

## A Preliminary Study of Honey Bee Foraging Range in Macadamia (*Macadamia integrifolia*, Maiden and Betche)<sup>1</sup>

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The pollination requirements of macadamia (*Macadamia integrifolia*, Maiden and Betche) were reviewed by Urata (1954), who observed that honey bees, *Apis mellifera* L. and several species of syrphid flies are the most frequent insect pollinators. The comparative value of these pollinators has not been determined. Honey bees appear to be the most abundant and active insects foraging on macadamia. It is difficult to determine the economic value of honey bees as pollinators of macadamia, although there is evidence that some varieties apparently do benefit significantly from honey bee pollination, as reported by Shigeura (1967) and Shigeura, Lee, and Silva (1970).

More efficient utilization of honey bees as pollinators requires more information on the flight range, distribution within orchards, and foraging activities. This information is needed to determine the optimum distribution of hives and the numbers of hives necessary to insure adequate pollination in all areas of orchards. Also, the population of feral honey bees should be determined since abundant feral honey bee colonies are within flight range of most macadamia orchards in Hawaii.

The objectives of this research were to conduct a preliminary study on the flight range of honey bees in a macadamia orchard and to estimate feral bee populations. Concurrently, the project provided an opportunity to conduct a preliminary experiment on a new magnetic capture/recapture method for determining the distribution and flight range of honey bees (Gary, 1971).

### METHODS AND MATERIALS

The experiment was conducted in the 1,250 acre Keaau orchard of the Royal Hawaiian Macadamia Nut Company near Hilo, Hawaii. Fifty-one colonies of bees were placed on location at the edge of the orchard on 21 February 1970 (Fig. 1). Consequently, the bees had adequate time to adjust to the foraging area prior to the experimental period (1-7 March).

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Flight range data were obtained by the method of Gary (1971). Bees were captured while foraging on the trees. Each bee was labeled with a tiny, numbered, ferrous metal tag attached to the abdomen, and released approximately 30 meters from the apiary. Preliminary experiments demonstrated that bees released near the apiary returned successfully to their hives. When the tagged bees returned to their respective hives they passed through magnetic traps attached to the hive entrances. Magnets in these traps pulled the metal labels from the bees and retained them as evidence of recapture. Control bees were treated identically, except they were captured initially at the hive entrances of specific colonies, as they were returning from foraging.

Magnetic traps were installed on the hives on 28 February. On 1 March, a preliminary flight range determination was made by tagging bees from five equidistant sampling areas along a line starting at sample plot 1 (Fig. 2) and ending in Section G' approximately 1,280 m from the apiary (366 m beyond sample plot 6). Very few bees were recaptured from Section G'. Consequently, sample plots 1-6 (Fig. 2) were established at 150 m intervals along a line within the 915 m range in Section G. Each plot consisted of 15 trees, spaced at 7.6 m intervals, in a 3 × 5 tree block. The orchard contained interplanted varieties, and the varieties in sample plots were as follows: 246 (53%), 386 (29%), 660 (7%), 425 (5%), 508 (4%), and 333 (2%). Foraging bees were collected at each sample plot within 3 m from the ground by a long hose connected to a portable vacuum cleaner, powered by a 12 volt battery in a pull cart. Gentle suction was used, just sufficient to pull bees from the flowers, and hold them against a cloth filter positioned 1.3 cm inside the tip of the collection hose. Captured bees were immediately transferred to small holding cages and provided with sugar candy as food. Samples were taken by one operator on 2 March and two operators on 5 and 6 March. Each operator began sampling at opposite ends of the line of sample plots, and proceeded in opposite directions. Samples of 10 bees were collected at each plot. Control bee samples were taken at the hives before and after field sampling. The bees were taken indoors for tagging. They were anesthetized for 30-60 seconds with CO<sub>2</sub>, immediately chilled for 10 minutes at 2°C and tagged dorsally on the abdomen. A paint dot was applied to the scutum of the thorax as a secondary identification mark to identify any bees that might be captured a second time, following initial release in the field. All tagged bees were returned to holding cages. The 2 March sample was held overnight and released the next morning. Samples collected 5 and 6 March were released at approximately 5 PM on the day of capture. During confinement, some bees were lost from samples because of (a) mortality, (b) inability to fly at release time, or (c) loss of tag while confined. Successfully released bees were those that retained tags during confinement and flew immediately after being released.

