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Foraging Behaviour of the African Honey Bee (*Apis mellifera adansonii*) on *Annona senegalensis*, *Croton macrostachyus*, *Psorospermum febrifugum* and *Syzygium guineense* var. *guineense* Flowers at Ngaoundéré (Cameroon)

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Abstract: To determine the apicultural value of *Annona senegalensis* Pers. 1806 (Annonaceae), *Croton macrostachyus* Hochst. Ex Del. 1847 (Euphorbiaceae), *Psorospermum febrifugum* Spach 1836 (Hypericaceae) and *Syzygium guineense* (Will.) DC var. *guineense* 1828 (Myrtaceae), *Apis mellifera adansonii* Latreille 1804 (Hymenoptera: Apidae) activity was observed on their flowers in the area of Ngaoundéré, from January to May, in 2002 and 2003. Flowers of each plant species were prospected at least four days per month, between 7 am and 6 pm, for the registration of the nectar and/or pollen foraging behaviour of *A. m. adansonii* workers. Results show that *A. m. adansonii* harvested nectar and pollen of each plant species. The greatest number of workers foraging simultaneously on a plant varied from 9 in *P. febrifugum* to 3600 in *S. g. guineense*. *A. m. adansonii* workers were faithful to each plant species. *A. senegalensis*, *C. macrostachyus*, *P. febrifugum* and *S. g. guineense* could be cultivated and protected to increase honey production. *A. senegalensis* could enable beekeepers to increase their pollen production as a hive product. During foraging, *A. m. adansonii* workers increased pollination possibilities of each plant species.

Key words: Nectar, pollen, bee plant, apicultural value, pollination

INTRODUCTION

The basic foods of each honey bee colony are nectar and pollen (Crane, 1999; Weidenmüller and Tautz, 2002). Nectar is transformed into honey. Pollen and honey are stored in the hive for future use. These substances have been exploited by human for million of years (Crane, 1999). Honey and pollen production depends mainly on the abundance of some plant species and their attractiveness to honey bees (Williams and Carreck, 1994; Segeren *et al*., 1996). Thus the sustainable beekeeping in a given region needs a detailed knowledge of the bee plants which grow in the environment of the hives (Segeren *et al*., 1996; Riedacker, 1996; Bakenga *et al*., 2000).

Before this study, literature is scant on the relationships between the honey bee and many plant species in Cameroon. Nevertheless, in this country, owing to increasing demand for hive products such as honey and pollen, beekeeping needs to be developed. Highest quantities of honey consumed or marketed in Cameroon came from the Adamawa region which has a climate particularly favourable to the proliferation of bees (Inades, 2000a). Despite this attribute, the region is equally concerned by the problem of low beekeeping production (Inades, 2000b).

The main objective of this research undertaken in Ngaoundéré during the dry season and the beginning of the rainy season (period of the highest honey production by honey bees in this region) of 2002 and 2003 was to contribute to the knowledge of the relationships between honey bees and *A. senegalensis*, *C. macrostachyus*, *P. febrifugum* and *S. g. guineense*. This knowledge is essential for an efficient management of these plants.

For each plant species, specific objectives were, the registration of the activity of *A. m. adansonii* on flowers, the estimation of the apicultural value and the evaluation of the efficiency of *A. m. adansonii* as pollinator.

MATERIALS AND METHODS

Site and biological materials: Studies took place from January to May, in 2002 and 2003 at Dang, a village of Ngaoundéré in the Adamawa region. This region belongs to the high altitude guinean savannah agro-ecological zone. The climate is characterized by two seasons: a rainy season (April-October) and a dry season (November-March). The annual rain fall is about 1500 mm. The mean annual temperature is 22°C. The mean annual relative humidity is 70%.

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Plants chosen for observations were located on an area of 3 km in diameter, centred on a Kenyan top-bar hive inhabited by an *A. m. adansonii* colony. The hive is located at the latitude 7°24.949'N, the longitude 13°32.870'E and the altitude 1093 masl. The number of honey bee colonies located in this area varied from 32 in December 2001 to 67 in January 2002. The vegetation was represented by crops, ornamental plants, hedge plants and native plant species of the savannah and gallery forests.

