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FORMICID FAUNA OF CONTRASTING TROPICAL RAINFOREST AGRO-ECOSYSTEM AND THEIR ENVIRONMENTAL IMPLICATIONS

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ABSTRACT

The pitfall technique was used to study ants in a secondary re-growth forest and a fallow plot at the Permanent Site of Nnamdi Azikiwe Awka from January to December, 1998. The selected environmental variables including mean soil temperature, mean relative humidity and rainfall. Species of ant obtained from the two sampling sites were Acantholepsis sp. Camponotus acvapimensis, C. perrisi, Myrmicaria striata, C. maculatus, Dorylus affinis Paratrechina sp., Megaponera foetans, Pheidole sp., Crematogaster sp. and Oecophylla longinoda. Statistical differences existed only in the distribution of Camponotus acvapimensis and C. perrisi with less catches recorded at the forest than the fallow plot. There was positive correlation coefficient between the density of Dorylus affinis and mean soil temperature (r = 0.84) at the forest while at the fallow plot negative correlation value (r= -0.61) was obtained between the population density of Acantholepsis sp. Populations of Acantholepsis also recorded a positive correlation (r = 0.54) with monthly mean soil temperature and mean relative humidity. These results do not only suggest a reflection of response of these ant species to these environmental variables during their foraging activities but their implications during the exploratory activities of these ants carried out in relation to temporal organization of the foraging systems, with these ants species exhibiting centrifugal polytheism associated with ant societies. The environmental implications of the trapping of these formicid species in the habitats studied were also discussed.

Keywords: Formicid fauna, Tropical rainforest, Agro-ecosystem, Environmental variables

INTRODUCTION

The pitfall technique has been found effective and used extensively in trapping crawling animals especially arthropods in various habitats. In studying arthropods these traps have been installed with or without preservatives (Greenslade, 1976; Ewuim, 1996, 1997; Ewuim and Nwuba, 2002). Studies on the use of the pitfall traps in studying ant fauna inhabiting the litter of forest and agro ecosystems in Nigeria include those of Ewuim, 1996, 1997; Ewuim and Ezenwugo, 1997; Ewuim *et al*. 1997). Earlier studies on litter arthropod species include those of Lasebikan (1974), Lasebikan *et al.* (1985) and Badejo and Van Straalen (1993), which focused on various aspects of the ecology of the collembolan fauna of forests and cassava plot in Ile-Ife. Other similar earlier studies on litter arthropods fauna (Lasebikan, 1977; 1985) dwelt more on Acarina and Collembola than any other group of litter arthropods (Ewuim *et al*., 1997).

The formicids (ants) are a distinct group among the arthropods with an outstanding degree of eusociality in the structural organization. These ants are noted for their co-existence, resource partitioning and population stability while being highly abundant and widespread in distribution, with unparaleled effects on all organization (Caroll and Janzen, 1973; Torres, 1984; Ewuim, 1996, 1997. These formicids in the tropics are the most successful insects on the planet earth, having evolved to secure a wide range of dissimilar ecological niches as herbivores, predators, fungus grazers, seed-harvesters, leaf-cutters, aphid-tenders (Boorman, 1981). In spite of the fact that species are characterized by the detailed fit of their form and function in relation to their way of life and environment by adaptive complexity. (Bourke and Franks, 1995), the population density of these species and their distribution are usually influenced either directly or indirectly by their pattern of interaction with one another within the given ecosystem. The foraging workers (of ants) as a result of reproductive altruism are involved in foraging activities in order to promote the survival and reproduction of the brood they rear (Bourke and Franks, 1995).

In this paper therefore, the species composition and the relative abundance of foraging ants on the forest floor and a fallow plot in a tropical rainforest zone in Nigeria will be studied using the pitfall trap and in relation to the influence of selected environmental variables on some of the species. The possible environmental influence of some of these species will also be highlighted. It is envisaged that this investigation will help upgrade the available information on formicid fauna in the tropics.

