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Foraging behaviour of three insect pollinators of *Jatropha curcas* in Samaru - Zaria, Nigeria

Alamu O. T.[1]*, Amao A. O.[2], Oke O. A.[3] and Suleiman R. A.[4]

[1]Savanna Forestry Research Station, P. M. B. 1039, Samaru, Zaria, Nigeria.
[2]Forestry Research Institute of Nigeria, Jericho, Ibadan, Nigeria.
[3]National Horticultural Research Institute (NIHORT), Idishin, Ibadan, Nigeria.
[4]Trial Afforestation Research Station, Afaka, Kaduna, Nigeria.

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ABSTRACT

Insects visit flowers for several reasons, the predominant reason being for food. *Jatropha curcas* is a flowering plant that attracts different insect visitors for pollination. Three insect pollinators, *Apis mellifera* (Hymenoptera: Apidae), *Chrysomya chloropyga* (Diptera: Calliphoridae) and *Eristalis tenax* (Diptera: Syrphidae) were observed on *J. curcas* in Samaru – Zaria, Northwestern Nigeria. It was observed that the population of *C. chloropyga* was higher than *A. mellifera* and *E. tenax*. The foraging number of the three species reached the peak in the third week of observation, a period coinciding with the floral boom of *J. curcas* in the locality. The foraging number of *A. mellifera* (3.09±1.3) was high in the morning hours, *C. chloropyga* (13.66±3.95) in the afternoon while *E. tenax* was active in the morning (1.23±0.56) and afternoon (1.83±0.7). *A. mellifera* spent less time (10.9±0.60 s) on *Jatropha* inflorescence than *C. chloropyga* (10.2±0.69 s) and *E. tenax* (6.9±0.69 s). *Jatropha* farmers in the study locality could benefit from domestication of *A. mellifera* for honey production in addition to its importance as *Jatropha* pollinator.

INTRODUCTION

Jatropha curcas L. (Euphorbiaceae) is a widely cultivated crop in Africa, Central and South America, India and Southeast Asia (Katembo and Gray, 2007; Maes et al., 2009). Depending on the variety, the decorticated seeds contain 40–50% of oil (Liberalino et al., 1988; Gandhi et al., 1995; Makkar and Becker, 1997; Sharma et al., 1997; Wink et al., 1997; Openshaw, 2000), which is used for many purposes such as lighting, as a lubricant, for making soap (Rivera-Lorca and Ku-Vera, 1997) and most importantly as biodiesel (Tiwari et al., 2007). The plant can be used to prevent soil erosion, to reclaim dry, marginal and degraded areas and grown as a live fence, especially to exclude farm animals (Heller, 1996). It is also cultivated in waste stretches under waste land development progarmmes as well as under commercial plantation under irrigated conditions with fertilizer application utilizing the hybrid varieties (Parthiban et al., 2009). *Jatropha* ecosystem is associated with an array of organisms such as pests, predators, parasitoids and floral visitors thus, exhibiting great bio-diversity (Banjo et al., 2006). The composition and richness of these organisms vary with locations.

Jatropha is monoecious with male and female flowers on the same plant and in the same inflorescence (Raju and Ezradanam, 2002; Chang-wei et al., 2007). During rainy seasons flowers are formed terminally and individually with large female flowers. It has been reported that the adhesiveness of the pollen, the smoothness of the stigma and a pollen flow by wind of 2.8 grains cm^{-2} make wind pollination almost impossible (Chang-wei et al., 2007). However, the bright yellow colour of anther, male flowers opening and evenly spread

*Corresponding author. E-mail: olaniyialamu@yahoo.com.

over the inflorescence life span, the fragrance of the flowers, nectar availability and large quantities of pollen with many verrucae on their exine for adhesion make insect pollination possible (Chang-wei et al., 2007).

Different types of flower visitors have been reported on *J. curcas* which includes honey bees, *Apis florae, Apis cerena indica, Apis dorsata* Fabricius*, Apis mellifera* L. (Apidae); ants, *Camponotus compressus* (Fabricius)*, Vespa* sp., *Xylocopa* spp., *Meghachile* sp., *Anthophora* sp. *Crematogaster* sp., *Solenopsis geminata* (Fabricius)*, Pheidole spathifer* Forel; thrips, *Scirtothrips dorsalis* Hood*, Thrips hawaiiensis* (Morgan); flies, *Chrysomya megacephala* (Diptera: Calliphoridae); butterflies, *Catopsilia* sp*., Euploe core* Cramer*, Chilasa (Papilio) clytia*; beetle, Ox*ycetonia versicolor*; and stingless bee, *Trigona iridipennis* (Raju and Ezradanam, 2002; Muthuraman and Saravanan, 2004; Ashoke et al., 2005).

