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Pollination efficiency of *Xylocopa torrida* Westwood 1838 (Hymenoptera, Apidae) on *Mimosa pudica* Linnaeus 1753 (Fabaceae) inflorescences at Yassa (Douala - Cameroon)

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Abstract
At Yassa, from 2014 to 2015, flowers of *Mimosa pudica* were observed for the study of the foraging behavior of insects and the determination of the impact of these arthropods on pod or seed yields. Two treatments were determined from labeling of 120 inflorescences. Treatments were differed according to whether ridges or the inflorescence were protected or not against insect visits. A third treatment was made up of 50 inflorescence that were protected then exposed exclusively to *X. torrida* visits when flowers were opened. The foraging and pollination activity of insects and the apicultural value of the plant were studied. On 13 insect species recorded on flowers of *M. pudica*, *X. torrida* was the most represented insect with 35.41% of 401 visits. This carpenter bee harvested intensely the pollen. The activity of insects started around 7 am and ended around 2 pm, with a peak between 10 am and 11 am. Insects were faithful to the flowers of this plant during foraging bouts. Data obtained allow the classification of the plant between the highly polliniferous. Insects improved the yields of this plant. The pollination efficiency of *X. torrida* has signicantly increase the number of fruits per inflorescence by 52.31% and 53.17%, the number of seeds per pod by 5.68% and 4.26% and the percentage of the normal seeds by 7.78% et 6.02%, respectively in 2014 and 2015. *M. pudica* can be cultivated and protected to increase pollen production as a honey bee hive product. The conservation of *Xylocopa* nests near the population of *M. pudica* is encouraged to increase fruit and seed yields in the region.

Keywords: *Xylocopa torrida*, *Mimosa pudica*, pollen, pollination

Introduction
In Cameroon, the amount of research on bees is increasing due to their vital importance in the pollination of foods crops [1, 2, 3, 4, 5, 6]. *Xylocopa torrida* is a large bee that is black in color and both males and females can reach 30 mm in length [7]. This xylocope is found in several African countries including the Congo, Cameroon, Gabon and Nigeria [8]. The female digs a gallery in the dead wood, which she divides into ten cells by partitions of sawdust agglutinated with saliva [7]. In each cell, she lays an egg on a small ball of pollen mixed with nectar [7, 9]. She likes to live in artificial nests made of cut bamboo stems or wooden blocks pierced with holes [7]. She forages by affinity the Fabaceae [10].

Mimosa pudica is a creeping plant 10 to 40 cm in height [11]. It can reach two meters in horizontal extension [11]. The stems are erect when the plant is young but become creeping with age; they are cylindrical, full and more or less strewn with weakly curved thorns [11]. The foliage is generally evergreen; the leaves are petiolate, alternate, compound and bipinnate [11]. The very numerous flowers consist of a tiny calyx and a corolla with four fused petals, campanulate 2 to 3 mm [11]. The fruit is a linear-oblong; almost flat pod measuring between 1 and 2 cm in length and 3 mm in width, with hairs at the edges [11]. Pods are attached in groups of 2 to 8 [11]. The root system consists of a deep, strong taproot and large fibrous roots with nodules [11].

Bees usually increase the fruit and seed yields of plants species through pollination [12, 13, 14, 15, 16, 17, 18, 19].

The main objective of this research undertaken in Douala in 2014 and 2015 was to increase the knowledge in the relationships between carpenter bees and *M. pudica*. This is essential for an efficient management of this plant. Specific objectives include: (1) the registration of the activity of *X. torrida* on *M. pudica* inflorescences; (2) the evaluation of the apicole value of this plant; (3) the evaluation of the impact of flowering insects on pollination, on pods and seeds yields of this Fabaceae, and (4) the estimation of the pollination efficiency of *X. torrida* on *M. pudica*.

