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Ecology of lady bird's species (Coccinellids) in farmland and bushes within the university of Calabar area, Calabar, Southern Nigeria

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Abstract
Ladybirds (Coccinellidae) are natural predators of insect pests, offering an environmentally friendly alternative to chemical pest control in agricultural systems. My study aimed at assessing the abundance and diversity of ladybirds across four sites: a cassava farm (Site A), a grassy field (site B), bushes (site C), and shrub stands (site D) over a six-month period (July-December 2017). Sampling was done randomly within quadrants (10x10 meters) of each site for 1-2 hours, with individuals collected via netting and hand-picking. A total of 864 ladybird individuals, comprising six species across three sub-families (Chilocorinae, Coccinellinae, and Epilachninae), were recorded. Chilocorus stigma (38%) was the most abundant species, while Harmonia octomaculata (2%) was the least. Site A had the highest abundance (571 individuals), and site B had the lowest (2 individuals). Predatory ladybirds outnumbered herbivorous ones. The population was significantly higher ($p<0.05$) during the dry season (694 individuals) than the rainy season (170 individuals). Chilocorus stigma dominated both seasons, with peak abundance in November. Ladybird populations were lowest in July and highest in November. These findings suggest that frequent surveys are necessary to evaluate ladybird fauna for supporting integrated pest management. Additionally, conservation of natural habitats is crucial as ladybirds are sensitive to habitat changes.

Keywords: Conservation ecology, lady birds, coccinellids, farmland, Calabar, Nigeria, pest control

Introduction
Insect have always been around longer than we can remember and have always been a threat to agricultural productivity globally (Pearson, 2004) [14], that is not to say that they have entirely been mischievous. They have played amazingly significant roles in balancing man's ecosystem. Their roles as pests has somewhat clouded their enormous benefits. In result, the crop productivity per unit area is often reduced far less than the actual potentials where insect pests exist or are not effectively controlled. Eventually it is however important that harmful insects are controlled (Pearson, 2004) [14].

The ladybird beetles belong to a family Coccinellidae. The family Coccinellidae is placed in the superfamily Cucujoidea, series Cucujiformia within the suborder Polyphaga and order Coleopteran (Vandenberg, 2002) [22]. The subfamilies include Chilocorinae, Coccinellinae, Coccidulinae, Scymninae, Sticholotidinae and Epilachninae. Among these subfamilies, five (5) are predacious and one (1) Epilachninae is phytophagous in nature (Vandenberg, 2002) [22]. Their colours are usually bright, commonly yellow, orange, or scarlet with small black spots on their elytra, with black legs, heads and antennae (Seago *et al.*, 2011) [16]. These colour patterns vary enormously, along with the number of spots available. Coccinellids are found worldwide, with over 5,000 species described (Judy and Tudor, 2000) [10]. Coccinellidae are referred to commonly as "ladybirds" (in Britain, Ireland, the Commonwealth, and some parts of the southern United States), "ladybugs" (originating in North America) or "ladycows", among other names (Judy and Tudor, 2000) [10]. Adults ladybirds are oval shaped, and range in length from about 1mm to over 10mm depending on the species. Their hind wings have been modified to form a hard covering called the elytra that serves as a protective sheath for its delicate body (Vandenberg, 2002) [22]. They exhibit sexual dimorphism with females often larger than males on average (Horowitz *et al.*, 2007) [8].

Coccinellids are more or less worldwide in distribution. About six thousand (6000) species of