Jatropha is one of the crops cultivated in Nigeria for its medicinal and environmental importance. However, there are inadequate information on the insect pollinators' status in terms of diversity and foraging behaviour on *Jatropha* in Nigeria despite the awareness of its environmental and economic importance. The objective of this work therefore is to elucidate the abundance and foraging behaviour of three main insect pollinators of *Jatropha* in Samaru – Zaria, Nigeria.

MATERIALS AND METHODS

Samaru, Zaria is situated on latitude 11° 04' N and longitude 07° 42' E, at an altitude of 550-700 m above sea level. It possesses a tropical continental climate with a pronounced dry season, which last up to seven months (October - May). The rainy season lasts from May to September/ October with long-term annual rainfall of 1040 mm in about 90 rain days. The relatively deep tropical ferruginous soils and climate conditions of Zaria are suitable for a good cover of savanna woodland (Northern Guinea Savanna) with a variety of grasses, woody shrubs and short trees.

The experimental locality is also characterized with forest tree species such as *Eucalyptus camaldulensis*, *Eucalyptus citriodora, Eucalyptus tereticornis, Khaya senegalensis, Azadirachta indica, Cassia auriculiformis, Parkia biglobosa* and fruit tree species which include *Mangifera indica, Citrus* spp. and *Psidium guajava*. Some of these are either grown in the wild, plantation or on farm lands as agroforestry trees. These tree species produce flowers at different times during the year and thus, they are good sources of pollen and nectar to bees and other insects that forage on flowers.

The experiment was carried out in *Jatropha* plantation of Savanna Forestry Research Station, Samaru - Zaria established in 2009. The dimension of the field was 60 m × 40 m, while the planting distance was 2 m × 2 m. Ten *Jatropha* stands were tagged randomly at the onset of rainy season in May, 2012 on which observation of insect pollinators were made. Observations were made on the abundance and foraging frequency at morning (8:00 am–9:00 am), afternoon (1: 00 pm–2:00 pm) and evening (5:00 pm–6:00 pm) three times weekly for seven weeks. Observations on the abundance of insect pollinators and number of visited flowers/minute were conducted by visual counting. The time of handling a flower/second was determined with the aid of stop watch. Insects were collected with sweep net and preserved in 70% ethanol in a plastic vial. The insects were identified at the insect museum of Forestry Research Institute of Nigeria, Ibadan. Data collected were analysed using Analysis of Variance and means were separated using Fisher's Least Significant Difference at 5% level of probability.

RESULTS

The three prominent pollinators on which observations were made are: *C. chloropyga* (Diptera: Calliphoridae), *A. mellifera* (Hymenoptera: Apidae) and *E. tenax* (Diptera: Syrphidae), respectively (Figure 1). Daily abundance of *A. mellifera* and *E. tenax* was similar but lower than that of *C. chloropyga* which had an average of 6.6 insects/plant (Figure 2). Also, a similar trend was observed on the weekly abundance (Figure 3). There was an increase in the population of the 3 pollinators from the first week and reached the peak in the third week and thereafter started declining and by the 7th week, *A. mellifera* and *E. tenax* were no longer observed on the plants (Figure 3).

The foraging number of *A. mellifera* was significantly higher in the morning than in the afternoon and evening which were not significantly different from each other. A significantly higher population of *C. chloropyga* was recorded in the afternoon on *Jatropha* flower than in the morning and evening while the population of *E. tenax* was significantly low in the evening than in the morning and afternoon (Table 1). The foraging populations of *A. mellifera* and *C. chloropyga* were not significantly different from each other in the morning but were significantly higher than *E. tenax*. It was observed in the afternoon and evening that foraging number of *C. chloropyga* was significantly higher than *A. mellifera* and *E. tenax*; however, numbers of *A. mellifera* and *E. tenax* were not significantly different from each other both in the afternoon and evening. Flower handling period was significantly shorter in *A. mellifera* (5.3 s) compared to *C. chloropyga* (10.5 s) and *E. tenax* (9.8 s) which were not significantly different from each other. The number of flowers visited per minute was significantly lower (6.9) in *E. tenax* than in *A. mellifera* and *C. chloropyga* which were almost the same, 10.9 and 10.2 respectively (Table 2).

