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Yield responses of *Cucumeropsis mannii* (Cucurbitaceae) to the presence or the absence of the insect foraging activity at Nkolbisson in Cameroon.

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1 SUMMARY

Experiments were made to evaluate the impact of the floral activity of the insect visiting fauna on *Cucumeropsis mannii* yields. Two lots of 566 female flowers (in 2004) and 759 female flowers (in 2006) were differentiated according to the presence or the absence of protection for insect visits. The foraging entomofauna, the rhythm of insect activity, the fruit set rate and the mean number of seeds per fruit were recorded. Results showed 33 and 29 insect species foraged on *C. mannii* flowers. Among them, *Apis mellifera* was prominent. Insects foraged throughout the day light period and during the whole blooming period of the plant. Their activity was highest in the morning hours. During their visits, bees intensively and preferably harvested nectar coming into contact with anther or stigma when foraging. The fruit and seed sets were exclusively effective in unprotected female flowers whereas those of protected female flowers were nulls in both years. Then, the foraging activity of insects mainly bees on *C. mannii* appears as the limiting factor in the production of this crop. Therefore, the installation of *A. mellifera* colonies and the conservation of the wild bee nests close to *C. mannii* field are recommended to maintain and improve yields in the region.

2 INTRODUCTION

The white-seeded melon, *Cucumeropsis mannii* (Naudin 1866) synonymous *Cladosicyos edulis* (Hooks. f. 1876) or *Cucumeropsis edulis* ((Hooks. f.) Cogn. 1881) is of African origin, from Bissau-Guinea, South Soudan, Uganda and Angola (Okoli, 1984). This cucumber species is widely cultivated in Nigeria, Ivory-Coast, RCA and Cameroon where it is commonly called pistachio (Ndabalishye, 1995) or egusi (Schippers, 1997). In Cameroon particularly, cucumbers do exist in various species belonging to different bio-climatic regions: *Cucumeropsis mannii* or white melon, *Cucurbita maxima* or Winter squash or potiron, *Cucurbita moschata* or butternut squash or pumpkin, *Lagenaria siceraria* or bottle gourd or opo squash, *Cucumis melo* or muskmelon and *Cucumis sativus* or pikling cucumber (Achu *et al.*, 2006). Only, *Cucumeropsis mannii* and *Cucumis sativus* are known in the rain forest region of this country (Westphal *et al.*, 1981). Among the two species, *Cucumeropsis mannii* is by far the most cultivated (Achu *et al.*, 2005).

Cucumeropsis mannii is a partially drought-resistant cucurbit (Figure 1; Okoli, 1984). It is a giant and climbing herb up to 5-10 m long which is often cultivated close to small trees and shrubs, fences, or similar support. This plant is monoecious. The corolla of flowers is yellow. Male flowers are arranged in axillaries raceme more or less umbel-like. Female flowers are solitary in leaf axils. Fruit, issued from the female flower, is an ellipsoid to ovoid berry 17-25 x 8-18 cm, smooth, green to pale yellow or creamy white (Achigan *et al.*, 2006). The fruit flesh is tender and white. It has viscous aspect around seeds (Schippers, 1997). The seeds are embedded in the flesh. These seeds are extracted after the flesh rotting. Thus, gashes are done before on mature fruits with a machete or the fruits are smashed with sticks in order to accelerate the fruit rotting that is effective after a week.

Figure 1 : Plant of *Cucumeropsis mannii* (Nkolbisson July 12, 2006)

Cucumeropsis mannii occupies a prominent place in the diet, culture and life of many ethnic groups in Africa (Fomekong *et al.*, 2008). It is cultivated for its seeds which are sold almost three times more expensive than cocoa and about seven times more expensive than coffee (Zoro Bi *et al.*, 2003). Seeds of *C. mannii* constitute important lipid and protein sources (Achu et *al.*, 2005; Ponka *et al.*, 2006). These seeds are used to prepare dough or sauces (Zoro Bi *et al.*, 2003). The food and economic importance of cucumber in Cameroon make this crop a potential important source for the improvement of the income and livelihood of the farmers (Fomekong *et al.*, 2008). Some studies have been done on the entomofauna of *C. mannii* in the tropical zone (Appert and Deuze, 1984). It is mentioned that *C. mannii* flowers are pollinated by insects (Schippers, 1997). However, in the literature, very little data do exists on the relationships between *C. mannii* and the anthophilous insects.