TABLE 1. *Recapture of tagged foraging bees in Keaau macadamia orchard. 1970.*<sup>a</sup>

Sample Plot	Capture Date			Total	% Recovery
	2 March	5 March	6 March		
1	0/8	5/16	8/19	13/43	30.2
2	3/9	13/17	13/19	29/45	64.4
3	7/9	7/15	13/19	27/43	62.8
4	3/10	10/20	9/19	22/49	44.9
5	5/9	11/17	10/17	26/43	60.5
6	1/5	6/18	7/20	14/43	33.6
Total	19/50	52/103	60/113	131/266	
% Recovery	38.0	50.5	53.1		
Controls	14/21	27/30	27/29	73/80	91.3

<sup>a</sup>Number recaptured/number released.

The following meteorological conditions prevailed during the study: temperature 17–28°C, humidity 61–95%, wind 3–12 km/hour, and partially cloudy skies, with a trace of rainfall each day.

#### RESULTS AND DISCUSSION

The data on recaptured bees are summarized in Table 1.

Foraging bees from the apiary were distributed approximately uniformly within the sampled area except at plots 1 and 6. The sharp reduction of bees from the apiary at sample plot 6 suggests that this plot was near the outer edge of the area that was foraged most actively by bees from the apiary. Contrary to expectations, the highest proportion of bees originating from the apiary did not occur in plot 1 nearest the apiary. This could indicate that there was greater competition from feral bees in the peripheral areas of the orchard, thereby making it more “profitable” for bees from the apiary to penetrate more deeply into the orchard. Another possibility is that bees may fly a short distance from the apiary before foraging extensively.

The ratio of bees originating from the apiary to feral bees originating from nearby forest area was estimated by the percentage of recaptured bees in the samples, after making appropriate corrections based on the percent recapture of control samples, shown in the following formula:

$$\frac{a}{b/c \times d} \times 100 = \% \text{ of bees originating from apiary}$$

a = number of recaptured foraging bees

b = number of recaptured control bees

c = number of released control bees

d = number of released foraging bees

For example, 57.0% of the bees sampled on March 2 originated from the apiary ( $\frac{19}{14/21 \times 50} \times 100$ ). The remaining 43.0% of field bees

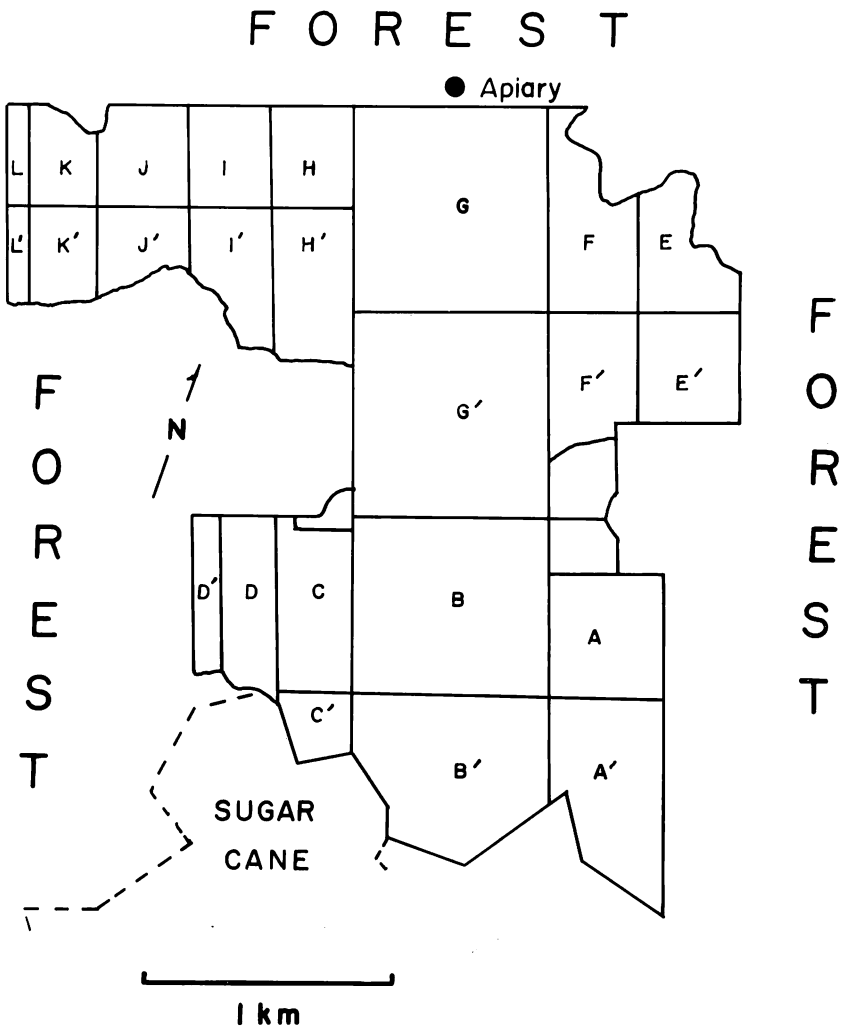


FIG. 1. Large scale map of 1,250 acre Keaau macadamia nut orchard near Hilo, Hawaii, showing apiary location and Section G where bee samples were collected.

