World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Diversity of flowering insects of *Jatropha gossypiifolia* L. 1753 (Euphorbiaceae) in Maroua (Far North, Cameroon)

Barbara Kayaoda Tchabra [1,*], Clemence Ndiklai Fango [1] and Denis Djonwangwe [2]

[1] *Laboratory of Biological Sciences, Faculty of Sciences, University of Maroua, P.O.: 814 Maroua, Cameroon.*
[2] *Laboratory of Life and Earth Sciences, Ecole Normale Supérieure, University of Maroua, BP 55 Maroua, Cameroon.*

World Journal of Advanced Research and Reviews, 2026, 30(02), 133-144

Publication history: Received on 15 March 2026; revised on 26 April 2026; accepted on 28 April 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.2.1086

Abstract

In order to determine the floricultural entomofauna of *Jatropha gossypiifolia*, flowers were observed in 2022 and 2023 in Maroua (Far North, Cameroon). From July 24 to August 01, 2022 and from July 19 to 29, 2023 in Maroua, 120 floral bouquets (at a rate of 60 bouquets for each year of observation) labeled and left in free pollination were observed, the different species of insects visiting the flowers of *J. gossypiifolia*, the relative frequency of visits, the food products sought, the daily regularity of the various species of flowering insects and their abundances per flower and per 1000 flowers were determined. In 2022 and 2023, the diversity of flowering insects of *J. gossypiifolia* was 33 and 23 species of insects respectively in Maroua. Most insects visited the flowers of this plant species for nectar and/or pollen, only *Calidea panethiopica* visited the blooming flowers and flower buds to suck the sap from the plant. The most common insects were *Seladonia* sp., *Apis mellifera, Lipotriches hylaeooides* and *Belonogaster juncea* with a relative frequency of 30.49%, 19.44%, 7.61% and 5.91% respectively. The peak of activity of all insects was between 12 p.m. and 1 p.m. The abundance was one individual per flower for all insect species. The mean abundance per 1000 flowers was 28.86 in *Apis mellifera*, 42.21 in *Seladonia* sp. and 29.99 in *Belonogaster juncea*. Growers of *J. gossypiifolia* who wish to control *Calidea panaethiopica* to avoid the period of activity of other floricultural insects during insecticide treatments.

Keywords: Diversity; Floricultural Insects; *Jatropha gossypiifolia*; Maroua; Nectar; Pollen

1. Introduction

Jatropha gossypiifolia L. is an erect, monoecious, softwood perennial shrub that averages 2.5 m in height but exceeds 4 m in some areas [1].The leaves are sticky, covered with extra-floral nectaries, deeply trilobed and bronze when juvenile but green when mature [1]. The inflorescence is a cyme opposite the leaves, with sparse flowers, with solitary female flowers at the end of each main axis, the male flowers in lateral cymules. The peduncle up to 6 cm long, briefly hairy; The small red flowers with a yellow center are unisexual and appear in clusters. Various parts of *J. gossypiifolia* are used in traditional medicine. The seeds and fruits are used against influenza but also as a laxative [2], sedative, analgesic or anti-diarrhoeal [3]. In addition to its use as a biofuel, *J. gossypiifolia* is also used to treat wounds, ulcers, eczema, dermatomycosis, scabies, and venereal diseases [4].

To our knowledge, the only published work on the entomofauna of *J. gossypiifolia* is that of [5] in India. From this work, it appears that the foraging insects of the flowers of this Euphorbiaceae are recruited in three orders: the Hymenoptera (*Trigona* sp., *Apis florea, Apis cerana indica, Scolia cruenta, Rhynchium metallicum, Ropalidia spatulata*); the Diptera (*Sarcophaga orchidea, Rhyncomya viridaurea*) and the Lepidoptera (*Catopsilia crocale*). This work aims to identify the flowering insects of this Euphorbiaceae in Maroua in order to use these data later in the preservation of beneficial insects. It includes two specific objectives:

* Corresponding author: Kayaoda Tchabra Barbara

- Determine the diversity of flowering insects of *J. gossypiifolia*;
- study their foraging activities.

2. Material and methods

2.1. Study site

The study took place from July to August 2022 and 2023 in Maroua, Diamaré Department, Far North Region of Cameroon.

The study station is a field belonging to a farmer centered on the point of geographical coordinates: 10°36'4.13136''N Latitude, 14°18'31.79016''E Longitude and 403 m Altitude. The choice of this study station is justified by the availability of *Jatropha gossypiifolia* plants, whose flowers are accessible to the observer.

The climate is of the Sudano-Sahelian type characterized by two seasons: a long dry season (November to May) and a short rainy season (June to October) [6]. August is the rainiest month [6]. Rainfall varies between 400 and 1100 mm; the annual temperature varies between 29 and 38 °C, with a daily temperature range of between 6 and [6].

2.2. Equipment

The plant material was represented by the feet of *J. gossypiifolia* planted by a peasant as a living hedge.