In Cameroon, the higher *C. mannii* seed yields are fairly obtained through the application of several farming techniques like crop rotation, organic manures, and pest control. Farmers don't know the importance of flower-visiting insects on the pollination and the productivity of cultivated plants, they still ignore that yield of various plants can be decreased by half or more in the absence or the presence of insufficient number of insect pollinators during flowering (Philippe, 1991). Yet, it is known that foragers, mainly Apoidea, exhibit the strongest biological relationship to flowers and provide substantial economic and ecological benefits to entomophilous crops and wildlife (Bozena, 2009). Moreover, in a given region, the knowledge of the relationships between anthophilous insects and cultivated crops can encourage harbouring of certain insect species for pollination and plant production (Jacob-Remacle, 1989; Dequesne, 1996). The present study is a contribution to the knowledge of the interactions between *C. mannii* and flower visiting insects. The specific objectives were: (1) to characterise the anthophilous insects, observe foraging on *C. mannii* flowers and (2) to evaluate the impact of the presence or the absence of anthophilous insects on fruit and seed yields of this crop plant for its optimal management.

3 MATERIALS AND METHODS

The study was carried out in Nkolbisson, a Western suburb of Yaoundé in the Centre Region of Cameroon, from February to September, in 2004 and 2006. This site is located on latitudes 3°47-3°36 north and longitudes 11°10-11°45 east. The climate is of the Guinean type with four seasons: a small rainy season (March-June), a small dry season (July-August), a big rainy season (September-November) and a big dry season (November-March). Annual rainfall can reach 2000 mm and mean annual temperature is about 25°C. Experiments took place for more than two years in an old fallow limited on a 0.25 ha surfaces. Cleaning and ploughing of the experimental area took place from February 1 to March 5, 2004 and 2006 respectively prior to sowing. Seeds were bought at Nkolbisson market for the two experimentations. On March 11, 2004 and March 19, 2006, seeds of *C. mannii* were sown three per hole. The space between two holes was 2 m on rows and 2 m between rows. Ten days after germination, plantlets were trimmed to one per hole. Weeding was manually done for it was necessary to maintain a weed-free parcel.

On April 7, 2004 and April 15, 2006 respectively, 120 *C. mannii* plants were labelled at random and split into two treatments. In treatment 1 (100 plants), female flowers were left to exposed pollination. The opened female flowers were tagged on labelled plants every day. In treatment 2 (20 plants), female flowers were protected from insects using gauze bags (5x10 cm). This operation was realised every day, as soon as female flowers appeared and just before their opening. In 2004, a total of 430 and 136 female flowers were studied in treatment 1 and treatment 2 respectively. In 2006, the corresponding numbers were 631 and 128 in these treatments.

Direct observations on treatment 1 flowers were made on natural population of insects present in the experimental field, during the blooming period from May 2 to July 28, 2004 and from May 8 to August 12, 2006 and between 7:00 a.m. and 6:00 p.m. (local time). The relative importance of different insect species on the flower visiting fauna of *C. mannii* was determined based on observations of the flowers of treatment 1 plants at 6 periods: 7:00-8:00 a.m., 9:00-10:00 a.m., 11:00-12:00 a.m., 1:00-2:00 p.m., 3:00-4:00 p.m. and 5:00-6:00 p.m. The mean temperature and hygrometry corresponding to each observation interval was registered in the meteorological station of Institute of Agricultural research for development of Nkolbisson, Yaoundé, Cameroon located at the vicinity of the study site. In transect walk along each plant of the treatment 1, we recorded, with a specific code, the identity of every insect seen visiting egusi flowers. Only, effective visits: visits during which insects came into contact with the stigma or the anther (Freitas, 1997) were recorded. The cumulated visits of different insects encountered were expressed on the number of visits. Specimens of all anthophilous insect species recorded were captured with the pliers or the suction device. Some of insect species were conserved each in a box containing 70% of ethanol for future taxonomy, besides butterflies which were fixed with needle. At least, two specimens of each insect species were captured. Bee identifications were done by Dr. Alain Pauly, Department of Entomology Royal Belgian Institute of Natural Sciences Brussels Belgium. The other insect species were identified in the laboratory of Zoology of the University of Yaoundé I, the laboratory of entomology, Institute of Agricultural Research for the Development (Nkolbisson, Yaoundé), the use of the identification key of Delvare and Aberlenc (1989) which is adapted to the insects of the tropical zone. Also, the floral product harvested (nectar or pollen) was registered mainly for bee species. It was done based on the foraging behaviour of each species. Nectar foragers were seen introducing the head between the stigma or the anther and the corolla, while pollen gatherers directly scratched the anthers with the mandibles or the legs. Also, the foraging speed that means the number of flowers visited per minute (Jacob-Remacle, 1989) was assessed.