must have been feral bees. Consequently, the calculated ratio of bees from the apiary to feral bees was 57: 43, 56: 44, and 57: 43 for 2, 5, and 6 March, respectively. The feral bee population in the sampled area is estimated by calculation to be approximately 43%.

A second method of estimating the apiary bee: feral bee ratio yields a similar result. According to Gary (1971), approximately 90% of released tagged bees normally are recaptured when all hives in the area have traps.

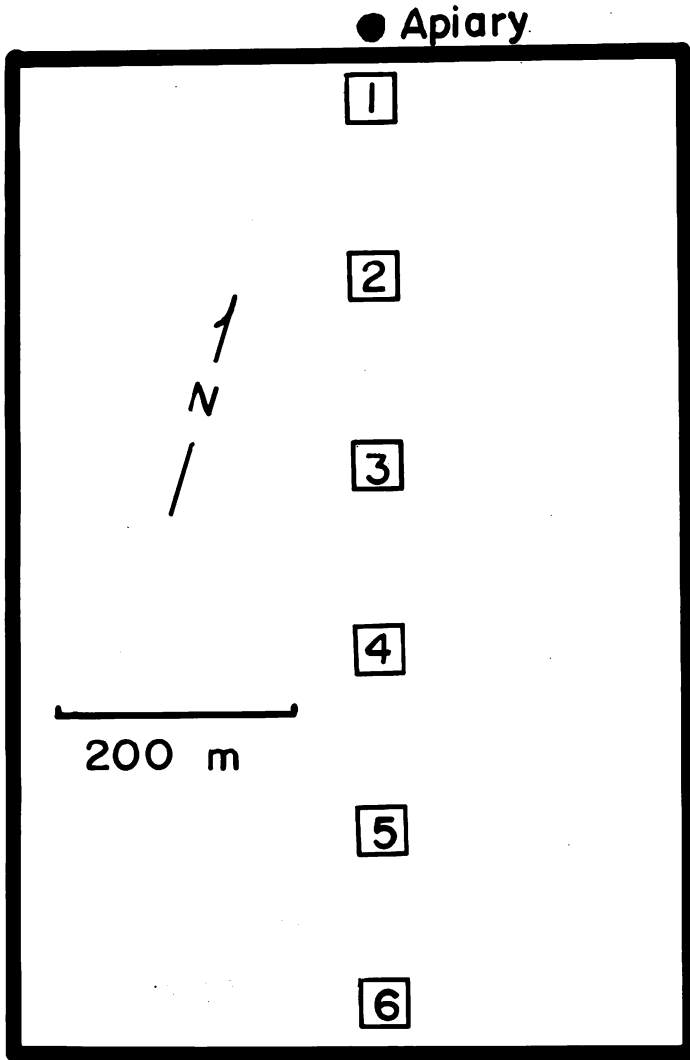


FIG. 2. Small scale map of Section G showing sample plot locations. Section G is surrounded by high, dense windbreak composed of Norfolk pines.

Approximately 10% are lost owing to mortality in the field, tags that fall off, or other unknown causes. Consequently the difference between the actual recapture percent and the 90% expected recapture represents foraging bees that originated from colonies without traps. Since all hives in the apiary had traps, the tagged bees that were not accounted for at the apiary must have originated from feral colonies in the nearby forest area. In this study, tags from 131 of 263 (49.8%) tagged and successfully released