Table 1 describes plant species studied. For each of these plant species, Table 2 shows the relative abundance of opened flowers per month, during the two studied periods.

Study of the foraging activity of *A. m. adansonii* on flowers: From the 1st January 2002 to 31 May 2002, then from 1st January 2003 to 31 May 2003, at least 4 days per month (preferably on Sundays), between 7 am and 6 pm, period divided into three hourly brackets (7-11 h, 11-15 h and 15-18 h), flowers of different plant species were observed for the registration of the foraging behaviour of *A. m. adansonii* workers. Table 3 gives the number of observation days for each plant. For each plant species which flowers are visited by these bees and for each observation date, the following parameters were registered for each hourly bracket and if possible, on at least 10 individual plants: floral product (nectar or pollen) harvested during each floral visit, abundance of foragers (greatest number of individuals foraging simultaneously on a flower or an individual plant), duration of individual flower visit (using stopwatch), influence of the fauna (disruption of foragers activity by competitors or predators) and impact of the competitive flora (attractiveness of other plant species with respect to *A. m. adansonii*). The influence of the competitive flora was assessed by two methods: a) direct observation on the relationships between honey bee workers foraging on a given plant species and other plant species in flower near the plant under observation; b) study of the pollen loads carried by *A. m. adansonii* workers caught on the flowers of *C. macrostachyus* and *S. g. guineense*: during each of the three days of full flowering, each day, two pollen foragers have been caught on flowers of each of these two plant species; pollen loads of each worker were then remove from pollen baskets and subjected to the microscopic analysis for the determination of the pollen profile.

Evaluation of the apicultural value of different plant species: Like for other plant species, (Guerriat, 1996; Tchuenguem Fohouo *et al.*, 2004), the apicultural value of each plant studied was evaluated using data on the flowering intensity and the attractiveness of *A. m. adansonii* workers with respect to nectar and pollen.

Evaluation of the influence of *A. m. adansonii* on pollination: To measure the ability of *A. m. adansonii* to act as pollinator of each plant species, visits during which the forager came into contact with the stigma were counted together with the duration of the flower visits (Freitas, 1997).

Data analysis: Data were analysed using descriptive statistics, student's t-test for the comparison of means of two samples, Correlation coefficient (r) for the evaluation of the association between two variables and Microsoft Excel.

Table 1: Scientific name, botanic family, biotope, some characteristics and strength (in the observation station) of different plants studied

					Strength	
Scientific name	Family	Biotope	FP	DCOF	December 2001	December 2002
A. senegalensis	Annonaceae (+; sh)	Savannah	Jan-May	Yellowish	28353	26368
C. macrostachyns	Euphorbiaceae (+; tr)	Savannah	Apr-May	Whitish	6284	4213
P. febrifugum	Hypericaceae (+; sh)	Savannah	Jan-May	White	8327	7137
S. g. guineense	Myrtaceae (+; tr)	Forest gallery	Jan-March	Whitish	119	119

+: Spontaneous plant; tr: tree; sh: shrub; FP: Flowering Period; DCOF: Dominant Colour of Opened Flower

Table 2: Relative abundance of opened flowers according to plant species and time

	January to May 2002					January to May 2003				
Plant species	J	F	M	A	M	J	F	M	A	M
A. senegalensis	1	4	4	4		1	3	4	4	
C. macrostachyns			1	2	4				2	4
P. febrifugum	3	4	4	4	4	4	4	4	4	4
S. g. guineense	4	4	1			4	4	1		

1: ≤100 flowers = rare; 2: >100 and ≤500 flowers = little abundant; 3: >500 and ≤1000 flowers = abundant; 4: >1000 flowers = very abundant

RESULTS

A. m. adansonii foraging activity on flowers

Floral product harvested, intensity and frequency of collection of different products: The identity of the foods harvested by *A. m. adansonii* workers on flowers of each plant species under investigation as well as the intensity and the frequency of the collection of each food are shown in Table 3 and 4.

