EFFECTS OF BRAZILIAN CLIMATIC CONDITIONS UPON THE AGGRESSIVENESS OF AFRICANIZED COLONIES OF HONEYBEES

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SUMMARY

The present research is related to a study of the effect of climatic conditions upon the aggressiveness of Africanized bees in two different regions of Brazil, Recife in the Northeast and Ribeirão Preto in the Southeast. The study was based on a program of successive queen transfers and on aggressiveness tests, carried out after each queen transfer. Five behavioral and two climate variables were studied, as well as the weight of the hive as a control on population size. This research was carried out from August 1975 to March 1977. The following main results and conclusions were reached :

a) The Africanized colonies (controls) in the Recife region were much more aggressive (three to fourteen times as much) than the Africanized bees (controls) in the Ribeirão Preto region.

b) The group of colonies derived from transferred queens (SP-queens and PE-queens) which were tested in both climatic regions, responded differently each time they were reconstituted after queen transfer from one region to the other. Thus, the pool of genes representative of the Africanized bees from each of the two Brazilian regions were submited to the climatic conditions of Ribeirão Preto and Recife throughout the whole experiment. The small differences observed between the averages of PE and SP colonies tested in both regions for the five behavioral characteristics were not statistically significant. The main responsibility for the different behavioral responses recorded in Ribeirão Preto and in Recife was atributed to climatic conditions.

c) Africanized colonies descended from both SP and PE queens showed the same aggressive response when tested in Ribeirão Preto ; likewise in Recife. The bees derived

from SP and PE transferred queens were much more aggressive in Recife than in Ribeirão Preto.

d) In general, supposing that the Africanized bees from each region studied are hybrids which are being selected in nature by the climatic conditions of each region, the results indicate that natural selection for aggressiveness was surprisingly almost the same for bees from both regions. The main responsibility for the different aggressive response of Africanized bees in Ribeirão Preto and in Recife is attributed to immediate effects of climatic conditions.

e) The temperature in Recife is at least 5°C higher than in Ribeirão Preto and much more stable. In Recife there is practically no winter season. The relative humidity in Recife is higher than in Ribeirão Preto and more stable. The precipitation in Ribeirão Preto is higher than in Recife and better distributed through the year.

f) There was a significant correlation among all the 5 variables related to aggressive behavior, which confirms the results of Stort (1971).

g) The temperature at the moment of the aggressiveness test had influence on the aggressive behavior of the Ribeirao Preto bees (positive correlation) and on the Recife bees (negative correlation). These results were different from those obtained by Stort (1971).

h) According to correlation analysis with total data, relative humidity has a significant influence on the aggressive behavior of bees. The analysis of data collected in Ribeirão Preto only, showed no significant correlation. The data collected in Recife showed a positive correlation between humidity and «Number of stings in the leather ball». Relative humidity in Recife is higher than in Ribeirão Preto and, considering that the Recife bees are much more aggressive (three to fourteen times as much) than the Ribeirão Preto ones, it can be concluded that humidity plays an important role as an external factor on the aggressive behavior of the bees.

RESUMEN

Efecto de las condiciones climáticas de Brasil sobre la agresividad de colonias de abejas africanizadas

El trabajo fué desarrollado en Ribeirão Preto-SP y Recife-PE, en Brasil, con la finalidad de comprobarse la influencia del clima en el comportamiento hostil de las abejas africanas. Fueron utilizadas 40 colmenas en cada lugar, siendo ellas pobladas con abejas africanizadas, obtenidas en las regiones de estudio (muestra SP y PE). Todas las colmenas tuvieron su hostilidad, esto es, comportamiento de defensa, probados según la prueba desarrollada por Stort (1974) y los resultados iniciales muestran que las abejas de Recife son cuatro veces más hostiles que las de Ribeirão Preto.

Después, fue ejecutado un plano de transposición de reinas de Recife para Ribeirão Preto y en sentido contrario, siendo luego las colmenas medidas nuevamente, después de

60 días. Este fué el tiempo necesario para que las obreras fueran substituidas por obreras hijas de las reinas transportadas. Los resultado mostraron que las abejas de ambas colmenas al ser trasladadas para Recife, eran mas hostiles, mientras que en Ribeirão Preto la hostilidad disminuyó.

El análisis de los resultados de hostilidad (defensa) muestra que la diferencia inicial de hostilidad entre las abejas fué debido a la diferente influencia del ambiente de las regiones de Recife y Ribeirão Preto, y no la diferencia entre las proprias abejas. Se notó también, que la diferencia de comportamiento hostil inicial se reduce con la permanencia de las abejas SP e PE en un mismo lugar.

El estudio de alguna relación entre los datos climatológicos y ambientales, muestra una relación positiva entre la humedad relativa y la hostilidad de la abeja, y relación negativa entre la variación de la temperatura y el comportamiento hostil.

De acuerdo a otros trabajos, es probable que la influencia de la humedad relativa no sea directa, y si, por intermedio de variaciones en el potencial electrostatico de la colmena.

Otros factores climatológicos como la temperatura, el estado general del tiempo y la lluvia, presentan relación con la hostilidad. Lo mismo sucede con el peso de las colmenas, aunque este factor se tenga relacionado negativamente con la lluvia, lo que puede ser de posible interés para el estudio de la biologia de la abeja africanizada.

También se observó, que al compararse los resultados obtenidos por Stort (1974) en 1965, con nuestros resultados en 1976, hubo una disminución en la hostilidad de las abejas africanizadas de la region de Ribeirão Preto, SP.

INTRODUCTION

Over the last ten years, increased attention has been focused on the problem of bee aggressiveness related to the introduction of African bee (*Apis mellifera adansonii*) into Brazil and their possible future spreading throughout the Americas. African bees were introduced into Brazil in 1956 in an attempt to increase honey production. Unfortunately, however, in 1957, 26 queens, mated in Africa, escaped with swarms from an experimental apiary near Rio Claro, SP. (Kerr, 1967). The drones from these swarms and the new queens mated with the European subspecies present in the surrounding areas with the resulting formation of hybrids. These hybrids are correctly called «Africanized bees» because they are not native and because they sometimes resemble *Apis mellifera adansonii* in several behavior characteristics, especially aggressiveness.

The spread of Africanized bees from 1956 to 1977 has been relatively rapid. The extent of the occupied area was described by Kerr (1968), Gonçalves (1974), Michener (1975) and Taylor (1977). According to

Taylor (1977), Africanized bees were found in Guyana and Venezuela in 1976. Several morphological and behavioral characteristics must be studied in order to recognize an Africanized colony of bees but unfortunately attention has been focused only on aggressiveness. This procedure has been causing much misinterpretation in the identification of these bees.

It must be remembered that the behavior of any strain of honeybees, as for instance aggressiveness (considered as a phenotype), is the product of interaction between the genetic composition of the individuals (genotype) and environmental factors. In many cases it is difficult to decide which of these components (genotype and environment) is the more important. Genetic analysis of behavior is only possible when there is homogeneity in the population which is being studied. This is only obtained through mating control, for instance with the use of artificial insemination, and with inbred lines.

The first evidence indicating genetic control of aggressive behavior of honeybees was that of Rothenbuhler (1960 ; 1964) who analyzed two inbred lines of honeybees (Van Scoy and Brown Lines) which were different in temperament. He showed that the difference in stinging behavior between the two lines was controlled by more than two loci. The differences in temperament between Italian and Africanized bees have been studied in detail by Stort since 1970, using methods to measure the aggressiveness of bees (Stort, 1970, 1971, and Gonçalves & Stort, 1977). Stort carried out several aggressiveness tests with Africanized and Italian parental colonies of bees, F_1-hybrids, as well as Africanized and Italian backcross colonies ; he concluded that eight is the number of genes involved in the aggressive behavior (Stort, 1971 ; Gonçalves & Stort, 1977). However, it is important to mention that the same genotypes can produce completely different behavior because of environmental influences. Many behavioral patterns in honeybees are caused primarily by external stimuli such as temperature, light, chemical products, humidity, etc., which are detected by a network of specialized sensory cells. The same genotype submitted to different environmental conditions such as different climates can produce completely opposite responses.

