Available online at www.aexpbio.com

ISSN : 2348-1935

RESEARCH ARTICLE

Annals of Experimental Biology
2014, 2 (3):41-51

Flower biology of a beeplant *Vitellaria paradoxa* (Sapotaceae) in the sudano-sahalian zone of Cameroon

Delphine Dongock Nguemo*, Pierre Marie Mapongmetsem, Fernand-Nestor Tchuenguem Fohouo, Damolai Gounhagou and Hamawa Yougouda

Department of Biological Sciences, Faculty of Sciences, University of Ngaoundere, Cameroon
Po. Box 454 Ngaoundere
Corresponding email: dndongock@yahoo.fr
(Received:) (Accepted:)

ABSTRACT

A study of flower biology on Vitellaria paradoxa was carried out in the Sudano-Guinean zone of Cameroon. Phenological data was collected and specimen insects captured. It was noted that the shading of leaves of Vitellaria paradoxa was from November to January according to individuals. Preflowering last for about four weeks and is characterised by different morphogenetic phases from the apparition of a flower bud to the fall of corolla. Vitellaria paradoxa flowers between November and June usually on leafless branches. Flowering is influenced by temperature and during flowering period, relative humidity is low. The anthese period oscillates between 18 and 23 hours. More than 54.22% flowers complete their anthese process. For fruit bearing, the treatment effect is highly significant (P>0.001). 2616 visits of 45 species of insects were registered on Vitellaria paradoxa flowers during the observation period.

Key Words: Flower biology, *Vitellaria paradoxa*, floral entomofaune, Cameroon.

INTRODUCTION

Vitellaria paradoxa commonly called shea butter is a Sapotaceae with deciduous leaves in African Savannah. The average height of the tree is 15m. The area of distribution stretches from Senegal to Sudan through Guinea Bissau, Sierra Leone, Ivory Coast, Ghana, Togo, Benin, Burkina- Faso, Niger, Nigeria, Chad, Central Africa Republic and Cameroon [1, 2, 3]. *Vitellaria paradoxa* is a tree with a socio- economic interest [4, 5]. The vegetative apparatus secrets white latex. All its parts are valorised from the fruit with an ellipsoid shape of 5 to 8 cm long weighing 21g is the most utilised. The pulp with 33 to 75% of the total weight of the fruit is eaten raw while the seed is used for the production of oil with multiple virtues (food, medicinal and cosmetic) [6, 7] the seed contains 45- 60% fats and 9% of proteins [8, 2]. In the Sudano-guinean Savannah, *Vitellaria paradoxa* is among the species with high added value because of its butter whose commercial value is not negligible 2.29 – 5.34€ a Litre [9]. It therefore constitutes a potential market for peasants with low incomes [10, 2]. It is confirmed that the tree has a long vegetative period (at least 15 years) consequently, the only initiative they have is limited at protecting the stems during the clearing of farms [8, 11]. This species is one of the most valorised fruit tree by the local population of the Savannah zones [11]. Many studies have already been carried on this plant [12-16]. Studies on leave shading, flowering and fruit bearing of *Vitellaria paradoxa* has been carried out in the Uganda Savannah [16]. Despite the numerous studies carried out, there is very few data on flower biology in ecological conditions of the Sudano- Guinean zone of Cameroon.

According to horticulture technicians, in other to satisfy the production of ochar (high output, regular harvest and obtaining good quality fruits) it is indispensable to master the flower biology of this specie. The objective of this research is to analyse the reproductive biology of *Vitellaria paradoxa* with the perspective of developing

domestication strategies of the plant. More specifically to determine the flowering and anthesis period, make an inventory of floral entomofauna in order to identify the insects that intervene in pollination.

MATERIALS AND METHODS

Study site

This study was carried out in the two zones presented in figure 1. The Guinean zone of Ngaoundere and the Sudanian zone of Garoua. The two zones extends from latitude 7º to 10º north of the equator. The climate of the Sudanian zone is made up of two seasons: a dry season of six months from November to April and a rainy season from May to February. The average temperature is 32ºC; rainfall is less than 1000mm. The Savannah is made up of Combretaceae. The soil is composed of dune, sand, limestone and clay [17]. The Guinean zone of Ngaoundere also has two seasons: a dry season of five months from November to March and a rainy season from April to October [17, 18]. The savannah is dominated by *Daniellia oliveri* (Fabaceae Caesalpinoideae) and *Lophira lanceolata* (Ochnaceae). The Andropogoneae represents 70% of the herbaceous stratum [17]. The vegetation is on ferruginous and lateritic soil.

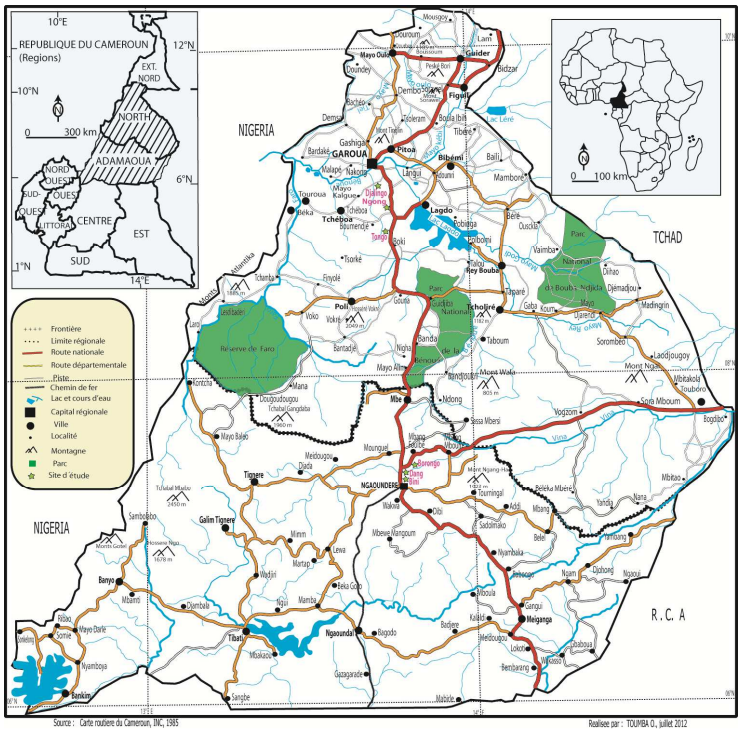

Fig. 1 : Map presenting the two study zones

Observations were carried out from November 2010 to February 2011 in the Guinean zone notably in the peripheries of Ngaoundere, then from February to June 2011 in the periphery of Garoua in the Sudanian zone. In each of the two climatic zones three localities were randomly chosen. The observations were therefore carried in the localities of Bini, Dang and Borongo in the Guinean zone and in Ngong, Tongo and Djalingo in the Sudanian zone. A total of 90 *Vitellaria paradoxa* plants that is 15 plants per locality were followed up.

