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Effect of time of day, weather parameters and fruit stage on insect visitors of *Carissa edulis* Vahl and *Jasminum dichotomum* Vahl in a protected Nigerian habitat

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Abstract: *Effect of time of day, fruits stage and weather parameters was investigated on foraging activities of insect species on Carissa edulis and Jasminum dichotomum fruits. Data was collected through video recording of insect activity on fruits between June and August, 2011. A bunch of more than 15 fruits was zoomed on 3 different sections on the plant for 15 minutes each in the morning, afternoon and evening. Temperature, humidity and rainfall were recorded at the start and end of each session. The videos obtained were transcribed into the following information: number of insect visitors and duration of foraging. Results showed that insect visit rate and duration of visit did not vary significantly between morning, afternoon and evening. Visit rate varied significantly but duration of foraging did not vary among insect orders between morning, afternoon and evening. Number of visits of insect orders when considered separately was not affected by time of day and weather parameters. The various insect orders responded differently to weather parameters and time of day in their foraging behaviours.*

Keywords: *Carissa edulis, Jasminum dichotomum, Time of day, Weather parameters, Foraging activity*

I. Introduction

Animals generally use their internal circadian clocks to monitor environmental variables and daily events in order to determine suitable times of activity [1]. Insects like other animal groups partition their niches by being active during specific seasons and specific times of the day. [2-3]. According to Biesmeijer and de Vries [4] internal and external factors influence foraging activity in insects. Internal factors such as individual memory and threshold response allow them to react to the foraging stimuli while external factors such as environmental and colony conditions determine the level of exposure to stimuli associated with the decision [4-5]. Scientists have carried out studies on effects of environmental factors with much emphasis on social insects but general insect groups have not been covered and studies focusing specifically on influence of weather conditions on insect fruit foraging has not been studied in the tropics. Studies on general behavioural patterns of social insects with respect to environmental factors have received considerable attention from scientists [6–17]. However, these findings do not represent the entire insect groups because of the distinct variation in behaviour patterns of social insects which are strictly hymenopterans from other insect groups such as dipterans, coleopterans, homopterans and orthopterans. Reports from these studies show that weather conditions, light intensity, humidity, food availability, competition, colony state, and physiological conditions of individuals are important factors that influence the foraging activities of Melipona species. Influence of time of day and weather conditions on foraging activity of insects have been reported from previous works of scientists [18- 21] where temperature and humidity were recorded to influence nectar feeding by insects. The study of effect of environmental factors on foraging activities of insects is important in understanding the ecological interactions of different insect groups with the environment. Weather variables especially temperature influence resource availability and also drives insects to be active at distinct times of the day. Hence, species that utilize the same resources at the same ecological niche and at distinct times of the day are considered essential models for effect of temperature on foraging activity.

Carissa fruits are produced during the rainy season usually from May to August while Jasmine fruits are usually produced from November to June. Insect fruit utilization of these plants has been studied and result showed that Carissa was utilized more by insects than Jasmine [22]. This is probably due to the succulent nature of the fruits of Carissa that makes it more palatable for insect consumption than Jasmine. Since weather variables influence different aspects of insect behaviours, it is therefore necessary to investigate the effect of weather variables (temperature and rainfall and/or humidity) on the foraging behaviour of insects in Amurum Forest Reserve.

II. Materials And Methods

2.1. Description of study area

This research was carried out in Amurum Forest Reserve (9º53'N, 8º 59'E). It is located in Laminga village, 15 km northeast of Jos, Plateau state, North-Central Nigeria. It covers an area of about 300 ha and a mean annual rainfall of 1375 mm-1750 mm per annum with a mean temperature of 10-13 ºC. The vegetation is a rocky outcrop in dry scrub savannah with gallery forests and patches of grassland (Fig. 1). The most unique species of biological significance are the avifauna population, diverse plant and insect species. The reserve holds about 300 species of birds which includes the nationally endemic Lagonosticta sanquinodorsalis and its brood-parasite Vidua maryae. The common tree species include Khaya senegalensis, Daniella oliveri, Parkia biglobosa, Lophira lanceolata, Ficus spp [23].