In honeybees, aggressiveness is caused primarily by internal factors (eight genes, according to Stort) but it is well known that this behavior is influenced also by external factors such as smoke, chemicals, smell, touch, sounds, etc. The genes for aggressive behavior interact with environmental factors to produce the final behavioral phenotype. Schua (1952) concluded that the aggressiveness of colonies increases with external temperature, a fact confirmed by Rothenbuhler (1974). However, Stort (1971), while working on the aggressiveness of Italian and Africanized backcrosses, not under the direct

incidence of the sun rays, did not confirm the influence of temperature, at least under the climatic conditions of Ribeirão Preto, São Paulo, Brazil. According to Lecomte (1963), the influence of wind and stormy weather on the aggressiveness of bees is important but the influence of temperature is less certain. Warnke (1976) reported that changes in weather and clouds produce local changes of electric charge on individual bees and in the colony, and this fact influences aggressive behavior. Other external factors, such as nectar flow, also influence honeybees aggressiveness (Lecomte, 1963 ; De Santis & Cornejo, 1968). This report describes a study on the effects of Brazilian climatic conditions upon the aggressiveness of Africanized colonies of honeybees. The research was planned and carried out with the financial support of the United States Department of Agriculture and with a cooperative agreement between the USDA and the Departamento de Genética da Faculdade de Medicina de Ribeirão Preto, University of São Paulo.

Two sites for the aggressiveness tests were : the Southeast Experiment Station in Ribeirão Preto, São Paulo State, with an apiary located about 5 km from the Department of Genetics, and the Northeast Experimental Station, located in Recife, Pernambuco State, about 2500 km north of Ribeirão Preto, with the apiary located near the Tapacurá flood-gate, about 37 km from the Departamento de Zootecnia da Universidade Federal Rural de Pernambuco. The climatic conditions of both regions are given in Table III and Figures 5 and 6, and will be discussed later.

MATERIAL AND METHODS

Forty Langstroth hives were located in Ribeirão Preto and populated with honeybees collected in this region, and 40 were located in Recife and populated with Africanized bees from that region. Thus, each lot had bees with a gene pool representing the typical genotype of the region. Each hive was painted and numbered. The open mated queens were marked with colored plastic numbers, white for the queens from Ribeirão Preto (SP_1 to SP_{40}), and green for the queens from Recife (PE_1 to PE_{40}). Colonies in each apiary were housed two meters apart. In order to study the effect of the climatic conditions of each region upon the aggressiveness of the Africanized honeybees, the colonies were submitted to aggressiveness tests in order to select colonies whose queens should be transferred from one station to the other simultaneously. A group of 10 colonies was left in each apiary as control. The aggressiveness tests were done according to Stort's method (Stort, 1970, 1971), which consists basically of the following : small black leather ball stuffed with cotton, about three centimeters in diameter, is jerked up and down for 60 seconds at a distance of five centimeters from the entrance of the hive. After this time the observer leaves the place. In order to avoid disturbing the colonies being

tested, the hives were transported two at a time the night before the test, to a place about two km from the apiary by a roadside where the observer could walk at least two km, in order to record the distance of persecution by the bees. The following data were recorder :

- Time until the first sting to the leather ball.
- Time for the colony to become aggressive.
- Distance that the bees follow the observer.
- Number of stings in the leather ball.
- Number of stings in the gloves of the observer.
- Weight of each colony on the day of the test.
- Temperature at the moment of the test.
- Relative humidity of the region.

The aggressiveness test was repeated five times on each hive at 20 minute intervals, using a fresh leather ball each time. All the tests (four series) were done by the same observer (Brandeburgo), in both regions and at the same period of time. It took about 45 days to carry out each series of aggressiveness tests for all the hives of both stations. The first series of aggressiveness tests was made in August 1975 for the 40 colonies of each station. After the tests, the queens of 30 colonies from Ribeirão Preto were transferred to Recife and the queens of 30 colonies from Recife were brought to Ribeirão Preto. Ten colonies were left in each station as controls. The queens were transported by airplane in small cages with 8 to 10 workers. After the transfer, the queens were immediately introduced into the hives with the 2nd series of aggressiveness tests being carried out only 70 days later, and so on. This procedure is due the fact that the life span of the workers averages 45 days ; thus, all the bees found in the colonies would be offspring of the transported queen. The four series of tests were carried out at both stations (August-September 1975 ; February-March 1976 ; July-August 1976 ; January 1977). About 20 % of the queens were lost during each trip, either during transportation or at the time of their introduction into the hives. The lost queens were replaced with other queens and the same procedure repeated. After 70 days the offspring of the new queens was tested, and so on.

After the first queen transfer, 20 to 25 queens were brought back to their original station after the aggressiveness tests. The remaining 5 to 10 queens stayed at the new site. This meant that few Africanized colonies from the region of Ribeirão Preto stayed in Recife up to the end of the experiment, and vice versa. With this program of queen transfers, it was possible to submit the same genotype at two different seasons of the year to different environmental conditions, such as different temperature, humidity, precipitation, flora, etc. The influence of some of these external factors on the aggressive behavior of Africanized bees (phenotype) was studied.

To analyse the data collected in both regions on offspring of the transferred queens and the controls, we calculated the average of the five repetitions in each series of tests for each variable and for each colony. Finally, the averages of the behavioral characteristics of the Africanized bees of each region were estimated. The controls were analyzed

independently of the offspring of transferred queens. The averages of the Ribeirão Preto colonies were compared with the averages of the Recife colonies, for each variable studied (1st series of aggressiveness tests). After the first transfer, the data for both the transferred lots and the controls were compared. For instance, a comparison was made of the averages for the bees from Ribeirão Preto tested in Ribeirão Preto and later tested in Recife. These averages were compared also with the controls of both regions. The same was done with the bees from Recife which were brought to Ribeirão Preto. The same procedure was followed in the other transfers. When the four series of aggressiveness tests were finished all the data were submitted to an IBM program in which variance analysis, student t-tests, correlation analysis, etc., were carried out.

Data on temperature, relative humidity and precipitation for both regions were recorded during 1975 and 1976 (Table III and Figures 5 and 6) to help in the interpretation of the results. These data were supplied by meteorological stations and do not correspond to the exact moment when the aggressiveness tests were carried out. The observer also recorded the temperature at the moment of the test and the weights of the colonies on the day of the test as control of population size.

RESULTS

Behavioral characteristics (Aggressiveness)

Tables I and II show the results of aggressiveness tests done on colonies of Africanized bees in Ribeirão Preto, São Paulo State and in Recife, Pernambuco State. A total of 213 colonies were tested, of which 152 had transferred queens and 61 had untransferred queens (control). They were tested five times in each series of tests, corresponding to a total of 1065 aggressiveness tests carried out at both experimental stations. Table I shows the general results of the tests and Table II shows the statistical analysis.

Table I shows the results for two groups, the first consisting of offspring (workers) of transferred SP and PE queens, and the second representing the control (non-transferred queens). The result for the first group clearly shows the oscillation each time the queens were transferred from one region to the other, independently of the season of the year (see Fig. 1, 2 and 3). In general the data for the five behavioral characteristics showed an increase in aggressiveness when the queens were transferred to Recife and decrease in aggressiveness when they were transferred to Ribeirão Preto. The colonies were tested after the first queen transfer, but after this series of tests (Feb/76 in Recife, March-April in Ribeirão Preto) six queens from each lot were not transferred as would have normally been the case. Four to six months later these colonies were tested again in the same place (results in parentheses) and

Table I – Results of four series of aggressiveness tests carried out from August 1975 to January 1977 on colonies of Africanized bees descending from transferred and non-transferred (control) queens from Ribeirão Preto (SP-queens) and Recife (PE-queens). Data for behavorial characteristics, hive weight and relative humidity on the day of the test and temperature at the moment of the test.

Tabla I – Resultados de cuatro tests de agresividad llevados a cabo desde Agosto 1975 hasta Enero 1977 en colonias de abejas africanizadas descendientes de reinas transferidas y no transferidas (control) de Ribeirão Preto (reinas-SP) y Recife (reinas-PE). Datos de características conductales, peso de la colmena y humedad relativa en el día del test y temperatura en el momento del test.