The animal material consisted of insects naturally present in the environment and which visited the flowers of *J. gossypiifolia.*

2.3. Methods

2.3.1. Determination of the diversity and relative frequency of flowering insects of Jatropha gossypiifolia in Maroua

The observations were made every day, from July 24 to August 1, 2022 and from July 19 to July 29, 2023, according to six time slots: 6 – 7 a.m., 8 – 9 a.m., 10 – 11 a.m., 12 – 1 p.m., 2 – 3 p.m. and 4 – 5 p.m. The observer passed once over each labelled bouquet and this during each of the above time slots. At each visit, the different insects encountered on the flowers were codified and the number of visits counted. As insects were not tagged, the cumulative results were expressed by the number of visits [7]. All the different species of insects recorded on the flowers constituted the diversity of the entomofauna of *J. gossypiifolia*. The data obtained were used to determine the frequency of each insect species (Fx) on the flowers of *J. gossypiifolia*. For each year of study, Fx = {[Vx /Vy]*100}, with Vx = number of visits by insect x on labelled flowers and Vy the number of visits by all insects on these same flowers [8].

Two to five insects (per species) active on the flowers of *J. gossypiifolia* were captured by hand or entomological net. In the field, captured insects were kept in vials containing 70% ethanol, with the exception of Lepidoptera which were kept in packets, as recommended by [9] for later determination using identification keys [9, 10, 11]. Shannon's diversity indices (H) and Simpson's index (D) were calculated

Shannon's index (H')

$$H' = -\sum_{i=1}^{S} Pi\ lnPi$$

Where i: a species of the study environment; Pi: proportion of a species i in relation to the total number of species (S) in the study medium, which is calculated as follows: P(i)=ni/N; Where ni is the number of individuals for species i and N is the total number of all species. H' is minimal (H'=0) if all individuals in the stand belong to one and the same species or if each species in a stand is represented by a single individual [12] cited by [13]. The index is highest when the distribution of individuals of all species is equally present (Frontier 1983) [14].

The Simpson index (D) measures the probability of two randomly selected individuals belonging to the same species. If D= 0 then we have a maximum of diversity and if D=1 we will have a minimum of diversity. It is calculated by the formula:

$$D = \frac{\sum_{i=1}^{n} ni(ni-1)}{N(N-1)}$$

ni = number of individuals of the given species; N = total number of individuals.

2.3.2. Study of foraging activity

Floral products collected

The aim was to note whether the visiting insect was collecting pollen, nectar or both foods from a *J. gossypiifolia* flower. An insect that sinks its mouthparts or head deep into the corolla of a flower is a nectar forager; if it scratches the anthers with its mandibles and/or legs, it is a pollen forager [15]. Collected pollen can be observed on the transport organs, such as in the pollen baskets of the hind legs in Apidae, the collecting hairs of the legs in the Halictidae or the belly brush in the Megachilidae [9].

Evaluation of the regularity and rhythm of visits according to time slots

The number of visits to each species of flowering insect of *J. gossypiifolia* grouped by time slot and by day of observation made it possible to determine the frequency of visits according to the time slots and days of observation. The results are expressed in terms of percentage (*P*): *P* = (*nv*/*N*) *100, where *nv* is the number of visits per time slot (or per day of observation) and *N* is the total number of visits to the insect recorded during the observation period. These operations made it possible to determine, for each species of insect, the highest percentage of visits per time slot, which corresponds to the peak of activity of this insect. The frequency of visits (*f (%)),* which is the percentage of the number of days the insect was observed in relation to the total number of days observed, was estimated using the formula: *f*(%) = (*ni* / *N*) * 100, where *ni*: number of days of insect presence during *N* days of observation.

Determination of the abundance of foraging insects

The aim was to count the largest number of workers simultaneously active on a flower and on 1000 flowers during the observation period [7].

Abundances per flower are recorded following direct counts Abundance per 1000 flowers (*A1000*) is calculated using the following formula:

A1000 = [(*Ax* / *Fx*) x 1000], where *Fx* and *Ax* are respectively the number of blooming flowers and the number of foraging insects actually counted on the flowers at time *x* [7].

2.4. Data processing

The data analysis was done using:

- Descriptive statistics (for the calculation of averages, standard deviations and percentages);
- Student's t-test for the comparison of the means of two samples;
- Excel 2013 and SPSS.25 were used.

3. Results and discussion

3.1. Species diversity and relative frequency

In 2022 and 2023, 1767 and 2524 visits of 33 and 23 species of insects belonging to 18 families and 4 orders respectively were counted out of 1688 and 2306 flowers of *J. gossypiifolia.* The Shannon-Weaver Diversity Index (H1) was 4.67 in 2022 and 6.56 (H2) in 2023. These indices show that species diversity in 2022 is lower than in 2023. This means that for the two years of study, the population of this site is not the same. The Simpson index (D) was 1.03 (100%) and 0.84 (84%) in 2022 and 2023, respectively. These indices show that there is a 100% and 84% chance of randomly sampling two individuals of the same species, respectively. These results are contrary to those of [16] in Maradi. Shannon's indexes for this locality were 1.43 in 2010 and 1.40 in 2011. The Simpson index was 0.95 in 2010 and 0.94 in 2011. This difference is thought to be caused by the high toxicity of *J. curcas* with insect repellent effects.