these beetles have been reported worldwide (Vandenberg, 2002) [22]. Firstly, many ladybirds have bright contrasting colour patterns. Secondly, about ninety percent (90%) of the approximately four thousand two hundred (4200) Coccinellid species are considered beneficial because of their predatory activities, mainly against homopterus insects (aphids and scale insects) and phytophagous mites, which are harmful to a number of agricultural and forest plants (Shah, 1985) [17]. Ladybird beetles are charismatic and have great ecological and economic significance and are cannibalistic, successfully preying upon larvae and eggs of other aphid predators (Vandenberg, 2002) [22]. Ladybirds are well known to exhibit intraguild predation, and this has led to their widespread use and their proliferation as invasive species (Pearson, 2004) [14].
Ladybird beetles lay their eggs on leaves, stems and sometimes on the bark of plants often near prey. The eggs of most species are long, usually oval and vary from a light yellow to a deep orange color (Pearson, 2004) [14]. Larvae are usually bright colored, with various protuberances on the body segments. Larvae go through four (4) instars and then pupate on leaves or branches by attaching the body to a leaf surface. Although, the pupae are generally thought to be inactive, they are not completely immobile. Their lifecycle is completed in one month, depending upon location and temperature; two or three generations are generally produced a year (Hodek *et al.,* 2012) [5]. Adults are seen during dry season in sheltered locations such as tree holes and other natural hiding places (Hodek *et al.,* 2012) [5].
The importance of lady birds to farmers cannot be over emphasized. In a world where the use of chemicals is preferred by farmers for the control of pest, lady birds have been well documented to be more than useful in the control of harmful pest (Hodek *et al.,* 2012) [5]. To this end, it is pertinent to study the ecology of ladybirds in University of Calabar fields, an area where no documented research has been carried out on ladybirds. Highlighting the ecology and potentials of ladybirds in pest control will increase baseline information on the species. The present study is aimed at gaining a proper understanding on the ecology of ladybirds in farmlands and bushes of the University of Calabar, under the following objectives: 1) The abundance of ladybirds, 2) The diversity and species composition of ladybirds, and 3) The seasonal variation in the availability of ladybirds in the University of Calabr farmlands.

Materials and Methods

Study area

The University of Calabar is located in latitude 8.35° North, longitude 4.94° East (Fig. 1), and is adjacent to the great Kwa river located in latitude 8.20° North, longitude 4.45° East, in the Southern parts of Cross river (Akpan *et al.,* 2002) [1]. The area experiences a tropical weather, with the average temperature of 35 °C average annual rainfall is about 2750 mm. The area consists of a lot of horticulture and agriculture, and its climate is governed by two seasons, namely the wet and the dry. Recently, durations of both seasons have become somewhat of an issue with yearly alternations typifying the effects of global warming. The field study was carried out at Obufa Esuk, close to the University of Calabar staff quarters adjacent to the Great Kwa River.

Collection of lady birds

The study area was divided into 4 different sites and labeled A, B, C, and D respectively. The sites sampled included: a nearby cassava farm (site A), a grassy field (site B), Bushes (site C), and stands of shrubs (site D). The ladybirds were collected from the 4 different sites (A, B, C and D respectively) over a period of six months. The selected sampling sites were divided into plots or quadrants of similar sizes (10 meters by 10 meters). Sampling was done randomly within the quadrant in each site. Samples were collected in July, August, and September 2017 for the wet season and October, November, and December 2017 for the dry season.
Each site was frequently visited daily. Sampling was carried out between 8am and 6pm daily. Each sampling session lasted 1–2 hours. The adult ladybird specimens on the shrubs, crops, and weeds were collected into a well-washed sampling container randomly by netting, and hand picking when fully engulfed. Samples were first treated in vials containing 75% ethanol, and then pinned and placed in a collection box. Each species was labeled noting the place of collection, date of collection, and host plant species, then brought to the Zoology and Environmental Biology Laboratory of the University of Calabar. All specimens collected were sorted, counted, and identified using Ladybirds naturalist handbook (Horowitz *et al*., 2011) [7].

Determination of population density

The number of individuals counted within each quadrant was recorded and averaged. The population density was expressed in number of individuals per quadrant area. Population density was estimated using the formula:

$$N = \left(\frac{A}{a}\right) \times \mathbf{n}$$

Where N = the estimated total population
A= the total study area
a = the area of the quadrant
n = the number of organisms per quadrant

Determination of species richness

Species richness was calculated as described by Menhinick (1964) as shown below:

$$D = \frac{S}{\sqrt{N}}$$

Where
D = species richness
N= total number of individuals
S=Total number of individuals of a particular species

Diversity indices

Shannon's index (H), Simpson's diversity index (D), and equitability index (E) were used to measure the diversity of species in the selected areas.