The analysis of Table 3 reveals that: a) on the flowers of each plant species, *A. m. adansonii* workers collect nectar and pollen; b) the type of floral products foraged by *A. m. adansonii* on a given plant species can vary with time; c) in general, the intensity (very weak, weak, high, very higher) of nectar or pollen collection vary with plant species and time; d) considering plant species on which honey bees harvest nectar, frequency (percentage compare to the number of observation days) of harvest of this food varies from 43.75% in *S. g. guineense* to 100% in *C. macrostachyus*; e) for the plant species on which honey bees harvest pollen, the harvesting frequency (percentage compare to the number of observation days) varies from 18.75% in *P. febrifugum* to 100% in *C. macrostachyus* and *S. g. guineense*.

The simultaneous analysis of Table 2 and 3 suggests that in general, the intensity of nectar or pollen collection by honey bees coincides more or less with the flowering rhythm of the corresponding plant species.

Table 4 shows that during the day time, the type of flower substance harvested by *A. m. adansonii* on a given plant species can varies with hourly brackets.

Density of foragers: The greatest number of *A. m. adansonii* workers foraging simultaneously was 1 per flower of each of the studied plant species. Table 5 shows that the abundance of *A. m. adansonii* workers per individual plant varies from 9 (*P. febrifugum* in March 2002 and 2003) to 3600 (*S. g. guineense* in February 2003).

Duration of visits per flower: Table 6 indicates that in general: a) the mean duration of a flower visit varied with plant species and for a plant species, with the type of floral product collected; b) the mean duration of a visit per flower did not vary significantly from year to year.

The difference between the mean duration of a flower visit for nectar collection and that for pollen collection was highly significant in *A. senegalensis* (2002: $t = 12.25$, $p<0.001$; 2003: $t = 10.90$, $p<0.001$) and in *S. g. guineense* (2002: $t = 6.68$, $p< 0.001$; 2003: $t = 5.57$, $p<0.001$). Thus in *A. senegalensis A. m. adansonii* spent more time on a flower for pollen collection than for nectar. In *S. g. guineense* this bee spent more time for nectar collection than for pollen.

The duration of visits was partially influenced by the anthophilous fauna via disruptions. Thus for 165 honey bee workers visits registered on *C. macrostachyus* in 2002, 19 were disrupted by other *A. m. adansonii* (12 visits), *Paratrechina longicornis* (Latreille 1802) (3), *Camponotus flavomarginatus* Mayr 1862 (3) and *Belonogaster juncea* Fabricius 1781 (1). For 108 visits registered on *S. g. var. guineense* flowers in 2003, 41 were disrupted by other *A. m. adansonii* (21), *Lasioglossum* sp). (13), *Xylocopa calens* Lepeletier 1841 (3), *Calliphora* sp. (2) and *B. juncea* (2).

Influence of neighbouring flora: During the observation periods of each of the plant species under investigations, flowers of many other plant species growing in the study area were visited by *A. m. adansonii* workers, for nectar or pollen.

During one foraging trip, an individual bee foraging on a given plant species scarcely visited another plant species (for each plant species studied, not more than three observations of such behaviour, for the study period). In addition, the analysis of the pollen loads collected from the pollen baskets of some worker bees shows that the percentage of the foreign pollen grain varied from 0.56% in *S. g. guineense* to 4.82% in *C. macrostachyus* (Table 7).

Table 3: Food harvested by *A. m. adansonii* on flowers of various plant species according to time, harvesting intensity and frequency of each food

	Food harvested														
	January to May 2002					January to May 2003									
Plant species	J	F	M	A	M	J	F	M	A	M	TD	nDN	pDN (%)	nDP	pDP (%)
A. senegalensis		N^3P^3	N^3P^3	N^2			N^3P^3	N^3P^3	N^3		58	52	89.66	43	74.14
C. macrostachyns			N^2P^2	N^3P^2	N^4P^2				N^3P^2	N^4P^2	32	32	100.00	32	100.00
P. febrifugum	N^2	N^2P^1	N^2P^1	N^2P^1	N^2	N^1	N^2P^1	N^2P^1	N^1	N^1	80	68	85.00	15	18.75
S. g. guineense	N^4P^1	N^4P^1	N^4			N^4	N^4P^2	N^4P^2	N^4		48	21	43.75	48	100.00