Materials and methods

Study site and biological material

The experiment was carried out during raining season, from May to June 2014 and 2015 at Yassa, a quater of Douala in the Littoral Region of Cameroon located between the 2nd and the 5th degree of North latitude and between the 7th and 12th degree of East longitude. It covers 20 239 km^2 and belongs to the ecological known as the monomodal rainfall zone [20]. The climate is of the cameroonian equatorial coastal subtype, characterized by a short dry season (December to February) and a long rainy season (March to November). According to [21]., the mean annual rainfall is about 4000 mm. The extreme temperatures vary to 22 °C from 24 °C for the minima and from 30 °C to 32 °C for the maximum [22]. The mean annual relative humidity is 100%. Plants chosen for observations were located at three km away in diameter, centered on experimental field. This hive is located at 4°00.469'N, 9°48.648'E and 15 m above sea level. The number of honeybee colonies located in this area varied from 1 in May 2014 to 2 in June 2015. The vegetation was represented by ornamental hedge and native plants of the equatorial forests.

Methods

Estimation of the frequency of *Apis mellifera* visiting inflorescences of *Mimosa pudica*

From 2nd to 3rd June 2014, we made 60 quadrats of 1 m^2 of flowering *M. pudica*. Out of these plants, 290 inflorescences with flowers at the bud stage were labelled among which 120 were left unattended (treatment 1) and 120 bagged (treatment 2) to prevent visitors. On June 1st 2015, 290 inflorescences of *M. pudica* with flowers at the bud stage were labelled among which 50 were left for unlimited visits (treatment 3). The frequency of *X. torrida* in the inflorescences of *M. pudica* was determined based on observations on inflorescences of treatment 1 and treatment 3, every day, from June 2nd to June 15th 2014 and from June 3rd to June 15th 2015, at 6 – 7h, 7 – 8h, 8 – 9h, 9 – 10h. In a transect walks along all labelled inflorescences treatment 1 and treatment 3, the character of all insects visiting *M. pudica* was recorded. Specimens of all insect taxa were caught with insect net and conserved in 70% ethanol for subsequent taxonomy identification. All insects met on inflorescences were registered and the cumulated results expressed in number of visits to determine the relative frequency of *X. torrida* in the anthophilous entomofauna of *M. pudica*.

Adding to the determination of the floral insects' frequency, straight observations of the foraging activity on flowers were made on insect pollinator fauna in the experimental field. The floral products (pollen) collected by *X. torrida* during floral visit were recorded based on its foraging behavior. Pollen gatherers scratched the anthers with their mandibles or legs. During each sampling day, the number of opened flowers carried by each labelled inflorescence was counted. During the same days, as for the frequency of visits, the duration of individual flower visits was recorded (using a stopwatch) for the following time frames: 6 – 7h, 7 – 8h, 8 – 9h, 9 – 10h. Furthermore, the number of pollinating visits during which the bee came into contact with the stigma, the abundance of foragers or the highest number of individuals foraging simultaneously on a flower or on 1000 flowers: [23] and the foraging speed as the number of flower visited by a bee per min as described by [24, 25] were evaluated. The interruption of the activity of foragers by competitors or predators and the attractiveness exerted by other plant species on *X. torrida* were also assessed.

A mobile thermo-hygrometer was used to register the temperature and the relative humidity in the experimental site during the investigation periods.

Evaluation of the effect of *Xylocopa torrida* and other insects on *Mimosa pudica* yields

The estimation was founded on the impact of flowering insects on pollination, the result of pollination on fructification of *M. pudica*, and the comparison of yields (mean number of fruit per inflorescence, mean number of seed per fruit and proportion of normal seeds) of treatment X (unlimited Inflorescences) and treatment Y (bagged inflorescences). The mean number of fruit per inflorescence due to the influence of foraging insects (F_{ri}) was calculated by the formula: $F_{ri} = \{[(Fr_X – Fr_Y) / Fr_X] * 100\}$ where Fr_X and Fr_Y were the mean number of fruit per inflorescence in treatment X and treatment Y. The mean number of seeds per fruit and the percentage of normal seeds per fruit were then calculated for each treatment. The positive influence of flowering insects on seed yields was evaluated using the same method as mentioned above for mean number of fruit per inflorescence [23].