Labelling and follow-up of trees

Tagging consisting of tieing plates with numbers and the name of the locality on one of the branches of the tree using a rope. The data from the tagged trees were collected simultaneously or separated in time. In order to understand the leaf shooting, flowering tree stems were chosen from the tagged trees in each locality. 10 buds of flowers were chosen at different positions at upper part of the tree (North, South, East, West, summit and base). The number of leaves on each bud was counted. Observations were carried out on branches that had not yet shade their leaves. During the flowering period the number of flowering spots formed on each bud was evaluated.

In order to determine the flowering period, the labelled trees were visited every day and the observation of flowers and insects was carried out during the month of February in the two zones. Data on the growth and flower morphogenesis were collected through simple observation. The data collected was on the number of flowering plants at the end of each week. The total number of insects found on the flowers during the observation period, the

different groups of visiting insects or not. On the field, specimens were captured with the aid of net and taken to the laboratory for identification and conservation.

Inventory and identification of floral entomofauna

An inventory of insects that visited *Vitellaria paradoxa* tree was made. Counting was done alongside the determination of the flowering period. Observation were carried out in November to December in the Guinean zone, February to March in the Sudanian zone on 20 *Vitellaria paradoxa* trees; 10 for each zone. Notes were taken every four days for seven hours at different intervals: 6- 7am, 8- 9am, 10- 11am, 12- 1pm, 2- 3pm, 4-5pm, 6- 7pm. During the counting period, the number of individuals captured with hand or with the aid of a net were conserved in 70°C ethanol while butterflies were conserved in paper. At the end of the inventory of insects, their identification was carried out in the Biology Laboratory of the University of Ngaoundere.

Evaluation of *Vitellaria paradoxa*'s yields

The evaluation of the yields was done in all the localities that is Bini, Dang and Borongo (Ngaoundere); Tongo, Djalingo and Ngong (Garoua). Three treatments were carried out in each *Vitellaria paradoxa* tree at each locality. The first treatment (Tp) consisted of covering the flower with cloth so that no insects can pass through. The second treatment (Tg), the flowers were covered with cloth containing holes that ants could pass through; the third treatment (Tm) was the reference tree uncovered. The relative impact of each insect visits was calculated following the method used by Bétayéné [19]. The relative rate of fructification as a result of visit of each insect (Fr) was estimated using the formula : Fr =[Fi x Vr] / Vi; where Fi is the fruiting rate due to all flower visiting insects identified; Vi is the visit rates of all insects listed on flowers and Vr is the visit rates of each order of insects. The fruit obtained were collected and counted in each locality of the two zones.

Collection of eco-climatic data

Meteorological data on temperature and rainfall were obtained from ASECNA in Garoua and to the meteorological service of Ngaoundere Airport.

The analysis of statistics

Descriptive statistics with the calculation of averages and frequencies were used to analyse the data. The Chi Square was used to compare the percentages, the probability retained was $P<0.05$ to $P>0.01$.

RESULTS AND DISCUSSION

Leaf shading of *Vitellaria paradoxa*

Leaf shading of *Vitellaria paradoxa* irrespective of the zone starts from November to January according to individuals. Leaf shading does not take place at the same time on the branch. The period of leaf shading varies according to individuals and also in function of branches on the plant. The shading of leaf starts in early November in Ngaoundere and in Garoua late December. It is preceded by the generalised yellowing of the leaves. This result corresponds to those obtained by Okullo [16] in the Ugandan Savannah where leaf shading increase from December to February. Leaf shading on some branches of certain individuals is precocious. As such it is possible that a tree at the same moment can have young shots, yellow leaves at shading phase, open, closed flower and fruits. This variable is corroborated with the result of Mapongmetsem [20] who had already signalled that leaf shading-flowering relationship was not evident in some tropical trees. In the two zones, the flowering of the shea tree is on completely or partially leafless trees. This observation was equally made by Sallé *et al.* [16] in the course of their study on this tree which is a potential wealth. *Vitellaria paradoxa* is unequally distributed, they are abundant in the Garoua than in Ngaoundere site. Agropastoral activities have a negative effect on the environment and is threatening particularly species whose regeneration is difficult [21]. Harault [22] and Tchotsoua [23] has indicated that anarchical rearing of animals has led to a profound modification of the vegetal cover in the past ten years. The unsustainable use of pasture in Adamawa is already a problem. It has neither method nor any concern for conservation; this has led to overgrazing which has caused serious degradation of the soil.

Development of *Vitellaria paradoxa* flowers

Growth of flower buds

The development of flowers are observed directly and is characterised by different morphological phases. The first phase that last for about three weeks consist of the putting in place at the summit of branches thick spherical floral buds carried by short peduncle. The number of floral buds varies from 40 to 200 according to branches. The size of the floral bud also varies according to the apparition on the corymb. The grey part of perianth is formed and an imbricate preflowering. More than 60% of the total floral buds formed falls after their development, this leads to a considerable loss of flowers and later of fruits. 32% is caused by the attack of biting or sucking insects. The second phase last for about one week the peduncle lengthens and the size of the buds increases. The calyx part still tied

together presents a greenish colour and longitudinal dehiscence lines starts to form between the sepals. The floral bud that reaches this stage generally reaches the anthese. The third phase is more discrete and last for about four days. The base of the spherical bud increase there by increasing the size of the flower.