The number of female flowers and fruits counted on each labelled plant permitted to evaluate the ability of these plants to bear fruits using the fruit set rate [(number of fruits formed/number of female flowers labelled per a plant) x 100] (Tchuenguem Fohouo *et al.*, 2004). Moreover, the mean number of mature seeds per fruit and per treatment was evaluated. Data were subjected to descriptive statistics. Correlation coefficient (r) was used for the evaluation of the association between two variables using Microsoft Excel. Values are given as mean ± standard deviation.

4 RESULTS

Table 1 shows the 21147 and 22502 visits of 33 and 29 insect species belonging to 16 and 14 families included on 8 and 7 orders recorded on treatment 1 flowers in 2004 and 2006 respectively.

Table 1: Number and percentage of insect visits on *Cucumeropsis mannii* flowers in 2004 and 2006.

Orders	Families	Species	2004		2006	
			nv_1	a_1	nv_2	a_2
Hymenoptera	Apidae	*Apis mellifera*	15263	72.18	16834	75%
		*Meliponula nebulata**	1721	8.14	1546	6.87
		*Meliponula bocandei**	1042	4.93	1213	5.4
		*Dactylurina staudingeri**	754	3.56	813	3.61
		Allodape collaris *	452	2.14	505	2.24
		*Xylocopa olivaceae**	384	1.81	407	1.81
		*Allodape maculata**	200	0.95	221	1.05
		*Allodape derufata**	107	0.51	112	0.52
		Braunsapis sp.*	231	1.09	129	0.57
		*Hypotrigona gribodoi**	156	0.74	31	0.14
		Xylocopa sp. 1*	32	0.15	6	0.03
		Xylocopa sp. 2*	13	0.06	1	0
	Total Apidae		20355	96.25	21808	96.92
	Halictidae	*Ipomalictus* sp.*	143	0.67	96	0.43
		*Thrinchostoma bequaerti**	6	0.03	0	0
	Total Halictidae		149	0.70	96	0.43
	Formicidae	*Camponotus flavomarginatus**	237	1.12	227	1.01
		Phaerocrema sp.*	62	0.29	93	0.41
		*Pheidole megacephala**	56	0.26	52	0.23
	Total Formicidae		355	1.68	372	1.65
	Sphecidae	*Philanthus triangulum**	32	0.15	0	0
Total Hymenoptera			20891	98.79	22276	98.99
Lepidoptera	Lycaenidae	*Virachola antalus**	53	0.25	16	0.07
	Nymphalidae	(1 sp.)*	32	0.15	27	0.12
	Pieridae	(1 sp.)*	25	0.12	8	0.03
	Acraeidae	*Acraea acerata**	14	0.06	24	0.11
	Amateidae	(1sp.)*	10	0.05	0	0
Total Lepidoptera			134	0.63	75	0.34
Diptera	Muscidae	*Musca domestica**	24	0.11	19	0.08
	Stratiomydae	*Hermetia* sp.*	0	0	11	0.05
	Syrphidae	*Paragus borbonicus**	28	0.13	25	0.11
	Calliphoridae	(1sp.)*	7	0.03	0	0
Total Diptera			59	0.28	55	0.24
Coleoptera	Lagriidae	*Lagria villosa**	16	0.07	24	0.11
	Coccinellidae	*Cheilomenes lunata**	0	0	8	0.03
	Chrysomelidae	*Aulacophora foveicollis**	7	0.03	0	0
Total Coleoptera			23	0.11	32	0.14
Orthoptera	Pyrgomorphidae	*Zonocerus variegatus**	19	0.09	43	0.19
		(1sp.)*	7	0.03	16	0.07
Total Orthoptera			26	0.12	59	0.27
Hemiptera		(1sp.)*	7	0.03	0	0
Dictyoptera	Mantidae	*Mantis religiosa**	7	0.03	5	0.02
TOTAL			**21147**	**100**	**22502**	**100**

Legend: nv_1 and nv_2= Number of individual visits in 2004 and 2006; $a_1 = nv_1/21147 \times 100$; $a_2 = nv_2/22502 \times 100$; a_1 and a_2 are percentages of individual visits in 2004 and 2006; *= Insects registered for the first time on *C. mannii* flowers.