MATERIALS AND METHODS

Site Description: The investigation was carried out in two contrasting sites - a fallow farmland, and a secondary regrowth forest, all of which are located at the Permanent Site of the Nnamdi Azikiwe University, Awka. Awka, is the capital of Anambra State of Nigeria, is located in the lowland rain forest zone of Southern Nigeria (Keay, 1965; Charter, 1970).

The fallow farmland lies between latitude 6.25054^O N and longitude 7.12078^O E. The plot has been left fallow for twelve years after the previous cultivation and therefore was overgrown with plants and common weeds of fallows. Identified herbaceous plants included *Chromolaena odorata* (Kings and Robinson), *Aspilia africana* C.D. Adams), T*ridax procumbens* (L.), *Axonopus compressus (*Beauv.), *Mariscus longibracteatus* (Cherm.), *Sida acuta* (Burm). *Panicum maximum (*Jacq.) and *Veronia ambigua (*Kotchsky and Peyr.) Trees found at the plot included *Pentaclethra macrophyla* (Bentham), *Chlorophora excelsa* (Welw.) *Mangifera indica* (L.), *Combretum molle (*R. Br.), *Eleais guineensis* (Jacq.), *Newbouldia laevis* (P. Beauv.), *Terminalia ivorensis* (A. Chev.) and., *Anthonata macrophylla* (P. Beauv.). The fallow farmland which is sandy loam and over 1000m^2 in area is separated from the cultivated farmland by a tarred road leading from the first gate of the Permanent Site of the Nnamdi Azikiwe University, Awka.

Similarly the forest under study can be described as a secondary regrowth forest in an area of forest – agricultural mosaic (Lasebikan, 1974). The study area lies between latitude 6.25774^O N and longitude 7.11275^O E. Alternatively it is located south east to east of the School of Postgraduate Studies and general south east of Rufai Garba Square with an approximate bearing of 125^O and a distance of 200m from the centre point of the Square. The size of the sampling plot is about 2000 m in area.

The herbaceous plants found at the fringe of the forest included *Chromolaena odorata* (L.) and *Panicum maximum (*Jacq.) In addition, shrubs like *Mallotus oppositifolius* (Giezel), and trees *Newbouldia laevis* (P. Beauv.), *Alstolia boonei (*de Wild), *Diallum guineensis* (L.), *Alchornea cordifolia* (Schum and Thonn.), *Alstonia bonei* (de Wild), *Ceiba pentandra* (Linn.) Gaertn., *Chlorophora exelsa (*Welw.) *Harungana madagascariensis (*Lam and Pols), *Newbouldia laevis* (P. Beauv)., *Mormda lucida* (Benth.), *Pterocarpus milbraedii (*Harrns.), *Ricinodendron heudelotti* (Bail)., *Rauvolfia vomitoria* (Afyel) and *Fagara macrophylla (*Engl.) were found.

Sampling Method: Eight pitfall traps made of plastic containers, with mouth diameters of 9.80 cm and 6.2 cm deep were set in all the study sites on monthly, for a twelve month period. The traps were filled to one-third with 5 % formalin. The traps were collected after twenty-four hours and the insects caught were sorted and counted under a dissecting microscope.

Rainfall data was collected during the sampling period using the rain gauge, while mercury in bulb thermometer was used to measure aerial and soil temperature on each sampling occasion. The readings of those temperatures were taken twice in each case both at the time of setting the traps and during their collection. Relative humidity was measured three times (with their average taken) on each sampling occasion using the whirling hygrometer. The relative humidity was obtained from the reading of wet and dry bulb thermometers of the whirling hygrometer by reference to an accompanying and usually laminated hygrometrical (conversion) table.

The insects and their larvae were identified using insect of Nigeria – Check List and Bibliography by Medler (1980). The identification of the specimens was verified in the Department of Crop Protection, Institute of Agricultural Research, Ahmadu Bello University, Zaria Nigeria. The voucher specimens were also kept as point for further studies. The t-test was used to compare the forest and the fallow plot. Linear correlation test was carried out between selected environmental variable and the ant species sampled from the two contrasting habitats to assess any closeness of relationship. The site location was carried out using the Global Positioning System (GPS).