Assessment of the pollination efficiency of *Xylocopa torrida* on *Mimosa pudica*

At the same moment of the constitution of treatments 1 and 2, 50 inflorescences were isolated (treatment 5) as those of treatment 2. Parallel to the make-up of treatments 3 and 4, 50 inflorescences were isolated (treatment 6) as those of treatment 4. Between 7 am and 13 pm of each investigation date, the gauze bag was delicately removed from each inflorescence carrying new opened flowers, the inflorescence were observed for up to 20 minutes and then protected again.

The role (Fr_a) of *X. torrida* in the fructification was calculated by the formula: $Fr_a = \{[(Fr_Z – Fr_Y) / Fr_Z] * 100\}$, where Fr_Z and Fr_Y are the mean number of fruit per inflorescence in treatment Z (bagged inflorescences and flowers visited exclusively by *X. torrida*) and treatment Y (bagged inflorescences). At maturity, fruits were harvested from treatment 5 and treatment 6 and the number of fruit per inflorescence counted. The mean number of seeds per fruit and the proportion of normal seeds were then calculated for each treatment. The impact of *X. torrida* on seed yields was also gauged using the same method as mentioned above for number of fruit per inflorescence [23].

Data analysis

For data analyze we used descriptive statistics, student's t-test for the comparison of means between two samples, correlation coefficient (r) for the study of the association between two variables, chi-square (χ^2) for the comparison of percentages using SPSS statistical software and Microsoft

Excel programs.

Results

Frequency of *Xylocopa torrida* in the floral entomofauna of *Mimosa pudica*

In table 1, presenting about 212 and 189 visits of 11 and 12 insect species recorded on *M. pudica* inflorescences, respectively in 2014 and 2015, *X. torrida* was the first most represented insect with 79 visits (37.26%) and 63 visits (33.33%), respectively in 2014 and 2015. The difference between these two percentages is not significant ($\chi^2 = 0.68$; $df = 1$; $P > 0.05$). (Table 1). *X. torrida* was active on *M. pudica* inflorescences from 6 am and 13 pm, with a peak of visits between 10 am and 11 am in 2014 as well as in 2015 (Table 2).

Activity of *Xylocopa torrida* on *Mimosa pudica* inflorescences

Floral products harvested

From our field observations, *X. torrida* were found to collect pollen intensively and regularly on *M. pudica* inflorescences. From 79 and 63 visits recorded in 2014 and 2015 respectively, (100.00%) were devoted to exclusive pollen harvest. Pollen was harvested all scheduled time frame long.

Daily rhythm of visits

X. torrida foraged on *M. pudica* inflorescences during the whole daily flowering period, with a highest moment of activity situated between 10 and 11 am (Table 2). Climatic environments influenced the activity of *X. torrida* in the field of *M. pudica* (Table 2). In 2014, the correlation was positive and not significant ($r = 0.52$; $df = 3$; $P < 0.05$) between the number of *X. torrida* visits on *M. pudica* inflorescences and the temperature, while it was negative and not significant ($r = -0.49$; $df = 3$; $P < 0.05$) between the number of visits and relative humidity. In 2015, the correlation was negative and not significant ($r = -0.39$; $df = 3$; $P < 0.05$) between the number of *X. torrida* visits on *M. pudica* flowers and the temperature, while it was positive and highly significant ($r = 0.99$; $df = 3$; $P < 0.05$) between the number of visits and relative humidity (Table 2).

Rhythm of visits according to the flowering stages

Visit was most abundant on the research plot when the number of inflorescences carrying opened flowers was highest (table 3 and table 4). Moreover, we recorded a positive and very highly significant correlation between the number of *M. pudica* opened flowers and the number of *X. torrida* visits in 2014 ($r = 0.92$; $df = 10$; $P < 0.001$) as well as in 2015 ($r = 0.93$; $df = 9$; $P < 0.001$).

Abundance of *Xylocopa torrida*

In 2014, the uppermost mean number of *X. torrida* simultaneous in activity was 1 per inflorescence ($n = 54$; $sd = 17.69$) and 36.75 per 1000 inflorescences ($n = 79$; $sd = 17.02$; maxi = 83.33). In 2015, the equivalent numbers were 1 (n = 63; s = 0) and 38.93 ($n = 47$; $sd = 22.02$; maxi = 93.7). The difference is highly significant between the mean number of carpenter bees per 1000 inflorescences in 2014 and 2015 ($t = 3.13$; $ddl = 99$; $P < 0.01$; HS).