Figure 1. Main pollinators of *Jatropha curcas*. (A) *Chrysomya chloropyga*; (B) *Apis mellifera*; (C) *Eristalis tenax*.

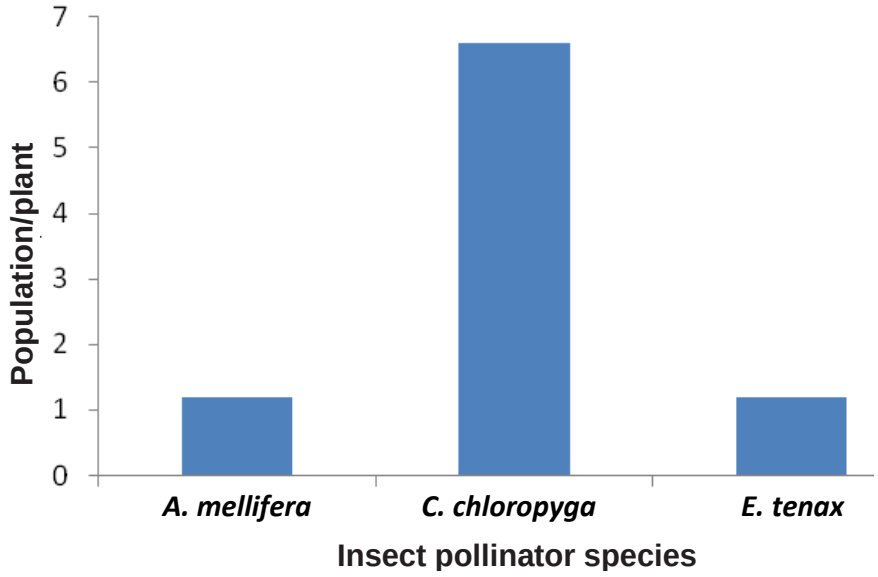

Figure 2. Mean daily number of three insect pollinators of *J. curcas*.

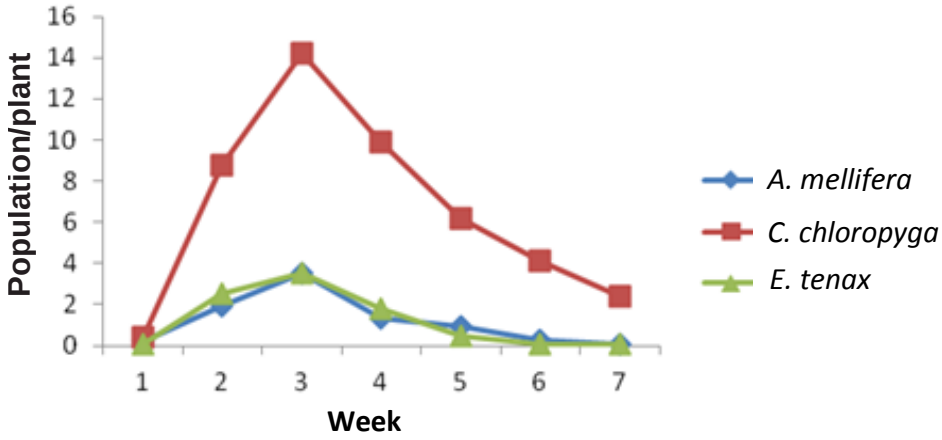

Figure 3. Weekly changes in the number of three insect pollinators of *J. curcas.*

Table 1. Foraging population of insect pollinators of *Jatropha curcas* at different times of the day in Samaru-Zaria, Nigeria.

Period of the day	Insect species			
	A. mellifera	***C. chloropyga***	***E. tenax***	**LSD (0.05)**
Morning	3.09±1.3	2.17±0.77	1.23±0.56	1.35
Afternoon	0.39±0.1	13.66±3.95	1.83±0.74	6.40
Evening	0.04±0.02	3.90±1.03	0.64±0.29	1.70
LSD (0.05)	2.21	7.12	1.67	

Values are mean of insects' species visitors ± standard error.