QUEENS	SERIES OF QUEENS	NUMBER OF COLONIES	SITE OF TEST	DATE	BEHAVIORAL CHARACTERISTICS (AVERAGES) Nº 1 in sec.	Nº 2 in sec.	Nº 3 in meters.	Nº 4 in units/min.	Nº 5 units/min.	HIVE WEIGHT KG (AVERAGES)	TEMP (ºC) DURING TESTS (AVERAGES)	RELATIVE HUMIDITY % (AVERAGES)
TRANSFERRED	SP-QUEENS											
	1st Series	30	Ribeirão Preto	Sept/75	41.4	47.8	192.1	11.3	24.6	24.1	28.2	47.6
	2nd Series	26	Recife	Feb/76	33.6	44.3	171.4	17.6	24.2	26.9	28.3	61.7
	3rd Series	13(6)	Recife	Aug/76	(24.2)	(31.8)	(255.8)	(16.4)	(59.9)	(31.5)	(25.7)	(67.2)
	3rd Series	7	Ribeirão Preto	July/76	56.6	59.6	18.0	0.2	0.6	25.7	24.5	54.7
	4th Series	6	Recife	Jan/77	26.9	29.5	267.1	23.5	118.2	34.2	32.2	-
		Total 75										
	PE-QUEENS											
	1st Series	30	Recife	Aug/75	8.1	20.8	586.9	56.6	350.1	23.1	25.2	69.2
	2nd Series	27	Ribeirão Preto	March-Apr/76	37.7	45.6	112.5	12.3	14.3	21.4	27.2	64.7
	3rd Series	15(6)	Ribeirão Preto	July/76	(51.3)	(58.8)	(2.3)	(1.7)	(0)	(27.0)	(24.2)	(50.1)
	3rd Series	9	Recife	Aug/76	34.3	39.9	163.8	18.9	16.0	33.0	26.0	59.5
	4th Series	5	Ribeirão Preto	Jan/77	44.0	53.8	44.4	4.6	1.9	30.0	25.9	73.1
		Total 77										
CONTROL	SP/PE-QUEENS											
	1st Series (SP)	10	Ribeirão Preto	Sept/75	35.9	44.0	264.5	13.2	21.0	23.6	30.0	50.6
	1st Series (PE)	10	Recife	Sept/75	8.0	23.1	541.1	41.7	166.3	21.4	25.0	67.9
	2nd Series (SP)	7	Ribeirão Preto	March-Apr/76	45.1	46.4	84.3	16.1	7.3	20.4	28.2	47.9
	2nd Series (PE)	7	Recife	Feb/76	20.5	33.6	265.7	34.0	75.0	25.8	26.7	69.3
	3rd Series (SP)	7	Ribeirão Preto	July/77	50.6	53.8	71.4	2.7	4.1	27.3	24.8	42.7
	3rd Series (PE)	7	Recife	Aug/76	25.7	37.1	208.7	18.9	22.0	34.1	26.0	66.6
	4th Series (SP)	7	Ribeirão Preto	Jan/77	42.0	56.6	49.8	6.2	2.2	30.4	27.8	60.4
	4th Series (PE)	6	Recife	Jan/77	13.1	15.5	407.6	48.3	218.5	34.5	31.6	-
		Total 61										

Behavioral characters (aggressiveness)

1 – Time until the first sting to the leather ball
2 – Time for the colony to become aggressive
3 – Distance that the bees follow the observer
4 – Number of stings in the leather ball
5 – Number of stings in the gloves of the observer

OBS. – In the 3rd series of tests the numbers in parentheses correspond to the colonies whose queens stayed at the site after the first transfer and after 2nd series of aggressiveness tests.

Caracteristicas conductuales (agresividad)

1 – Tiempo transcurrido hasta antes de la primera picadura en la pelota de cuero
2 – Tiempo necesario para que la colonia sea agresiva
3 – Distancia que las abejas siguen al observador
4 – Numero de aguijones en la pelota de cuero
5 – Numero de aguijones en los guantes del observador

OBS. – En la 3ra serie de tests los numeros en parentesis corresponden a las colonias cuyas reinas permanecieron en su sitio después de la primera transferencia y después de la 2da serie de tests de agresividad.

the results showed that the colonies tested in Recife in August/76 had become more aggressive than the colonies tested in February/76. For example, for characteristic 1 (Fig. 1) «Time until the first sting to the leather ball», the average was 33.6 seconds in February/76 and 24.2 seconds in August/76, a time reduction representing an increase in aggressiveness. The same kind of response was observed for the other behavorial characteristics (Fig. 1 à 3).

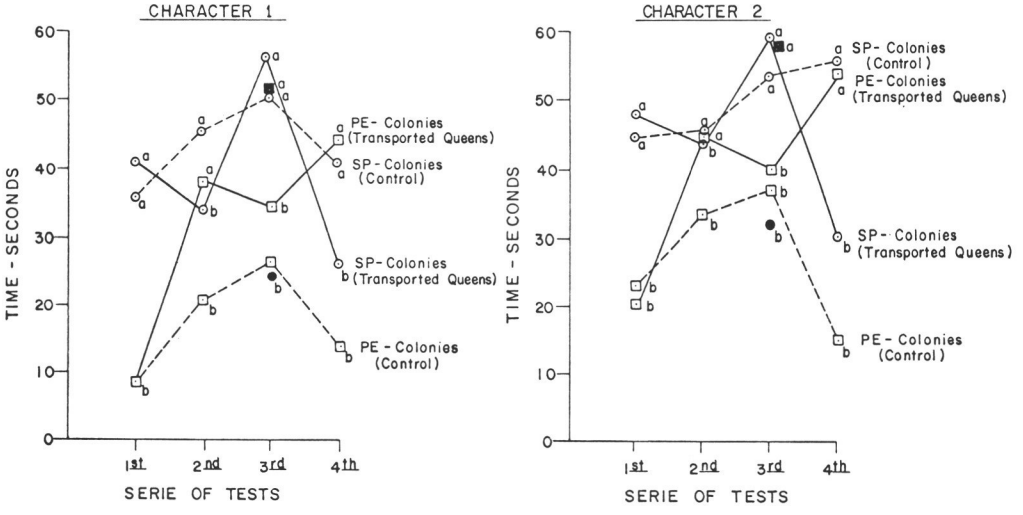

Fig. 1 – Results of aggressiveness tests carried out on Africanized bees descending from transferred and non-transferred (control) SP and PE queens. These graphs show the oscillation of response presented by the descendents of transferred queens after each queen transfer. The colonies whose queens remained at the site after the 2nd series of tests (in parenthesis in Table I) are shown in black.
Characteristic 1 =Time at which the first sting reaches the leather ball – Characteristic 2 =Time for the colony to become aggressive
Site of aggressiveness tests : a =Ribeirão Preto, SP – b =Recife, PE

Fig. 1 – Resultados de tests de agresividad llevados a cabo en abejas africanizadas descendientes de reinas SP y reinas PE transferidas y no transferidas. Estos gráficos muestran la oscilación de respuesta que presentan los descendientes de reinas transferidas después de la transferencia de cada reina. Las colonias cuyas reinas permanecieron en su lugar después de la 2da serie de tests (entre paréntesis en Tabla I) se muestran en negro.
Característica 1 =Tiempo en que el primer aguijón alcanza la pelota de cuero – Característica 2 = Tiempo que toma la colonia en llegar a ser agresiva
Lugar de los tests de agresividad : a =Ribeirão Preto, SP – b =Recife, PE

As to the PE queens, it can be seen that the colonies which were tested in Ribeirão Preto in March-April/76 became gentler in July/76. For example, see characteristic 1 in which the average increased from 37.7 seconds to 51.3 seconds. The response for the other characteristics was comparable.