Duration of visits per inflorescence

In 2014, the mean duration of a visit was 1.33 seconds ($n = 290$; $sd = 0.77$), for pollen harvest. In 2015, the matching numbers were 1.38 sec ($n = 222$; $sd = 0.45$). The difference is highly significant between the duration of the visit to harvest pollen in 2014 and 2015 ($t = 9.64$; $ddl = 510$; $P < 0.001$; HS).

Foraging speed of *Xylocopa torrida* on *Mimosa pudica* inflorescences

On the research plot of *M. pudica*, *X. torrida* visited between 20 and 80 inflorescences /min in 2014 and between 2 and 100 inflorescences/min in 2015. The mean foraging speed was 39.31 inflorescences/min ($n = 61$; $sd = 14.83$) in 2014 and 37.56 inflorescences /min ($n = 60$; $sd = 14.91$) in 2015. The difference between these two means is highly significant ($t = 3.53$; $ddl = 119$; $P < 0.001$; HS).

Influence of neighboring flora

During the observation period, flowers of many others plant species growing near *M. pudica* were visited by *X. torrida*, for pollen. Amongst these plants were *Brachiara brizantha* (Poaceae), *Zea mays* (Poaceae), *Psidium guajava* (Myrtaceae), *Manihot esculenta* (Euphorbiaceae), *Oxalis barrelieri* (Oxalidaceae) and *Mimosa invisa* (Fabaceae).

Impact of *Xylocopa. torrida* and others anthophilous insects' activity on pollination and on the fruit and seed yields of *Mimosa pudica*

Foraging insect always check flowers and regularly contacted anthers and stigma. The flowering insect improved the pollination chance of *M. pudica*. The comparison of the amount of fruit per inflorescence (Table 5) shown that the differences observed are very highly significant between treatments 1 and 2 ($t = 1121.71$; $df = 3872$; $P < 0{,}001$) and treatments 3 and 4 ($t = 912.98$; $df = 3704$; $P < 0{,}001$). The difference between the treatments 1 and 3 was highly significant ($t = 223.06$; $df = 5075$; $P < 0.001$).

Therefore, in 2014, the number of fruit per inflorescence of unprotected inflorescences (treatment 1) was higher than that for protected inflorescences (treatment 2); whereas in 2015, the number of fruit per inflorescence of the unprotected inflorescences (treatment 3) was higher than that of protected inflorescences (treatment 4).

The percentage of number of fruit per inflorescence was 22.24% for treatment 1 and 10.31% for treatment 2 in 2014; the difference between these two treatments is very highly significant ($t = 1121.71$; $df = 3872$; $P < 0{,}001$); b) the percentage of number of seeds per fruit was 3.14% for treatment 1 and 2.99% for treatment 2 in 2014; the difference between these two treatments is very highly significant ($t = 779.98$; $df = 11975$; $P < 0.001$); c) the percentage of normal seeds was 96.41% for treatment 1 and 85.17% for treatment 2 in 2014; the difference between these two treatments is very highly significant ($\chi 2 = 492.27$; $df = 1$; $P < 0.001$).

The percentage of number of fruit per inflorescence was 20.42% for treatment 3 and 10.72% for treatment 4 in 2015; the difference between these two treatments is very highly significant ($t = 912.98$; $df = 3704$; $P < 0{,}001$); b) the fraction of number of seeds per fruit was 3.13% for treatment 3 and 2.92% for treatment 4 in 2015; the difference between these two treatments is very highly significant ($t = 328.05$; $df = 6050$; $P < 0.001$); c) the fraction of normal seeds was 97.25% for treatment 3 and 91.31% for treatment 4 in 2015; the difference between these two treatments is very highly significant ($\chi 2 = 199.59$; $df = 1$; $P < 0.001$).