The total species richness of flowering insects of *J. gossypiifolia* was 33 in 2022 and 23 in 2023. This species richness is higher than that found by [17] which was of 3 species of insect in Samaru-Zaria in Nigeria on the flowers of *Jatropha curcas*. Thus, as pointed out by several authors including [18, 7, 19, 20], the diversity of floricultural entomofauna varies with plant species and for the same plant, over time.

Figure 1 shows some insect visitors to the flowers of *J. gossypiifolia*. The most common insects were *Seladonia* sp., *Apis mellifera, Lipotriches hylaeooides* and *Belonogaster juncea* with a relative frequency of 30.49%, 19.44%, 7.61 and 5.91 respectively. The orders richest in visiting species of *J. gossypiifolia* flowers were Hymenoptera with 33 species of insects, followed by Diptera and Lepidoptera during the two years of study with six species of insects each. The order most weakly represented was that of the Hemiptera with a single species. The same results were obtained by [21] in Zambia and Malawi, where the largest number of insect visitors to *J. curcas* flowers was in the orders Hymenoptera and Diptera.

Table 1 Diversity and frequency of flowering insects of *Jatropha gossypiifolia* in Maroua in 2022 and 2023

			Years of observation					
		Insects	**2022**		**2023**		**Total**	
Order	Family	Genus, species	n 1	p 1 (%)	n 2	p 2 (%)	n t	p t (%)
Hymenoptera	Apidae	*Apis mellifera*	328	18.56	513	20.32	841	19.44
		Amegilla sp.	33	1.87	-	-	33	0.94
		Hypotrigona squamosa	15	0.85	-	-	15	0.43
		Cleptotrigona cubiceps	34	1.92	-	-	34	0.96
		Amegilla calens	-	-	41	1.62	41	0.81
		Afromelecta fulvonirta	-	-	30	1.19	30	0.60
	Halictidae	*Seladonia* sp.	506	28.64	816	32.33	1322	30.49
		Lipotriches rubella	20	1.13	45	1.78	65	1.46
		Lipotriches azarensis	23	1.30			23	0.65
		Lipotriches hylaeooides	-	-	384	15.21	384	7.61
		Augochloropsis metallica	36	2.04	22	0.87	58	1.46
	Crabonidae	*Philantus triangulum*	40	2.26	26	1.03	66	1.65
	Vespidae	*Rhynchium marginellum*	33	1.87	-	-	33	0.94
		Fuscatus Polists	20	1.13	-	-	20	0.57
		Polistes annularis	25	1.41	-	-	25	0.71
		Synagris calida	31	1.75	-	-	31	0.88
		Vespa sp.1	23	2.99	-	-	23	1.50
		sp.2	35	1.98	-	-	35	0.99
		sp.3	19	1.07	-	-	19	0.54
		sp.4	39	2.21	-	-	39	1.11
		Vespula vulgaris	-	-	10	0.40	10	0.2
		Sinoeca sp.	-	-	15	0.59	15	0.30
		Celonites abbreviatus	-	-	15	0.59	15	0.30
		Ammophila sabulosa	-	-	25	0.99	25	0.50
		(1sp.)	-	-	25	0.99	25	0.50

	Strotiomydae	*Hermetia illucens*	15	0.85	-	-	15	0.43
	Pompilidae	*Fabriogena* sp.	36	2.04	-	-	36	1.02
		Prionemis sp.	37	2.09	-	-	37	1.05
		(1sp.)	38	2.15	-	-	38	0.08
	Eumenidae	*Belonogaster juncea*	25	1.41	256	10.14	281	5.91
	Sphecidae	*Isodontia paludosa*	31	1.75	-	-	31	0.88
	Scoliidae	*Scolia dubia*	29	1.64	-	-	29	0.82
	Megachilidae	*Megachile bituberculata*	22	1.25	-	-	22	0.63
Diptera	Calliphoridae	*Chrysomya chloropyga*	43	2.43	37	1.47	80	1.95
		Chrysomya megacephala	33	1.87	22	0.87	55	1.37
		Sarcophaga carnania	28	1.58	-	-	28	0.79
	Syrphidae	*Eristalis tenax*	-	-	20	0.79	20	0.40
		Episyrphus balteatus	-	-	27	1.07	27	0.54
	Tephritidae	*Carpomya* sp.	15	0.85	-	-	15	0.43
Lepidoptera	Pieridae	*Catopsilia florella*	53	3.00	50	1.98	103	2.49
		Eurema senegalensis	51	2.89	40	1.58	91	2.24
		Colitis sp.	-	-	35	1.39	35	0.70
	Hesperiidae	*Genoa hottentota*	-	-	25	0.99	25	0.50
	Acraeidae	*Acraea serena*	-	-	35	1.39	35	0.70
	Nymphalidae	*Danaus chrysippus*	48	2.72	-	-	48	1.36
Hemiptera	Scutelleridae	*Calidea panaethiopica*	3	0.17	10	0.40	13	0.09
Total	**18**	**46**	**1767**	**100.00**	**2524**	**100.00**	**4291**	**100.00**

n1: number of visits to 1688 flowers in 2022; N2: Number of visits out of 2306 flowers in 2023; P1 percentage of visits in 2022 (P1 = (n1 / 1767) x 100); P2: percentage of visits in 2023 (P2 = (n2 / 2524) x 100); PT.= average percentage of visits during the two years of observation (P1+P2)/2; nt = total number of visits (n1+n2).