Shannon weiner index (H): Shannon weiner index was calculated according to Shannon and Weiner (1949) [18] as shown below:

$$H = \sum \frac{Ni}{N} \log_2 \frac{Ni}{N}$$

Where;
N = total number of individual in the sample

Ni = total number of individuals of species *ith* in the sample

Simpson index (D): Simpson's index was calculated according to Simpson (1949) [21] as follows:

$$D = \sum_{i=1}^{s} (Pi^2)$$

Where
D = value of Simpson diversity index
P_i = Proportion of individuals of the ith species
S = number of species

The value of D ranges from 0 to 1. With this index, 0 represents infinite diversity and, 1, no diversity. That is, the bigger the value the lower the diversity.

Species equitability or evenness (E): This was calculated according to Pielou (1966) [15] using the equation:

$$E = \frac{H}{In\ S}$$

Where
H = Shannon and Wieners index.
S = Number of species in samples

Statistical analysis
Analysis of variance was used to test for the significant difference in the numerical abundance of Coccinellids between the sites. Student t-test was used to test for the significant of difference in the abundance between the dry and wet season using predictive Analytics Software (PASW version 20). All analysis was carried-out at 0.05 level of significance and at their relevant degree of freedom. Graphs were plotted with Microsoft Excel (version 2013).

Results

Composition and abundance of lady bird
The summary of the composition and abundance of lady bird (Coccinellids) is shown in Table 1. The study revealed that the population of predatory coccinellids was significantly higher than that of the herbivorous coccinellids. A total of 864 individuals of Coccinellids made up of 6 species and belonging to three sub-families namely Chilocorinae, Coccinellinae, and Epilachninae were collected through-out the study (Table 1). Most of the species were common while two rare species were observed at the study sites. The species collected includes *Cheilomenes lunata* (Fabricius, 1775), *Cheilomenes sulphurea* (Olivier 1791), *Harmonia octomaculata* (Fabricius, 1775), *Chilocorus stigma* (Say, 1835), *Henosepilachna reticulata* (Olivier 1791), and *Exochamus sp.* (Table 1). *Chilocorus stigma* was the most abundant (38%), followed by *Cheilomenes sulphurea* (21%), *Cheilomenes lunata* (19%), *Henosepilachna reticulata* (12%), *Exochamus sp.* (8%), with *Harmonia octomaculata* the rarest species with just 2% (Fig. 2).
Over the period of the study, the total number of individuals for each Coccinellids species were *Chilocorus stigma* (329 individuals), *Cheilomenes sulphurea* (185 individuals), *Cheilomenes lunata* (162 individuals), *Henosepilachna reticulata* (102 individuals), *Exochamus sp.* (70 individuals), and *Harmonia octomaculata* (16 individuals) (Table 1).
Throughout the study, Coccinellids were more abundant in site A (571 individuals), while site B had the least abundance (2 individuals) (Table 1). However, there was a significant difference in the numerical abundance of Coccinellids between the sites ($p<0.05$) (Table 1).
The most abundant Coccinellids species in site A was *Chilocorus stigma* (263 individuals), that of site B were *Chilocorus stigma* (1 individual) and *Henosepilachna reticulate* (1 individual), while *Henosepilachna reticulate* was the most abundant in sites C (77 individuals) and site D (24 individuals) (Table 1).

Diversity indices of lady birds
The summary of the diversity indices of Coccinellids in the sites studied around University of Calabar area is shown in Table 2. Simpson's dominance index revealed that site A (0.35) was more heterogenous in terms of abundance of commonest species when compared with site B (0.00), site C (0.32) and site D (0.17).
Shannon weinner's diversity index revealed that site D was the most diverse (1.75), followed by site C (1.23), site A (1.09), and lastly site B (0.69) (Table 2).