Pollination efficiency of *Xylocopa torrida* on *Mimosa pudica*

X. torrida contacted anthers and carried pollen on all flowers. With this pollen, the carpenter bees flew frequently from

inflorescences to inflorescences. *X. torrida* came into contact with visited inflorescences during 100% of visits. Thus this bee highly increased the pollination possibilities of *M. pudica* inflorescences.

The comparison of the number of fruits per inflorescence (Table 3) showed that the differences observed were highly significant between the treatments 2 and 5 (χ^2 = 879.02; *df* = 2176; *P* < 0.001) and treatments 4 and 6 (χ^2 = 1083.49; *df* = 2396; *P* < 0.001). The difference between the treatments 5 and 6 was highly significant (χ^2 = 76.07; *df* = 2071; *P* < 0.001).

Therefore, in 2014, the number of fruits per inflorescence on protected inflorescences and visited exclusively by *X. torrida* (treatment 5) was higher than that of flowers protected during their opening period (treatment 2); similarly, in 2015, the number of fruits per inflorescence of inflorescences protected and visited exclusively by *X. torrida* (treatment 6) was higher than that of inflorescences protected during their opening period (treatment 4).

The comparison of the percentages of normal seeds (Table 3) has shown that the differences were highly significant between treatments 2 and 5 (χ^2 = 600.44; *df* = 6667; P < 0.001) and treatments 4 and 6 (χ^2 = 368.19; *df* = 7146; *P* < 0.001). The difference between treatments 5 and 6 was highly significant (χ^2 = 380.31; *df* = 6432; *P* < 0.001).

Thus, in 2014, the percentage of normal seeds of inflorescences protected and visited exclusively by *X. torrida* (treatment 5) was higher than that inflorescences protected during their opening period (treatment 2); in 2015, the percentage of normal seeds of inflorescences protected and visited exclusively by *X. torrida* (treatment 6) was higher than that of inflorescences protected during their opening period (treatment 4).

The proportion of the number of fruits per inflorescence due to *X. torrida* activity was 52.31% in 2014 and 53.17% in 2015. For all the inflorescences studied, the percentage of the number of fruits per inflorescence attributed to the influence of *X. torrida* was 52.74%.

The proportion of the normal seeds due to *X. torrida* was 5.68% in 2014 and 4.26% in 2015. For all the inflorescences studied, the percentage of the number of seeds per pod attributable to influence of *A. mellifera* was 4.97%.

In short, the influence of *X. torrida* on fruit and seeds yields was positive and higher significant.

Discussion

Activity of *Xylocopa torrida* on *Mimosa pudica* inflorescence

Our study indicates that *X. torrida* was the main floral visitors of *M. pudica* during the observation periods. Preliminary observations in Yaounde showed that *Xylocopa olivacea* [4] and *Chalicodoma cincta cincta* [4, 5] intensely and regularly harvested pollen from this plant. Nevertheless, in other parts of the world such as Colombia [26] and Poland [27], other carpenter bees *Bombus terrestris*, *Xylocopa barrival* and *Apis mellifera*, respectively, have been reported as the main floral visitors of *Phaseolus coccineus*. The attractiveness of *M. pudica* pollen could be partially explained by its reported high nutritional quality. According to [28] and [29] in Nigeria; [30] in Bénin; [31] in Ghana; [2] and [32] in Cameroon, pollen produced by *V. unguiculata* attracts various insects in natural conditions. The no significant difference between the speed visit of *X. torrida* for the two studied years could be explained by the few number of nests of this insect near the experimental plot in 2014 compared to that of 2015. In conformity with study by Pando, that shows a significant difference between the percentages of *X. calens* visits for the 2 years of study could be explained by the presence of the nest of this insect near the experimental plot.

The peak activity of *X. torrida* on *M. pudica* inflorescence was between 10 am and 11 am. This period correlates with the highest availability of pollen in *M. pudica* inflorescence. This result confirms other findings reported by [27] on *P. coccineus* flowers. The decrease activity observed 12.00 to 13.00 h could be explained by the increase of the temperature in the experimental field. Although, foragers preferred warm or sunny days for good floral activity [33], the enhanced temperature positively influenced the insect activity on foraged flowers. Also, rainfall has been documented as an environmental factor that can disrupt the floral insect activity [34].