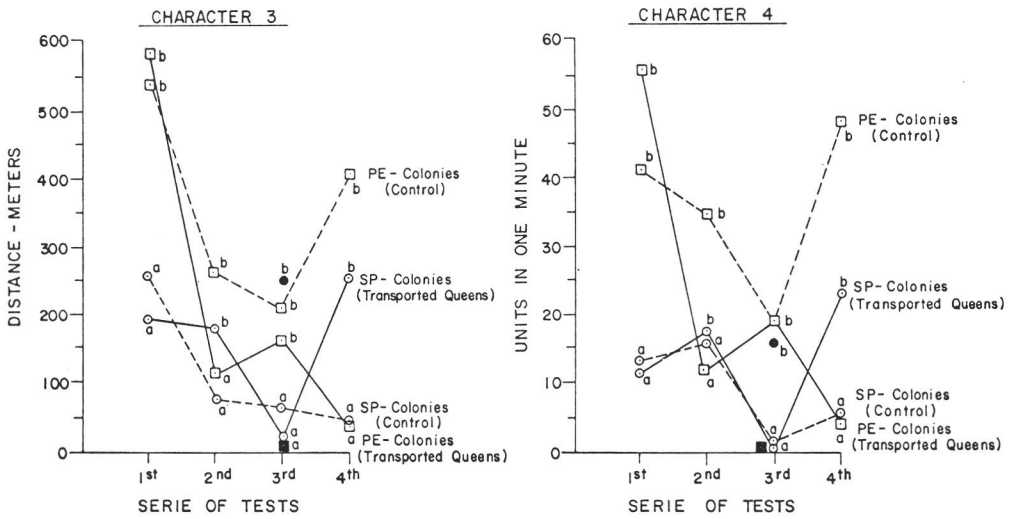

Fig. 2 – Results of aggressiveness tests carried out on Africanized bees descending from transferred and non-transferred (control) SP and PE queens. These graphs show the oscillation of response presented by the descendents of transferred queens after each queen transfer. The colonies whose queens remained at the site after the 2nd series of tests (in parentheses in Table I) are shown in black.
Characteristic 3 =Distance that the bees follow the observer – Characteristic 4 =Number of stings in the leather ball.
Site of aggressiveness tests : a =Ribeirão Preto, SP – b =Recife, PE

Fig. 2 – Resultados de tests de agresividad llevados a cabo en abejas africanizadas descendientes de reinas SP y reinas PE transferidas y no transferidas. Estos gráficos muestran la oscilación de respuesta que presentan los descendientes de reinas transferidas después de la transferencia de cada reina. Las colonias cuyas reinas permanecieron en su sitio después de la 2da serie de tests (entre paréntesis en Tabla I) se muestran en negro.
Característica 3 =Distancia que las abejas siguen al observador – Característica 4 =Número de aguijones en la pelota de cuero.
Lugar de los tests de agresividad : a =Ribeirão Preto, SP – b =Recife, PE

The second group of results in Table I (controls), is for 61 colonies with non-transferred queens only. These colonies were tested independently in each experimental station but always at the same time of the year, usually during the same month. The data for each series of five behavioral tests have been analyzed in pairs (SP and PE) in order to compare the results obtained in

Ribeirão Preto (for SP queens) and in Recife (for PE queens). The 20 pairs of data (SP and PE) for the controls always showed the same behavior, varying only in the degree of response. All of the data collected showed higher aggressiveness for the Recife Africanized bees when compared with the Africanized bees of Ribeirão Preto.

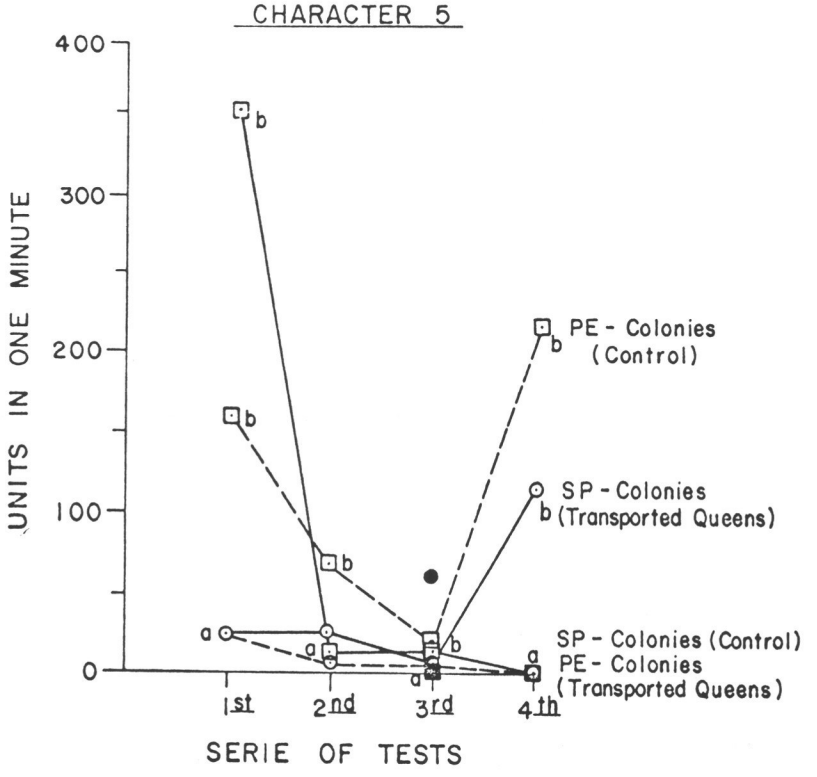

Fig. 3 – Results of aggressiveness tests carried out on Africanized bees descending from transferred and non-transferred (control) SP and PE queens. These graphs show the oscillation of response presented by the descendents of transferred queens after each queen transfer. The colonies whose queens remained at the site after the 2nd series of tests (in parentheses in Table I) are shown in black.
Characteristic 5 =Number of stings in the gloves of the observer
Site of aggressiveness tests : a =Ribeirão Preto, SP – b =Recife, PE

Fig. 3 – Resultados de tests de agresividad llevados a cabo en abejas africanizadas descendientes de reinas SP y reinas PE transferidas y no transferidas. Estos gráficos muestran la oscilación de respuesta que presentan los descendientes de reinas transferidas después de la transferencia de cada reina. Las colonias cuyas reinas permanecieron en su sitio después de la 2da serie de tests (entre paréntesis en Tabla I) se muestran en negro.
Característica 5 =Número de aguijones en los guantes del observador.
Lugar de los tests de agresividad : a =Ribeirão Preto, SP – b =Recife, PE

To focus on the results obtained in both regions and to make statistical comparisons, Table II was prepared from data in Table I. The results are presented in four groups according to the kind of comparisons made. The results of the t-tests are included in Table II and represented schematicaly in figure 4.

Groups 1 and 2 in Table II compare only data for transferred queens ; Group 3 compares only data for non-transferred queens (controls), and Group 4 compares the whole series of tests done in Ribeirão Preto with the whole series of tests done in Recife.

In Group 1 (transferred queens only) the aggressive behavior data for 75 SP-queens colonies obtained in Ribeirão Preto and in Recife were compared with the data for 77 PE-queens colonies also tested in both regions. This means that the pools of genes representative of the Africanized bees from each of the two regions were submitted to the climatic conditions of Ribeirão Preto and Recife during the whole experiment. Thus, in this group the average of the aggressive response for each characteristic analized represents the phenotype response of the Africanized bees from both Brazilian regions to the same climatic condition. As can be seen in Table I, first group, the bees responded differently each time they were moved from one region to the other. However, looking at Table II and Figure 4, it can be seen that the small differences observed between the averages of PE and SP colonies tested in both regions are not statistically significant. As an example, for characteristic number 2, «Time for the colony to become aggressive», the SP-queens workers had an average of 42.60 seconds and the PE-queens workers had an average of 43.78 seconds ($t = 0.14$ N.S.).

Thus, supposing that the Africanized bees from each region studied are hybrids which are being selected in nature for better adaptation to the climatic conditions of each region, the result for the first group in Table I and for group 1 in Table II lead us to postulate that natural selection for aggressiveness was surprisingly almost the same for both regions. We suppose also that the environmental conditions, especially the climatic conditions of each region (Ribeirão Preto and Recife), were mainly responsible for the different behavioral response recorded in Ribeirão Preto and in Recife, and for the similarity in behavioral responses when the «SP» and «PE» populations were submitted to the same environment of both regions.

