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Original article

Honey production in Venezuela: effects of feeding sugar syrup on colony weight gains by Africanized and European colonies

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Summary — Honey production by Africanized and European colonies as influenced by different rations of sugar syrup prior to the nectar flow was studied through a complete honey production season in Venezuela. A significant interaction of apiary, honey bee type and feed ration was detected. In the apiary with highest colony weight gains overall, European colonies had significantly higher weight gains than Africanized colonies. This general trend interacted with feed ration, the difference being most pronounced among colonies fed the 1 liter ration. Under the less favorable nectar flow conditions of the second apiary, significant differences in colony weight gains were not observed between geographical types. Significant differences in colony weight gains were detected between colonies fed 1 or 3 liters of syrup twice a wk. Colonies fed 1 liter of syrup had higher colony weight gains. Feeding honey bee colonies 3 liters of syrup twice a wk proved detrimental to colony development by restricting brood nest expansion.

Africanized honeybee / European honeybee / feeding / honey production / Venezuela

INTRODUCTION

Feeding honey bee colonies (*Apis mellifera* L) with dietary supplements prior to nectar and pollen flows has been shown to increase brood production and foraging activity (Crane, 1950; Sheesley and Poduska, 1968; Standifer *et al*, 1971). Increases in a colony's population of workers may result in increased honey

production per honey bee (Farrar, 1937, 1944; Moeller, 1961; Harbo, 1985) and increased efficiency in utilization of stored honey (Harbo, 1983). Providing honey bee colonies with differential supplementary feeding prior to the nectar flow should result in dissimilar population growth. If populous colonies are better able to exploit nectar flows, these differences in population growth should result in unequal colony weight gains.

Competition from feral colonies could reduce honey yields in managed colonies. Feeding colonies prior to the nectar flow should confer advantages in population growth over feral colonies. Upon initiation of the nectar flow, fed colonies should have a larger foraging population. This would increase their probabilities of securing nectar and pollen at a time when feral colonies are just commencing population growth.

This study assesses the effect of differential feeding of sugar syrup, prior to the nectar flow, on colony weight gains of Africanized * and European honey bees in 2 locations. Specific hypotheses tested were: are there differences in colony weight gains: 1) between Africanized and European honey bee colonies? 2) between colonies fed 1 liter or 3 liters of sugar syrup twice a wk? and 3) do interactions occur among the weight gains of Africanized and European colonies in 2 locations fed 1 or 3 liters of sugar syrup twice a wk?

MATERIALS AND METHODS

The experiment was conducted at Sarare, Estado Lara, Venezuela, from June through December, 1983. The floral resources available to the experimental honey bees were those of a tropical, deciduous lowland forest, surrounded by secondary successional grassland. Among the plants most commonly seen in bloom at the time of the nectar flow and identified by local beekeepers as providing the bulk of the harvest were *Hyptis* spp and *Gliricidia* spp.

Two apiaries, each with 20 colonies, were established 2 km apart. Ten Africanized and 10 European colonies were allocated at random to each apiary and randomly assigned to 1 of the 2 feeding treatments. In each apiary, 5 of the colonies of each geographical type received 1 liter of 50% (vol/vol) sugar syrup twice a wk. The other colonies each received 3 1-liter containers of syrup twice a wk. Feeders were inverted over the top bars immediately above the brood nest, maximizing accessibility of syrup to the bees. All colonies received protein rations consisting of 43% (vol/vol) expeller process soybean flour, 43% granulated sugar and 3% fresh pollen mixed in water. This material was fed as patties placed over the top bars above the brood nest and replaced weekly with new material so that bees could feed according to colony needs.

The honey production cycle for 1983 was divided into 2 seasons: 1) an intermediate season between the rainy and dry seasons (July–September) when rainfall per wk began to lessen and some nectar became available in late August and September; and 2) the dry season (October–March) when rainfall steadily decreased to nearly no rain, and nectar was plentiful. It is during the dry season that the bulk of honey is produced.

Differential feeding began on 6 June 1983 and ended on 28 October 1983, at the beginning of the nectar flow. All colonies were started (January 1983) as 2-frame nuclei. Commercial European size worker-foundation was provided to both bee types. During the rainy season prior to 6 June all colonies were fed 1 liter of sugar syrup twice a week. Non-fed controls were not used, as such colonies would have been lost to starvation or absconding. Colonies were

* The resident honey bees of Venezuela are considered Africanized. They are descendants of *Apis mellifera scutellata* imported from Africa that hybridized with various subspecies previously imported to South America. The European honey bees used in this study were from North America. In their ancestry such honey bees have representatives of several subspecies. Neither of the honey bees constitutes a subspecies nor a race, so their populations will be designated as geographical type or form to indicate that the honey bees showed major characteristics typical of temperate or tropical climate-adapted honey bees.

weighed every 15 d from June to December, 1983. Honey storage chambers were removed when three-quarters full and replaced with chambers containing comb foundation. In this way space was always available for ripening nectar and storing honey. As the colonies expanded their broodnests, space for expansion was provided by adding frames of foundation or adding another brood chamber. Statistical analyses were performed on changes in total colony adjusted appropriately for the empty equipment given to or taken from colonies.