N: Nectar; P: Pollen; 1, 2, 3, 4 in superscript, respectively: very low, low, high, very high collections; TD: Total number of observation days; nDN: Number of days where collection of nectar was observed; pDN: percent of days where collection of nectar was observed; nDP: Number of days where collection of pollen was observed; pDP: Percent of days where collection of pollen was observed

Table 4: Food harvested by *A. m. adansonii* on flowers of various plant species according to hourly brackets, following the 2002-2003 investigation period

	Hourly brackets		
Plant species	8-11 h	11-15 h	15-18 h
A. senegaleusis	-	Nectar and pollen	Nectar and pollen
C. macrostachyus	Nectar and pollen	Nectar and pollen	Nectar
P. febrifugum	Nectar and pollen	Nectar	Nectar
S. g. guineense	Nectar and pollen	Nectar and pollen	Nectar

Table 5: Abundance of *A. m. adansonii* workers per plant (maximum of individuals simultaneously in activity on opened flowers for three observations) according to plant species and months

	January to May 2002					January to May 2003				
Plant species	J	F	M	A	M	J	F	M	A	M
A. senegaleusis		9	16	8			12	14	8	
C. macrostachyus			40	80	400				30	350
P. febrifugum	3	7	9	4	2	6	8	9	3	2
S. g. guineense	920	1400	5			960	3600	12		

Table 6: Visiting time of *A. m. adansonii* on flowers of different plant species according to the study periods and harvested products

	January to May 2002					January to May 2003					Comparison of means of the two study periods	
	Visiting time per flower (sec)					Visiting time per flower (sec)						
Plant species	n	m	s	Min	Max	n	m	s	Min.	Max.	t-test	p-value
A. senegaleusis (N)	54	2.57	1.40	1	7	54	2.57	1.25	2	8	0.00	>0.05^{NS}
A. senegaleusis (P)	54	13.85	6.62	5	32	54	13.15	7.02	5	40	0.53	>0.05^{NS}
C. macrostachyus (N)	165	8.05	4.56	2	29	165	8.18	5.00	2	43	0.25	>0.05^{NS}
P. febrifugum (N)	54	4.85	3.25	1	15	54	5.65	5.35	1	26	-0.94	>0.05^{NS}
S. g. guineense (N)	54	12.89	12.27	2	51	54	9.70	10.73	1	62	1.44	>0.05^{NS}
S. g. guineense (P)	54	1.72	0.66	1	3	54	1.63	0.65	1	3	0.71	>0.05^{NS}

n: Number of visits studied, m: Mean; s: Estimated standard deviation; min: minimum; max: maximum; N: Nectar collection visits; P: Pollen collection visits; NS: Non significant difference

Table 7: Pollen profile of pollen loads collected in the corbiculae of some *A. m. adansonii* workers foraging on flowers of two plant species according to the investigation periods

	Pollen profile of pollen loads									
	January to May 2002					January to May 2003				
	No. of pollen grains					No. of pollen grains				
Plant species	Total	Host plant	Other plants	% foreign pollen	Identity of other plants	Total	Host plant	Other plants	% foreign pollen	Identity of other plants
C. macrostachyus	1584	1546	38	2.46	Xa	2457	2344	113	4.82	Xa
S. g. guineense	3235	3217	18	0.56	Ea	3652	3627	25	0.69	Ec

Xa: *Ximenia americana* L. 1753 (Olacaceae); Ea: *Entada africana* Guill. and Perr. 1832 (Mimosaceae); Ec: *Eucalyptus camaldulensis* Dehnh. 1832 (Myrtaceae)

Apicultural value of the plant species: During the observation period, we noted a well elaborated activity of *A. m. adansonii* workers on the flowers of each plant species. In particular, there were high density of workers per tree, good nectar collection on *A. senagalensis*, *C. macrostachyus* and *S. g. guineense*, high pollen collection on *A. senegalensis*, weak nectar collection on *P. febrifugum*, weak pollen collection on *C. macrostachyus*, *S. g. guineense* and *P. febrifugum* (Table 3) and constancy on flowers of each plant species. Furthermore, our field observations revealed that in the dry season (main period of honey flow), individual tree of each plant species under investigation could produce more than 20000 flowers.