RESULTS

The results of the monthly pitfall catches of ant species from the forest and the fallow plot are shown in Table 1. A total number of ten species belonging to eight genera were recorded during the twelve-month sampling period. From the statistical analysis of the data using the Student t-test all the species failed to show any significant differences in their trapping except *Camponotus acvapimensis* and *C. perrisi* which showed significant difference at a t-value of 2.564 and 2.131 respectively, with less catches obtained at the forest than the fallow plot. Table 2 shows the physical variables – mean soil temperature, mean relative humidity and monthly rainfall. The mean soil temperature in the forest was relatively lower at the forest than in the fallow plot. On the other hand the monthly mean relative humidity was consistently higher at the forest than the fallow plot. The highest monthly rainfall was experienced in May 1998 while the months of January, February and December failed to experience rainfall. Table 3 shows the correlation coefficient values (r) obtained when the pitfall catches of some of the species were correlated with selected physical variables - mean soil temperature, mean relative humidity and rainfall. Significant positive correlation values were obtained for *Camponotus perrisi* and *Dorylus affinis* at the forest with r values of 0.64 and 0.84 respectively at probability level ($p \leq 0.05$), when the pitfall catches were correlated with mean soil temperature. At the fallow plot however the relative populations of *Acantholepsis* correlated with mean soil temperature correlated with monthly mean soil temperature (r = 0.54)) at $p \leq 0.10$ but negatively correlated with monthly mean relative humidity (r = -0.61) at $p \leq 0.05$).

Table 1: Monthly pitfall catches of ants species from the forest and the fallow plot

Ant Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
***Acantholepsis* sp.**	2	-	-	-	-	-	-	-	-	-	-	6	8
	(13)	-	-	-	(7)	-	(1)	-	-	-	(3)	-	(24)
Camponotus acvapimensis	-	2	1	1	3	-	-	-	2	-	-	3	10
	(7)	-	-	(3)	(5)	(2)	-	(1)	(2)	(6)	(6)	(4)	(36)
C. *perrisi*	3	-	-	-	2	-	-	-	1	-	-	-	6
	-	(2)	(2)	(5)	(2)	-	(1)	(2)	-	-	(2)	(4)	(20)
C. maculatus	-	-	-	-	-	-	-	-	-	-	-	-	0
	-	(5)	-	-	-	-	-	-	-	-	(1)	-	(6)
Dorylus affinis	16	-	-	-	-	-	-	-	-	-	-	-	16
	-	-	-	-	-	-	-	-	-	-	-	-	(0)
Megaponera foetans	-	-	1	-	-	1	-	1	2	1	-	-	6
	(11)	(1)	-	-	-	-	-	-	-	(1)	-	-	(13)
***Pheidole* sp.**	-	-	14	-	2	4	-	2	-	3	6	10	41
	-	-	(1)	(1)	-	-	-	(1)	(1)	(3)	(2)	(11)	(24)
***Crematogaster* sp.**	-	1	-	-	-	-	-	-	-	-	-	-	1
	-	-	-	-	-	-	-	-	-	-	-	-	(0)
Oecophylla *ionginoda*	-	-	-	-	-	-	-	-	-	-	3	-	3
	-	-	-	-	-	-	-	-	-	-	-	-	(0)
Myrmicaria striata	1	-	-	-	-	-	-	-	-	-	-	-	1
	-	-	-	-	-	-	-	-	-	-	-	-	(0)

Number of ants in fallow plot in parenthesis

Table 2: Monthly means meteorological parameters obtained at the two study sites during sampling

Month in 1998	Mean soil temperature		Mean relative humidity		Rainfall (daily average)	
	Fallow Plot	Forest	Fallow Plot	Forest	Fallow Plot	Forest
January	35.50	33.50	52.00	78.00	-	-
February	35.75	28.50	53.50	63.00	0.6	0.60
March	37.00	29.00	44.50	57.00	1.20	1.20
April	30.75	27.50	76.50	77.00	4.00	4.00
May	31.25	28.00	74.50	83.00	13.60	13.60
June	29.00	28.00	84.50	87.00	11.00	11.00
July	29.25	26.50	80.50	87.00	12.60	12.60
August	33.50	26.00	88.50	96.00	3.20	3.20
September	30.00	28.50	79.00	85.50	9.80	9.80
October	29.00	31.00	68.00	63.00	12.50	12.50
November	26.00	30.00	65.50	74.00	-	-
December	27.50	29.00	73.00	72.50	-	-