Analyses of variance procedures (ANOVA) were performed on the data. A separate completely randomized design (CRD) was performed for each season, since sum of squares errors for each season varied considerably (table I).

RESULTS

A significant interaction of apiary, geographical type of honey bee and sugar syrup ration was detected throughout the study (table I). For each season, the 3-way interaction was simplified to a 2-way interaction of geographical type and sugar syrup ration. This allowed a more detailed examination of effects of experimental variables. Since the main nectar flow occurs during the dry season, and one of the objectives of the study was to examine the possible effect of pre-nectar flow feeding on honey production, particular attention was paid to the examination of treatment effects during this season.

Significant geographical type x apiary interactions occurred in the study (table I). In the apiary with the highest colony weight gains (Apiary 1), European bees became significantly heavier, reflecting greater honey production. In the apiary that produced less honey (Apiary 2), Africanized colonies accumulated numerically but not with significantly more weight (honey) (tables II, III). These results were consistent for both seasons even though the dry season produced 10-fold more honey.

Rations were consistently and significantly different in the intermediate season. Feeding colonies 1 liter of sucrose solution twice a wk resulted in greater weight gains (tables I–III). During the dry season these relations no longer held. A weakly significant interaction ($P = 0.06$; table I) suggested that ration interacted with apiary. In apiary 1, the site of greater honey production, colonies fed 1 liter twice a week gained numerically less weight while in apiary 2, the

Table I. ANOVA source table on colony weights (kg) for 2 CRDs by season, with 2 x 2 x 2 factorial treatment arrangement of geographical type, sugar syrup ration and apiary. Geo-type comparisons are 1-tailed tests.

Source	*Intermediate season*			*Dry season*		
	df	*SS (III)*	P	df	*SS (III)*	P
Geo-type	1	0.91	0.24	1	586.73	0.15
Apiary	1	0.68	0.54	1	305.58	0.45
Geo-type x apiary	1	7.20	0.05	1	2662.03	0.04
Ration	1	319.92	0.0001	1	50.27	0.76
Ration x apiary	1	0.06	0.86	1	2121.23	0.06
Geo-type x ration	1	1.10	0.43	1	63.88	0.73
Geo-type x ration x apiary	1	7.70	0.05	1	2153.73	0.06
Error	21	36.49		21	11035.73	

Table II. ANOVA source table on colony weights (kg) for 4 CRDs by season and apiary with 2 x 2 factorial treatment arrangement of geographical type (Geo-type) and sugar syrup ration (Ration). Geo-type comparisons are 1-tailed tests.

	Intermediate season			*Dry season*		
	df	*SS (III)*	P	df	*SS (III)*	P
Apiary 1						
Geo-type	1	3.68	0.04	1	2664.56	0.02
Ration	1	86.61	0.0001	1	703.84	0.28
Geo-type x ration	1	4.07	0.07	1	1371.83	
Error	15	19.99		15	6555.24	
Apiary 2						
Geo-type	1	1.62	0.19	1	406.60	0.19
Ration	1	178.37	0.0001	1	1532.87	0.11
Geo-type x ration	1	1.62	0.37	1	800.87	
Error	12	16.50		12	4480.06	

Table III. Least squares means ± standard errors of colony weights (kg) for geographical type (Geo-type) and sugar syrup ration (Ration). Means not followed by a common letter differ significantly, based on LSD calculated at an α level of 0.05. n = No of observation per mean. Geo-type differences were analyzed by 1-tailed tests.

Geo-type	*Ration*	*Intermediate season*	n	*Dry season*	n
Apiary 1					
Africanized		3.48 ± 0.71^a	6	20.10 ± 12.80^a	6
European		5.04 ± 0.42^b	10	52.75 ± 7.39^b	10
1 liter		8.06 ± 0.71^a	6	28.04 ± 12.80	6
3 liter		0.46 ± 0.41^b	10	44.82 ± 7.39	10
Africanized	1 liter	6.45 ± 1.29^b	1 *	0.00 ± 23.27	1 *
Africanized	3 liter	0.50 ± 0.58^a	5	40.20 ± 10.45	5
European	1 liter	9.66 ± 0.58^c	5	56.07 ± 10.45	5
European	3 liter	0.42 ± 0.58^a	5	49.43 ± 10.45	5
Apiary 2					
Africanized		4.28 ± 0.57	7	34.79 ± 9.33	7
European		3.53 ± 0.55	6	23.00 ± 9.11	
1 liter		7.81 ± 0.62^a	5	40.34 ± 10.18	
3 liter		0.00 ± 0.49^b	8	17.46 ± 8.15	8
Africanized	1 liter	8.55 ± 0.96^b	2	54.51 ± 15.78	2
Africanized	3 liter	0.00 ± 0.61^a	5	15.07 ± 9.98	5
European	1 liter	7.06 ± 0.78^b	3	26.18 ± 12.88	3
European	3 liter	0.00 ± 0.78^a	3	19.83 ± 12.88	3

