

Research Article

ROLE OF VISITS OF *CHALICODOMA CINCTA* (HYMENOPTERA: MEGACHILIDAE) ON BEAN (*PHASEOLUS VULGARIS*) FLOWERS AT SARH (CHAD)

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ABSTRACT

The role of visit of pollinator insect (*Chalicodoma cincta*) on the production of Bean (*Phaseolus vulgaris*, Rose variety), were studied at Sarh in September 2021 and 2022. The experiments were made on four treatments. The activity behavior of *Chalicodoma cincta* on the flower were appreciated to determinate its impact on the yield. Results indicate that among seven insect species recorded on flowers, *C. cincta* ranked first (31.41%) and harvested nectar. Throughout the importance of the flower visit, this insect provoked a significant increase of the podding rate (30.45 %), the mean number of seeds per pod (22.42 %) and the percentage of normal seeds (32.81%). The conservation and installation of *C. cincta* nests close the plantation fields is recommended to improve pod production.

Keywords: *Chalicodoma cincta*, *Phaseolus vulgaris*, Nectar, Pollination.

INTRODUCTION

Pollinators play an important role in sustainability and continuity of the ecosystem and agriculture (Klein *et al.*, 2007). Among the pollinators, about 80% of the commercial crops are pollinated by the insects (Free, 1993). The main group of these insect are the bees, wasps, butterflies, moths, flies and beetles (Kingha *et al.*, 2012). It is an ecosystem service in that wild pollinators, in particular wild bees, contribute significantly to the pollination of a large array of crops (Winfree *et al.*, 2008). The common bean, *Phaseolus vulgaris* is originated from America (Graham PH and Ranalli P, 1997). Bean plants came right 60 cm; the leaves alternate and compound

trifoliate (Ibarra-Perez *et al.*, 1999). 28-35 days after sowing the first flowers were appearing; the flower produces nectar/pollen which attracts insects (Debouck, 1991; Deli *et al.*, 2020; Douka C and Tchuenguem, 2013). Fabaceae flowers were reported to produce fewer seeds per pod in the absence of pollinators (Kingha *et al.*, 2012; Ibarra-Perez *et al.*, 1999). In Ngaoundere (Cameroon) the activities of *Xylocopa olivacea* on flowers of *P. vulgaris* (Bigarre variety) increase the fruiting rate by 39.48 %, the number of seeds/pod by 18.19 % and the normal seeds by 49.62 % (Deli *et al.*, 2020). Research conducted in Maroua in 2013 by Douka & Tchuenguem has revealed that *Apis mellifera* visits *P. vulgaris* (Red and Small Seeds variety)

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flowers for nectar and pollen and increase the fruiting rate by 55.32 %, the number of seeds/pod by 19.10 % and the normal seeds by 7.71 %. Cross-pollination of *P. vulgaris* by insects is generally observed (Deli *et al.*, 2020; Douka C and Tchuenguem, 2013) and this plant is autogamous/allogamous (Ibarra-Perez *et al.*, 1999; Deli *et al.*, 2020; Douka & Tchuenguem, 2013). Up to date, no previous research has been reported on the relationships between *P. vulgaris* Rose variety and *Chalicodoma cincta*. But, the activity and diversity of pollinators insects of a plant came vary with the period (Deli *et al.*, 2020). In Chad, *P. vulgaris* is consumed as vegetable or transformed into flour while, the stems and leaves are used to feed livestock; the domestic production is important (about 138 088 and 144 070 tons annually in 2015 and 2016 respectively) (Mainkété S *et al.*, 2019). Therefore, it is important to investigate on the possibilities of increasing the production of this plant by using insect. The main objective of this study was to contribute to analyze the relationships between *P. vulgaris* var. Rose and *C. cincta* for their optimal management. the objectives are: determine the percentage of visits of *C. cincta* in *P. vulgaris* flowers; study the activity of this Megachilidae; assess the important of flowering insects on seed production of this Fabaceae; evaluate the role of visit of this Megachilidae on *P. vulgaris*.