Table 3: Linear Correlation coefficient values between selected environmental variables and some ant species sampled at the forest and the Fallow Plot

Ant Species	Selected environmental variables at the plots					
	Mean soil temperature		Mean relative humidity		Rainfall (daily average)	
	Forest	Fallow plot	Forest	Fallow plot	Forest	Fallow plot
***Acantholepsis* sp.**	-	0.54++	-	-0.61+	-	-0.34
Camponotus perrisi	0.64+	-	0.19	-	-	0.09
Dorylus affinis	0.84+	-	0.02	-	-0.32	-
Megaponera foetans	-	0.39	-	0.45	-	-0.31
***Pheidole* sp.**	0.001	-0.49	-0.59+	-0.22	-0.46	0.09
Oecophylla ionginoda	-0.11	-	-0.01	-	-0.09	-

+ Significant at $p \leq 0.05$; ++ Significant at $p \leq 0.10$; - Absence of relevant information

At the forest while the pitfall catches of Ca*mponotus perrisi* correlated positively with monthly mean relative humidity (r = 0.64), the pitfall catches of *Pheidole* sp. showed a negative correlation (r = -0.59) with the monthly mean of the same environmental variable at $p \leq 0.05$.

DISCUSSION

The ants trapped from both the forest and the fallow plot under study largely represent the foraging ants. The non significant differences in the trapping of these foraging ant species except for *Camponotus acvapimensis* and *C. perrisi* is an indication that the fallow environment also favoured the nesting and foraging activities of this species and indeed other members within the genera (Ewuim, 1996). In addition it has been reported that *Camponotus acvapimensis* are wholly ground nesting apparently over a wide area (Tailor and Adedoyin, 1978; Ewuim, 1997, 2004a).

The relatively higher monthly mean temperature at the forest than in the fallow plot is in agreement with the observation by Whitmore (1998); Ewuim *et al*. (2004) and Ewuim (2006) that the forest provided an internal microenvironment different from the general climate outside the canopy. This also explains the relatively higher monthly mean relative humidity prevalent in the forest interior as opposed to the lower monthly mean relative humidity in the fallow plot which is censored by the observation of Ewuim *et al*. (2004) and Ewuim (2004b) that the forest is humid in nature.

The significant positive correlation obtained for the population of *Camponotus perrisi* and *Dorylus affinis* when correlated with monthly soil temperature was indicative of the importance of this environmental variable to the species. The significant correlation of the densities of ground foraging *Camponotus perrisi* and *Dorylus affinis* with mean soil temperature does not only confirm the ability of these ant species to adapt to these temperature and also explore space efficiently (Bourke and Franks, 1995) but emphasize the importance of soil activities carried out in relation to temporal and spatial organization of the foraging systems (Holldobler and Wilson, 1990), with these ant species exhibiting centrifugal polyethism (or tendency of the old workers to work outside nest) (Bourke and Franks, 1995) associated with ant societies. It has also been observed that *Dorylus* is subterranean in habit building temporary nests, which are abandoned after some (Olaniyan, 1978; Ewuim, 2004b) which also strengthens the importance of soil temperature to *Dorylus affinis.*

The significant positive correlation of the population of *Acantholepsis* with monthly mean soil temperature is an indication of the influence of this physical variable on the species at the fallow plot. The significant negative correlation observed for *Acantholepsis* with monthly mean relative humidity is an indication of the negative influence of this environmental variable with the species at the fallow plot.

The significant positive correlation of *Pheidole* species with monthly mean relative humidity at the forest is also indicative of the importance of this environmental to the foraging activities the species. The fallow plot evidently favoured the foraging activities of *Pheidole* which have been described as harvesters since they feed on plant seeds, like those of grasses abundant in the fallow plot (Wilson, 1959, Ewuim, 1997).