* SE estimated from pooled variance.

site of less honey production, colonies fed 1 liter gained numerical more weight.

DISCUSSION

Under the more favorable nectar flow conditions of Apiary 1, European colonies had significantly higher weight gains than Africanized colonies. The same trend was observed in another experiment performed simultaneously, where Africanized colonies consistently had lower weights than European colonies (Pesante *et al,* 1987). On the other hand, under the less favorable nectar flow conditions of Apiary 2, Africanized colonies showed weight gains similar to those of European colonies. The 2 geographical types behaved differently under different nectar flow conditions, and hence a significant interaction of geographical type x apiary x ration was detected throughout the study. These findings are in agreement with those presented by Rinderer *et al* (1985), who reported that Africanized colonies produced more honey than European colonies under poor to moderate nectar flow conditions, but that European honey bee colonies surpassed the honey production of Africanized colonies under more favorable nectar flow conditions. Significant variation attributable to location even over short distances (< 2 km) is a common occurrence in tropical environments. Increased species diversity and patchiness account for these variations and provide a possible explanation for the differences in colony weight gains between the 2 apiaries.

Africanized honey bees seem better adapted to foraging under tropical conditions similar to those in which they evolved, where the nectar flow season extends over 6 months and is generally weak to moderate in strength. On the other hand, European honey bees seem better adapted to exploit the resources present in temperate areas, environments in which the nectar flow is intense and of shorter duration. This apparent competitive superiority of the Africanized honey bee over the European honey bee in tropical environments helps explain the harvesting of honey from regions previously unoccupied by honey bees (Goncalves, 1975; Michener, 1975; Fletcher, 1978). Nonetheless, their lower yields in poor quality honey production areas should be of concern to beekeepers who operate in the world's richer honey production areas.

Colonies fed 1 liter twice a week had significantly higher weight gains than colonies fed 3 liters. These differences in results of feeding treatments were most noticeable during the intermediate season when colonies were moderate in size (between 5 and 8 frames of bees). Crane (1950) observed that colonies with up to 8 frames benefitted the most from supplemental feeding with sugar syrup. However, the difference between the 1 and the 3 liter treatments was most likely caused by overfeeding with sugar syrup. Honey bees in colonies fed 3 liters, although provided with extra storage space, tended not to use it. Such colonies regularly used the brood nest area for both ripening nectar and storing honey. In doing so, they reduced the space available for egg laying, slowed their colony growth and ultimately diminished their colony weight gains. Thus, while supplemental feeding may be of benefit, it should be done in ways that do not restrict the expansion of brood nests.

In conclusion, the data show that Africanized honey bees are undesirable stock for highly productive beekeeping. Under the nectar flow conditions required for commercial honey production, Africanized colonies exhibit lower honey production than European colonies. In addition, their defensive, swarming and absconding behavior (Otis, 1977; Winston, 1979; Collins

et al, 1982) are objectionable traits that further decrease their attractiveness.

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Résumé — La production de miel au Vénézuela : effets du nourrissement au sucre sur les gains en poids des colonies d'abeilles africanisées et d'abeilles européennes. Nous avons étudié l'influence du nourrissement au sirop de sucre donné avant la miellée sur des colonies d'abeilles africanisées et d'abeilles européennes au Vénézuela. Deux ruchers, distants de 2 km et comprenant 20 colonies chacun, ont été créés. Dix colonies africanisées et 10 colonies européennes ont été affectées à chacun des ruchers dans un ordre aléatoire. Dans chaque rucher, 5 colonies de chaque type géographique, prises dans un ordre aléatoire, ont reçu soit un litre de sirop de sucre à 50% (vol/vol) par ruche 2 fois par semaine, soit 3 l de sirop par ruche 2 fois par semaine. Le nourrissement a commencé le 6 juin 1983 et s'est terminé le 28 octobre 1983, début de la miellée. Nous n'avons pas utilisé de témoins non nourris, car ceux-ci seraient morts ou auraient déserté pendant la saison des pluies. Avant le 6 juin, toutes les colonies avaient reçu 1 l de sirop 2 fois par semaine. Les colonies ont été pesées tous les 15 j de juin à décembre 1983. Les hausses de miel ont été ôtées lorsqu'elles étaient aux 3/4 pleines et remplacées par des hausses avec des feuilles de cire gaufrée. Il y avait ainsi toujours de la place disponible pour la maturation du nectar et le stockage du miel. Le matériel ajouté ou prélevé dans les colonies a été pris en compte dans le calcul du poids des colonies.