MATERIALS AND METHODS

Study site

The studies were conducted from June to September, in 2021 and 2022, in the Moyen-Chari (latitude of 09° 04.875'

N, a longitude of 018° 25.721' E, an altitude 363.3 m.a.s.l.). The ago ecological zone is Sudanian (annual rainfall is 1100 ± 105 mm, temperature is 28 ± 11 °C, humidity 58 ± 09 °C) (Madjimbé *et al.*, 2013), witch two seasons long dry season (November to April) and a short rainy season (May to October). The vegetation is diverse and varied (crops, ornamental, native plants and gallery forests). The experimental plot was an area of 437 m².

Biological materials

The animal material was represented by insects naturally present in the environment, nests of *Chalicodoma cincta* (Hymenoptera: Megachilidae) located close to the experimental field and seed of *P. vulgaris* Rose variety (Figure 1) collected in the surrounding of the Unit for Apply Apidology of the University of Ngaoundere, Cameroon.

Preparation of experimental plot

From 24th to 29th June 2021 and from 03rd to 06th July 2022, the experimental plot was delimited and divided into eight subplots (8*4.5 m²). On June 29th to July 07th 2021 and 2022, sowing was done on six lines per subplot, each of which had 16 holes per line (Mainkété *et al.*, 2019). Four seeds were sown per hole. Holes were separated 50 cm from each other, while lines were 75 cm apart (Figure 2). From germination to the development of the first flower, the field was regularly weeded with hoe and was performed manually as necessary to keep plots weed-free until the maturation of pods. A week after germination, the plants were thinned and only were left per hole.



Figure 1. Seeds of *Phaseolus vulgaris* Rose variety.



Figure 2. Field of *Phaseolus vulgaris* Rose variety.

Determination of the reproduction mode of *Phaseolus vulgaris*

On September 19th 2021, 240 flowers at bud stage were labeled and divided in two treatments: 120 unprotected flowers (treatment 1) (Figure 3) and 120 bagged flowers using gauze bags net to avoid all visits (treatment 2) (Figure 4). On September 16th 2022, the same treatments were performed (treatments 3 and 4). For each cropping year, a week after shedding of the last labeled flower, the number of pods was assessed in each treatment. The



Figure 3. Plant of *Phaseolus vulgaris* showing unprotected flower.

fruiting index (P_i) was then calculated as described by Tchuenguem (Mainkété *et al.*, 2019; Demarly Y, 1998): $P_i = Fb/Fa$, where Fa is the number of viable flowers initially set and Fb the number of the formed pods. The allogamy rate (Alr) from which derives the autogamy rate (Atr) was expressed as the difference in fruiting indexes between treatment X (unprotected flowers) and treatment Y (bagged flowers): $Atr = \{[(P_{iX} - P_{iY}) / P_{iX}] * 100\}$, where P_{iX} and P_{iY} are the fruiting indexes in treatments X and Y respectively; $Alr = 100 - Atr$.



Figure 4. Plant of *Phaseolus vulgaris* showing a flower isolated from insects.

Determination of the place of *Chalicodoma cincta* on *Phaseolus vulgaris* entomofauna

Observations were conducted on flowers of treatments 1 and 3, every day, from 19th to 25th September 2021 and from 16th to 22th September 2022. During each observation day, before starting visit counts, the number of opened flowers in each treatment was counted. Data were taken according to six daily time frames: 6 - 7 am, 8 - 9 am, 10 - 11 am, 12 - 13 pm, 14 - 15 pm and 16 - 17 pm. In a slow walk along all labeled flowers of treatments 1 and 3, the identity of insects that visited *P. vulgaris* flowers was recorded (Deli *et al.*, 2020). All insects encountered on flowers were registered and the cumulated results expressed as the number of visits to determine the relative frequency of each insect species in anthophilous entomofauna of *P. vulgaris* (Kingha *et al.*, 2012). Data obtained were used to determine the frequency of visits (F_i) of each insect species on *P. vulgaris* flowers. For each study period, $F_i = [(V_i / V_t) * 100]$, with V_i the number of visits of insect i on treatment with unprotected flowers and V_t the total number of insect visits of all recorded insect species on these flowers recorded (Mainkété *et al.*, 2019). Specimens (3 to 4) for all insect taxa, excluded were caught using insect net on unlabeled flowers and conserved in 70% ethanol, excluding butterflies that were preserved dry recorded (Demarly, 1988; Tchuenguem *et al.*, 2005) for subsequent taxonomic identification.