Morphogenesis of the flowers

At the fourth stage, the pistil emerges from the summit of the floral bud and increases in length for three days. Whitish corolla appears from the gaps between the sepals five hours before the effective opening of the flowers. At the fifth stage the petals opens at the upper summit forming a tube with a small orifice with eight cogwheel petaloides staminodes. The corolla tube enlarges progressively and this lead to the turning down of the perianth. About 45 minutes after the opening of a flower the anther regroups around the pistil and then a longitudinal gap opens on the internal face thus liberating pollen powder. The stigma remains on top of the regrouped anthers. The dimension of the floral parts at this stage are very significant. The diameter of a corolla tube is 3.2 ± 0.28 cm, the number of ovary loges is 5.56 ± 0.46; the length of style is 2.89 ± 0.04 cm; the style measures 3.6 ± 0.03 cm and the length of stamens is 2.89 ± 0.04 cm. The last stage which corresponds to the falling of floral parts last for an average of three days in the Guinean Savannah and for one day in the Sudanian Savannah. The calyx part tighten around the ovary causing the direct corolla to come out with stamens. The pistil disappears a few days after the fall of the corolla. The development of *Vitellaria paradoxa* flower in a process that last for about four weeks from the effective apparition of the influential bud to the fall of the corolla.

Flowering of *Vitellaria paradoxa*

The flowering period of *Vitellaria paradoxa* is represented by figures 2 and 3 respectively for the Sudanian and Guinean zone. They are well spread throughout the year in the Sudanian zone of Garoua with five months of flowering from February to June. In this zone, the peak of flowering is in March, seconded by the month of February with 57.5% to 17.5% of the 45 trees studied in this zone. In the months of April, May and June only few *Vitellaria paradoxa* plants have flowers with 7.5%, 10% and 7.7% respectively for the 45 plants considered in this zone. On the other hand in the Guinean zone of Ngaoundere, the flowering period covers four months from November to February. The highest percentage of flowering is in December with 52.62% of trees considered. The months of January has 23.6%. The months of November and February registered 2.63% and 5.26% respectively for the plants with flowers. Flowering period vary in function of the zone considered.

The results obtained in Guinean zone resemble that of Adamou [24] in Burkina Faso and Nyomo [12] who carried out research in Guinean Savannah zone of Ngaoundere. They indicated that the flowering period of *Vitellaria paradoxa* is between December and January. These results also close to those obtained by Sallé et *al.* [4] on their research on Shea tree a potential wealth and those of Okullo et *al.* [16] in Ugandan savannah where flowering starts from November and continues to April and some species starts in May. The flowering peak is situated between January to February during the dry season.

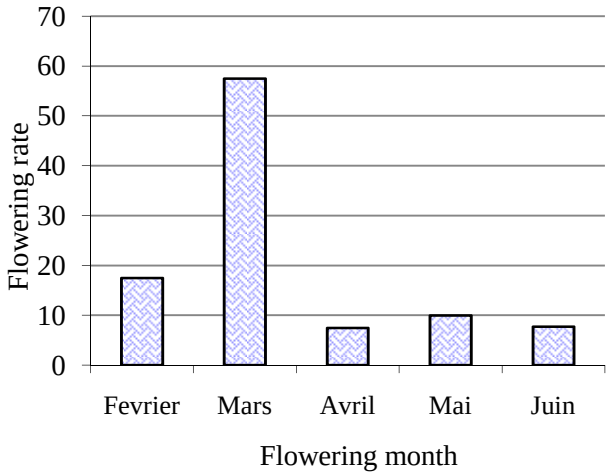

Fig. 2 : Flowering period in the Sudano zone of Garoua

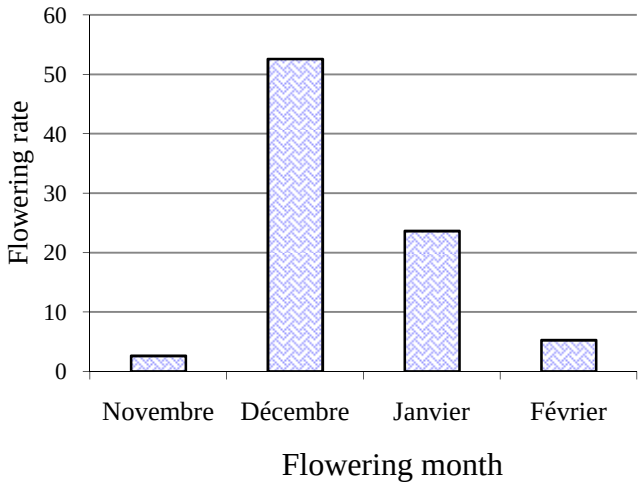

Fig. 3: Flowering period in the Guinean zone of Ngaoundere

Leaf shading-preflowering relationship

Leaf shooting and leaf shading of *Vitellaria paradoxa* is generally linked to flowering in the two study zones. The higher the number of leaves on the branches, the greater the number of floral buds. Leaf shooting intervenes in floral induction in *Vitellaria paradoxa*. This result confirms Gautier [25] hypothesis which stipulates that leaves synthesises organic matter whose proportion should always be above those of nitrogen elements, if not floral bend will be disturbed. The position of branches equally plays role in the flowering-leaf shading relation phenomenon. In effect, it was noticed that the lower branches of the tree had the tendency of maintaining their leaves or shaded them much more later while the upper branches shades their leaves faster. All the lower branches did not bear fruits.