2.2. Video recordings of insect activity and fruit stage

Insect observation was done by taking video clips of insect activity on the focal plants using Camcorder (SONY, DCR-SR20; CANON, HR10). A total of 20 individual plants were observed for Carissa and 14 individual plants for Jasmine. Each plant was visited three times a day: in the morning (0700 - 0900 hours), afternoon (1200 - 1400 hours) and in the evening (1600 - 1800 hours). Three clusters having greater than five fruits were selected at three different locations per focal plant and recorded for 15 minutes each. Video records obtained from the camcorders were transcribed into the following information: Average insect visit rates per hour and average time spent. Ripe and unripe fruits were counted in each video clip. Videos obtained from the camcorder were transcribed to obtain the average visit rate per insect species per hour and average time spent per insect species. Insect identification was done using Photographic Atlas of Entomology and Guide to Insect Identification by James L. Castner [24] ; The pictoral Encyclopedia of Insects by V. J Stanek [25].

2.3. Recording of weather parameters

Weather parameters which included temperature, humidity and rainfall were recorded before and after each observation from weather station located within the reserve to compute average values for the variables.

2.4. Data analysis

Data analysis was carried out using R statistical package (3.0.3). Histogram frequency plots of the response variables was carried out to test for normality of the response variables. Weather parameters recorded in this study included: rainfall, humidity and temperature, however, other variables such as plant species, fruit stage and session were also considered. In order to avoid the effect of multicollinearity, significant predictor variables were selected using a stepwise selection in a generalized negative binomial model where variables that were not significant predictors were automatically removed returning the model with the least (best) AIC. The variables included in the model were: temperature, humidity, rainfall and fruits stage (ripe and unripe fruits). The predictor variables returned in the model with the best AIC were temperature for number of visits and rainfall for duration of visits. To test for the effect of temperature on number of visits and effect of rainfall on duration of visits, a generalized negative binomial model (glm.nb) was used. This model fitted the non-normality nature of the data which appeared strongly skewed to the left in a histogram and has variance which is greater than the mean for both number of visits and duration of foraging. Kruskal Wallis test was used to determine any difference in visit rate between morning, afternoon and evening.

III. Results And Discussion

3.1. Effect of temperature and time of day on Insect visit rate (cumulative)

The model with the best AIC was selected with temperature as the only predictive variable; Insect fruit visit rate decreased with increase in microhabitat temperature though this was not significant (GLM: $z = -1.808$, $p = 0.0706$; Table 1). Generally, mean number of visits by individual insects was higher in the morning followed by afternoon then evening (4.45±0.98, 4.39±0.8, 3.88±1.46 respectively), even though the variation was not significant (Kruskal-Wallis test, $X^2 = 0.12$, $df = 2$, $p = 0.94$).

Table 1: Effect of temperature on number of visits

Coefficients	Estimate	Std.Error	z value	Pr(>|z|)	
(Intercept)	0.90395	0.3133	2.885	0.00391	**
Temperature	-0.02555	0.01413	-1.808	0.0706	.

3.2. Influence of time of day and weather parameters on duration of visit of insects (Cumulative frequency).

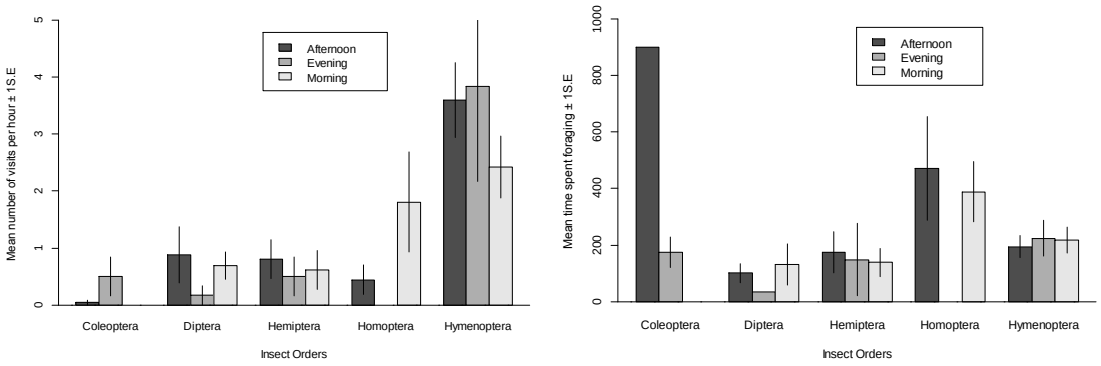
Mean time spent foraging by insect species also did not vary significantly between morning, afternoon and evening sessions (Kruskal-Wallis test, $X^2 = 3.4189$, $df = 2$, $p = 0.181$). The only significant predictor variable of duration of insect visits on fruits was rainfall (GLM: $z = 2.717$, $p = 0.00659$; Table 2)