In group 2 of Table II and Figure 4, which includes also transferred queens, the comparison was based on the site of the aggressiveness tests and the SP and PE colonies were included together in two lots. The data for 75 SP + PE colonies tested in Ribeirão Preto were compared with 77 SP + PE colonies tested in Recife, and the results showed different phenotypic (Aggressiveness) responses for characteristics 1, 2, 3 and 4. The apparent

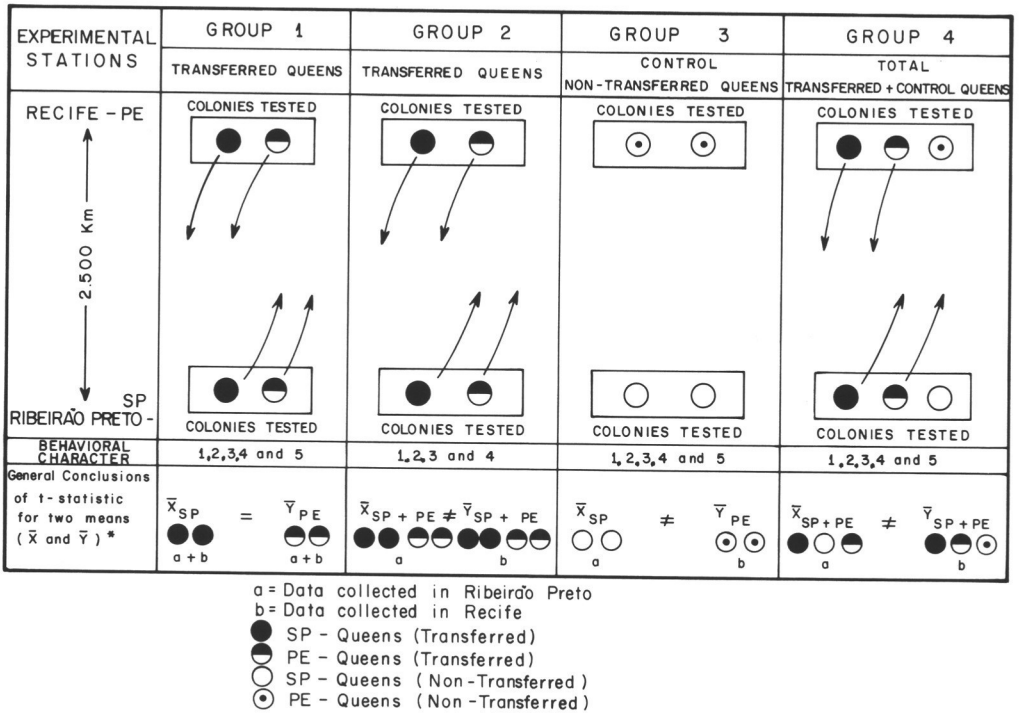

Fig. 4 – Schematic representation of four Groups of comparisons of data for aggressiveness tests on Africanized bees (see Table II) – Group 1 : Compares results for SP colonies (X_{SP}) tested in both regions (a + b) with results of PE-colonies (Y_{PE}) also tested in both regions – Group 2 : Compares results of SP + PE colonies tested in Ribeirão Preto : with results of SP + PE colonies tested in Recife – Group 3 : Compares results of the control colonies tested in their original places – Group 4 : Compares results of all colonies tested in Ribeirão Preto (transferred + control) with the results of all colonies tested in Recife (transferred + control).

Fig. 4 – Representación esquemática de cuatro grupos de comparaciones de datos para tests de agresividad en abejas africanizadas (ver Tabla II) – Groupo 1 : Compara resultados de colonias SP (X_{SP}) probadas en ambas regiones (a + b) con resultados de colonias PE (Y_{PE}) también probadas en ambas regiones – Grupo 2 : Compara resultados de colonias SP + PE probadas en Ribeirão Preto con resultados de colonias SP + PE probadas en Recife – Grupo 3 : Compara resultados de colonias control probadas en sus lugares de origen – Grupo 4 : Compara resultados de todas las colonias probadas en Ribeirão Preto (transferidas + control) con resultados de todas las colonias probadas en Recife (transferidas + control).

differences between the averages obtained for characteristic 5, «Number of stings in the gloves of the observer», were not statistically significant ($t = -1.70$). The results for group 2 show that the Africanized bees from both SP and PE transferred queens were much more aggressive in Recife than in Ribeirão Preto.

Table II – Results of student t-tests for four groups of data on agressiveness, tests carried out on colonies of Africanized bees descending from transferred (Groups 1 and 2), non-transferred queens (Control, Group 3) from Ribeirão Preto (SP-queens) and Recife (PE-queens), and total data (Group 4). Data for behavioral characteristics, hive weight on the day of the test and temperature at the moment of the test. NS = not significant – * = t-student statistically significant at a level of 5 %.

Tabla II – Resultados de tests-t de Student para cuatro grupos de comparaciones de datos sobre agresividad, llevados a cabo en colonias de abejas africanizadas descendientes de reinas transferidas (grupos 1 y 2), reinas non transferidas (grupo 3, control) de Ribeirão Preto (reinas-SP) y Recife (reinas-PE) y datos totales (grupo 4). Datos de características conductuales, peso de la colmena en el dia del test y temperatura en el momento del test. NS = significativo – * = test-t de Student estadisticamente significativos a nivel del 5 %.

GROUPS	QUEENS	Queens	Site of tests	Number of colonies	Date	Behavioral Characteristics (Averages) Nº 1 in sec.	Nº 2 in sec.	Nº 3 in meters	Nº 4 units/min.	Nº 5 units/min.	Hive weight kg Averages	Temp. °C during tests Averages
1	TRANSFERRED	SP	Ribeirão Preto and Recife	75	Sept-75/Jan-77	36.54	42.60	180.88	13.80	45.50	28.48	27.78
		PE	Recife and Ribeirão Preto	77	Aug-75/Jan-77	35.08	43.78	181.98	18.82	76.46	26.90	25.70
						t=0.16 (NS)	t=-0.14 (NS)	t=-0.01 (NS)	t=-0.47 (NS)	t=-0.43 (NS)	t=0.55 (NS)	t=1.47 (NS)
2		SP+PE	Ribeirão Preto	75	Sept-75/Jan-77	46.20	53.12	73.86	6.02	8.28	25.64	26.00
		SP+PE	Recife	77	Aug-75/Jan-77	25.42	33.26	289.00	26.60	113.68	29.74	27.48
						t=3.55*	t=3.98*	t=-2.53*	t=-2.58*	t=-1.70 (NS)	t=-1.63 (NS)	t=-0.98 (NS)
3	CONTROL	SP	Ribeirão Preto	31	Sept-75/Jan-77	43.40	50.20	117.50	9.53	8.65	25.43	27.70
		PE	Recife	30	Sept-75/Jan-77	16.83	27.33	355.78	35.73	120.45	28.95	27.55
						t=5.34*	t= 3.97*	t=-2.66*	t=-3.72*	t=-2.52*	t=-0.91 (NS)	t=0.09 (NS)
4	TOTAL	SP+PE	Ribeirão Preto	106	Sept-75/Jan-77	44.96	51.82	93.26	7.59	8.44	25.54	26.76
		SP+PE	Recife	107	Aug-75/Jan-77	21.60	30.62	318.68	30.66	116.69	29.39	27.51
						t=5.81*	t=5.71*	t=-3.79*	t=-4.29*	t=-2.90*	t=-1.85 (NS)	t=-0.68 (NS)

Behavioral characteristics (aggressiveness)

1 – Time until the first sting to the leather ball
2 – Time for the colony to become aggressive
3 – Distance that the bees follow the observer
4 – Number of stings in the leather ball
5 – Number of stings in the gloves of the observer

Caracteristicas conductales (agresividad)

1 – Tiempo transcurrido hasta antes de la primera picadura en la pelota de cuero
2 – Tiempo necessario para que la colonia sea agresiva
3 – Distancia que las abejas siguen al observador
4 – Numero de aguijones en la pelota de cuero
5 – Numero de aguijones en los guantes del observador

Group 3 in Table II (see Fig. 4) consists of data for non-transferred queens, the control group. The averages for the 31 SP-colonies and 30 PE-colonies correspond to the means of the four series of tests (control) presented in Table I. The Africanized bees from each region were tested in their original environment and the results were compared. As an example, characteristic 1, «Time until the first sting to the leather ball», was 43.40 seconds in Ribeirão Preto and 16.83 seconds in Recife (t = 5.34, statistically significant at the 5 % level). For characteristic 3 «Distance that the bees follow the

observer», the Ribeirão Preto Africanized bees averaged 117.50 meters and the Recife bees averaged 355.78 meters (t = - 2.66, statistically significant at the 5 % level). For characteristic 5 «Number of stings in the gloves of the observer» the average in Recife (120.45 units in one minute) was 14 times higher than in Ribeirão Preto (8.65 units in one minute) and the difference was statistically significant at the 5 % level (t = - 2.52). The results for these control colonies show that the Recife Africanized bees were much more aggressive than the Ribeirão Preto bees.

Group 4 in Table II consists of data for 213 colonies of Africanized bees from both Brazilian regions, with 152 colonies descending from transferred queens and 61 from the controls. The data were grouped into two lots, according to the place where they were obtained. The data for 106 SP + PE colonies tested in Ribeirão Preto were compared with the data for 107 SP + PE colonies tested in Recife. By looking at the results of this group it can be said that, in general, the Africanized bees descending from SP and PE queens, whether transferred or not, when tested in Recife, were much more aggressive than when tested in Ribeirão Preto. All the t-tests were statiscally significant at the 5 % level.