Eco- climatic characteristics

The eco- climatic characteristics noted were temperature and relative humidity. They have been summarised in figures 4 and 5. The temperatures are higher in the Sudanian zone of Garoua and vary between 24.50 to 33.40°C. While in the Guinean zone of Ngaoundere, temperatures are much lower between 19.31 to 23.45°C. During the flowering months the average temperature is 20.23°C in Guinean zone and 30.1°C in Sudanian zone. However they increase regularly during the flowering period in Sudanian zone of Garoua while in the Guinean zone of Ngaoundere the temperatures remains more or less constant from the first to the last month of flowering. This temperature variation was also observed by Okullo et *al.* [16] ranging from 15 to 33 °C throughout the year there by influencing leaf shooting, flowering and fruit bearing of *Vitellaria paradoxa* subs *P. Nilotica* in the Ugandan Savannah. Flowering is positively and imperfectly correlated to high temperatures (r= 0.41).

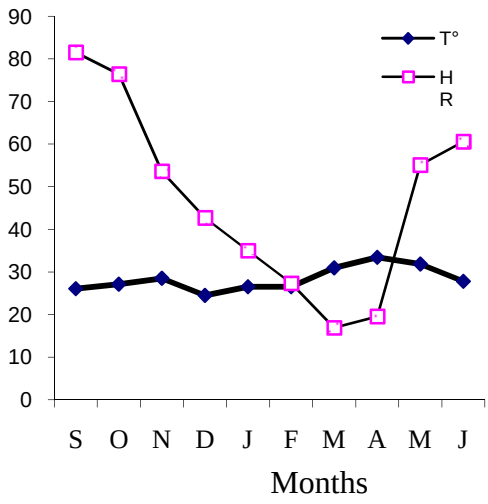

Fig.4 : Temperature (T°) and relative humidity (HR) in the area of Garoua

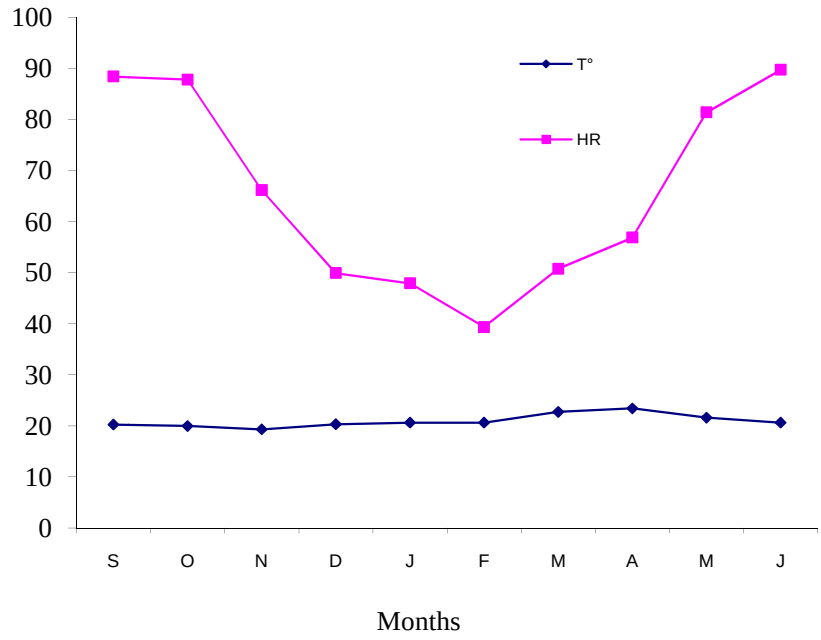

Fig. 5 : Temperature (T°) and relative humidity (HR) in the area of Ngaoundere

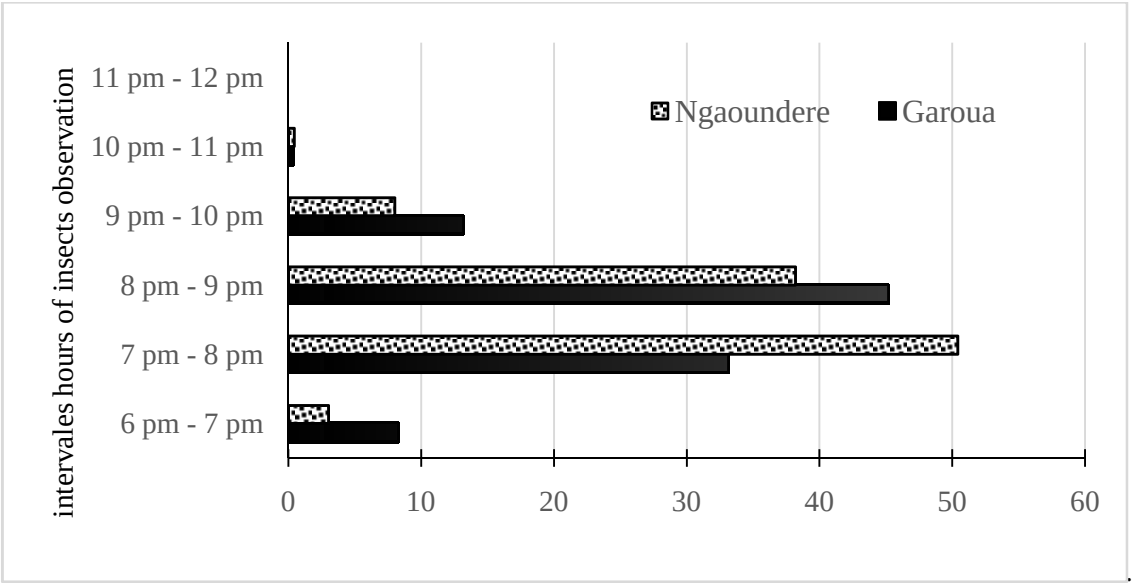

Fig. 6 : Variation percentages of anthesis rate in *Vitellaria paradoxa* in both Sudan and Guinean zones