Study of the foraging activity of *Chalicodoma cincta* on *Phaseolus vulgaris* flowers

Floral product harvested

The floral products (nectar or pollen) harvested by *C. cincta* during each floral visit were recorded based on its foraging behavior. Nectar foragers were expected to extend their proboscis in the corolla, while pollen gatherers were supposed to scratch anthers using mandibles and legs. During the same time that *C. cincta* visits on flowers were registered, the type of floral product collected by this megachile was noted (Ibarra-Perez FJ · 1999; Graham PH, Ranalli P, 1997; Jacob-Remacle, 1989).

Duration of visits and foraging speed

During the same days of taking data on frequency of visits, the duration of individual flower visits was recorded (using stopwatch) according to six time frames: 7 - 8 am, 9 - 10 am, 11 - 12 am, 13 - 14 pm, 15 - 16 pm and 17 - 18 pm. The stopwatch, previously on zero was switched on as soon as an insect landed on a flower. It was stopped when the insect leaves the flower. The related duration of visit corresponds to the red value on the stop watch (Tchuenguem, 2004). Moreover, the number of visits during which the megachile came into contact with the stigma (Tchuenguem, 2005) was registered. Concerning the

foraging speed (F_s) which is the number of flowers visited by an individual megachile per minute (Tchuenguem, 2004), data were registered during the same dates and according to same time frames and daily period as for duration of visits. The stopwatch, previously on zero was switched on as soon as an insect landed on a flower and stopped when it disappears. Concomitantly, the number of visited flowers was counted. The foraging speed was calculated using the following formula: $F_s = (N_f / d_v) * 60$, where d_v is the time (sec) given by a stopwatch and N_f the number of flowers visited during d_v . During the observation period, when a forager returns to previously visited flower, counting is performed as two different flowers (Mainkété, 2009).

Abundance per flower and per 1000 flowers

The abundance of foragers (highest number of individuals foraging simultaneously) per flower and per 1000 flowers ($A1000$) were recorded on the same dates and daily periods as the registration of duration of visits. Abundance per flower was recorded as a result of direct counting. For determining the abundance per 1000 flowers, foragers were counted on a known number of opened flowers and $A1000$ was calculated using the following formula: $A1000 = [(A_x / F_x) * 1000]$, where F_x and A_x are respectively the number of flowers and the number of foragers effectively counted on these flowers at time x (Jacob-Remacle, 1989).

Evaluation of the impact of the flowering insects including *Chalicodoma cincta* on *Phaseolus vulgaris* yields

Parallel to the constitution of treatments 1, 2, 3 and 4, 600 flowers at bud stage were protected in 2021 and 2022 and two treatments were formed: - Treatment 5: In 2021, 200 flowers were protected using gauze bag nets to prevent insect visits and destined to be visited exclusively by *C. cincta*. In 2022, the same treatment was performed (treatment 7). As soon as the flowers were opened, each flower of treatments 5 and 7 were inspected. Hence, gauze bag was delicately removed and this flower was observed for up to 10 minutes; the flowers visited by *C. cincta* were marked and then reprotected.- Treatment 6: In 2021, 100 flowers were protected using gauze bag nets and destined to be uncovered then rebagged without the visit of insects or any other organism. In 2022, the same treatment was performed (treatment 8). As soon as each flower of treatments 6 and 8 was opened, the gauze bag was removed and the flower was observed for up to 10 minutes while avoiding the visit by *C. cincta* or any other organism.