Figure 1 Some visiting insects collecting nectar in *Jatropha gossypiifolia flowers* in Maroua in 2022 and 2023

3.2. Floral products collected

Of the 46 species of visiting insects recorded on *J. gossypiifolia* flowers during the two years of study (table 1), 11 collected both nectar and pollen (*Seladonia* sp., *Apis mellifera*, *Chrysomya chloropyga*, *Chrysomya megacephala*, *Lipotriches azarensis, Lipotriches hylaeooides, Augochloropsis metallica, Lipotriches rubella, Episyrphus balteatus, Megachile bituberculata*, *Sinoeca* sp.), 34 collected exclusively nectar (*Hypotrigona squamosa, Cleptotrigona cubiceps, Afromelecta fulvonirta, Philantus triangulum, Rhynchium marginellum, Polistes fuscatus, Polistes annularis, Synagris calida, Catopsilia florella, Eurema senegalensis, Colitis* sp.*, Genenes hottentota, Acraea serena, Danaus chrysippus, Carpomya* sp.*, Eristalis tenax, Sarcophaga carnania, Belonogaster juncea, Isodontia paludosa, Amegilla* sp*, Amegilla calens, Scolia dubia,* four species belonging to the genus *Vespa*, *Vespula vulgaris, Celonites abbreviatus, Ammophila sabulosa, Hermetia illucens*, *Fabriogena* sp.*, Prionemis* sp, a wasp belonging to the family Vespidae and another belonging to the family Pompilidae) and a wasp belonging to the family Vespidae (*Calidea panaethiopica*). The floral product collected

was based on the needs of each insect species. It can therefore be seen from Table 1 that during the two years of study, the majority of the flowering insects of this Euphorbiaceae were foragers of nectar, which is a source of energy and vitamins [22]. This result is contrary to that obtained by [18] in Samaru-Zaria, Nigeria, which reported that the main insects collected nectar and pollen from the flowers of *Jatropha curcas.*

3.3. Evaluation of the frequency of visits according to time slots and frequency Daily visits

3.3.1. Daily Frequency of Visits

The daily regularity of insects on the flowers of this Euphorbiaceae varied according to the years of observation and the species of insects (Table 2). It appears from this table that *J. gossypiifolia* has more or less frequent visitors. Thus the floricultural insects were classified into three categories:

- very frequent visitors whose percentage of days of flower use was greater than 50% of the total number of days of observations; they were represented by *Apis mellifera, Seladonia* sp., *Philantus triangulum, Belonogaster juncea*, *Amegilla calens, Lipotriches rubella, Lipotriches hylaeooides, Lipotriches azarensis, Chrysomya chloropyga, Eurema senegalensis* and *Catopsilia florella* ;
- frequent visitors with a percentage of flower attendance between 25 and 50% of the total number of days of observations; *Hypotrigona squamosa, Cleptotrigona cubiceps, Afromelecta fulvonirta, Augochloropsis metallica, Rhynchium marginellum, Polistes fuscatus, Polistes annularis, Synagris calida,* three species of wasps belonging to the genus *Vespa* (*Vespa* sp.1, *Vespa* sp.2*, Vespa* sp.3) *Vespula vulgaris*, *Sinoeca* sp*., Celonites abbreviatus, Isodontia paludosa, Megachile bituberculata*, *Hermetia illucens, Fabriogena* sp*., Prionemis* sp., *Sarcophaga carnania, Chrysomya megacephala*, *Episyrphus balteatus, Genenes hottentota, Acraea serena, Scolia dubia* and a species belonging to the family Vespidae constituted this category of insects;
- rare visitors who had a percentage of attendance less than 25% of the total number of days observed, this category was represented by *Amegilla* sp. a wasp belonging to the genus *Vespa* (Vespa sp.4), *Ammophila sabulosa*, *Eristalis tenax, Carpomya* sp*., Danaus chrysippus, Colitis* sp., *Calidea panaethiopica* and a wasp of the family Pompilidae*.* These results are evidence that insects are attracted to the nectar and pollen produced by the flowers of *J. gossypiifolia.* The analysis in Table 2 shows that the attachment of insects to the flowers of *J. gossypiifolia* may vary from one species to another. These results confirm the work of [23] who show that the pollinating insects of *J. curcas* in Indonesia belonged mainly to the orders Hymenoptera, Diptera and Lepidoptera.