Relative humidity drops considerably in all the zones during the flowering period from 66.15 to 39.35% in Guinean zone of Ngaoundere from 27.30 to 60.55% in the Sudanian of Garoua. The lowest RH registered during the flowering period is 16.85% in March in Garoua and 39.35% in February in Ngaoundere. The highest is registered in November with 66.5% in Guinean zone on Ngaoundere and 55.05% in March in Sudanean zone of Garoua. The average RH is 30.72% and 50.8% in Garoua and Ngaoundere respectively. It should be noted that flowering in the two zones takes place when humidity is low. In Guinean zones, the fall in humidity is progressive from September (88.37%) to February (39.35%). Humidity rate in December is 49.9% and corresponds to the period of high flowering. In the Sahelian zone the drastic drop in humidity is observed from September to March with 81.55% and 16.85 respectively. The month of March with low relative humidity (16.85%) correspond to the periods which flowering reaches the peak. The rate of humidity that permits flowering therefore varies in function of the zone. This results ties with that of Mapongmetsem [20] in the forest zone of Cameroon. The percentage of trees with flower

from the flowering period during the years is on the whole higher in Sudanian zone than in Guinean zone. This corroborates Bonkoungou [21] predilection zone of the shea tree which is situated between 11° and 14° N where optimum temperature vary between 24- 32°C.

Anthesis period

The anthesis period according to Kengue [26] correspond to the opening of flowers. It oscillates between 18 and 23 hours in the two zones (fig. 6). Of the 45 trees studied in each zone 535 and 1544 flowers buds were counted respectively in Ngaoundere and Garoua. 54.22% and 62.48% terminated the anthesis process in the sahelian zones as against 45.78% and 37.52% in the Guinean zone on Ngaoundere. The most important anthesis period was registered at the interval between 8pm- 9pm with 45.17% of the total of 131 floral buds within this time interval, followed by the 7pm- 8pm interval with 33.1% of the 96 floral buds. From 6pm- 7pm and 9pm- 10pm very few *Vitellaria paradoxa* floral buds reaches anthesis. In the two sites, *Vitellaria paradoxa* flowers enter anthesis only after 10pm. However, the best anthesis period in the two zones starts from 7pm to 9pm. This time interval correspond to the period when the temperatures are a bit low and clouds present.

In agroforestry, the identification of anthesis period is very important because it is at this moment that the stigmata are most receptive to allow effective pollination. The manual pollination applied by Kengue [26] on *Dacryodes edulis* proved that the flowering rate was maximum when pollination was done during anthesis when compared to those realized 24 h before or after anthesis. During this period, the visit of nocturnal insects was observed on all flowers, which might mean that the anthesis period is during this time interval. It was noticed that the life span of a flower is about 14h, after this time, it loses it corolla and can no longer be visited by insects. It is therefore logical that pollination takes place in the night or early in the morning in Garoua because insects don't visit flowers without corolla. Given the fact that the perfume emitted by the flowers during the anthesis period attract more insects during this period, this therefore justify why night insects have great role in *Vitellaria paradoxa* pollination. These results are in accord with those of Bonkongou [21] in the same zone who noted that pollination in *Vitellaria paradoxa* interest mostly insects with nocturnal activities or those which are active in the early hours of the morning. The longest style observed in this species confirms the great role of cross pollination that involves many pollinating agents among which insects.

Floral entomofauna of *Vitellaria paradoxa*

A total of 2616 visits of 46 species of insects (table 1) were registered on *Vitellaria paradoxa* flowers in the two zones, that is 1395 visits for 38 species of insects in Guinean zone of Ngaoundere and 1228 for 42 species of insects in Soudanean zone of Garoua (table 2). The number of insect visit is low from those obtain by Fameni *et al.* [27]; they count 4585 and 4358 visits of five and ten insect species recorded on *Callistemon rigidus* flowers in 2009 and 2010.

The species of insects which visit *Vitellaria paradoxa* flowers are grouped in seven orders: Hymenoptera, Otoptera, Coleoptera, Dictyoptera, Hemiptera, Diptera and Lepidoptera. The Humenoptera are the most frequent with 2445 visits in the two zone that is 1293 in Ngaoundere and 1152 in Garoua, 49.42% and 44.03% respectively from the total of 2616 visits (table 2). Others are less represented with less than 30 visits. However, the diversification of insects was highly observed in Garoua with 91.3% as compared to 82.6% of the total number of insects counted, (table 2). In Hymenoptera order, three super families were noted: Formicidea, Vespidae and Apoidae; six families (Formicidae, Vespidae, Anthophoridae, Halicitidae, Apidae and Megachilidae) regroups 15 species. The Apoidae super- family was the most represented in terms of the number of species (table 1) with six species with 40% of the fifteen species of Hymenoptera, followed by Formicidae with five species and Vespidae with four species that is 33.3 and 26.7% respectively.

Table 2 : Distribution of insects depending on the species and number of visits on *Vitellaria paradoxa* flowers

zones		Coleo	Dictyo	Dipte	Hemi	Hyme	Lepido	Ortho	Total (nber)
		%							
Garoua	Species	16,66	2,38	19,04	7,14	30,95	16,66	7,14	42
	Visits	1,46	0,57	1,54	0,24	93,81	2,03	0,32	1228
Ngaoundere	Species	21,05	2,63	21,05	0	39,47	15,78	0	38
	Visits	1,36	0,35	4,22	0	92,68	1,36	0	1395

(Coleo: Coleoptera ; Dictyo: Dictyoptera ; Dipte: Diptera ; Hemi: Hemiptera ; Hyme: Hymenotera ; Lepido: Lepidoptera; Ortho: Orthoptera).

In this group, the Apidae have a very high proportion of visits (204) that is 65.8% of the 310 visits of Apidae in Ngaoundere (table 3) while in Garoua it is Halitidae (95) visits followed Apidae (92) respectively with 31.35% and 30.16% of the 303 visits in Garoua. The most frequently species in all zones (table 3) were *Componotus* sp, *Paratrechina logicornis*, *Apis mellifera*, *Crematogaser* sp with 945, 456, 296 and 228 visits respectively that is 38.68, 18.66, 12.11 and 9.33% for the 2445 visits of Hymenoptera.

