bottle served as an effective and convenient means to produce the water stream. Advantages of this system include accuracy (a single particular larva may be selected and removed), versatility (any larval stage can be removed), speed (the larvae readily wash from the cells), non-destructiveness (less than 1% were damaged), and portability (for use in the field as well as the laboratory).

This method easily can be adapted to obtain immature stages from any communal cell-nesting Hymenoptera. Another use of this method could include obtaining the very small larvae needed for queen rearing.

Table – A list of previous studies describing methods of removing larval honey bees from cells.

Reference	Removal method	Accuracy	Versatility	Speed	Injurious	Portability
Gary 1961	Water hose on uncapped brood	No	No	Fast	Yes, from uncapping	As long as the hose
Gilliam *et al.* 1978	Water hose + forceps	No	No	OK	Yes, from forceps	As long as the hose
Brey *et al.* 1980	Laboratory air source	Yes	OK	OK 40g/10 min	Very little	No
Thoenes & Schmidt 1990	Wash Bottle	Yes	Yes	Good 100g/10 min	<0.1%	Yes

Gary *Gleanings in Bee Culture* 89:550-552, 569
Gilliam, Taber, and Bray Rose *Apidologie* 9:75-89
Brey, Norris, and Erickson *J. Apicult. Res.* 19:200-201

49. Vergara, C. – AFRICANIZED BEE SWARMS PREFERENCE FOR DIFFERENT BAIT HIVES IN MEXICO – Some of the factors determining the preference of feral swarms for bait hives of different specifications have been examined by several authors (reviewed by Witherell, *Am. Bee J.* 125:823-829; Schmidt, *Am. Bee J.* 130: 333-334). However, the application of this knowledge for practical purposes is still in need of more information, especially with reference to the best suited locations for bait hives.

The purpose of the present study was to determine whether bait hive stations located in the vicinity of bee yards (near) or at least 2.5 km from the nearest bee yard (remote) were more attractive to swarms of Africanized Honey Bees in Southern Mexico. Six bait hive stations (3 near and 3 remote), consisting of 12 bait hives each, were deployed on a 60 km transect, where six bee yards had been installed. Each group of 12 bait hives consisted of 3 replicates of 4 different sets of conditions: 1. High (3-4 m from the ground level), with pheromone; 2. High, without pheromone; 3. Low (0.4-0.6 m from the ground), with pheromone and, 4. Low, without pheromone. Old Langstroth hive bodies, repaired to seal off holes that could allow small mammals to nest inside them, were used as bait hives. The pheromone used was a mixture of chemicals mimicking the Nassanoff pheromone (Pickett, *J. Chem. Ecol.* 6:425-434). The bait hives were checked every 6 to 10 days and any swarms found occupying the boxes were captured, weighed and sampled. The capture data presented in the table correspond to the period from March 1988 to July 1990 and represent the total number of swarms captured for each trap type.

The number of swarms captured in remote bait hives was greater than the number captured in near bait hives (Wilcoxon match-paired test; $P = 0.36$; the number of swarms captured in High bait hives was also greater than the number captured with Low bait hives ($P = 0.10$): the number of swarms captured with lured bait hives was also greater than the number captured with unlured bait hives

(P = 0.36). These results show that bait stations placed away from bee yards will be more effective in capturing swarms than those located in the proximity of bee yards and confirm that **High**, lured bait hives are more attractive to bee swarms than **Low**, unlured ones.

Table — Swarm captures in Tabasco, Mexico (March 1988-July 1990)

	Traps ≥ 2.5 km from nearest apiary		Traps near apiary		
Trap height	with pheromone	without pheromone	with pheromone	without pheromone	Total
3-4 meters	85	46	56	20	207
0.5 meters	5	7	7	6	25
Total	90	53	63	26	232

50. Waller, G. D.[a] and L. H. Hines[ll] — A SEARCH FOR TRACHEAL MITE RESISTANCE IN ARIZONA HONEY BEES — The honey bee tracheal mite, *Acarapis woodi*, was first determined to be an established honey bee pest in southeastern Arizona in 1988. Mandatory depopulation of mite-infested colonies was discontinued, so with the quarantine of southern Cochise County we had an opportunity to study mite-infested colonies. We now report two years of research on the impact and possible resolution of the honey bee tracheal mite problem in southern Arizona.