Table 2 Number and percentage of days of visits to *Jatropha gossypiifolia* flowers by the different flowering insects in Maroua in 2022 and 2023

	Years					
Insect species	2022		2023		Total	
	n 1	R1 (%)	n 2	R2 (%)	N t	Rm (%)
Apis mellifera	7	100	8	100	15	100
Amegilla sp.	7	100	-	-	7	50
Hypotrigona squamosa	5	71.43	-	-	5	35.715
Cleptotrigona cubiceps	5	71.43	-	-	5	35.715
Amegilla calens	-	-	8	100	8	50
Afromelecta fulvonirta	-	-	5	62.5	5	31.25
Seladonia sp.	7	100	8	100	15	100
Lipotriches rubella	7	100	8	100	15	100
Lipotriches azarensis	6	85.71	5	62.5	11	74.105
Lipotriches hylaeooides	-	-	8	100	8	50
Augochloropsis metallica	3	42.86	4	50	7	46.43
Philantus triangulum	7	100	8	100	15	100

Rhynchium marginellum	6	85.71	-	-	6	42.855
Fuscatus Polists	5	71.43	-	-	5	35.715
Polistes annularis	5	71.43	-	-	5	35.715
Synagris calida	4	57.14	-		4	28.57
Vespa sp.1	4	57.14	-	-	4	28.57
Vespa sp.2	5	71.43	-	-	5	35.715
Vespa sp.3	6	85.71	-	-	6	42.855
Vespa sp.4	3	42.86	-	-	3	21.43
Vespula vulgaris	-	-	6	75	6	37.5
Sinoeca sp.	-	-	5	62.5	5	31.25
Celonites abbreviatus	-	-	5	62.5	5	31.25
Ammophila sabulosa	-	-	2	25	2	12.5
Vespidae (1sp.)	-	-	4	50	4	25
Hermetia illucens	5	71.43	-	-	5	35.715
Fabriogena sp.	4	57.14	-	-	4	28.57
Prionemis sp	5	71.43	-	-	5	35.715
Pompilidae (1sp.)	3	42.86	-	-	3	21.43
Belonogaster juncea	7	100	8	100	15	100
Isodontia paludosa	7	100	-	-	7	50
Scolia dubia	6	85.71	-	-	6	42.855
Megachile bituberculata	7	100	-	-	7	50
Chrysomya chloropyga	4	57.14	7	87,5	11	72.32
Chrysomya megacephala	3	42.86	2	25	5	33.93
Sarcophaga carnania	6	85.71	-	-	6	42.855
Eristalis tenax	-	-	1	12.5	1	6.25
Episyrphus balteatus	-	-	5	62.5	5	31.25
Carpomya sp.	2	28.57	-	-	2	14.285
Catopsilia florella	5	71.43	8	100	13	85.715
Eurema senegalensis	5	71.43	4	50	9	60.715
Colitis sp.	-	-	2	25	2	12.5
Genoa hottentota	-	-	4	50	4	25
Acraea serena	-	-	5	62.5	5	31.25
Danaus chrysippus	2	28.57	-	-	2	14.285
Calidea panaethiopica	3	42.86	2	25	3	33.93

n1: number of days the insect was present during 7 days of observation in 2022; **N2:** Number of days the insect was present during 8 days of observation in 2023; NT: number of days of insect presence during 15 days of observation in 2022 and 2023; R1: Relative regularity of the insect (n1/7)*100 in 2022; R2: Regularity of the insect (n2 / 8)*100 in 2023; Rm: Average regularity of the insect (R1+R2)/2.

3.4. Evaluation of the frequency of visits according to observation time slots

The insects visited the flowers of *J. gossypiifolia* from 6 a.m. to 5 p.m. and the daily foraging period varied with the different insects as shown in Table 3. For the two years of observation, it appears from Table 3 that the peak of activity of all insects is between 12 p.m. and 1 p.m., i.e. 38.45% of visits. That time slot corresponds to the period of maximum availability of floral products of *J. gossypiifolia*. Indeed, by subdividing the day into three periods: morning (6-9 am), midday (10-1 pm) and evening (2-5 pm), from Table 3, it appears that the flowering insects of *J. gossypiifolia* could be classified into four groups:

- those who visited the flowers of *J. gossypiifolia* during all daily periods were represented by 21 species of insects (*Apis mellifera, Seladonia* sp., *Lipotriches rubella, Lipotriches azarensis, Lipotriches hylaeooides, Philantus triangulum, Vespa* sp.1 , sp.2, sp.4, *Belonogaster juncea, Isodontia paludosa, Scolia dubia, Megachile bituberculata, Chrysomya chloropyga, Episyrphus balteatus, Catopsilia florella, Eurema senegalensis, Genenes hottentota, Acraea serena, Danaus chrysippus, Calidea panaethiopica*);
- those whose activities began in the morning and ended at midday represented by 14 species (*Amegilla* sp., *Hypotrigona squamosa, Afromelecta fulvonirta, Polistes fuscatus, Polistes annularis, Synagris calida, Celonites abbreviatus, Vespidae* 1sp., *Pompilidae* 1sp., *Hermetia illucens, Prionemis* sp., *Chrysomya megacephala, Sarcophaga carnania, carpomya* sp.);
- those observable on flowers only at midday represented by two species (*Amegilla calens, Eristalis tenax*);
- those that began their activities at midday and foraged until the evening represented by nine species (*Cleptotrigona cubiceps*, *Augochloropsis metallica*, *Rhynchium marginellum*, *Vespidae sp3.*, *Vespula vulgaris*, *Sinoeca sp.*, *Ammophila sabulosa*, *Fabriogena sp.*, *Colitis sp.*).