These data allow plant species studied to be classify in four categories of bee plants: a) highly nectariferous: *C. macrostachyus*, *S. g. var. guineense* and *A. senagalensis*; b) slightly nectariferous: *P. febrifugum*; c) highly polliniferous: *A. senegalensis*; d) slightly polliniferous: *C. macrostachyus*, *P. febrifugum* and *S. g. guineense* (Table 8).

Table 8 shows the appropriate period to harvest honey or pollen in hives installed in an area of at least 3 km in diameter where flora in bloom is mainly made up of a strong population of each of the plant species with high apicultural value according to the investigation of the period 2001-2003. Considering the study region, it emerges from this table that in the Adamawa region of Cameroon: a) honey can be harvested in March, May and June, if the environment of apiary is dominated by a strong population of *S. g. guineense*, *A. senegalensis* and *C. macrostachyus*, respectively; b) pollen can be

Table 8: Apicultural value of various plant species and the most indicated period to harvest honey and /or pollen from hives installed in environment where the flowering vegetation is predominantly characterised by a high population of corresponding plant species in a delimited area of at least 3 km in diameter, following the 2002-2003 investigation period

	Apicultural value		Period of honey and or pollen collection	
Plant species	Nectar	Pollen	Honey	Pollen
A. senegalensis	3	3	End of May	April
C. macrostachyns	4	2	End of May or beginning of June	-
P. febrifugum	2	1	-	-
S. g. guineense	4	2	End of March or beginning of April	January-February

2nd column: 2 = Low nectariferous value; 3: High nectariferous value; 4 = Very high nectariferous value, 3rd column: 1 = Very low polliniferous value; 2 = Low polliniferous value; 3 = High polliniferous value

Table 9: Number and frequency of contacts between *A. m. adansonii* and the stigma during the floral visits of two plant species

	January to May 2002			January to May 2003			Total		
		Visits with stigmatic contacts			Visits with stigmatic contacts			Visits with stigmatic contacts	
Plant species	No. of studied visits	No.	%	No. of studied visits	No.	%	No. of studied visits	No.	%
A. senegalensis	108	108	100.00	108	108	100.00	216	216	100.00
C. macrostachyns	167	151	90.42	120	111	92.50	287	262	91.29
P. febrifugum	61	56	91.80	48	45	93.75	109	101	92.66
S. g. guineense	191	154	80.63	130	114	87.69	321	268	83.49

harvested in the hives in April, if the environment of the apiary is dominated by a strong population of *A. senegalensis*.

Impact of *A. m. adansonii* activity on pollination of the plant species: During the collection of pollen or nectar on flowers of each plant species, foragers regularly contacted anthers and carried pollen. With this pollen, they flew frequently from flower to flower. The percentage of the total number of visits during which worker bees came into contact with the stigma of the visited flower varied from 83.49% in *S. g. guineense* to 100% in *A. senegalensis* (Table 9).

DISCUSSION

The collection of nectar and pollen of *C. macrostachyus* by *A. m. adansonii* has also been noted in Ethiopia (Fichtl and Adi, 1994). In West Cameroon, *A. m. adansonii* collects only the nectar of this Euphorbiaceae (Dongock Nguemo *et al*., 2004). The collection of the nectar of *S. g. guineense* by *A. m. adansonii* has also been observed in Ethiopia (Fichtl and Adi, 1994). Thus the type of floral products harvested by *A. m. adansonii* on a given plant species can vary with the regions and years. The observed variations could be mainly explained by the availability of pollen or nectar at the level of flowers and by the needs of the colonies of the foraging bees.

The observed high densities of foragers per tree were due to the ability of honey bees to recruit a great number of workers for the exploitation of high yield food sources (Frisch, 1969; Louveaux, 1984; Schneider and Hall, 1997).