The high abundance of *X. torrida* foragers on 1000 flowers and the positive and highly significant correlation between the number of *M. pudica* inflorescence bloom and number of *X. torrida* visits, underscore the attractiveness of *M. pudica* pollen with respect to this carpenter bee. In fact, weather during bloom was demonstrated to affect the abundance and foraging of pollinator insects [35, 36].

The disruptions of visits by others insects reduced the duration of certain *X. torrida* visits. This obliged some carpenter bees to visit more flowers during a foraging trip in order to maximize their pollen loads. Similar observations were made for *Apis mellifera* workers foraging on flowers of: *Entada africana* (Fabaceae) and *Psidium guajava* L. (Myrtaceae) [37]; *Croton macrostachyus* (Euphorbiaceae) and *Syzygium guineense* var. *guineense* (Myrtaceae) [38]; *Persea americana* (Lauraceae) and *Vitellaria paradoxa* (Sapotaceae) [39]; *Vigna unguiculata* (L.) (Fabaceae) [40] and in *Meliponula erythra* (Hymenoptera: Apidae) foraging on the flowers of *Dacryodes edulis* (Burseraceae) [41].

The carpenter bee foragers had a high affinity with respect to *M. pudia* compared to the neighboring plant species, indicating their faithfulness to this Fabaceae, a phenomenon known as «floral constancy»[42, 43].

Impact of *Xylocopa torrida* activity on the pollination and yields of *Mimosa pudica*

During the gathering of pollen on each flower, *X. torrida* carpenters frequently come into contact with the stigma. They could thus provoke auto-pollination by applying pollen of one flower on its own stigma. *X. torrida* foragers were also able to carry pollen with their furs, legs and mouth accessories. They could, consequently, carry the pollen from a flower of one plant to stigma of another flower of the same plant (geitonogamy) or to that of another plant (xenogamy).

The influence of *X. torrida* on pollination of *M. pudica* is speciously more realistic than its density per 1000 flowers and its foraging visits are high.

The positive and significant contribution of *X. torrida* in pods and seeds yields of *M. pudica* could be justified by the action of this carpenter bee on pollination. Our results agree with those obtained in United State of America [44] which showed that *P. vulgaris* flowers produce less seeds per pod in the absence of insect pollinators.

The contribution of *X. torrida* to *M. pudica* through its pollination efficiency was significantly higher than that of all insects on the exposed flowers. The weight of *X. torrida* played a positive part: when collecting pollen, *X. torrida* shook flowers; this movement could facilitate the liberation of

pollen by anthers, for the optimal occupation of the stigma. This phenomenon was also reported by [39] for *X. bariwal*, an efficient pollinator of *Phaseolus coccineus* according to these authors. Insects' visits were effective in increasing cross-pollination, for the reason that the flowers opened exclusively to *X. torrida* provided more pods, more seeds per fruit and of better shape than the bagged flowers, in agreement to previous results reported on *Cajanus cajan* [4, 45].

Table 1: Diversity of insects visiting *Mimosa pudica* inflorescences in 2014 and 2015, number and percentage of insects visits.

Insects			2014		2015	
Order	**Familly**	**Genus and Species**	**n_1**	**p_1 (%)**	**n_2**	**p_2 (%)**
Diptera	Muscidae	*Musca domestica*	2	0.94	1	0.53
	Syrphidae	(sp.1)	10	4.72	5	2.65
		(sp.2)	-	-	6	3.17
Hymenoptera	Apidae	*Xylocopa torrida*	79	37.26	63	33.33
		Xylocopa olivacea	9	4.25	17	8.99
		Xylocopa sp.	16	7.55	15	7.94
		Apis mellifera	53	25	54	28.57
	Halictidae	*Halictus* sp.	-	-	4	2.12
		Lasioglossum sp.	21	9.91	13	6.88
		Leuconomia granulata	8	3.77	6	2.83
	Megachilidae	*Chalicodoma* sp.	6	2.83	2	1.06
		Megachile sp. 1	5	2.36	3	1.58
		Megachile sp. 2	3	1.42	-	-
Total			212	100	189	100
Number of species			11 species		12 species	

n_1: number of visits on 120 inflorescences in 11 days, n_2: number of visits on 120 inflorescences in 10 days, p_1 and p_2: percentages of visits, $p_1 = (n_1 / 212) *100$, $p_2 = (n_2 / 189) *100$; comparison of percentages of *X. torrida* visits for two years: $\chi^2 = 0.68$; $df = 1$; $P > 0.05$; NS.