Table 3 shows that the peaks of activity of the different species of flowering insects of *J. gossypiifolia* were spread over the first two daily observation periods. This strategy of occupying the flowers by insects would coincide with the period of maximum production of floral products.

Table 3 Frequency of visits according to observation time slots

Insects	**Daily periods**												
	Morning				**Midday**				**Evening**				
	6-7h		**8-9 hours**		**10-11 a.m.**		**12-13h**		**2-3pm**		**4-5pm**		**Total**
Apis mellifera	**-**	**-**	54	6.42	193	22.95	392	**46.61***	180	21.40	22	2.62	841
Amegila sp.	3	9.09	10	30.30	10	30.30	10	**30.30***	-	-	-	-	33
Hypotrigona squamosa	-	-	10	**66.67***	5	33.33	-	-	-	-	-	-	15
Cleptotrigona cubiceps	-	-	-	-	6	17.65	11	**32.35***	10	29.41	7	20.59	34
Amegilla calens	-	-	-	-	38	**92.68***	2	4.88	-	-	-	-	41
Afromelecta fulvonirta	-	-	10	33.33	5	16.67	15	**50***	-	-	-	-	30
Seladonia sp.	35	2.65	296	22.37	284	21.47	459	**34.47***	160	12.09	89	6.73	1322
Lipotriches rubella	10	15.38	5	7.69	22	33.85	25	**38.46***	5	7.69	-	-	65
Lipotriches azarensis	5	21.74	-	-	7	30.43	7	**30.43***	4	17.39	-	-	23
Lipotriches hylaeooides	64	16.66	44	11.45	70	18.23	110	**28.65***	66	17.19	30	7.81	384
Augochloropsis metallica	-	-	-	-	30	**51.72***	18	31.03	10	17.24	-	-	58
Philantus triangulum	15	22.73	20	**30.30***	10	15.15	17	25.76	4	6.06	-	-	66
Rhynchium marginellum	-	-	-	-	12	36.36	15	**45.45***	6	18.18	-	-	33
Fuscatus Polists	-	-	5	25	5	25	10	**50***	-	-	-	-	20
Polistes annularis	-	-	5	20	10	40	15	**60***	-	-	-	-	25
Synagris calida	-	-	8	25.81	3	9.68	20	**64.52***	-	-	-	-	31
Vespa sp.1	-	-	5	21.74	5	21.74	10	**43.48***	3	13.04	-	-	23
sp.2	-	-	5	14.29	5	14.29	15	**42.86***	5	14.29	5	14.29	35
sp.3	-	-	-	-	-	-	10	**52.63***	9	47.37	-	-	19

sp.4	-	-	9	23.08	10	25.64	15	**38.46***	5	12.82	-	-	39
Vespula vulgaris	-	-	-	-	-	-	7	**70***	3	30	-	-	10
Sinoeca sp.	-	-	-	-	2	13,33	9	**60***	4	26.67	-	-	15
Celonites abbreviatus	-	-	5	33.33	5	33.33	5	**33.33***	-	-	-	-	15
Ammophila sabulosa	-	-	-	-	-	-	15	**60***	10	40	-	-	25
(1sp.)	9	36	-	-	10	40	6	**60***	-	-	-	-	25
Hermetia illucens	-	-	5	33.33	5	33.33	5	**33.33***	-	-	-	-	15
Fabriogena sp.	-	-	-	-	-	-	22	**61.11***	10	27.78	4	11.11	36
Prionemis sp.	-	-	10	27.02	7	18.92	20	**54.05***	-	-	-	-	37
(1sp.)	2	5.26	9	23.68	16	**42.10***	11	28.95	-	-	-	-	38
Belonogaster juncea	5	1.78	20	7.12	80	28.47	100	**35.59***	40	14.23	36	12.81	281
Isodontia paludosa	6	19.35	5	16.13	5	16.13	8	**25.81***	5	16.13	2	6.45	31
Scolia dubia	-	-	9	31.03	5	17.24	10	**34.48***	5	17.24	-	-	29
Megachile bituberculata	-	-	4	18.18	8	36.36	10	**45.45***	2	9.09	-	-	22
Chrysomya chloropyga	-	-	15	18.75	35	**43.75***	20	25	10	12.5	-	-	80
Chrysomya megacephala	-	-	20	36.36	30	**54.55***	5	9.09	-	-	-	-	55
Sarcophaga carnania	-	-	11	**39.29***	10	35.71	7	25	-	-	-	-	28
Eristalis tenax	-	-	-	-	15	**75***	5	25	-	-	-	-	20
Episyrphus balteatus	-	-	4	14.81	7	25.93	10	**37.05***	6	22.22	-	-	27
Carpomya sp.	-	-	8	**53.33***	-	-	7	46.67	-	-	-	-	15
Catopsilia florella	-	-	10	9.71	22	21.36	40	**38.83***	20	19.42	11	10.68	103
Eurema senegalensis	-	-	5	5.49	35	38.46	41	**45.05***	9	9.89	1	1.10	91
Colitis sp.	-	-	-	-	9	25.71	20	**57.14***	6	17.15	-	-	35
Genoa hottentota	-	-	2	8	-	-	18	**72***	-	-	5	20	25
Acraea serena	-	-	4	11.43	10	28.57	18	**51.43***	3	8.57	-	-	35
Danaus chrysippus	-	-	4	8.33	12	25	20	**41.67***	8	16.67	4	8.33	48
Calidea panaethiopica	2	15.38	3	**23.08***	2	15.38	2	15.38	2	1.,38	2	15.38	13
Total	**141**	**3.29**	**619**	**14.43**	**1059**	**24.68**	**1650**	**38.45**	**627**	**14.61**	**218**	**5.08**	**4291**

sp.: species not determined; *: peak of activity.