In terms of the environmental implications of the ants sampled from the agro-ecosystem, ants are known to exert remarkable influence on ecosystems. In a heterogeneous environment where patches offer different conditions for growth, or have been disturbed at different times in the past, completive exclusion is likely to be very slow and might never reach completion (Palmer, 1994). More heterogeneous environments would then be expected to support greater number of species (Williams, 1964, Bell *et al*., 2000), with the ant species constituting predators, pathogen vectors, pests and of beneficial value.

The eight genera and ten species of ants taken in the pitfall traps with these ants belonging to the family Formicidae were represented in both habitats. Ant species (in addition to termites and earthworms) have been referred to as ecosystem engineers (Jones *et al*., 1994; Jones *et al*., 1996) in relation to their role in habitats. These ants are not only responsive to human impact but are important within the below ground process, not only through alteration of the physical and chemical environment, but through their effects on plants and micro-organisms (Folgarait, 1998).

Pheidole can also serve as bioindicators in habitats where they are found together with other species (Anderson, 1997). *Pheidole* is also implicated as a predator in tropical terrestrial ecosystem (Way and Khoo, 1992) with the exhibition of polyphenism, which allows the production of different castes in relation to colony needs and thus influencing their number in these habitats (Wheeler and Nijhout, 1983; 1984). *Pheidole* can serve as pests under synanthropic conditions. The predaceous, *Oecophylla longinoda* reputed to be the most aggressive insect, lives and nests in trees (De Pury, 1968). These tailor ant utilizes silk from larvae approaching metamorphosis to fasten the leaves of their nests together (Prudhomme *et al.,* 1985). By implication, therefore, *O. longinoda* is regarded as a nuisance pest capable of making harvesting of crops difficult, while reducing the photosynthetic efficiency of the leaves bound together in the course of building these nests (NFMANR and ODABG, 1996).

Crematogaster sp. are also tree nesting and have been classified as scavengers (Wilson 1959; De Pury, 1968) involved in tending honey dews produced by other insects. *Crematogaster* also produce phenolic compounds such as 3-pentylphenol from their metapleural gland with antibiotic properties for defense against pathogens (Chapman, 2000). By implication it is being suggested that their activities in their habitat may implicate them as pests under certain conditions. *Crematogaster* sp. including *C. gambiense* have been reported as a nuisance and a synanthropic formicid (ant) serving as pests of food stuff like crayfish in homes (Emosuairue, 1998). Species of *Crematogaster* occasionally damage cocoa and coffee (Le Pelley, 1968; Entwistle, 1972). *Crematogaster* sp. and *Oecophylla* sp. are arboreal (May, 1973; Bolton, 1973; Ewuim *et al.,* 1997), hence their low trapping in these pitfall traps e.g. (Ewuim *et al.,* 1997). It is therefore not surprising that even though *Oecophylla* were observed in their nests on some tree especially at the forest, their relative abundance was not reflected in the pitfall traps as opposed to the numbers of the ground nesting *Camponotus* species. These ground-nesting *Camponotus* species under indoor or environment can constitute a nuisance, as opposed to their asynanthropic conditions in the plots.

Predation is widespread among the *Camponotus* sp., *Dorylus affinis* and *Megaponera foetans* thus making them liable for use as control agents for noxious species. *M. foetans* has been used for control of certain termite species (Skaife, 1953). These observations are in agreement with the report that ants have a major influence on other organisms in the tropics where some important predatory species serve as control agent (Caroll and Risch, 1983; Way and Khoo, 1992). *Dorylus* sp. can however constitute a serious pest to crops (Viswanath and Veeresh, 1988).

Finally *Camponotus perrisi,* and other *Camponotus* sp. were also taken in the traps. *Camponotus* sp. have pest status in these habitats. *Camponotus* sp. for example can strip bark off the roots of plants species (Le Pelley, 1968). The camponotine ants in these two agro- ecosystems can play beneficial role, largely carnivorous and usually ground-nesting and can help to reduce termite populations where they are found (Skaife, 1953) and a strategy in their ecosystem engineering services (Folgarait, 1998).

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