Table 1 : Distribution of common insect species on *Vitellaria paradoxa* flowers based on the number of visits, time of visits and food foraging in the Garoua and Ngaoundere zones (N: night; D: day; ND: night-day; PN : pollen-nectar; N: nectar; PL: phytopageous-leave; Cn: nectariferous-carnivorous)

orders	Super-families	families	Genus and species (**46**)	Cumulative insect visits in both zones (**2616**)		Visits of insects in the Ngaoundere zone (**1393**)		Visits of insects in the Garoua zone (**1223**)		Periods visits	food collected
				Nombres	%	Nombres	%	Nombres	%		
Hymenoptera	Formicidea	Formicidae	*Camponotus sp*	842	31,18	366	26,27	476	38,92	ND	PN
			Camponotus brutus	103	3,93	54	3,87	49	4,00	ND	Cn
			Crematogaster sp	228	8,71	128	9,18	100	8,17	ND	PN
			Polyrachis sp	130	4,96	93	6,67	37	3,02	ND	N
			Paratrechina longicornis	456	17,43	300	21,53	156	12,75	ND	N
	Vespoidea	Vespidae	*Belonogaster juncea*	42	1,60	23	1,65	19	1,55	D	PN
			Philanthus triangulum	27	1,03	17	1,22	10	0,81	D	PN
			2 sp	2	0,07	2	0,14	0	0	D	P
	Apoidea	Anthophorida	*Xylocopa sp*	61	2,33	35	2,51	26	2,12	D	PN
			Ceratina sp	53	2,02	12	0,86	43	3,51	D	P
		Halictidae	*2 sp*	115	4,39	20	1,43	95	7,76	D	PN
		Apidae	*Apis mellifera*	296	11,31	204	14,64	92	7,52	D	PN
		Megachilidae	*1 sp*	88	3,36	39	2,79	49	4,00	D	P
Orthoptera	-	Acrididae	2 sp	2	0,07	0	0	2	0,16	ND	-
		Tettigoniidae	1 sp	2	0,07	0	0	2	0,16	ND	-
Coleoptera	-	Coccinilidae	2 sp	6	0,22	4	0,28	2	0,16	ND	P
		Scarabeidae	1 sp	8	0,30	0	0	7	0,57	D	PL
		Lycidae	*Lycus latissimus*	4	0,15	3	0,21	1	0,08	D	N
			Lytus sp	5	0,19	3	0,21	2	0,16	D	N
		Curcuhonidae	*2 sp*	2	0,07	2	0,14	0	0	D	N
		Autres Coleoptères	*2 sp*	12	0,45	7	0,50	5	0,40	D	N
Dictyoptera		Mantidae	*Mantis reliogiosa*	12	0,45	4	0,28	7	0,57	ND	-
Hemiptera		Pentatomidae	*2 sp*	2	0,07	0	0	2	0,16	D	-
		Autres Hemiptera	*1 sp*	1	0,03	0	0	1	0,08	D	P
Diptera		Muscidae	*Musca domestica*	33	1,26	28	2,01	4	0,32	D	N
		Syrphidae	*2 sp*	13	0,49	9	0,64	6	0,49	D	P
		Crysididae	*2 sp*	8	0,30	4	0,28	4	0,32	D	N
		Calliphoridae	*2 sp*	17	0,64	15	1,07	1	0,08	D	N
		Moustiques	*1 sp*	5	0,19	2	0,14	3	0,24	N	N
Lepidoptera		Nymphalidae	*Junonia oenone*	3	0,11	0	0	3	0,24	D	PN
		Sphingidae	*4 sp*	23	0,87	13	0,93	10	0,81	ND	PN
		Lycaenidae	*2 sp*	18	0,68	6	0,43	11	0,89	D	PN

The other species were less represented with less than 6% of the visits. On *Callistemon rigidus*, Fameni *et al.* [27] noted that *Apis mellifera adansonii* was the most represented insect with 3580 visits (78.08%) and 2565 visits (58.85%), in 2009 and 2010 respectively in the at Ngaoundere.

In the two zones, *Componotus* sp, was equally the most frequent with 534 and 420 visits that is 60.13 and 39.92% of the 873 and 1053 visits in Garoua and Ngaoundere zones respectively. Coleoptera and Diptera with the order that regrouped five families each (table 1) with nine and seven species respectively. When we consider the two zones whether in Garoua or Ngaoundere Hymenoptera was equally the most represented as summarised in tables 1 and 4 in terms of the proportion of visits with 93.81 in Garoua and 92.68% in Ngaoundere and species of insects with 30.95 in Garoua and 37.5% Ngaoundere in the two zones. In Ngaoundere zone, the most frequent species were *Componotus* sp, *Paratrechina longicornius*, *Apis mellifera*, *Crematogaster* sp with 420, 300, 204 and 128 visits respectively that is 28.3, 23.20, 15.77 and 9.89% for the 1293 visits of Hymenoptera in the zone. In the Garoua zone, it is some species that are most frequent but with different proportions. *Componotus* sp and 525 visits that is 45.57% of the total of 1152 visits of Hymenoptera *Paratrechina longicornius* had 156 visits with 13.54% and *Crematogaster* sp 100 visits with 8.82%. *Apis mellifera* was less frequent with 92 visits that is 7.98% of the 1152 visits in this zone. We can agree with Djonwangwe et al. [28] that pollination of this shea butter is necessary for the fruiting and that some visits of *Apis mellifera adansonii* have pollination impact.