3.5. Forager abundance

For each of the species of flowering insects of *J. gossypiifolia*, the highest number of individuals simultaneously active on a flower was one; during the 15 days of observation, in no case were more than one individual per flower observed. The small diameter of the flower of this Euphorbiaceae would limit the number of individuals that can forage simultaneously. Table 4 shows that the average abundances per 1000 flowers were 35.20 (n = 134; s = 24.70) in *Apis mellifera* in 2022 and 22.52 (n = 151; s = 21.39) in 2023. The difference between these two means is very highly significant (t = 4.49 *ddl* = 277, P < 0.001). At *B. juncea*, the abundances per 1000 flowers were 46.37 (n = 124; s = 35.26) in 2022 and 16.60 (n = 146; s = 19.90) in 2023. The difference between these two means is very highly significant (t = 8.61 *ddl* = 262, (P < 0.001). These differences would be due to the fact that in 2023 some plants of *J. gossypiifolia* were cut which resulted in a decrease in the number of exploitable flowers; moreover for *A. mellifera*, the high number of the honey bee *Philantus triangulum*, a formidable predator of the honey bee that same year, is thought to have had an impact on the abundance per 1000 flowers of *A. mellifera*. For *Augochloropsis metallica* the corresponding figures are 16.65 (n = 30; s = 7.03) in 2022 and 36.26 (n = 15; s = 34.29) in 2023. The difference between these two means is very highly significant (t = 2.88 *ddl* = 37, (P < 0.001). The increase in abundance per 1000 flowers in *Au. metallica* would be justified by the desertion of the first two species thus limiting competition at the flower level. The abundance per 1000 of *A. mellifera* was higher in [24] in Dang (Ngaoundere), with 21.25 in 2013 and 56.14 individuals on the flowers of *C. macrostachyus* (Euphorbiaceae).

Table 4 Abundance per 1000 flowers of some foraging insects of *Jatropha gossypiifolia in* Maroua in 2022 and 2023

Insect species	Abundance per 1000 flowers						
	2022			2023			
	N	m1	s	N	m2	S	M
Apis mellifera	134	35.20	24.70	151	22.52	21.39	28.86
Seladonia sp.	86	43.08	51.37	247	41.33	31.84	42.205
Chrysomya chloropyga	32	30.20	16.78	112	20.80	17.27	25.5
Philantus triangulum	45	23.47	11.30	66	71.80	47.69	47.635
Rhynchium marginellum	40	47	8.08	83	46.30	40.82	46.65
Augochloropsis metallica	30	16.65	7.03	15	36.26	34.29	26.455
Lipotriches rubella	37	21.46	12.88	22	21.51	19.41	21.485
Catopsilia florella	56	31.76	15.14	66	29.15	15.43	30.455
Belonogaster juncea	124	46.37	35.26	146	16.60	19.90	29.985
Chrysomya chloropyga	21	34.96	21.09	150	28.74	26.52	31.85
Chrysomya megacephala	32	15.01	8.37	42	13.13	8.15	14.07

n: number; **m1:** average abundance in 2022; **m2:** average abundance in 2023; **s:** standard deviation M: mean abundance of the two years of observation (M = m1+m2)/2

4. Conclusion

In Maroua, 46 species of insects divided into four orders visit the flowers of *J. gossypiifolia* including 33 species for the order Hymenoptera, six species for the order Diptera, six species for the order Lepidoptera and one species for the order Hemiptera. These insects search for the nectar, pollen or sap of this plant species on flowers. The nectar collectors are the Diptera, the Lepidoptera and 21 species of Hymenoptera; the nectar and pollen collectors are 12 species of Hymenoptera and the sap seeker is *Calidea panaethiopica* which is a Hemiptera. The most frequent species are *Seladonia* sp., *Apis mellifera, Lipotriches hylaeooides* and *Belonogaster juncea*. The peak of activity of all insects is between 12 p.m. and 1 p.m.

Growers of *J. gossypiifolia* who wish to control *Calidea panaethiopica* to avoid the period of activity of other flowering insects in order to benefit from their pollinating service.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that no conflict of interest regarding the publication of this paper.

References

[1] Dehgan B, Webster G.L. Morphology and infrageneric relationships of the genus *Jatropha* (*Euphorbiaceae*). *In Publications in Botany*. *USA–Editor* University of California. 1979; Vol.74.

[2] Sabandar C. W., Ahmat N., Jaafar F. M., and Sahidin I. "Medicinal property, phytochemistry and pharmacology of several *Jatropha* species (Euphorbiaceae): a review," Phytochemistry. 2013; vol. 85, pp. 7–29.