At maturity, pods were harvested and counted from each treatment. The mean number of seeds per pods, the percentage of normal (well developed) seeds (Kingham *et al.*, 2012) were then evaluated. For each observed year, the fruiting rate due to the flowering insects including *C. cincta* (P_{ri}) was calculated using the following formula: $P_{ri} = \{[(P_X - P_Z) / (P_X + P_Y - P_Z)] * 100\}$ (Diguir *et al.*, 2020; Adamou *et al.*, 2020) where P_X , P_Y and P_Z are the fruiting rates in treatment X (flowers left in free pollination),

treatment Y (flowers protected from all insect visits) and treatment Z (flowers bagged then uncovered and rebagged without insect or any other organism visit). The fruiting rate of a treatment (P_r) is given by the following formula: $P_r = [(b / a) * 100]$, where a is the number of viable flowers initially set and b the number of formed pods. The impact of flower visiting insects including *C. cincta* on the number of seeds per pods and the percentage of normal seeds were evaluated using the same method as mentioned above for the fruiting rate.

Assessment of the pollination efficiency of *Chalicodoma cincta* on *Phaseolus vulgaris*

The contribution of *C. cincta* on the fruiting rate, the number of seeds per pods and the percentage of normal seeds was calculated using the data of treatments 5 and 6 for 2021 and those of treatments 7 and 8 for 2022. For each observed year, the contribution of *C. cincta* on the fruiting rate (P_{rX}) was calculated using the following formula: $P_{rX} = \{[(P_C - P_Z) / P_C] * 100\}$, where P_C is the fruiting rate in treatment C (flowers visited exclusively by the *C. cincta* individuals) and P_Z is the fruiting rate in treatment Z (uncovered flowers then rebagged without the visit of insects or any other organism)^[16, 17]. The impact of *C. cincta* on the number of seeds per pods and the percentage of normal seeds were evaluated using the same method as mentioned above for the fruiting rate.

Data analysis

Data were analyzed using descriptive statistics (means, standard deviation and percentages), ANOVA (F) for the general comparison of means of more than two samples, student's t -test for the comparison of means of two samples, Pearson correlation coefficient (r) for the study of the association between two variables and chi-square (χ^2) for the comparison of percentages, using Microsoft Excel 2013 software and R commander version i386 3.2.0.

RESULTS AND DISCUSSION

The podding indexes of *P. vulgaris* were 0.68, 0.26, 0.83 and 0.37 for treatments 1, 2, 3 and 4 respectively (Table 1). Thus, in 2021, the autogamy rate was 14.42 %, whereas the allogamy rate was 62.2 %. In 2022, the corresponding figures were 16.51 % and 55.55 %. For the two cumulative years, the autogamy rate was 15.47 % and the allogamy rate was 58.88 %. It appears that *P. vulgaris* Rose variety has a mixed reproduction mode with the predominance of allogamy over autogamy. Amongst the 263 and 275 visits of seven insect species recorded on its flowers in 2021 and 2022 respectively, *Chalicodoma cincta* ranked first with 78 (29.66%) and 91 (33.09%) visits in 2021 and 2022 respectively (Table 2). The difference between these two percentages is not significant ($\chi^2 = 1.06$; $df = 1$; $P > 0.05$). During each flowering period, individuals of *C. cincta* were found (Fig 5) to harvest intensively and exclusively nectar on *P. vulgaris* flowers. In 2021 and 2022 the mean duration of *C. cincta* visit per flower was 5.89 sec ($n = 106$; $s =$

3.42; *maxi* = 12) and 4.87 sec (*n* = 98; *s* = 2.16; *maxi* = 15) respectively. The difference between these two means is highly significant (*t* = 17.92; *df* = 202; *P* < 0.001). This difference could be explained by the availability of nectar

in the visited flowers or the variation of diversity of flowering insects from one year to another. For the two cumulated years the mean duration per flower was 5.38 sec.

Table 1. Allogamy and autogamy rates of *Phaseolus vulgaris* in 2021 and 2022.

Years	Treatments	Number of flowers	Number pods	Podding indexes	Autogamy rate	Allogamy rate
2021	1 (unprotected flowers)	120	82	68.33	14.42	62.2
	2 (bagged flowers)	120	31	25.83		
2022	3 (unprotected flowers)	120	99	82.5	16.51	55.55
	4 (bagged flowers)	120	44	36.67		
Total		480	256	53.33	15.47	58.88

Table 2. Diversity of insects on *Phaseolus vulgaris* flowers in 2021 and 2022 at Doyaba, number and percentage of visits of different insects.