Table 3 : Distribution of families of Apoidea based on the number of species and visits on *Vitellaria paradoxa* flowers

Zones		Anthophorida	Apidae	Halictidae	Megachilidae	Total (nber)
		%				
Garoua	Species	33,33	16,66	33,33	16,66	6
	Visits	22,11	30,36	31,35	16,17	303
Ngaoundere	Species	33,33	16,66	33,33	16,66	6
	Visits	15,16	65,80	6,45	12,58	310

Tableau 4 : Distribution of frequent visitors on *Vitellaria paradoxa* flowers

Zones		Camponotus sp	Crematogaster sp	*Paratrechina longicornis*	*Apis mellifera*	Total (nber)
		%				
Garoua	Visits	60,13	11,45	17,86	10,53	873
Ngaoundere	Visits	39,92	12,16	28,51	19,39	1052

Repartition of insect's visits hours

Vitellaria paradoxa flowers are frequently visited by pollinating insects in the day as well as in the night (fig. 6). The day is the most appropriate period (6am- 7am) with 65.6% of the visits. From night fall to the night (5pm- 10pm) only 3.12% of the insects visits the flowers. However 31.35% of insects visits the flowers of these plants both in the day and in the night. Hymenoptera (Vespoides, Apoides), Coleoptera, Hemiptera, Diptera with the exeption of Mosquitos family and Lepidoptera (Nymphalidae, Lycaenidae) visits *Vitellaria paradoxa* during the day. Hymenoptera (Formicidea), Orthoptera, Coleoptera (Coccinilidae), Dictyoptera and Lepidoptera (Sphingidae) visit these flowers both in the day and in the night. In the night only the mosquito's family (Diptera) visits the flowers of the plant.

In the group of Hymenoptera which are the main visiting insects, whether in Garoua or Ngaoundere, it is the *Componotus* (Formicidae) that presents a high percentage of visits with 28.30 and 41.30% respectively, followed by *Paratrechina longicornius* (Formicidea) respectively with 23.20% and 13.54%. *Apis mellifera* scarcely visits the flowers of this plant with 15.77 and 7.98% in Ngaoundere and Garoua respectively. The visit rate of other insects is very low irrespective of the zone with less than 8.68% in each zone. This result corroborates those of Fameni *et al.* [27] where *Apis mellifera adansonii* foraged on *Callistemon rigidus* flowers daily throughout the blooming period, with the peak of activity between 10am and 11am daily.

In the Sudano zone in Garoua 27.88% of the insects visit the flowers of this plant between 8am- 9am followed by the 10am- 11am, 4pm- 5pm, 3pm- 4pm, 6pm- 7pm time intervals with 22.40, 14.55, 14.22, 10.87% of the total insects that visits the flowers in the corresponding time intervals respectively. Insect's visits rates on the flowers are low from 12pm to 3pm. in the Guinean zone of Ngaoundere, the 10- 11am time interval is highly preferred (30.51%) by insects especially Hymenoptera with 92.47% of insects identified during this interval time, followed from a great distance by Diptera and Lepidoptera with 3.29% and 5% respectively. The Coleoptera and Hemiptera less represented. In general, in the two zones as shown on table 6 insects essentially visits *Vitellaria paradoxa* between 8 am and 11am.

Repartition of nutrients harvested by insects from *Vitellaria paradoxa*

The insects that visit *Vitellaria paradoxa* have different feeding modes (figure 7). 36.7% of these insects *Componotus* sp (32.18%) and *Apis mellifera* (11.31%) pick pollen and nectar, 33.3% foraging only nectar (*Paratrechina longicornius* (17.43%)) ; 16.7% harvest only pollen with *Ceratina* sp (02.08 %) and *Megachilidae* sp (3.36%) the most represented. Carnivorous insects, nectariferous-carnivorous, phytophageies, polliniferous-phytophageie present 3.3% each. This result shows the importance of this plant for apiculture. The apicultural value of *Vitellaria paradoxa* has been equally stressed by Tchuenguem Fohouo et *al.* [27] in his works on the exploitation by *Apis mellifera adansonii*; also the works of Sallé *et al.* [19] on shea butter as a potential wealth and recently by Dukku [7] on the identification of plants visited by the bees *Apis mellifera* in the savannah zone of North East Nigeria. This Apidae harvest from the flowers of the plant both pollen and nectar. Djonwangue *et al.* [28] and Dukku [29] also noted that *Apis mellifera adansonii* regularly and intensively collect nectar and pollen on *Vitellaria paradoxa* flowers.

Fruits bearing of *Vitellaria paradoxa*

The variance analysis carried out on the average rate of fruits at the end of observation indicated the existence of a significantly high difference between treatment ($P<0.001$) while the influence of repetitions was not significant. As such the localities of Bini, Dang and Borongo on the other hand did not show a great variation on the general rate of fructification. In effect, the rate of fructification varies according to the different types of treatments.

In the two zones, the rate of fructification varies in function of treatment. It is higher no matter the locality for the reference samples with 8.25% and 24.29% in Ngaoundere and Garoua respectively. The samples that were treated registered a low fructification rate of 3.94% and 1.07% in Ngaoundere for Tg and Tp respectively. 24.29% and 8.16% in Garoua for Tg and Tp respectively. The effect of zone on the fruit output is highly remarkable. The rate is very high in Garoua (34.38%) as compared to Ngaoundere zone (13.19%). These results show that the region of Garoua constitutes a predilection zone for the shea tree. When we consider the two treatments (Tg and Tp) the output of fruits is higher in Tg more than of Tp shows that insects intervened positively in the fructification of *Vitellaria paradoxa*. Betayéné [4] and Sallé [23] mentioned that the flowers of isolated *Voacanga africana* did not produce any fruits. Despite, the counting of numerous ants of *Crematogaster*, *Paratrechina* gender on the flower of Tg, the rate of fructification was low. This explains their inaptitude to efficiently transport pollen. This notwithstanding the rate remains higher than that of Tp where the cloth was inaccessible to all categories of insects. This means that ants also play a non-negligible role in the output of the fruit trees. The contribution of all the floral insects in the output of this species is estimated at 10.05% in Ngaoundere and 28.59% in Garoua. The impact of insect's activity on fruits bearing of *Vitellaria paradoxa* is positive Djonwangue *et al.* [28]

CONCLUSION

The result of this work shows that the phenological behaviour of *Vitellaria paradoxa* varies according to agro-ecological zones. Flowering is much later and spread out in Guinean zone than Ngaoundere. The harvest period of fruit starts from May to July in Ngaoundere and from June to September in Garoua. The anthesis period in the two zones is situated in the night but with a slight difference in time that is 7-8pm in Garoua and 8-9pm in Ngaoundere concerning floricultural entomofauna. Some insect's visits both in the day and in the night while the other visit only in the day or in the night. The main visitors are of the Hymenoptera order. The impact of insects is significant and positive on the output of fruit trees. The result of this investigation contributes to the domestication process of this oleaginous species. *Camponotus sp, Apis mellifera, Ceratina sp* and *Megachilidae* play an interesting role in the pollination of the plant.