Table 2: Effect of rainfall on duration of visits of insects

Coefficients	Estimate	Std.Error	z value	Pr(>|z|)	
(Intercept)	-40.6652	17.0294	-2.388	0.01694	*
Rainfall	0.06161	0.02268	2.717	0.00659	**

3.3. Influence of time of day and weather parameters on foraging activity of insects (across order)

Visit rate and duration of visit was analyzed for insect orders separately to check the foraging behaviours of the different insect orders according to time of day. During morning visit, 4 out of 5 orders namely; Diptera, Hemiptera, Homoptera and Hymenoptera were recorded at an average temperature of 17.86 ^{o}C, average rainfall of 752.16 mm and humidity of 94.24 %, the order Coleoptera was not recorded. The order hymenoptera were the most abundant visitors (63 of 143 visits representing 44.06 %) followed by the order homoptera (47; 32.86 %). Mean number of visit varied significantly (Kruskal-Wallis test, X^2= 13.72, df = 4, p = 0.008; Fig. 1a) but time spent foraging did not vary significantly among insect orders in the morning (Kruskal-Wallis chi-squared, X^2 = 2.6275, df = 3, p = 0.4527; Fig. 1b). In the afternoon, 5 insect orders which included Coleoptera, Diptera, Hemiptera, Homoptera, and Hymenoptera were recorded at an average temperature of 25.5 ^{o}C, average rainfall of 749.92 mm and humidity of 63.8 %.The order hymenoptera were more abundant with 88 out of 145 (60.69 %.) individual visitors, followed by diptera with 22 individuals (15.17 %) recorded. Mean number of visit among insect orders varied significantly in the afternoon (Kruskal-Wallis test, X^2 = 12.10, df = 4, p= 0.017; Fig.1a). However, time spent foraging did not vary among insect orders in the afternoon (Kruskal-Wallis chi-squared, X^2 = 4.5356, df = 4, p = 0.3383; Fig.1b). The orders Coleoptera, Diptera, Hemiptera and Hymenoptera were recorded in the evening at an average temperature of 24.0 ^{o}C, rainfall of 750.07 mm and humidity of 69.7 %. Mean number of visits varied significantly (Kruskal-Wallis test, X^2 = 26.77, df = 6, p < 0.001; Fig.1a) but time spent foraging did not vary significantly (Kruskal-Wallis chi-squared, X^2 = 1.6993, df = 3, p = 0.6371; Fig.1b) among insect orders in the evening. Out of the 30 individual insects recorded in the evening, 23 (76.67 %) were hymenopterans, while the dipterans and coleopterans were only represented by 3 individuals (10 %) each. Temperature did not have significant effect on number of visits of any of the insect orders. The effect of rainfall on duration of visit of insect orders was also not significant.



(a) (b)

Figure 1: Insect orders recorded by time of day (a) Visit rate (b) Duration of visit

General insect activity was higher in the afternoon followed by morning and lower in the evening although there was no significant variation in visit rate and duration of visit of insects between morning, afternoon and evening periods when insects were considered collectively. Similar findings were previously reported [20;21] on insect visitors of Cucurbita maxima flowers and in Withania somnifera where insect activity was high between morning and afternoon hours than evening [26]. However, insect orders considered separately showed significant variation in number and duration of visit to fruits by time of day. This variation in activity pattern exhibited by insect orders across time of day allow them to exploit food sources, reduce competitor conflicts and avoid predators as suggested [3]. Coleopterans were recorded only in the afternoon and evening except morning. More coleopterans visited the fruits in the evening than afternoon but the fewer afternoon visitors spent a longer time foraging than the evening visitors. The dipterans and hemipterans exhibited a similar foraging behaviour in their visit rate. Visit rate increased progressively from morning reaching its peak in the afternoon and reducing in the evening. The dipterans spent a longer time foraging in the morning and for a shorter period in the evening, while the hemipterans spent a longer time foraging in the afternoon and shorter period of time in the morning. The homopteran group were recorded highest in the morning and a drastic decline in number of visit in the afternoon without any record in the evening. However, time spent foraging took an opposite trend where the fewer homopterans recorded in the afternoon spent a

longer time foraging than the larger number in the evening. The hymenopterans showed a progressive increase in visit rate from morning through afternoon reaching a peak in the evening. They spent a longer time foraging in the evening and morning and for a shorter period in the afternoon. This pattern of foraging behaviours of the insect orders varies with findings of other scientists where insect species mostly belonging to the order hymenoptera exhibited a high foraging activity during the morning hours with activities declining at early afternoon hours [20-21]. However, foraging behaviours in the dipterans and hemipterans showed a similar pattern as was previously reported [20-21] where insect activity progressed from morning reaching its peak in the afternoon hours and reducing in the evening.