Seasonal variation of lady birds
The summary of the seasonal variation of lady birds in the University of Calabar area is shown in Figure 3. During the dry season, a total number of 694 Coccinellidss were observed at the University of Calabar. The most abundant Coccinellid was *Chilocorus stigma* 207 (29.7%), followed by *Cheilomenes sulphurea* 174 (25.3%), *Cheilomenes lunata* 151 (21.8%), *Henosepilachna reticulata* 90 (12.9%), *Exochamus sp.* 60 (8.6%), and then *Harmonia octomaculata* being the least abundant with 12 (1.7%) individuals. (Fig. 3)
A total of 170 Coccinellids were collected at the University of Calabar during the rainy season. The most abundant Coccinellid was *Chilocorus stigma* 122 (71.8%) individuals, followed by *Cheilomenes sulphurea* 13 (7.63%) individuals, *Cheilomenes lunata* 9 (5.29%), *Henosepilachna reticulata* 12(7.1%) individuals, *Exochamus sp.* 10 (5.9%) individuals, and then *Harmonia octomaculata*the being the least abundant with 4 (2.4%) individuals (Fig. 3).
The mean abundance of Coccinellids varied significantly ($p<0.05$) between both seasons with the highest abundance recorded in the dry season. Coccinellid population was lowest in the month of July and peaked in the month of November (Fig 4).

Discussion

The study investigated for the first time the ecology of Coccinellids from the University of Calabar area. Knowledge of where Coccinellids live provide basic information for determining species niches, food and micro-climate preference, and factors limiting their distribution. A total of 6 species representing 3 subfamilies: Chilocorinae, Coccinellinae and Epilachninae was recorded at the University of Calabar.
The study revealed that the population of predatory Coccinellids was significantly higher than that of the herbivorous Coccinellids. The abundance of predatory species over the herbivores indicated their broad habitat range and possible predatory potential. Sheppard *et al*., (2004) [20] noted that within Coccinellid communities, the predatory species are always the dominant components and is not surprising therefore that they recorded a significant abundance over the herbivorous Coccinellids during the study. Hodek *et al*.,

(2012) [5] reported that coccinellids can distinguish and select habitats with qualities important to them. The coccinellids community present at each study site is a sample of the local fauna. The characteristic of each sites included prey abundance and species, host plant, -climate, surrounding landscape characteristics as well as intraguild and biotic factors. The high population of Coccinellidis within the cassava farm further highlighted the ability for predatory coccinellids to migrate in search of prey and their dependency on prey population. Ofuya (1999) [12] reported that the population of *Cheilomenes lunata* increased as the associated pest of cowpea increased around cowpea growing areas.

Ladybirds are density dependent predators, their numbers increase as the prey number increases (Dixon, 2000) [2]. During the study, the population of Coccinellids increased in the early dry season due to the abundance of the pest's species. The predaceous Coccinellids within the cassava farm benefited from the maintenance of field diversity, which supported the population of prey such as aphids, thrips and mites. This was so because field diversity increases the chances of predatory Coccinellids locating prey and greatly reduces intriguild predation. This result is in consonance with report by Iperti and Paoletti (1999) [9] who noted that predaceous coccinellids tend to increase reproductive activities as prey population increased.

Most notably the farmers practiced mixed cropping where *Abelmoschus esculentus, Zea mays* and *Manihot esculenta* was cultivated on the same plot. Coccinellids frequently benefit from diversification created by planting different crop species together. Wetzler and Risch (1984) [23] reported that the abundance of *Coccinella maculate* was increased by growing beans (*Phaserlus vulgaris)* with *Zea mays* providing a source of pollen and aphids. The present study further confirmed this as 80% of the *Cheilomenes sp* collected was on the maize pollen which was grown along with cassava.