From the table, it also appears that the percentage of visits was done mainly by Hymenoptera (98.79% in 2004 and 98.99% in 2006), instead of the other orders (Lepidoptera (0,63% and 0,34%), Diptera (0,28% and 0,24%), Coleoptera (0,11% and 0,14%), Ortoptera (0,12% and 0,27%), Dictyoptera (0,03% and 0,02%) and Hemiptera (0,03% and 0%)) which represented 1.21% and 1.01% of total insect visits respectively in 2004 and in 2006. The different families in the order of their importance were Apidae (96.25%), Formicidae (1,68%), Halictidae (0.70%), Lycianidae (0.25%), Nymphalidae (0.15%), Syrphidae (0.13%), Pieridae (0.12%), Muscidae (0.11%), Pyrgomorphidae (0.09%), Lagriidae (0.07%), Acraeidae (0.06%), Amateidae (0.05%), Sphecidae (0.05%), Calliphoridae (0.03%), Chrysomelidae (0.03%), and Mantidae (0.03%) in 2004 then Apidae (96.92%), Formicidae (1.65%), Halictidae (0.43%), Pyrgomorphidae (0.19%), Nymphalidae (0.12%), Syrphidae (0.11%), Lagriidae (0.11%), Muscidae (0.08%), Lycianidae (0.07%), Stratyomidae (0.05%), Acraeidae (0.03%), Pieridae (0.03%), Coccinellidae (0.03%) and Mantidae (0.02%) in 2006. Among the total species, only *Apis mellifera adansonii* with 72.18% in 2004 and 75% in 2006 was prominent.

From Table 2, it appears that anthophilous insect foraged *C. mannii* flowers almost during the whole daily period. The individual insect foraging activity was higher between 9:00 and 10:00 a.m. For Hymenoptera, besides *Xylocopa* sp. 1 and sp. 2 which only foraged at the first daily interval time, *H. gribodoi* and *Ipomalictus* sp. which highly foraged at 11:00-12:00 a.m., all the other species were prominent at 9:00-10:00 a.m. time interval. After 9:00-10:00 a.m., the anthophilous insect activity highly decreased due undoubtedly to the temperature raising. To this end, it appears from Table 3 that the correlation between the daily rhythm of insect activity and the variation of the field temperature was negatively significant (r = -0.64 in 2004 and - 0.53 in 2006; n = 6). Contrary to the temperature, the correlation between the daily rhythm of insect activity and the variation of the field hygrometry was positively significant (r = 0.79 in 2004 and 0.74 in 2006; n = 6).

Table 2: Daily distribution of individual bee visits on *Cucumeropsis mannii* flowers.

	Insect species	Daily period (hours)						Total
		7-8	9-10	11-12	13-14	15-16	17-18	
	Apis mellifera	3958	5404*	2979	1803	906	213	15263
	Meliponula nebulata	78	696*	611	254	66	16	1721
	Meliponula bocandei	15	351*	263	217	124	72	1042
	Dactylurina staudingeri	54	440*	152	66	42	-	754
	Allodape collaris	112	237*	73	24	6	-	452
	Xylocopa olivaceae	6	210*	123	45	-	-	384
I	*Allodape maculata*	24	101*	37	29	9	-	200
	Allodape derufata	7	67*	21	8	4	-	107
	Braunsapis sp.	66	122*	39	4	-	-	231
	Hypotrigona gribodoi	-	11	73*	72	-	-	156
	Xylocopa sp. 1	32*	-	-	-	-	-	32
	Xylocopa sp. 2	13*	-	-	-	-	-	13
	Ipomalictus sp.	-	6	83*	51	3		143
	Thrinchostoma bequaerti	-	4*	2	-	-	-	6
	Non-bee species	42	135*	225	175	47	19	643
	Total	**4407**	**7784***	**4681**	**2747**	**1207**	**320**	**21147**
	Apis mellifera	3612	6036*	3404	2227	1304	251	16834
	Meliponula nebulata	155	705*	365	262	53	6	1546
	Meliponula bocandei	47	526*	302	194	108	36	1213
	Dactylurina staudingeri	67	521*	192	26	7	-	813
	Allodape collaris	23	248*	163	58	13	-	505
II	*Xylocopa olivaceae*	14	220*	142	28	3	-	407
	Allodape maculata	19	102*	54	24	13	-	221
	Allodape derufata	12	66*	20	13	-	-	112
	Braunsapis sp.	24	72*	28	5	-	-	129
	Hypotrigona gribodoi	-	-	18*	13	-	-	31
	Xylocopa sp. 1	6*	-	-	-	-	-	6