In *A. senegalensis* the fact that *A. m. adansonii* spent more time on a flower for pollen harvest than for nectar could be explained by the abundance and/or the accessibility to each of these floral products: in this plant species, pollen is produced in great quantity and is easily accessible to bees; in contrast, nectar is produced in small quantity and is less accessible to bees. Under these conditions, a worker honey bee can obtain its pollen load by visiting a few flowers during a foraging trip.

In *S. g. guineense*, the fact that *A. m. adansonii* spent more time on a flower for nectar collection than for pollen collection could be explained by the abundance of each of these floral products: in this plant species, pollen is produced in small quantity by anthers, which are situated on the top of stamen and are thus easily accessible to bees, whereas nectar is produce in great quantity between the base of style and the stamens and is thus less accessible. Under these conditions, a worker honey bee can obtain its nectar load by visiting few flowers during a foraging trip. Similar results were found in *Callistemon rigidus* R. Br. 1819 (Myrtaceae) (Tchuenguem Fohouo *et al*., 1997, 2004).

The disruptions of visits reduced the duration of certain *A. m. adansonii* visits. This obliged some worker bees to visit more flowers during a foraging trip, in view to obtain their maximal pollen or nectar loads.

Present study shows that during one foraging trip, an individual bee foraging on a given plant species scarcely visited another plant species. This result indicates that *A. m. adansonii* shows flower constancy (Louveaux, 1984; Basualdo *et al*., 2000) for the flowers of each plant species studied. This floral constancy is due to the fact that in honey bees, individual forager is generally capable of memorizing and recognizing the shape, colour and odour of the flowers visited during previous foraging strips (Hill *et al*., 1997; Wright *et al*., 2002).

Since *C. macrostachyus*, *S. g. guineense* and *A. senagalensis* are highly nectariferous bee plants, they should be planted and protected to increase honey production. Besides, *C. macrostachyus* pollen has been identified in the honey collected in the study area in 2001 (3 samples of the 3 samples analysed) (Tchuenguem Fohouo, 2005). *S. guineense* pollen has been identified in honey samples collected in the same study area in 1999 and 2000 (7 samples of the 7 samples analysed) (Mbofung *et al*., 2000), then in 2001 and 2002 (11 samples of the 11 samples analysed) (Tchuenguem Fohouo, 2005).

As a highly polliniferous bee plant, *A. senegalensis* could permit the increase of pollen production as a hive product.

All the plant species studied contributed more or less to the feeding and thus to strengthen honey bee colonies. Consequently, they should be planted and protected in the environment of the apiaries.

We have seen that, during the collection of pollen or nectar on flowers of each plant species, *A. m. adansonii* foragers regularly contacted anthers and carried pollen with which they flew frequently from flower to flower. Thus *A. m. adansonii* workers could induce self pollination, by applying the pollen of a flower on the stigma of the same flower. Foragers carried pollen from a flower of one tree to the stigma of another flower of the same tree (geitonogamy) or to that of another tree (xenogamy). Consequently *A. m. adansonii* workers increase the pollination possibilities of *C. macrostachyus*, *S. g. guineense*, *A. senagalensis* and *P. febrifugum* flowers.

Installation of *A. m. adansonii* colonies near the population of each plant species studied should be recommended. Furthermore, insecticide treatments should be avoided during the flowering period of each plant species studied. If these treatments are necessary, the choice of the insecticides that are less toxic for bees or the integrated pest control should be recommended to protect pollinating insects such as *A. m. adansonii*.

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REFERENCES

Bakenga, M., M. Bahati and K. Balagizi, 2000. Inventory of melliferous plants of Bukavu and its neighbourhood (South -Kivu, East of the Democratic Republic of Congo). Tropicultura, 18 (2): 89-93.

Basualdo, M., E. Bedascarrasbure and D. De Jong, 2000. Africanized honey bees (Hymenoptera: Apidae) have a greater fidelity to sunflowers than European bees. J. Econ. Entomol., 93 (2): 304-307.

Crane, E., 1999. The World History of Beekeeping and Honey Hunting. Duckworth, London.