The results for the four groups of comparisons presented in Table II and Figure 4 led us to the conclusion that the Africanized bees from both Brazilian regions respond identically when in the same environment (climatic conditions). We concluded that the Africanized bees are much more aggressive in Recife than in Ribeirão Preto. The Africanized bees of both regions, when transported from one region to the other, respond with higher aggressivity in the Northeast of Brazil and lower aggressivity in the Southeast of Brazil because of the different climatic condition of these regions. The aggressive behavior of the populations of Africanized bees in each region was much more influenced by external factors (climatic conditions) than by their genotypic compositions.

Considerations on the climatic conditions of Ribeirao Preto (SP) and Recife (PE)

Temperature (see Table III and Fig. 5) : the yearly average temperature in Ribeirão Preto was 20.85° C in 1975 and 20.65° C in 1976. The average maximum was 31.8°C in 1975 and 29.5°C in 1976 and the minimum average was 9.9° C in 1975 and 11.8° C in 1976. The variability rate (maximum-minimum) was 22°C in 1975 and 18°C in 1976. In Recife the yearly average temperature was 26.40° C in 1975 and 25.05° C in 1976. The average maximum was 32.7° C and 31.2° C in 1975 and 1976, respectively. The minimum

Table III – Climatic data (temperature, relative humidity and precipitation) for the regions of Ribeirão Preto (SP) and Recife (Tapacurá) (PE), where aggressiveness tests with Africanized bees were carried out. Data were collected in 1975 and 1976 by the meteorological stations* in both regions.

Tabla III – Datos climáticos (temperatura, humedad relativa y precipitación) para las regiones de Ribeirão Preto (SP) y Recife (Tapacurá) (PE), donde se realizaron los testes de agresividad con abejas africanizadas. Los datos fueron colectados en 1975 y 1976 por las estaciones meteorológicas* de ambas regiones.

Site	Year	Temperature (averages) °C			Relative humidity (averages) %			Precipitation MM		
		Max.	Min.	Mean	Max.	Min.	Mean	Total	Max. Occur.	Min. Occur.
Ribeirão Preto (SP)	1975	31.8	9.9	20.85	65.5	24.7	45.1	1,759.5	Nov.	May
Altitude : 621 meters Latitude : 21° 11' S Longitude : 47° 43, W/GR	1976	29.5	11.8	20.65	68.1	44.7	56.2	1,523.6	Febr.	April
Recife (Tapacurá) (PE)	1975	32.7	20.1	26.40	77.0	54.0	65.5	1,524.4	July	Oct.
Altitude : 120 meters Latitude : 8° 9' S Longitude : 35° 6'W/GR	1976	31.2	18.9	25.05	72.0	59.0	65.5	1,090.8	March	Sept.

OBS. Distance from Ribeirão Preto to Recife (Tapacurá) : 2.500 km

* Instituto de Pesquisas Agronômicas – Setor de climatología Agricola – Recife-PE
Secretaria da Agricultura do Estado de São Paulo – Inst. Agronômico – Secção Climatologia Agrícola

average was 20.1° C and 18.9° C in 1975 and 1976, respectively. The variability rate was 12° C in both 1975 and 1976.

These results show that the yearly average temperature is at least 5° higher in Recife, and that the temperature oscillation in Ribeirão Preto is about twice the oscillation in Recife. The honeybees suffer a higher temperature oscillation in Ribeirão Preto than in Recife where the temperature is more stable throughout the year and where there is practically no winter season.

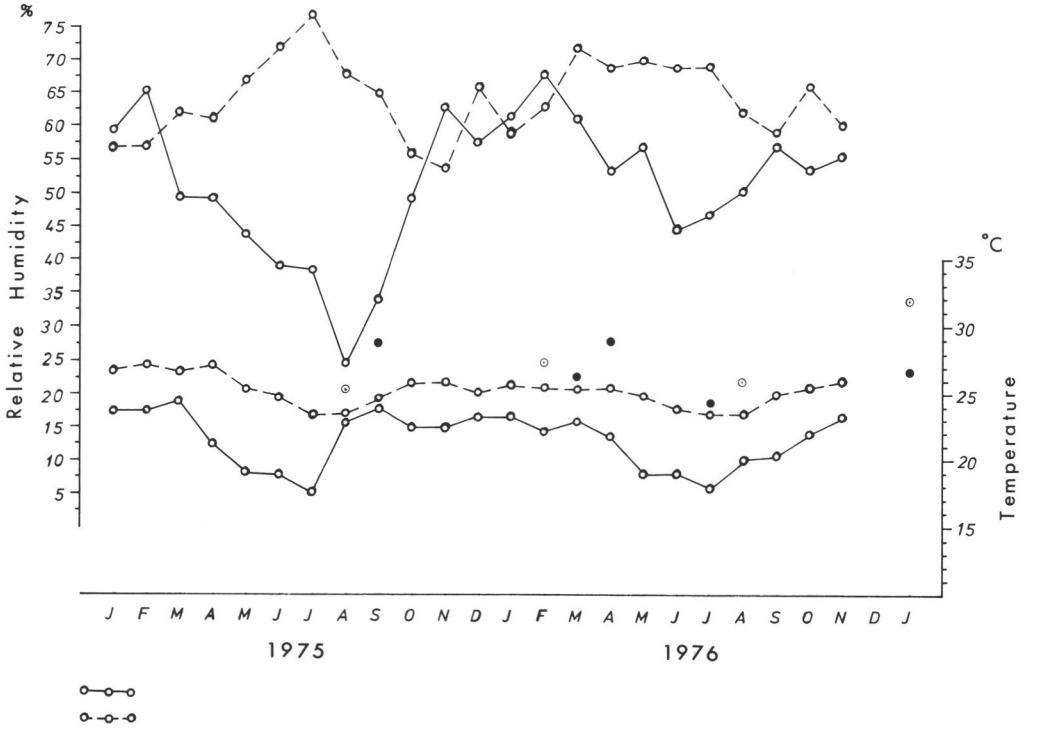

Fig. 5 – Monthly climatic date for temperature and relative humidity in Ribeirão Preto (SP) and Recife (PE) during 1975 and 1976. The average temperature at the times of the aggressiveness tests is shown by black (Ribeirão Preto) and dotted (Recife) circles.

Fig. 5 – Datos climáticos mensuales de temperatura y humedad relativa en Ribeirão Preto (SP) (líneas continuas) y Recife (PE) (líneas entrecortadas) durante 1975 y 1976. Las temperaturas medias al momento de los tests de agresividad se indican por círculos negros (Ribeirão Preto) y círculos punteados (Recife).

Tables I and II show that there was no difference between the average temperature recorded during the aggressiveness tests. However, it must be mentioned that 90 % of the tests were carried out between 2 PM and 4 PM in both experimental stations and this is the warmest period of the day. This is the reason why the mean temperatures recorded in Tables I and II are higher than the averages recorded in Table III and Figure 5, which correspond to the yearly average temperatures based on data collected daily by both regional meteorological stations.

The correlation analysis presented later was made by considering only the temperatures recorded by the experimenter at the moment of the aggressiveness test and not the data collected by the meteorological stations. Thus, it is possible that the aggressive responses showed by the bees are related not only to the influence of temperature on that particular day or at the moment of test but also by the temperature of one, two, or more days before the test. This analysis was not done and the correlation analysis of the temperature with other variables will be discussed later.

Humidity (see Table III and Fig. 5) : the relative humidity in Recife (Tapacurá) was higher than in Ribeirão Preto in both 1975 and 1976. In Ribeirão Preto the mean relative humidity in 1975 and 1976 was 45.1 % and 56.2 %, respectively, and in Recife 65.6 % in both years. However, the oscillation of the relative humidity was higher in Ribeirão Preto. The minimum in Ribeirão Preto to was 24.7 % in 1975 and 44.7 % in 1976, and in Recife 54.0 % and 59.0 % in 1975 and 1976, respectively. The Recife region has a higher and more stable relative humidity than Ribeirão Preto.

The relative humidity data for both regions were obtained by the meteorological stations and not by the experimenter at the moment of the aggressiveness tests. Thus, the data used for the correlation analysis that will be discussed later correspond to the mean of the day.