Xylocopa sp. 2	1*	-	-	-	-	-	1
Ipomalictus sp.	3	16	53*	21	3		96
Non-bee species	36	133*	211	135	47	36	598
Total	**4019**	**8645***	**4952**	**3006**	**1551**	**329**	**22502**

Legend: I = May 2 – July 28, 2004; II = May 8 – August 12, 2006; * = Pick of insect visits.

Table 3: Daily distribution of total insect visits on *Cucumeropsis mannii* flowers, mean temperature and mean humidity of the study site.

Year	**Parameters**	**Daily time period (hours)**					
		7-8	**9-10**	**11-12**	**13-14**	**15-16**	**17-18**
2004	Number of visits	4407	7784	4681	2748	1207	320
	Percentage of visits (%)	20.84	36.81	22.13	13.00	5.71	1.51
	Temperature (°C)	23.6	25.2	25.9	28.7	28.8	27.1
	Hygrometry (%)	80.1	77.4	71.7	67.8	66.4	66.6
2006	Number of visits	4019	8645	4952	3006	1551	329
	Percentage of visits (%)	17.86	38.42	22.01	13.36	6.89	1.4
	Temperature (°C)	24.3	25.6	26.7	30.2	29.4	27.8
	Hygrometry (%)	78.2	77.4	75.7	73.1	72.4	73.2

For temperature and hygrometry, each figure represents the means of four observations per hourly period and per day, within 15 days.

From our field observations, it appeared that bee species collected primarily nectar than pollen. Bee workers harvested nectar and pollen on male flowers and nectar on female flowers. Pollen collection occurred in the morning (7:00-10:00 a.m.). Nectar collection occurred throughout the day. Each visit for pollen harvesting or nectar gathering was an effective one during which foragers contacted *C. mannii* anther or stigma before taking off. In fact, the floral diameter of *C. mannii* was 1.14 ± 0.21 cm for 50 male flowers and 1.43 ± 0.42 cm for 50 female flowers. During the collection of pollen or nectar on male flowers, bee foragers always carried pollen. With this pollen, they flied to female flower, contacted stigma and then induced *C. mannii* pollination. The mean foraging speed varies with the studied bee. It was 8.3 ± 2.1 (n = 100) and 9.6 ± 1.8 (n = 83) for *Apis mellifera*, 7.60 ± 2.50 (n = 86) and 9.07 ± 2.35 (n = 100) for *M. Bocandei*, 6.57 ± 2.63 (n = 85) and 5.94 ± 3.21 (n = 70) for *M. nebulata* then 13.06 ± 3.26 (*n* = 79) and 11.33 ± 2.83 (n = 30) for *X. olivaceae*. From Table 4, it appears that the fruit set rate was 78.37% and 81.14% in treatment 1 (unprotected female flowers) and 0 in treatment 2 (protected female flowers) in both years. The mean number of seeds per fruit was 137 ± 43 (n = 57 fruits) and 185 ± 56 (n = 182 fruits) in treatment 1 and since there were no fruits 0 in treatment 2 respectively in both years. Consequently, the influence of insects mainly bees was positive and decisive for *C. mannii* production; unvisited female flowers by bees fall within about 4 days following anthesis.

Table 4: fructification rate and mean number of mature seeds per fruit on treatment 1 and treatment 2 in 2004 and 2006

	2004		**2006**	
	Treatment 1	**Treatment 2**	**Treatment 1**	**Treatment 2**
Female flowers studied (a)	430	136	631	128
Fruit formed (b)	337	0	512	0
Fructification rate (%)	78.37	0	81.14	0
Mean number of seeds/fruit	137 ± 43	0	185 ± 56	0