[3] Apu AS, Hossain F, Rizwan F, Bhuyan SH, Matin M and Jamaluddin ATM. Study of pharmacological activities of methanol extract of *Jatropha gossypifolia* fruits. Journal of Basic and Clinical Pharmacy. 2013; 4(1):20–24.

[4] Schmelzer, G.H. & Gurib-Fakim, A. (Publishers), Plant resources of tropical Africa 11(1). Medicinal plants 1. Plant Resources of Tropical Africa 11. Medicinal plants 1. 2008]. PROTA Foundation, Wageningen. The Netherlands / Backhuys Publishers, Leiden, the Netherlands / CTA, Wageningen. The Netherlands. 2008; 869 pp.

[5] Reddi, E.U.B. & Reddi, C.S. Pollination ecology of *Jatropha gossypiifolia* (Euphorbiaceae). *Proceedings Indian Academy of Science* (Plant Science). 1983; 92(2), 215-231.

[6] Kuete M., Melingui A., Mounkam J. & Nofiele D. New Geography of Cameroon. EDICEF. 1993; 207 p.

[7] Tchuenguem F.F.N., Messi J. & Pauly A. Activity of Meliponula erythra on Dacryodes edulis flowers and its impact on fruiting. Fruits. 2001; 56: 179-188.

[8] Tchuenguem F.F.N. Foraging and pollination activity of Apis mellifera adansonii Latreille (Hymenoptera: Apidae, Apinae) on the flowers of three plants in Ngaoundéré (Cameroon): Callistemon rigidus (Myrtaceae), Syzygium guineense var. macrocarpum (Myrtaceae) and Voacanga africana (Apocynaceae). State Doctoral Thesis, University of Yaoundé I. 2005; 103 p.

[9] Borror D. J. & White R.E. Insects of North America (north of Mexico). Broquet (ed.), Laprairie. 1991; 408 p.

[10] Pauly A. The grass bees or Lipotriches Gerstaecker, 1858, sensu stricto (Hymenoptera: Apoidea: Halictidae: Nomiinae) of sub-Saharan Africa. Belgian Journal of Entomology. 2014; 20, 1-393.

[11] Kioko E, Musyoki A, Luanga A, Sese J, Nyangena L, Mwinzi D. Occurrence data of hawkmoths (Lepidoptera: Sphingidae) in the National Museums of Kenya Zoological Collection. 2021 ; v.1.7.

[12] Dajoz, R. La biodiversité : l'avenir de la planète et de l'homme. Ellipses, Paris. 2008 ; 275 p.

[13] Pando, J.B., Djongwangwé, Balti, M.O., Tchuenguem, F.F-N., & Tamesse, J.L. Diversity of flowering insects of Abelmoschus esculentus (Malvaceae) and their impact on fruit and grain yield in Maroua-Cameroun. Journal of Animal & Plant Sciences. 2020; 43; l7350-7365.

[14] Frontier S. Statistical method applicable to Biology, Medecine and Ecology. Masson, Paris. 1991; 246 p.

[15] Jacob - Remacle A. Foraging behavior of domestic bees and wild bees in apple orchards in Belgium. Apidology. 1989; 20: 217–285.

[16] Zakari A. H., Toudou A. Eric., Haubruge G. M., & Verheggen F. J. Analysis of the entomological fauna associated whith Jatropha curcas L. in the Maradi region of southeast Niger. Faunistic Entomology. 2013;66, 97-107

[17] Alamu O.T.Amao A.O., Oke O.A., Suleiman R.A. Foraging behavior of three insect pollinators of Jatropha curcas in Samaru-Zaria, Nigeria. International Journal of Advence Agricultural Research. 2013; pp.87.91.

[18] Roubik, D.W. Pollination system stability in Tropical America. Conservative Biology. 2000; 14:1235-1236.

[19] Michener C. D. The bees of the world. 2nd edition. The John Hopkins University Press, Baltimore and London. 2007; 953 p.

[20] Gallais N., Salles J.M., Settele J. & Vaissière B.E. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics.* 2009; 68: 810-821.

[21] Negussie, A., Achten, W.M.J., Verboven, Hermy, M. & Muys, B. Floral displayand effects of natural and artificial pollination on fruiting and seed yield of the tropical biofuel crop *Jatropha curcas* L. G*CB Bioenergy* in press. African Crop Science Journal. 2013; 21 (2):133-141.

[22] Louveaux J., & Albisetti J. Preliminary observation of pollen harvests by bees in the large landes of the countryside forest. The annals of the bee. 1963; 6 (3) :229 – 234.

[23] Rianti P., Suryobroto B. & Atmowidi T. Diversity and effectiveness of insect pollinators of *Jatropha curcas* L. (Euphorbiaceae). HAYATI *Journal of Bioscience.* 2010; 17(1):38-42.

[24] Népidé N.C & Tchuenguem F.F.N. Pollination efficiency of *Apis mellifera adansonii* Latreille (Hymenoptera: Apidae) on *Croton macrostachyus* (Euphorbiaceae) flowers at Dang, Ngaoundéré, Cameroon. *International Journal of Biosciences.*2016; 9 (3):75 - 88.