Precipitation (see Table III and Fig. 6) : in the years 1975 and 1976 the precipitation in Ribeirão Preto (1759 mm and 1523 mm) was higher than in Recife (1524 mm and 1090 mm). The rainy season in Recife is the March-August period, in Ribeirão Preto the November-March period. Figure 6 shows that the precipitation in Ribeirão Preto is better distributed throughout the year than in Recife.

In July 1975 there was excessive precipitation in Recife which caused catastrophic flood. In 1976 the rainy season was normal, but in 1977 the rainy season again caused a severe flood in Recife although less than in 1975. Despite the fact that the yearly precipitation in Recife is lower than in Ribeirão Preto, the relative humidity is higher in Recife due the fact that Recife (Tapacura) is about 120 meters above sea level and Ribeirão Preto is 621 meters above sea level.

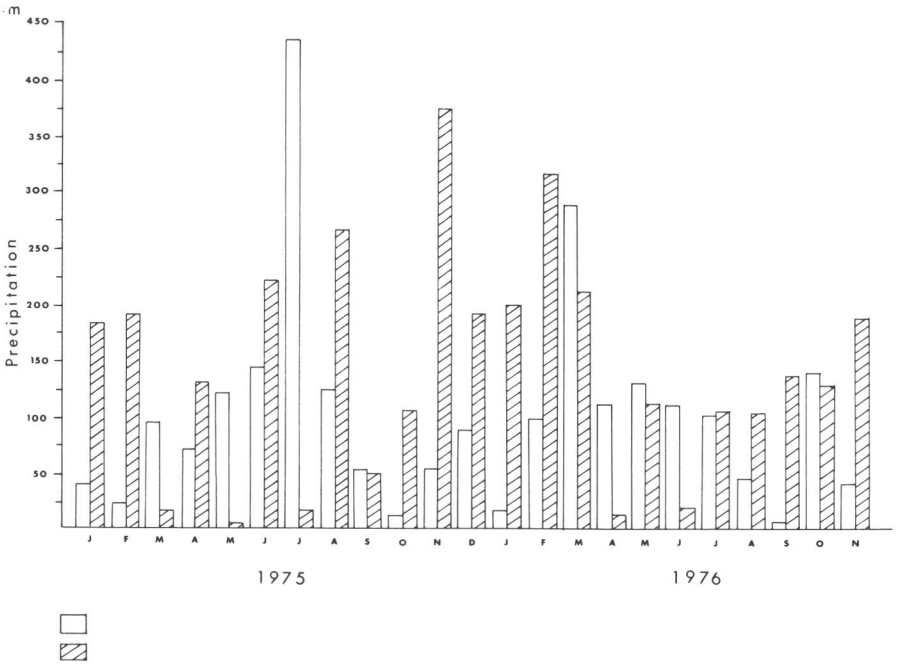

Fig. 6 – Monthy precipitation in Ribeirao Preto (SP) white and Recife (PE) (cross hatched) during 1975 and 1976.

Fig. 6 – Precipitación mensual en Ribeirão Preto (SP) (blanco) y Recife (PE) (achurado) durante 1975 y 1976.

Considerations on the weight of the colonies

In order to check the size of the honeybee population of each colony used which had only one super, bottom and cover, the colonies were weighed the day before each aggressiveness test. At the beginning of the experiment all colonies had about the same bee population and the hives had about the same weight. At the end of the experiment the averages of the SP-colonies did not differ statistically from the averages of the PE-colonies. The results are shown in Table II. The t-student tests were not statistically significant in the four groups comparisons. Mean weight of the hives in Ribeirão Preto was 25.54 kg and in Recife 29.39 kg (t = 1.85, N.S.). However this record must not be considered as representative of productivity because the hives had no honey supers, no honey flow control, and most were submitted to a constant program of queen substitution after each transfer between the two experimental stations.

Table IV – Correlation analysis (total data) between 5 behavioral characteristics (X_1, X_2, X_3, X_4 and X_8), 2 climatic variables (temperature X_5 and relative humidity X_7) and hive weight (X_6). Data for Africanized bees from Ribeirao Preto and Recife.

Tabla IV – Análisis de correlación (datos totales) entre 5 características conductuales (X_1, X_2, X_3, X_4 and X_8), 2 variables climáticas (temperatura, X_5 y humedad relativa, X_7) y peso de la colmena (X_6). Datos para abejas africanizadas de Ribeirão Preto y Recife.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1		- 0.88*	- 0.83*	- 0.50*	- 0.08 NS	- 0.01 NS	- 0.20*	0.91*
X_2			0.84*	0.70*	0.05 NS	- 0.05 NS	0.14 NS	- 0.88*
X_3				0.68*	0.01 NS	- 0.04 NS	0.20*	- 0.81*
X_4					- 0.07 NS	- 0.04 NS	0.15 NS	- 0.54*
X_5						- 0.06 NS	- 0.41*	- 0.07 NS
X_6							- 0.05 NS	0.02 NS
X_7								- 0.17*
X_8								

Variables : X_1 : Time until the first sting to the leather ball – X_2 : Distance that the bees follow the observer – X_3 : Number of stings in the leather ball – X_4 : Number of stings in the gloves of the observer – X_5 : Temperature at the moment of the test – X_6 : Weight of each colony on the day of the test – X_7 : Relative humidity in the region – X_8 : Time for the colony to become aggressive.
N =135 – * : Significant at 5 % level – r = 0.17 – NS = Not significant.

Variables : X_1 : Tiempo transcurrido hasta antes de la primera picadura en la pelota de cuero – X_2 : Distancia que las abejas siguen al observador – X_3 : Número de aguijones en la pelota de cuero – X_4 : Número de aguijones en los guantes del observador – X_5 : Temperatura al momento del test – X_6 : Peso de cada colonia en el día del test – X_7 : Humedad relativa en la región – X_8 : Tiempo necesario para que la colonia sea agresiva.
N =135 – * : Significativo a nivel del 5 % – r = 0.17 – NS = No significativo.

Correlation analysis among the five behavioral characteristics : temperature, relative humidity and weight of the hives

A Pearson product-moment correlation analysis was performed on the data collected in both experimental stations in 1975 and 1976. The analysis was carried out in two ways : with the total data (Table IV), and with the data of Ribeirão Preto and Recife processed separately (Table V). The eight variables were coded as follow :

X_1 : Time until the first sting to the leather ball.
X_2 : Distance that the bees follow the observer.
X_3 : Number of stings in the leather ball.
X_4 : Number of stings in the gloves of the observer.

X_5 : Temperature at the moment of the test.
X_6 : Weight of each colony on the day of the test.
X_7 : Relative humidity in the region.
X_8 : Time for the colony to become aggressive.

Behavorial variables (X_1, X_2, X_3, X_4 and X_8). The correlation analysis presented in Tables IV and V shows that there was a significant correlation among all the variables related to aggressive behavior, in both types of analysis, i.e. total data and data separated according to region. For instance, in Table IV the characteristic, «Time until the first sting to the leather ball», showed a negative correlation with the characteristics, «Distance that the bees follow the observer» (r = - 0.88), «Number of stings in the leather ball» (r = - 0.83), and «Number of stings in the gloves of the observer» (r = - 0.50) and a positive correlation with the «Time for the colony to become aggressive» (r = 0.91).

The same kind of relationship among the behavioral characteristics was observed separately (Table V). The only exception was for the correlation between the «Time until the first sting to the leather ball» and «Number of stings in the leather ball», but the data collected in Ribeirão Preto showed a negative correlation (r = - 0.82) which means that, the shorter the time for the first sting to occur, the higher the number of stings in the ball. However, in Recife the correlation was positive (r = 0.80), which is a curious fact without a clear explanation because, when it loses its sting the bee releases an alarm substance which attracts new bees to that site.

From the correlation analysis (Tables IV and V) we can conclude that, in general, there was good relationship among the 5 variables related to aggressive behavior, in agreement with the observations by Stort (Gonçalves and Stort, 1977).

Temperature (variable X_5). The only significant result observed in Table IV (total data) was the correlation between temperature at the moment of the tests and relative humidity on the day of the test (t = - 0.41). The other variables showed no significant correlation with temperature. The data collected in Recife and Ribeirão Preto showed other significant correlations among the variables when they were analyzed separately, as can be seen in Table V.