Temperature was the only predictive weather variable that could influence visit rate of insect visitors to fruits, but the effect was not significant for cumulative insect abundance and also for specific insect orders. Warmer temperatures usually between morning and afternoon hours influenced more insect visits to fruits, while hotter temperatures between afternoon and evening however, was associated with decrease in visit rates [27-28]. Increase in temperature resulted in a decrease in visit rate of insect visitors, however this decrease in visit rate at higher temperatures was quite negligible. While Rainfall was the variable that influenced duration of visit and not temperature, its effect was not significant on duration of insect visits both collectively and across orders. Kumar et al [20-21] similarly reported a negative effect of temperature and humidity on insect activities on Mangifera indica and Cucurbita maxima flowers.

Fruit stage did not have any predictive influence on visit rate as well as duration of visit of insects.

IV. Conclusion

The findings of this research shows that time of day and weather parameters influenced insect preference for fruit and their activity pattern for foraging. Other features such as the inherent characteristics of fruits and fruit stage (ripe and unripe) however, did not influence insect foraging behaviour. Activity pattern of insects did not vary significantly between time of day. This study on insects foraging behaviour in relation to time of day and prevailing weather conditions has provided a vital information for ecologists in understanding how environmental conditions could shape animal-plant interactions. The impact of this interaction is rewarding to the insects but unfavourable to these plants in terms of dispersal efficiency. This is because when insects feed on fruits, they reduce the attractiveness of the fruits to avian visitors who are effective dispersers of the plant seeds. In addition, since weather parameters play an important role in insect frugivory, the application of these findings in horticulture and pest management will make useful contribution to fruit dressing and preservation as well as pest control.

References

[1]. P. Jayatilaka, A . Narendra,. S. F., Reid, P. Cooper, and J, Zeil, Different effects of temperature on foraging activity schedules in sympatric Myrmecia ants, The Journal of Experimental Biology, 214, 2011, 2730-2738.

[2]. B. P, Kotler, J. S. Brown, S. R. X. Dall, S. Gresser, D. Ganey and A. Bouskila, Foraging games between gerbils and their predators: temporal dynamics of resource depletion and apprehension in gerbils. Evol. Ecol. Res. 4, 2002, 495-518.

[3]. N. Kronfeld-Schor, and T. Dayan, Partitioning of time as an ecological resource. Annu. Rev. Ecol. Evol. Syst. 34, 153-181.

[4]. J. C. Biesmeijer and H. de Vries (2001). "Exploration and exploitation of food sources by social insect colonies: a revision of the scout-recruit concept," Behavioral Ecology and Sociobiology,. 49 (2-3), 2003, 89–99.

[5]. D. L. do Nascimento and F. S. Nascimento, Extreme Effects of Season on the Foraging Activities and Colony Productivity of a tingless Bee (Melipona asilvai Moure, 1971) in Northeast Brazil, Psyche, doi: 10.1155/2012/267361, 2012.

[6]. A. Kleinert-Giovannini, The influence of climatic factors on flight activity of Plebeia emerina Friese (Hymenoptera, Apidae, Meliponinae) in winter, Revista Brasileira de Entomologia, 26, 1982, 1–13.

[7]. M. J. Sommeijer, G. A. de Rooy, W. Punt, and L. L. M. de Bruijn, A comparative study of foraging behaviour and pollen resources of various stingless bees (Hymenoptera, Meliponinae) and honey bees (Hym., Apinae) in Trinidad, West-Indies, Apidologie, 14, 1983, 205–224,.

[8]. M. Ramalho, V. L. Imperatriz-Fonseca, A. Kleinert- Giovannini, and M. Cortopassi-Laurino, Exploitation of floral resources by Plebeia remota (Holmberg) (Apidae, Meliponinae): floral preferences, Apidologie, 16, 1985, 307–329.