Ordre	Insects		2021		2022		2021 / 2022		
	Family	Genus and species	<i>n</i>	<i>p</i> (%)	<i>n</i>	<i>p</i> (%)	<i>n</i>	<i>p</i> (%)	
Hymenoptera	Apidae	<i>Amegilla</i> sp. (Ne)	67	25.48	57	20.72	124	23.05	
		<i>Apis mellifera</i> (Ne, Po)	21	7.98	29	10.55	50	9.29	
		<i>Xylocopa inconstans</i> (Ne)	45	17.11	52	18.91	97	18.03	
		<i>Xylocopa olivacea</i> (Ne)	36	13.69	31	11.27	67	12.45	
		Megachilidae	<i>Chalicodoma cincta</i> (Ne)	78	29.66	91	33.09	169	31.41
			<i>Chalicodoma rufipes</i> (Ne)	14	5.32	11	4	25	4.65
Lepidoptera	Pieridae	<i>Eurema</i> sp. (Ne)	2	0.76	4	1.45	6	1.11	
Total		7 species	263	100	275	100	538	100	



Figure 5. *Chalicodoma cincta* collecting nectar in a *Phaseolus vulgaris* Rose variety flower at Doyaba.

*n*₁ and *n*₂: number of visits on 120 flowers in 12 days, *p*₁ and *p*₂: percentages of visits, *p*₁ = (*n*₁/263) * 100; *p*₂ = (*n*₂/275) * 100. Comparison of percentages of *Chalicodoma cincta* is its (2021/2022): $\chi^2 = 1.06$; *df* = 1; *P* > 0.05; Ne: collection of nectar; Pe: collection of pollen; sp.: unidentified species. In 2021 and 2022 the mean duration of *C. cincta* visit per flower was 5.89 sec (*n* = 106; *s* =

3.42; *maxi* = 12) and 4.87 sec (*n* = 98; *s* = 2.16; *maxi* = 15) respectively. The difference between these two means is highly significant (*t* = 17.92; *df* = 202; *P* < 0.001). This difference could be explained by the availability of nectar in the visited flowers or the variation of diversity of flowering insects from one year to another. For the two cumulated years the mean duration per flower was 5.38 sec.

In 2021, the highest mean number of *C. cincta* simultaneously in activity was 1 per flower ($n = 184$; $s = 0.79$) and 191 per 1000 flowers ($n = 196$; $s = 98.97$; $maxi = 128$). In 2022, the corresponding figures were 1 ($n = 171$; $s = 0.4$) and 153 ($n = 308$; $s = 14.06$; $maxi = 102$). The difference between the mean number of foragers per 1000 flowers in 2021 and 2022 was highly significant ($t = 72.46$; $df = 502$; $P < 0.001$).

During nectar harvest on *P. vulgaris*, some foraging insects always shake flowers and contact anthers and stigma, increasing the cross-pollination possibilities of this Fabaceae. The comparison of the podding rate (Table 3) showed that the differences observed were highly significant between treatments 1 and 2 ($\chi^2 = 43.50$; $df = 1$; $P < 0.001$) and treatments 3 and 4 ($\chi^2 = 52.34$; $df = 1$; $P < 0.001$). Consequently, in 2021 and 2022, the podding rate of unprotected flowers (treatments 1 and 3 respectively) was higher than that of flowers protected during their flowering period (treatments 2 and 4 respectively). The comparison of the mean number of seeds per pod (Table 3) showed that the difference observed were highly significant between treatments 1 and 2 ($t = 12.27$; $df = 904$; $P < 0.001$) and treatments 3 and 4 ($t = 3.21$; $df = 121$; $P < 0.001$). As a matter of fact, in 2021 and 2022, the mean number of seeds per pod in opened flowers was higher than that of flowers bagged during their flowering period. The comparison of the percentage of normal seeds (Table 3) showed that the difference observed were highly significant between treatments 1 and 2 ($\chi^2 = 23.08$; $df = 1$; $P < 0.001$) and treatments 3 and 4 ($\chi^2 = 72.40$; $df = 1$; $P < 0.01$). Hence, in 2021 as well as 2022, the percentage of normal seeds of exposed flowers was higher than that of flowers bagged during their flowering period. In 2021, the numeric contributions of anthophilous insects on the podding rate, the mean number of seeds per pod and the percentage of normal seeds were 62.20%, 27.49% and 26.25% respectively. In 2022, the corresponding figures were 55.56%, 3.42% and 62.09% respectively. For the two cumulate years, the numeric contributions of flowering insects were 58.88%, 15.46% and 44.17% on the podding