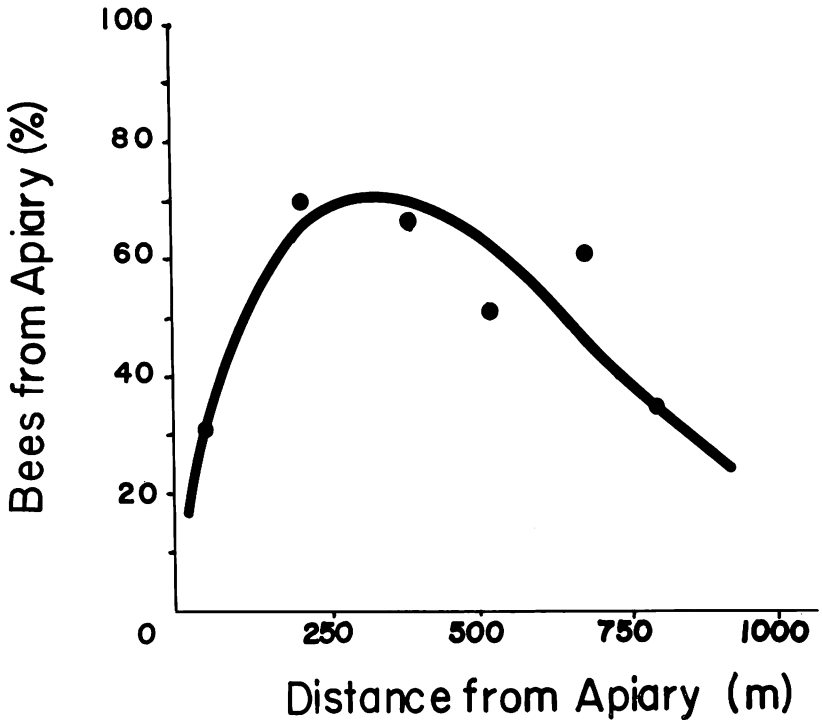


FIG. 3. Proportion of bees originating from the apiary in foraging bee samples captured at various distances from the apiary.

field bees were recaptured at the apiary. If this is corrected on the basis of the 90% expected return, the calculated percent of bees that originated from the apiary is 55.3% ( $\frac{49.8\%}{90/100} = 55.3\%$ ), and the feral bee population estimate becomes 44.7%.

The percentage of foraging feral bees probably increased greatly as the distance from the apiary increased beyond the "intensive foraging zone", located within approximately 915 m from the apiary, where apiary bees appeared dominant (Fig. 3). The edge of this zone appears to be in the vicinity of plot 6, as indicated by the rapidly decreasing proportion of apiary bees in samples taken there. Since this zone occupies only a small portion of the overall orchard (Fig. 1), we estimate that more than half of all foraging bees in the orchard must have oriented from feral colonies. It follows that the number of feral colonies in the thousands of acres of forest surrounding the orchard greatly exceeds the number of colonies in the apiary.

Only two paint-marked bees were recaptured in the field; this indicated that the possibility of tagging the same bees repeatedly is not a problem.

Several problems were encountered in this preliminary study. The relatively sparse flowers and low bee populations made it very difficult to obtain adequate samples of bees. Another problem concerned the possibility that a small percentage of the tagged feral bees may have become disoriented by being released near the apiary, and may have been attracted to the apiary hives. A brief experiment was conducted to evaluate this possibility. Fifty bees were captured on 7 March from several hives located in Hilo, located approximately 11 km from the orchard. These bees were tagged, along with 50 similarly captured bees from hives in the apiary at the macadamia orchard. All bees were captured as they were returning to their respective hives. When released, 5 of 46 successfully released Hilo bees were recaptured, compared to 34 of 46 apiary bees. These data suggest that the frequency of entry of feral bees into the hives of the apiary probably was insignificant. All of the bees from Hilo should have been disoriented because they were released in an unfamiliar area. However, most of the feral bees released at the apiary should have been familiar with the surroundings and should have returned to their respective feral colonies.

These preliminary data on foraging range of bees in macadamia suggest that the orchard area would be within range of foraging bees whenever apiaries are located so that orchard areas are within approximately a 1 km radius from one or more apiaries. Also, in order to take maximum advantage of the feral and apiary bee populations, most of the hives should be located at points most distant from the anticipated feral bee sources. If the orchard is surrounded by forest, apiaries could be placed near the central orchard area. The basic strategy is to minimize competition for foraging area between apiary and feral bees.

The relatively high proportion of feral bees found in this preliminary survey suggests that macadamia pollination in Hawaii presently is accomplished primarily by feral bees. It seems inevitable that these populations will decline in the future as nest sites are destroyed when forest land is cleared and developed, or pesticide usage reduces these populations. Commercial bee colonies can be manipulated more efficiently for pollination purposes, but the management of these colonies is contingent upon more extensive studies that integrate data on the effects of many variables, e.g., apiary placement, numbers of hives per acre, flight range, and population density of foraging bees in the orchard.

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