In Ribeirão Preto, the temperature, which is lower than in Recife (see Table III), showed a positive and significant correlation with the «Time until the first sting to the leather ball» (r = 0.27), with the «Distance that the bees follow the observer» (r = 0.33), with the «Number of stings in the leather ball» (r = 0.25), with the «Number of stings in the gloves of the

Table V – Correlation analysis between 5 behavioral characteristics (X_1, X_2, X_3, X_4 and X_8), 2 climatic variables (temperature X_5 and relative humidity X_7) and hive weight (X_6). Data for Africanized bees from Ribeirão Preto (A) and Recife (B).

Tabla V – Analisis de correlación entre 5 características conductuales (X_1, X_2, X_3, X_4 and X_8), 2 variables climáticas (temperatura, X_5 y humedad relativa, X_7) y peso de la colmena (X_6). Datos para abejas africanizadas de Ribeirão Preto (A) y Recife (B).

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	A		- 0.86*	- 0.82*	- 0.70*	- 0.27*	- 0.09 NS	- 0.01 NS	0.93*
	B		- 087*	0.80*	- 049*	0.23*	0.25*	- 0.21 NS	0.88*
X_2	A			0.74*	0.78*	0.33*	- 0.07 NS	- 0.15 NS	- 0.86*
	B			0.84*	0.72*	- 0.29*	- 0.34*	0.18 NS	- 0.86*
X_3	A				0.84*	0.25*	0.01 NS	- 0.07 NS	- 0.84*
	B				0.67*	- 0.30*	- 0.33*	0.27*	- 0.75*
X_4	A					0.30*	0.07 NS	- 0.15 NS	- 0.72*
	B					- 0.27*	- 0.25*	0.13 NS	- 0.53*
X_5	A						- 0.10 NS	- 0.48*	- 0.29*
	B						0.02 NS	- 0.27*	0.26*
X_6	A							- 0.25*	0.10 NS
	B							- 0.17 NS	0.22*
X_7	A								- 0.01 NS
	B								- 0.15 NS
X_8	A								
	B								

Variables : idem to Table IV.
A : In Ribeirão Preto, N = 61 – B : In Recife, N = 74 – * Significant at 5 % level – NS = Not significant.

Variables : idem Tabla IV.
A : En Ribeirão Preto, N = 61 – B : En Recife, N = 74 – * Significativo a nivel del 5 % – NS = No significativo.

observer» (r = 0.30), and negative correlation with the «Relative Humidity» (r = - 0.48) and with «Time for the colony to become aggressive». These results mean that, in Ribeirão Preto, the higher the temperature the higher the aggressiveness. Stort (1971) did not find a correlation between temperature and aggressive behavior in data collected in Ribeirão Preto with Italian and Africanized bees.

In Recife, where the temperature is more stable and higher than in Ribeirão Preto, the relationship between the temperature and the other variables analyzed was different where compared with the results observed in Ribeirão Preto.

The temperature was positively correlated with only two characteristics in Recife : «Time until the first sting to the leather ball» (r = 0.23) and «Time for the colony to become aggressive» (r = 0.26). For this last characteristics (X_8) the result was opposite to that in Ribeirão Preto where the correlation was negative (- 0.29). This means that in Ribeirão Preto the aggressiveness of the Africanized bees (character X_8) increases with increase of temperature and in Recife the aggressiveness diminishes with increase of temperature. The temperature presented a negative and significant correlation with the following characteristics : «Distance that the bees follow the observer» (r = - 0.29), «Number of stings in the leather ball» (r = - 0.30), and «Number of stings in the gloves of the observer» (r = -0.27). This means that in Recife the aggressivenes of the Africanized bees does not increase with the increase in temperature as observed in Ribeirão Preto.

It is interesting to note the difference in relationship between temperature and aggressive behavior in these two regions of Brazil. The results were surprising, which leads us to think that other variables must be interacting with this behavior. However, it must be remembered that, on the average, the temperature in Recife is at least 5°C higher than in Ribeirão Preto and that the yearly temperature oscillation in Recife is low compared to that observed in Ribeirão Preto. The results of the Aggressiveness tests presented in Tables I and II showed that the Africanized bees were much more aggresive in Recife than in Ribeirão Preto. The statistical tests carried out with the data for the four comparison groups presented in Table II led to the conclusion that the factors mostly responsible for the higher aggressiveness of the Recife Africanized bees were climatic and not genetic. These results confirm experimentally the hypothesis of Schua (1952), Rothenbuhler (1974), Warnke (1977) and the field observations of Gebreyesus (1976).

Relative humidity (variable X_7). The relative humidity on the day of the test showed a negative correlation with temperature at the moment of the test (r = - 0.41) (Table IV). The data for Ribeirão Preto (r = - 0.48) and Recife (r = - 0.27) (see Table V) gave the same results. The relationship between the

humidity and the other variables was not the same in both regions. It must be remembered that the relative humidity is higher in Recife (Tapacurá) than in Ribeirão Preto (see Table III and Fig. 5). Correlation analysis of total data showed positive correlation with only one characteristic, «Number of stings in the leather ball» ($r = 0.20$). There were negative correlations with the following characteristics : «Time until the first sting to the leather ball» ($r = -0.20$) and «Time for the colony to become aggressive» ($r = -0.17$). This means that the higher the relative humidity, the higher the aggressiveness of the bees. The other results were not statistically significant.

In Ribeirão Preto, the relative humidity (45.1 % in 1975 and 56.2 in 1976, Table III) had no influence on the aggressiveness of Africanized bees, according to the results for variables X_1, X_2, X_3, X_4 and X_8 presented in Table V, all of which were not statistically significant.

In Recife the relative humididy (65.5 % in 1975 and 1976, Table III) had a positive correlation with the characteristic «Number of stings in the leather ball» ($r = 0.27$). Correlations with other variables related to aggressiveness were not statistically significant.

It appears that the data for Ribeirão Preto and Recife, when analyzed separately, were not sufficient to provide a good analysis. The total data permitted a better analysis, and the results seem to agree with those of the aggressiveness tests, because the Africanized bees in Recife, where the humidity is higher, showed a much higher aggressiveness than those in Ribeirão Preto. This research is not conclusive as to the effect of temperature and humidity on the aggressive behavior of Africanized bees, but the results support the hypothesis that the aggressive behavior of Africanized bees is much influenced by relative humidity in Recife and more influenced by temperature in Ribeirão Preto.

Weight of the hives (variable X_6). The correlation analysis with the total data showed no significant relationship between this variable and the other variables sutied (Table IV).

The data collected in Ribeirão Preto showed only one significant result, the negative correlation between «Relative Humidity» and «Weight of the hive» ($r = -0.25$). In Recife there was a positive correlation between «Weight of the hive» and «Time until the first sting to the leather ball» ($r = 0.25$), and the «Time for the colony to become aggressive» ($r = 0.22$). Comparisons of the averages for the hives from Ribeirão Preto and Recife showed no significant differences (see Table II). The results for both correlation analyses (Total data and data analyzed separately) were not sufficient to give a conclusive answer about the influence of the weight of the hive on aggressive behavior ; on the other hand, the variable «Weight of the hive»

was not used to study its influence on aggressive behavior but only as a control for colony size, as previously mentioned.

CONCLUSIONS

The general nature of aggressive behavior in honeybees, which can be considered as a phenotype, is the product of interaction between genetic composition (Genotype) and environmental factors. In many cases it is difficult to decide which of these two components (Genotype and Environment) is more important. Genetic behavior analysis of whole colonies requires a worker homogeneity which can be obtained, for example, by backcrossing a drone from a F_1 queen with a virgin queen of the parental inbred line (Rothenbühler, 1960). Some responses are caused by internal or external factors ; climatic conditions, for example, can be external factors influencing bee aggressiveness (Schua, 1952 ; Lecomte, 1963 ; Rothenbuhler, 1964 ; Warnke, 1976, etc.). It must also be pointed out that the chain reaction observed in bee stinging is defensive behavior rather than a form of aggression. This means that the honeybees react or respond in a definite pattern to specific stimuli.

In conclusion it can be said that the aggressive behavior of Africanized bee populations in both regions studied was much more influenced by external factors (climatic conditions) than by the bees'genotypic composition. Our results confirm experimentally the hypothesis of Schua (1952), Rothenbuhler (1974) and Warnke (1977), who pointed out the importance of climatic conditions on the aggressive behavior of bees. This research also confirms that the genes for aggressive behavior obviously do not function alone but interact with environmental factors to produce the final behavioral phenotype.

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