rate, the number of seeds per pod and the normal seeds, respectively.

During the nectar harvest from flowers, individuals of *C. cincta* were always in contact with the stigma and the anthers. Thus, this megachile highly increased the pollination of *P. vulgaris* flowers. The comparison of the podding rate (Table 3) shows that the differences observed were significant between treatments 5 and 6 (17.59 ; $df = 1$; $P < 0.01$) and no significant between treatments 7 and 8 ($\chi^2 = 4.20$; $df = 1$; $P > 0.05$). Hence in 2021 and 2022 the podding rate of flowers exclusively visited by *C. cincta* (treatment 5 and 7 respectively) was significantly higher than that of flowers bagged, opened and closed without insect or any other organism visit during their flowering period (treatment 6 and 8 respectively). The comparison of the mean number of seeds per pod (Table 3) showed that the difference observed were highly significant between treatments 5 and 6 ($t = 32.68$; $P < 0.001$) and treatments 7 and 8 ($t = 2.69$; $P < 0.01$). For the two years, the difference was highly significant between the mean number of seeds per pod of flowers bagged and visited exclusively by *C. cincta* (treatment 5 and 7 respectively) and those of flowers bagged, then opened and closed without insect or any other organism visit (treatment 6 and 8 respectively). The comparison of the percentage of normal seeds (Table 3) showed that the differences observed were highly significant between treatments 5 and 6 ($\chi^2 = 20.06$; $df = 1$; $P < 0.001$) and significant treatments 7 and 8 ($\chi^2 = 22.11$; $df = 1$; $P < 0.05$). Hence, in 2021 as well as in 2022, the percentage of normal seeds of flowers exclusively visited by *C. cincta* (treatment 5 and 7 respectively) was significantly higher than that of flowers bagged, opened and closed without insect or any other organism visit during their opening period (treatment 6 and 8 respectively). In 2021, the numeric contributions of *C. cincta* on the podding rate, the number of seeds per pod and the normal seeds via a single flower visit were 39.53%, 29.58% and 37.15% respectively. In 2022, the corresponding figures were 21.37%, 15.26% and 28.48% respectively. For the two cumulate years, the corresponding figures were 30.45%, 22.42% and 32.81% respectively.

Table 3. Podding rate, mean number of seeds per pod and the percentage of normal seeds according to the different treatments of *Phaseolus vulgaris* in 2021 and 2022 at Doyaba.

Years	Treatments	NF	NP	PrR (%)	Number of seeds / pods		TNS	NS	% NS
					<i>m</i>	<i>df</i>			
2021	1 (UF)	120	82	68.33	3.42	1.82	295	251	85.08
	2 (Pf)	120	31	25.83	2.48	1.37	102	64	62.75
2022	3 (UF)	120	99	82.5	3.80	1.33	386	298	77.20
	4 (Pf)	120	44	36.67	3.67	0.94	82	24	29.27
2021	5 (FPvCc)	200	129	64.5	4.09	0.94	377	241	63.93
	6 (Fpwv)	100	39	39	2.88	1.52	112	45	40.18
2022	7 (FPvCc)	200	117	58.5	2.49	1.66	409	307	75.06
	8 (Fpwv)	100	46	46	2.61	0.78	136	73	53.68

NF: number of flowers; NP: number of pods; PrR: podding rate; TNS: total number of seeds; NS: number of normal seeds; %NS: percentage of normal seeds; *m*: mean; *df*: standard deviation; Uf: unprotected flowers; Pf: protected flowers; FpvCc: flowers visited exclusively by *Chalicodoma cincta*; Fpww: flowers bagged then uncovered and rebagged without visit by insect or any other organism.