REFERENCES

[1] J. B. Hall, D.P. Aebischer, H.F. Tomlinson, E. Osei-Amaning, J.R Hindle, *A Monograph. School of Agricultural and Forest Sciences*. University of Wales, Bangor, U.K. **1996**

[2] C. Kapseu, C. Tchankou Leudeu, C. Tchiegang, B. Hassana, *Cameroon Journal of Ethnobotany*. **2004**, 1 (1) 112-118.

[3] M. Arbonnier. *Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest*. CIRAD/MNHN/UICN. **2000**, 541.

(4] G. Sallé, J. Boussim, Raynal-Roques, F. Brunck. *Bois et Forêt des Tropiques*. **1991**. 228. 11- 23.

[5] P.M. Mapongmetsem. *Thèse de Doctorat d'Etat*. Université de Yaoundé I. **2005**, Yaoundé, Cameroun.

[6] Booth, F., Wickens, G. E., *Non timber uses of selected arid zone trees and shrubs in Africa*. FAO conservation guide **1988**, 19, 34-45.

[7] C. Tchiégang-Megueni, P.M. Mapongmetsem, *Actes du Séminaire sur le séchage et la valorisation du karité et de l'Aile*. **1999**, Ngaoundéré, Cameroun.

[8] M. Baumer, *Arbres, arbustes et arbrisseaux nourriciers en Afrique occidentale*. ENDA-Editions. Dakar, Sénégal. **1995**, 49-54.
[9] P.M. Mapongmetsem, Y. Hamawa, P. Djeumene, D. Maissele, C.F. Kossebe, J.F. Ndoum, J.B. Nduryang, F. Bebbe, D. Bouba, S. Wouldata, L. Zigro, M. Barbi. *Développement de l'Agro-industrie et création des richesses (Ngaoundéré, Cameroun : Actes, Conférence International)*. **2008**, 50 – 61.
[10] P. M Mapongmersem, C.Tchiégang Megueni, H.C. Akagou Zedong, Nyomo, Laissou Moussou, *Proceedings of 2nd African year workshop* **1997**, 7: 13-25.
[11] P. M Mapongmersem, C.Tchiégang Megueni, H.C. Akagou Zedong, Nyomo, Laissou Moussou. *Actes du 2ème séminaire International sur la valorisation du safoutier et les autres oléagineux non conventionnels*. Ngaoundéré, Yaoundé, Presses Universitaires de Yaoundé. Cameroun. **1998,** 13–24.
[12] H. Nyomo. *Mémoire de Maîtrise*. Université de Ngaoundéré. (Ngaoundéré, Cameroun. **1997**).
[13] M. Laissou. *Mémoire de Maîtrise*, Université de Ngaoundéré. (Ngaoundéré, Cameroun. **1997**)
[14] F.N. Tchuenguem Fohouo, P.M. Mapongmetsem, H.J. Hentchoya, J Messi, *Actes du 2ème séminaire international sur la valorisation du safoutier et des autres oléagineux non conventionnels*, Ngaoundéré, Cameroun. Presses Universitaires de Yaoundé. **1998**, 89–96.
[15] F.N Tchuenguem Fohouo, D. Djongwangwe, A.P.Mbianda, J. Messi, D. Brückner. *International Journal of Tropical Insect Science*s. **2008**, 28, 4. 225-233.
[16] J.B.L. Okullo, B J. Hall, J.Obua. *Agroforestry Systems.* **2004**. **60:** 77–91,.
[17] S. Yonkeu, Thèse de doctorat, Sciences Biologiques, Université de Rennes 1. (Rennes, France, **1993**).
[18] R. Letouzey, *Etude phytogéographique du Cameroun*. Paris, Ed. Paul Lechevalier. Ed Paris. **1968,** 511 p.
[19] E. D. Betayéné. *Mémoire de Maîtrise*. Université de Ngaoundéré. (Ngaoundere, Cameroun **1996**)
[20] P.M. Mapongmetsem. Thèse de Doctorat 3eme cycle, Université de Yaoundé I. (Yaoundé, Cameroun, **1994**)
[21] E.G. Bonkoungou, *Monographie du karité Butyrospermum paradoxum* (Gaertn.f.). Hepper. Espèce agroforestière à usages multiples, Ouagadougou, Burkina-Faso, Institut de Recherche en biologie et écologie tropicale. **1987**, 34 – 45.
[22] J. Hurault, Evolution récente des vallées de l'Adamaoua occidental (Cameroun-Nigéria). Rev. De Géomorph. Dyn., **1990**, 2, 49-62, Strasbourg.
[23] M. Tchotsoua, HDR. Université d'Orléans. **2005**.
[24] I.N. Amadou, Note préliminaire sur les espèces à usages multiples: *Acacia albida* Del, *Butyrospermum parkù* G. Don. Karité. Mesmes, Kamboise Burkina Faso. **1987**, 25p.
[25] M. Gautier. La fructification des arbres fruitiers. In : La culture fruitière. Lavoisier, Paris. **1993**. 56 - 73
[26] J. Kengue, Thèse de doctorat, Université de Yaoundé. (Cameroun. Yaoundé **1990**).
[27] S. Fameni Tope, F-N. Tchuenguem Fohouo, D. Brückner. *International Journal of Tropical Insect Science* **2012**, 32. 1. 2-11.
[28] D.Djonwangwe, F-N.Tchuenguem Fohouo, J. Messi., D. Brückner. *Int. J. Biol. Chem. Sci*. **2011**, 5, 4, 1538-1551.
[29] U.H. Dukku. *African Journal of Plant Science*. **2013**, 7, 7, 273-284.