In December of 1988 we began monitoring for tracheal mite presence in selected apiaries. The results are presented using the terminology of Dr. Eischen who proposed "prevalence (w)" for the percentage of workers in a hive or apiary that test positive for the mite and "prevalence (c)" for the percentage of colonies in an apiary that test positive. The pattern of mite prevalence (w) in the several test apiaries ranged from zero to near 100% in Dec. '88 to Feb. '89, dropped sharply to a mean of 5% in the following months, and rose again as winter approached. The number of colonies we were able to follow from winter '88-'89 through winter '89-'90 was limited because many colonies perished during the first winter. Prevalence (c) was near 100% in four of five test apiaries, and by October '89, 26 of 28 colonies in the fifth apiary also tested positive. This suggests that once this pest is established in an apiary, there will soon be no mite-free colonies.

Our plan throughout the past 2 years has been to allow this new pest to run its course and thus establish mite-resistant bees by allowing the mites to eliminate those most susceptible. Each winter we've had a natural attrition of about ⅓ of the colonies, and those dead or moribund have had typical symptoms associated with tracheal mite infestation. Perhaps the most unusual behavior we've seen is large numbers of infested workers that walk away from their hive leaving only a handful of attendants with the queen and whole frames of brood and honey. Such behavior leaves abandoned equipment that is subject to robbing of honey by other bees and wax moth damage.

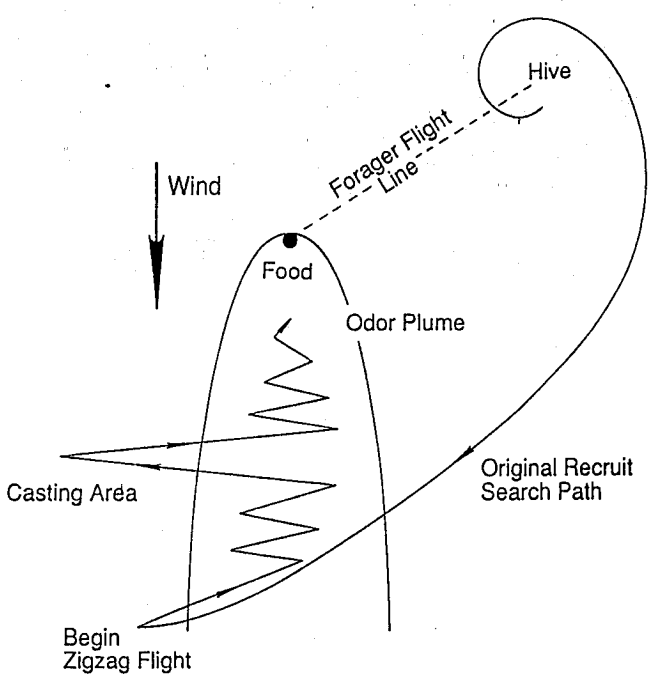
In 1989 we identified 25 surviving colonies as a resource for potential breeder queens (PBQ). These PBQ's were moved to an isolated, but easily accessible apiary and installed on colonies of mite-free bees. Although no special precautions were taken to prevent the introduction of the mites to this apiary, in November 1989 we tested 1006 workers and found only 2 bees with mites. Subsequently, in 1990, we established 6 colonies of mite-free bees on equipment from which badly infested bees had been removed the previous day and after 2 and 4 months, found no mites in any of the bees tested. These results suggest that fumigation of "mite-contaminated" equipment is unnecessary.