Dongock Nguemo, D., J. Foko, J.Y. Pinta, J. Tchoumboué and P. Zango, 2004. Inventory of melliferous plants of the sudano-guinean zone of West Cameroon. Tropicultura, 22 (3): 139-145.

Fichtl, R. and A. Adi, 1994. Honeybee Flora of Ethiopia. Margraf Verlag. Weikerskein.

Freitas, B.M., 1997. Number and distribution of Cashew (*Anacardium occidentale*) pollen grains on the bodies of its pollinators, *Apis mellifera* and *Centris tarsata*. J. Apic. Res., 36 (1): 15-22.

Frisch, K. Von, 1969. Life and Habits of Honey Bees A. Michel, Paris.

Guerriat, H., 1996. Be performant in beekeeping. H. Guerriat, Daussois.

Hill, P.S.M., P.H. Wells and H. Wells, 1997. Spontaneous flower constancy and learning in honey bees as a function of colour. Anim. Behav., 54 (3): 615-627.

Inades, 2000a. Report of the workshops with Adamawa beekeepers. INADES-Formation Cameroun, Maroua Antenna, Maroua.

Inades, 2000b. Support programme to the Beekeeping network. INADES-Formation Cameroun, Maroua Antenna, Maroua.

Louveaux, J., 1984. The Honey Bees in its Relations with Cultivated Plants. In: Pollination and Plant Productions, Pesson, P. and J. Louveaux (Eds.). INRA, Paris, pp: 527-555.

Mbofung, G., F.N. Tchuenguem Fohouo, O. Boukar, J. Hentchoya Hemo and D. Brückner, 2000. Characterization of some honeys from the Adamawa, Cameroon using melissopalynological methods. Biosci. Proc., 7: 108-120.

Riedacker, A., 1996. Plants that indicate what we do not see. L'Abeille de France, 815: 205.

Schneider, S.S. and H.G. Hall, 1997. Diet selection and foraging distances of African and European-African hybrid honey bee colonies in Costa Rica. Insectes Sociaux, 44: 171-187.

Segeren, P., V. Mulder, J. Beetsma and R. Sommeijer, 1996. Beekeeping in the Tropics. 5th Edn. Agromisa, Wageningen.

Tchuenguem Fohouo, F.N., Nyomo, J. Hentchoya Hemo and J. Messi, 1997. Introduction to the study of *Apis mellifera* activity on *Callistemon rigidus* R. Br. (Myrtaceae) flowers at Dang (Adamawa, Cameroon). Cam. J. Biol. Biochem. Sci., 7 (1): 78-85.

Tchuenguem Fohouo, F.N., J. Messi, D. Brückner, B. Bouba, G. Mbofung and J. Hentchoya Hemo, 2004. Foraging and pollination behaviour of the African honey bee (*Apis mellifera adansonii*) on *Callistemon rigidus* flowers at Ngaoundere (Cameroon). J. Cameroon Acad. Sci., 4 (2): 133-140.

Tchuenguem Fohouo, F.N., 2005. Foraging and pollination behaviour of *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae, Apinae) on flowers of three plant species at Ngaoundéré (Cameroon): *Callistemon rigidus* (Myrtaceae), *Syzygium guineense* var. *macrocarpum* (Myrtaceae) and *Voacanga* africana (Apocynaceae). Ph.D Thesis, University of Yaoundé I.

Weidenmüller, A. and J. Tautz, 2002. In hive behavior of pollen foragers (*Apis mellifera*) in honey bee colonies under conditions of high and low pollen need. Ethology, 108: 205-221.

Williams, I.H. and N.L. Carreck, 1994. Land Use Changes and Honey Bee Forage Plants. In: Forage for Bees in an Agricultural Landscape, Matheson, A. (Ed.). IBRA, Cardiff, pp: 7-20.

Wright, G.A., B.D. Skinner and B.H. Smith, 2002. Ability of honeybee, Apis mellifera, to detect and discriminate odors of varieties of canola (*Brassica rapa* and *Brassica napus*) and snapgragon flowers (*Antirrhinum majus*). J. Chem. Ecol., 28 (4): 721-740.