[9]. A. Kleinert-Giovannini and V. L. Imperatriz-Fonseca, Flight activity and responses to climatic conditions of two subspecies of Melipona marginata Lepeletier (Apidae, Meliponinae), Journal of Apicultural Research, 25, 1986, 3–8.

[10]. S. A. Corbet, M. Fussell, R. Ake et al., Temperature and the pollinating activity of social bees, Ecological Entomology, 18, (1), 1993, 17–30.

[11]. J. C. Biesmeijer, The organization of foraging in stingless bees of genusMelipona: an individual-oriented approach [Ph.D. thesis], Universit¨at Utrecht, Utrecht, The Netherlands, 1997.

[12]. L. L. M. de Bruijn and M. J. Sommeijer, Colony foraging in different species of stingless bees (Apidae, Meliponinae) and the regulation of individual nectar foraging, Insectes Sociaux, 44, (1),1997, 35–47.

[13]. S. D. Hil´ario, V. L. Imperatriz-Fonseca, and A. de M. P. Kleinert, Flight Activity and colony strength in the stingless bee Melipona bicolor bicolor (Apidae, Meliponinae), Revista Brasileira de Biologia, 60,2000, 299–306.

[14]. C. Cortopassi-Laurino, Seasonal strategies of harvesting by Melipona sp. in the Amazon region: in Proceedings of the 8th IBRA International Conference on Tropical Bees and VI Encontro Sobre Abelhas, 2004, 258–263, Ribeir˜ao Preto, Brazil.

[15]. A. O. Fidalgo and A. M. P. Kleinert, Foraging behavior of Melipona rufiventris Lepeletier (Apinae; Meliponini) in Ubatuba, SP, Brazil, Brazilian Journal of Biology, 67(1), 2007, 133–140.

[16]. A. O. Fidalgo and A. M. P. Kleinert, Floral preferences and climate influence in nectar and pollen foraging by melipona rufiventris lepeletier (Hymenoptera: Meliponini) in Ubatuba, S˜ao Paulo State, Brazil, Neotropical Entomology, 39 (6), 2010, 879–884.

[17]. S. D. Hil´ario and V. L. Imperatriz-Fonseca, Pollen foraging in colonies of Melipona bicolor (Apidae, Meliponini): effects of season, colony size and queen number, Genetics and Molecular Research, 8 (2), 2009, 664–671.
[18]. P. Bergman, U. Molau and B. Holmgren, MicrometeorologicalImpac tson Insect Activityan dP lant ReproductiveSuc cess in anA lpine Environment, Swedish Lapland, 28 (2), 1996, 196-202.
[19]. Somerville, D.. Honey bees in cherry and plum pollination. Agnote DAI/126, 1996.
[20]. P. Kumar, S. Baskaran, C. Sundaravadivelan, J. Anburaj and T. Kuberan, Insect visitors of pumpkin, Cucurbita maxima Duch., in relation to temperature and relative humidity, 8(2), 2012a, 501-513.
[21]. P. Kumar, S. Baskaran, C. Sundaravadivelan, T. Kuberan and J. Anburaj, Influence of environmental factors on insect pollination activity of Mangifera indica Linn, 2 (6), 2012b, 692-698.
[22]. M. R. Yilangai, G. S. Mwansat, A. A. Chaskda and O. Akwashiki, A comparative study of insect utilization of the fruits of Carissa (Carissa edulis Vahl) and Jasmine (Jasminum dichotomum Vahl) in a protected forest. IOSR Journal of Environmental Science, Toxicology and Food Technology, 7(1), 2013, 43-47.
[23]. A. U Ezealor, Critical sites for biodiversity conservation in Nigeria. (Nigerian Conservation Foundation: Lagos, Nigeria, 2002).
[24]. J. L. Castner, Photographic Atlas of Entomology and Guide to Insect Identification , (Feline Press, 2000).
[25]. V. J. Starnek, The pictoral encyclopedia of insects (The Hamlyn Publishing Group Limited, 1972).
[26]. M. K. Kaul, A. Kumar and A. Sharma, Reproductive biology of Withania somnifera (L.) Dunal. Current Science 88, 2005, 1375-1377.
[27]. C. McCall and R. B. Primack, Influence of flower characteristics, weather, time of day and season of insect visitation rates in three plant communities American Journal of Botany 794, 1992, 34-442.
[28]. D. P. Abrol, Sunflower polination: abundance and diversity of pollinting insects and their effect on seed yield. Indian Bee J., 58, 1996, 60-63.