Table 2: Distribution of *Xylocopa torrida* visits on *Mimosa pudica* opened inflorescences during the day depending on the year and followed over 11 days in June 2014, then 10 days in 2015 at Yassa.

Years	**Saved settings**	**Daily periods**			
		6h – 7 h	**8h – 10 h**	**10h – 11 h**	**12h – 13 h**
2014	Number of visits	2	31	43	3
	Percentage of visits (%)	2.53	39.24	54.43	3.79
	Temperature (°C)	22	26.6	28.6	31.8
	Hygrometry (%)	92.6	86.6	74.2	65.9
2015	Number of visits	2	22	37	2
	Percentage of visits (%)	3.17	34.92	58.73	3.17
	Temperature (°C)	21.5	25.2	28.3	32.2
	Hygrometry (%)	110.6	100.4	78.2	65.6

For 2014, the temperature and hygrometry represent the means of two observations per hour and per day, for 11 days. For 2015, the temperature and hygrometry represent the means of two observations per hour and per day, for 10 days.

Table 3: Distribution of the number of *Mimosa pudica* opened inflorescences and the number of *Xylocopa torrida* visits from June 2 to 11 2014 in Yassa.

From June 1st to 13											
	01	02	03	04	05	06	07	08	09	10	11
Number of inflorescences	10	32	27	33	25	29	33	15	5	2	1
Number of *X. torrida* visits	0	1	3	5	11	14	19	16	7	2	1

Table 4: Distribution of the number of *Mimosa pudica* opened inflorescences and the number of *Xylocopa torrida* visits from June 1 to 13 2015 in Yassa.

From June 2nd to 11										
	02	03	04	05	06	07	08	09	10	11
Number of inflorescences	11	26	25	24	26	31	19	9	10	9
Number of *X. torrida* visits	1	1	6	8	10	16	11	6	3	1

Table 5: *Mimosa pudica* yields in different Treatments.

Years	**Treatments**	**Nf/i**		**Ns/f**		**Nsfr**	**Nns**	**Pns**
		m	***Sd***	***m***	***sd***			
2014	1(Fi)	22,24	10.21	3.14	0.46	8309	8011	96.41
	2(Pi)	10,31	05.10	2.99	0.55	3668	3124	85,17
	5(Iv *X. torrida*)	21,62	6.41	3.17	0.21	3011	2781	92.36
2015	3(Fi)	20,42	10.47	3.13	0.47	7724	7512	97.25
	4(Pi)	10,72	04.54	2.92	0.68	3725	3401	91.31
	6(Iv *X.torrida*)	22,89	6.35	3.05	0.22	3423	3326	97.16

Fi: free inflorescences, Pi: protected inflorescences, Iva: flowers visited exclusively by *X. torrida*, Nf/i: number of fruits per inflorescence, Ns/f: number of seeds per fruit, Nsfr: number of seeds formed, Nns: number of normal seeds, Pns: percentage of normal seeds.

Conclusion

On 13 insect species recorded on flowers of *M. pudica*, *X. torrida* was the most represented insect with 35.41% of 401 visits. This carpenter bee harvested intensely the pollen. The uppermost mean number of *X. torrida* simultaneous in activity per 1000 inflorescences was 37.84. The pollination efficiency of *X. torrida* has signicantly increase the number of fruits per inflorescence by 52.74%, the number of seeds per

pod by 4.97% and the percentage of the normal seeds by 6.90%. So, the investment management of *X. torrida* interms of nest provision at proximity of *M. pudica* field is worthy while for agronomists.

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