Legend: Fructification rate = *b/a x 100*

5 DISCUSSION

This study results confirm other report that Hymenoptera, mainly bees, are the most important foragers for a greatest number of crop plants (Klein *et al.*, 2007). Among bee species, *Apis mellifera* appears like the most important. This bee species was already mentioned in *C. mannii* floral entomofauna in Cameroon (Fomekong *et al.*, 2008). Moreover, *Apis mellifera* is known as the main forager of other cucurbitaceous plant species: *Ecballium elaterium* (Rust *et al.*, 2003), *Cucumis sativus* (Free, 1993; Gingrass *et al*., 1999; Stanghellini *et al*., 2002; Slaa *et al*., 2006), *Cucurbita pepo* (Nepi and Paccini, 1993), *Cucurbita maxima* (Asworth and Galetto, 2001) and *Citrullus lanatus* (Stanghellini *et al*., 1998; Njoroge *et al*., 2004; Azo'o *et al*., 2010). Besides *Apis mellifera*, the other anthophilous insects marked with an asterisk in Table I are documented on the floral entomofauna of *C. mannii* for the first time, comparatively with those mentioned foraging on *C. mannii* flowers by Fomekong *et al.* (2008). Overall, this study results and those previously obtained also revealed that the specific richness of the floral entomofauna of *C. mannii* varies in the same site with the cultivating seasons. This observation agrees with that mentioned on *Syzygium guineense* var. macrocarpum in 2000 and 2001 where 51 and 29 anthophilous insect species were recorded on this plant species at Dang, Ngaoundéré, Cameroon (Tchuenguem Fohouo, 2005).

The fact that studied bee species intensively foraged on *C. mannii* flowers in the morning appears to be specific traits of nutrition in this insect group (Roubik, 1989). The same observations were made on *Citrullus lanatus* in Cameroon (Azo'o *et al*., 2010). Besides, in Philippines, on *Cucumis sativus*, it was documented that the intense morning activity of bee species is synchronized with the higher nectar secretion which occurs 2 to 3 hours after flowers opening at dawn (Cervancia and Bergonia, 1991). However, the anthophilous insect activity decreased after 9:00 a.m.-10:00 a.m. due to the increase of the temperature on the experimental field. In fact, although foragers preferred warm or sunny days for the good floral activity (Kasper *et al*., 2008), the negative influence of the up temperature is higher on the plant as pollen and nectar producer than on the foragers. Thus, though the temperature allowed floral anthesis, it accelerates flower wilting and the decrease of nectar production (Pesson and Louveaux, 1984).

During their visits on *C. mannii* male flowers, wild bee foragers always contacted anthers and carried pollen with their body hair. With this pollen, they flew from flower to flower. On female flowers, workers came into contact with the stigma and then induced *C. mannii* pollination. In fact, in entomophilous plants, most pollination involves pollen transferred on the body of insects (Vaissière *et al*., 1996). Bees could carry the pollen from a male flower of one plant to the stigma of a female flower of the same *C. mannii* plant or that of another plant. Moreover, some of them had a higher foraging speed. This is one of the reasons why they play an efficient role on *C. mannii* pollination (Jacob-Remacle, 1989).

The highest fruit set rate and number of mature seeds obtained from unprotected female flowers were due to the foraging activity of anthophilous insects in general, including mainly *Apis mellifera adansonii* and wild bees on *C. mannii* flowers. Then, the insect visits on the flowers of *C. mannii* may have done a contribution in the pollination and the fructification of this plant. In fact, it is known that the more a female flower receives pollen grains, the better chance it has to be transformed into a fruit with many seeds (Jean Prost, 1987). The absence of fruit set in treatment 2 indicated that there is no developed fruit without pollen contribution on the stigma of *C. mannii* female flowers. Thus, the foraging activity of anthophilous insects, mainly bees appears to be the limiting factor in fruit and seed productions of *C. mannii*. The same observation was made on the other species of Cucurbits (Free, 1993; Stanghellini *et al*., 1998; Gingrass *et al*., 1999; Slaa *et al*., 2006; Azo'o *et al*., 2010). Besides, in many plant species a decline in pollination quantity and quality result in a decline of seed set (Steffan Dewenter and Tscharntke, 1999; Tomimatsu and Ohara, 2002). Then, *C. mannii* is strictly an entomophilous plant. It is also neither parthenocarpic nor apomictic under natural conditions as most cultivars of squashes and melons (Vaissière and Froissart, 1996). Therefore, the conservation of *A. m. adansonii* colonies and the wild bee nests in surrounding areas of *C. mannii* plantations in bloom is very important for the fruit and seed production.

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