Using marked, newly emerged workers from PBQ's we have attempted to evaluate relative mite resistance by distinctively marking these young bees and putting them either into cages with mite-infested bees or directly into mite-infested colonies. Although our recovery and examination provides rather clear results, we doubt that this technique is sufficiently rigorous to identify resistant stock. Thus, we have now installed the 18 PBQ's remaining from our 1989 study into hives stocked with bulk package bees having uniform mite levels. We will evaluate their performance this coming winter.

During 1990 our main efforts have been in the area of identifying additional PBQ'S from colonies that demonstrated outstanding performance (mite resistance) during the winter and spring 1989-90. Forty of these PBQ's now head colonies placed in groups of 10 on a 2-mile grid isolated from other bees in a large Spanish Land Grant. Queens from these PBQ's have mated while flying from nucleus hives at the center of this grid. What we hope to accomplish is similar to using the closed population concept, but using open mating rather than instrumental insemination. Also, we will replace some of these 40 PBQ lines with other queens that appear to offer improvement. In addition to selecting for mite-resistance, we are also selecting for queens that show resistance to both chalkbrood and European foulbrood. Our goal is accelerate the natural selection process that apparently occurs wherever and whenever the tracheal mite becomes established in a population of honey bees.

51. Wenner, A. M.,[mm] J. E. Alcock,[nn] and D. Meade[nn] — REMOVAL OF FERAL HONEY BEE COLONIES FROM SANTA CRUZ ISLAND, CALIFORNIA — We are now removing wild colonies of European honey bees from Santa Cruz Island (a segment of the Channel Islands National Park) off the coast of Santa Barbara, California. Robbin Thorp of the University of California at Davis is concurrently studying pollination and recovery of the native bee populations.

European honey bees were first introduced into Cali-



Revised odor-search model. Experienced foragers routinely fly their "beeline" between hive and food while orienting by landmarks. Newly recruited bees previously exposed to food and locality odors present on dancers in the colony fly in an ever-expanding spiral path until they are downwind from the appropriate food source and/or aerial pathway of foragers. They then proceed upwind in a zigzag flight as long as they continue to perceive the appropriate odor molecules. If odor contact is lost, they "cast" until they are once again within the odor plume (Details in Wenner and Wells, 1990 — ANATOMY OF A CONTROVERSY: The Question of a "Language" Among Bees; Columbia University Press).

fornia in 1853 and reached Ventura County in 1875. Before 1880 a beekeeper introduced bees into the center of the island near the ranch buildings. After that introduction, offspring of the original colony or two spread over most of the 96 square mile mountainous island during the next 110 years. The strain is remarkably homogeneous; according to a genetic analysis run by Rob Page and a morphometric analysis run by Dan Meade, they may be a German strain, even though Italian bees were apparently already present in Southern California.

While colony removal work proceeds, we are studying the comparative pollination of plants both on Santa Cruz Island and on Santa Rosa Island, six miles to the west (an island nearly as large but lacking honey bees). Our perception of colony foraging range and patterns, as well as individual recruitment behavior with respect to wind direction (see figure), is also changing rapidly as we work in this isolated area, permitting modification of an odor-search model first outlined by von Frisch in 1938 and described by me in 1974. Honey bee odor-search behavior while seeking food sources appears to be very similar to that of other flying insects.

52. Wilson, W. T.,[n] W. L. Rubink,[n] E. Sugden,[n] A. M. Collins,[n] and J. Vargas[oo] – INCIDENCE OF MULTIPLE HONEY BEE QUEENS *(APIS MELLIFERA)* IN MANAGED HIVES AND SWARM-TRAP COLONIES – Africanized honey bee queens are known to invade colonies headed by European queens (Vergara *et al.*, *Am. Bee J.* 129:824-825) and some African swarms have multiple queens (Smith, *Bee Wld.* 39:29-36). Consequently, it is important to know the frequency of multiple European queens in commercial and feral colonies before the predicted invasion of U.S. beekeeping by Africanized bees from Mexico.