Table 2. Visiting frequency of insect pollinators of *Jatropha curcas*.

Insect pollinators	Visiting frequency	
	Flower/second	**Flower/minute**
A. mellifera	5.34±0.92	10.90±0.60
C. chloropyga	10.45±3.16	10.20±0.69
E. tenax	9.77±1.30	6.90±0.69
LSD (0.05)	4.26	1.93

Values are mean ± standard error.

DISCUSSION

The obtained results showed that *C. chloropyga, A. mellifera* and *E. tenax* are important pollinators of *J. curcas*. The source of *A. mellifera* could possibly have been from Savanna Forestry Research Station apiary of eight colonies located at about 200 m away from the experimental site. Also, bees could possibly have come from other traditional bee hives own by local farmers not far from experimental site. Sources of *C. chloropyga* may be from cow dung from cattle farms of National Animal Production Research Institute (NAPRI) and Divisional College of Agricultural Sciences (DAC), Ahmadu Bello University, Zaria which are located at short distances to the experimental site. The source of *E. tenax* could also be from other flowering plants in the wild. *A. mellifera* and *C. chloropyga* were reported as pollinators of *J. curcas* in South Africa (Neguisse et al., 2013) and *E. tenax* in Indonesia (Rianti et al., 2010). Pollinators are attracted by *J. curcas* for floral rewards (nectar and pollen) and they play a large role in the transport of pollen between flowers, inflorescences and trees (Neguisse et al., 2013). Bees and flies are known to collect pollen and nectar from flower. Nectar is the main source of energy for bees, while pollen provides proteins, lipids, vitamins and minerals for brood rearing and development (Nicolson, 2011). Studies have shown that pollen is required by female syrphids for normal ovarian development (Maier, 1978) and possibly by males to initiate sperm production (Kevan, 1970).

Considering the abundance of the three insects, *C. chloropyga* was significantly higher than *A. mellifera* and *E. tenax*. A similar observation has been reported on *J. curcas* in Zambia (Neguisse et al., 2013) where *C. chloropyga* was noted to be the most abundant of *Jatropha* visitors. The peak of the population of the three pollinators in the third week could be attributed to the period of flower bloom of *Jatropha* in the study area while the decline in population could be due to flower senescence and fruit development. The high activity observed of *A. mellifera* in the morning and *C. chloropyga* in the afternoon was similar to the report of Neguisse et al. (2013) that the populations of *A. mellifera* and *C. chloropyga* were high in the morning and afternoon respectively in Zambia while population of *A. mellifera* was higher in the afternoon than in the morning in Malawi. This suggests that foraging activities of pollinators may vary at different times in different locations. Ashoke et al. (2005) reported that *J. curcas* show forenoon pattern of anthesis with subsequent pollen release. This might have influenced the high foraging activities of *A. mellifera* before noon in order to obtain sufficient floral pollen reward.

Observation on foraging frequency showed that *A. mellifera* spent shorter time handling a flower than *C. chloropyga* and *E. tenax*. This observation is similar to that of Negussie et al. (2013) who reported that bees collected pollen and nectar inconsistently, with short durations per inflorescence; while flies spent long periods in a single inflorescence. In another development, *A. mellifera* has been reported to spend shorter time on mango inflorescence than *Chrysomya* sp. (Sung et al.,

2006). With shorter time spent by *A. mellifera* to handle a flower; one would have expected that many flowers will be visited in one minute than *C. chloropyga*. However, it was observed that almost the same numbers of flowers were visited in one minute by these two insects. The short flower handling time of *A. mellifera* could be because it is more active in flight moving from one flower stalk to another or from one tree to another while *C. chloropyga* spent most of the time foraging or basking within the flowers on the same stalk

Conclusion

Three main pollinators were observed in this study (*C. chloropyga, A. mellifera and E. tenax*). *A. mellifera* was noted to be faster in flight than *C. chloropyga* and *E. tenax* and can easily move among flowers within the same tree and other trees which may result in effective pollination and high yield of *Jatropha*. The integration of apiculture into *Jatropha* farming is highly recommended in the study area for a better fruit yield of *Jatropha*. In addition, the inclusion of apiculture in *Jatropha* farming can bring additional and immediate income to *Jatropha* producers from honey and other beehive products.

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