Une interaction significative au niveau des gains de poids a été trouvée en fonction du rucher, du type géographique et de la quantité de nourrissement. Dans le rucher ayant les gains de poids les plus élevés, les colonies européennes ont pris significativement plus de poids que les africanisées. Dans le second rucher, qui avait des conditions de miellée moins favorables, des différences non significatives dans le poids des colonies ont été observées entre les 2 types géographiques. Des différences significatives dans les gains de poids ont été trouvées entre les colonies qui avaient reçu 1 l de sirop et celles qui en avaient reçu 3 l, 2 fois par semaine pendant la saison intermédiaire; les premières ont pris plus de poids. Mais la différence a disparu pendant la saison sèche. La différence obtenue entre les 2 types de nourrissement était vraisemblablement due à un surnourrissement. Les abeilles des colonies qui avaient reçu 3 l de sirop, bien que disposant de plus d'espace de stockage, ont régulièrement utilisé la zone du nid à couvain pour le stockage et la maturation du nectar. L'espace disponible pour la ponte était ainsi fortement réduit, ce qui affectait ensuite le développement de la colonie et donc son poids.

abeille africanisée / abeille européenne / nourrissement / production de miel / Vénézuéla

Zusammenfassung — Honigproduktion in Venezuela: Der Effekt von Zuckerfütterung auf die Gewichtszunahmen von afrikanisierten und europäischen Bienenvölkern. In Venezuela wurde der Einfluß unterschiedlicher Zuckerfütterung vor der Nektartracht auf die Honigproduktion

afrikanisierter und europäischer Bienenvölker untersucht. Es wurden zwei Bienenstände zu je 20 Völkern in zwei Kilometer Entfernung errichtet. Auf jedem Stand wurden in zufälliger Anordnung 10 afrikanisierte und 10 europäische Völker aufgestellt und in zufälliger Anordnung einer der beiden Fütterungsarten unterzogen. Auf jedem Stand erhielten fünf Völker jeder geographischen Type zweimal wöchentlich einen Liter 50% (1:1) Zuckersyrup. Die anderen erhielten zweimal wöchentlich je drei Liter Sirup.

Mit der Fütterung wurde am 6 Juni 1983 begonnen und sie wurde am 28.Oktober 1983 mit Beginn der Tracht beendet. Nichtgefütterte Kontrollen wurden nicht benutzt, da diese während der Regenzeit abgestorben oder ausgezogen wären. Vor dem 6.Juni erhielten alle Völker zweimal wöchentlich einen Liter Sirup. Von Juni bis Ende Dezember wurden die Völker alle 15 Tage gewogen. Die Honigräume wurden abgenommen, sobald sie zu 3/4 gefüllt waren, und durch neue mit Mittelwänden ersetzt. Auf diese Weise war immer genügend Raum zum Reifen und zur Einlagerung des Honigs vorhanden. Entnommene oder hinzugefügte Waben bzw. Honigräume wurden in das Gewicht eingerechnet.

Für die Gewichtsdaten wurden signifikante Wechselwirkungen zwischen Bienenstand, geographischem Typ und Zuckermenge gefunden. Auf dem Stand mit den größten Gewichtszunahmen zeigten die europäischen Völker signifikant höhere Zunahmen. Unter den weniger günstigen Trachtbedingungen des zweiten Standes wurden nur nichtsignifikante Unterschiede in den Gewichtszunahmen festgestellt.

Zwischen Völkern, denen zweimal wöchentlich ein oder drei Liter Zuckersirup in der Zwischensaison gefüttert worden waren, wurden signifikante Unterschiede gefunden. Die Fütterung von einem Liter Zuckersirup zweimal wöchentlich führte zu höheren Gewichtszunahmen. Während der Trockenzeit verschwand jedoch dieser Unterschied. Die Unterschiede zwischen den Behandlungen mit einem und mit drei Litern waren vermutlich durch Überfütterung verursacht. Völker, denen drei Liter gefüttert wurden, benutzten regelmäßig die Brutflächen zur Ablagerung des Honigs, obwohl ihnen genügend Speicherrraum zur Verfügung stand; auf diese Weise wurde die verfügbare Fläche zur Eiablage verringert und darunter litten sowohl Volksentwicklung wie Gewichtszunahmen.

Afrikanisierte Biene / Zuckerfütterung / Gewichtszunahme / Venezuela / Europäische Biene / Honigproduktion

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