In April and May 1989, five colonies in a south Texas apiary of 30 USDA-ARS colonies were found to have multiple queens. Four colonies each had two laying queens while the fifth had four virgins. In each of the four brood-producing colonies, mature queens were laying eggs, occasionally on the same side of the brood comb with no apparent aggressive behavior. One queen was marked while the other was not (presumed mother/daughter). Butz (M. S. Thesis, U. of GA. 1989) reported a similar lack of aggression between queens during brief encounters. In the early 1980's a queen breeder used this same apiary (Las Pumpas) to maintain selected stocks that had a propensity for tolerating more than 1 queen (W. Chandler, pers. comm. 1989). Remnant of this stock may have persisted through feral colonies and an earlier ARS purchase of a few queens. The spring survey was expanded near Weslaco, TX and 30 more colonies in three apiaries were examined. One colony had two laying queens.

In March 1990, 215 wintered colonies in six commercial apiaries near Rio Grande City, TX were examined. Two queens were found in each of two colonies. In May, 450 nucleus colonies in 10 apiaries near Woodville, MS in a migratory operation were inspected. Two queens were found in each of three colonies.

With the exception of the Las Pumpas apiary, mature multiple queens occurred in about 1% (range: 0.7-3.3%) of commercial colonies with European ancestry. We believe that two queens per colony is usually associated with the process of supersedure.

In spring 1988, two extensive transects with a total of 396 bait-hives (swarm traps) were established in south Texas and northeast Mexico to attract bee swarms (Rubink, *et al.*, *J. Kan. Entom. Soc.* 63:288-297) with *ca.* 600 additional bait-hives added in 1989 and 1990. Through April 1990, *ca.* 250 swarms were captured in Texas and 375 in Mexico. Outside the Texas transect, there are 194 additional ARS bait-hives in south TX that captured 267 swarms. Since most established swarms (1-30 days in hive) were rearing worker brood, queens were undoubtedly present. The entire swarm was frozen and later examined in detail for caste representation in more than 67% of swarms collected. Queens were recovered only from *ca.* 85% due to disruption during killing and collection. None had multiple queens. Although difficult to prove, we believe that during flight, swarms have 1 queen. This is supported by Kigatiira (In: *Africanized Honey Bees and Bee Mites*. Needham, *et al.*, 1988) where long-distance flights were made only by clusters with 1 queen. When African swarms amalgamate, this results in multiple queens for a short time (Kigatiira 1988). We believe that the frequency of multiple queens in Africanized feral colonies could increase once the bee is established in south Texas.

53. Zeltzer, A.[a] – MANAGEMENT PRACTICES AND PERCEIVED INFORMATION NEEDS OF BEEKEEPERS – Although honey bee management techniques have been the subject of considerable study, research has often had little impact on management practices of beekeepers in the United States. During 1990, a questionnaire was designed to obtain (1) an overview of current beekeeping practices, and (2) perceived information needs and the appropriate format for the information. The questionnaire was distributed to beekeepers attending meetings of the American Honey Producers, American Beekeeping Federation and Eastern Apicultural Society, as well as to members of the Georgia State Beekeepers Association in its newsletter.

A total of 527 questionnaires were distributed and 288 were returned. Seven respondents were from outside the United States and not considered in the results. Beekeepers were divided into the following classes: Hobbyist (1-24 colonies); Part-time (25-299 colonies); Commercial 1 (300-999 colonies); and Commercial 2 (1000 + colonies). Responses were received from 102 Hobbyist, 67 Part-time, 37 Commercial 1, and 76 Commercial 2 beekeepers. A total of 22 questions were asked: 14 related to current practices, and 6 related to perceived information needs and the appropriate format for the information. Results from selected questions are in the table.

Respondents indicated difficulty interpreting researchers' terminology, thus research recommendations have had little impact on their practices. Respondents emphasized the need for colony genetic management techniques that are economically feasible.

The entire results of the questionnaire will be published in A. Zeltzer (Master of Science Thesis, Univ. of Ariz., in prep.).

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