Results obtained from these experiments indicated that *P. vulgaris* has a mixed reproduction mode that is allogamous-autogamous with the predominance of allogamy over autogamy. The same result has been obtained by Kingha *et al.*, 2012 at Ngaoundéré in Cameroon, indicating that autogamy predominates over allogamy to *P. vulgaris*. At Doyaba in Chad according to (Mainkété *et al.*, 2019) allogamy predominates over autogamy to this plant species. *Chalicodoma cincta* was the first insect visitor of *P. vulgaris* flowers with 29.66 and 33.09 % respectively in 2021 as well in 2022 in this observation in Thad. The significant difference between the two percentages of *C. cincta* visit for the two study years could be the consequence of climatic factors and seasonal variations in flower resources availability. It can also be attributed to the variation of the number of *C. cincta* nests in the study site from one year to another (seven nests in 2021 and nine in 2022). Similar observations have revealed that *A. mellifera* was the most frequent insect visitors on flowers of *P. vulgaris* after *X. olivacea* (Graham PH, Ranalli P, 1997) and *Chalicodoma calens* (Douka, 2019) at Dang and at Maroua in Cameroon respectively.

Chalicodoma cincta intensely and exclusively collected nectar. The high abundance of foragers per 1000 flowers, underscores the attractiveness of *P. vulgaris* nectar for *C. cincta*. This attractiveness could be partially explained by its high production and the accessibility of these products (Deli, 2020; Douka, 2013; Mainkété *et al.*, 2019). The significant difference observed between the duration could be explained by the accessibility or availability of each of these floral products or the variation of diversity of flowering insects in 2021 and in 2022. Pollen is produced by the anthers, which are on the top of the stamen and are thus easily accessible to *C. cincta* whereas nectar is between the base of style and stamens and is thus less accessible. The weight of *C. cincta* played a positive role: when collecting nectar, by shaking flowers. This movement could facilitate the liberation of pollen by anthers, for the optimal occupation of the stigma. This phenomenon was also reported by Deli *et al.*, 2020 for *X. olivacea* on flowers of the same plant species at Ngaoundéré.

The higher productivity of pods and seeds in unlimited flowers when compared with bagged flowers showed that insect visits were effective in increasing cross-pollination. Our results confirmed those of (Douka & Tchuenguem, 2013) who revealed that *P. vulgaris* flowers set little pods in the absence of insect pollinators. Similar experiments observed in Ngaoundéré and in (Mainkété *et al.*, 2019) have shown that pollination by

insects was always needed. Thus, pollination requirements may be different between regions. During the collection of nectar on each flower, *C. cincta* individuals regularly come into contact with the stigma and anthers. They were also able to carry pollen with their hairs, legs and mouth accessories from a flower of one plant to stigma of another flower of the same plant (geitonogamy), to the same flower (autogamy) or to that of another plant (xenogamy). The foragers can thus influence self-pollination and cross-pollination (Tchuenguem, 2005). This has also been observed by others studies such as on *A. mellifera* at (Diguir *et al.*, 2020; Douka, 2013; Adamou *et al.*, 2020) in Cameroon.

CONCLUSION

The results obtained from this study reveal that *Phaseolus vulgaris* is a plant that highly benefits from the pollination by insects. *Chalicodoma cincta* is the efficient insect of common bean and harvests only nectar. The comparison of pods and seed sets of flowers visited exclusively by *C. cincta* with those of flowers bagged then opened and rebagged without visit of this megachile or any other organism underscores the value of *C. cincta* in increasing the fruiting rate, the mean number of seeds per pods and the percentage of normal seeds of *P. vulgaris*. Thus, the conservation and installation of *C. cincta* nests close to *P. vulgaris* is recommended to improve its pods production as well as seed quality and to stabilize the population of this megachile in the Moyen-Chari province.

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