Bushes serve as alternative habitat for preys and mostly predators and this was confirmed by the study as it recorded the second highest population of Coccinellids. Elmira *et al*., (2013) [3] noted that populations of ladybirds were greatly dependent on the amount of ground cover available to them in an environment. The present study also showed that coccinellids are mostly distributed in crop fields and shrubs than grassy fields.

The study revealed that the grassy field had the least number of Coccinellids encountered. This was similar to findings by Ohashi *et al*., (2005) [13] that grassy fields are more exposed to the sun thus resulting in high temperature and reduced abundance of Coccinellids. Elmira *et al*., (2013) [3] also showed that grassy plants had the least abundance of Coccinellids when compared to other habitats. Plant structure affects Coccinellids searching efficiency, and this explains the association of Coccinellids with particular trees (Hacker and Bertness, 1995) [4]. The greater abundance of herbivorous Coccinellids around bushes was due to the presence of trees which offered numerous nutrition through its leaves. However, the spaces between the bushes allowed for easy movement and feeding. The Coccinellids community inhabiting strand of shrubs were more diverse than other habitats. This was so because the flora was rich in prey population which attracted both the herbivorous Coccinellids and the predatory Coccinellids. The result was similar to the findings of Honek *et al.,* (2007) [6] who noted that Coccinellids fauna of wild herbs and shrubs consist both of species for the herbaceous stratum and predatory stratum.

Most of the species collected at the cassava farm were found on *Abelmoschus esculentus*, and *Zea mays*, respectively. The host plants were heavily infested with aphids and thrips further confirming Coccinellid's ability to locate host crops and prey. Studies by Maredia *et al*., (1992) [11] showed similar results as ladybirds migrated between crop fields throughout the season depending on the availability of prey and level of habitat disturbance. This further confirms why the cassava farm had the greatest number of Coccinellids.

The Coccinellids inhabiting the strands of shrubs were more diverse than other communities due to the composition of wild herbs and a more favourable micro-climate. The densely packed leaves provided cover from heat and predation from birds and reptiles, also providing an array of prey. The herbivorous Coccinellids also benefited from the plant host. The results are similar to the findings of Hodek *et al.,* (2012) [5], who noted that wild shrubs show more Coccinellids diversity than crop or grass fields.

The study revealed the diversity of the Coccinellids across sites. The differences in diversity of Coccinellids within the four sites when compared was largely due to the prevailing factors of each of the sites (prey abundance and species, host plant, micro-climate and biotic factors). Like most insects Coccinellids are sensitive to changes in their habitat which influences their distribution and abundance.

In terms of seasons, a total of 170 individual of Coccinellids were observed during the wet season. There was a sharp increase during the dry season with a total of 694 individual Coccinellids were collected. The density of grasses and green leaves increased shortly after the rain providing ample source of food for the plant pest, which in turn led to the increase in predator population. The shortage of rain over the months signaled limited resources for the prey population leading to a decline in their population hence the number of Coccinellids decreased. *Chilocorus stigma* was recorded throughout the period of sampling with other species showing increase towards the end of the rainy season. Good number of vegetation of ground herbs and flowering plants at crop fields makes the condition ideal for Coccinellids feeding and roaming. The early dry season had good green vegetation and favourable climate so prey species benefited from the abundance of greens as their numbers increased, this eventually lead to an increase in the predatory Coccinellids population. In a study by Elmira (2013) [3] peak diversity and abundance of Coccinellids was observed in the month of September and lowest in July and this corroborated with the findings from this study. Hodek *et al*., (2012) [5] noted that Coccinellids are active when temperature is relatively high and thus tend to be more prevalent during the early dry periods. Seasonal variation was observed within all the species of Coccinellids at the study area as they all recorded a higher abundance during the dry season than in the wet season.

Table 1: Abundance of Coccinellids species at the University of Calabar area.

Species	Site A	Site B	Site C	Site D	Total
Cheilomenes lunata	140	0	4	18	162
Cheilomenes sulphurea	165	0	0	20	185
Harmonia octomaculata	1	0	3	12	16
Chilocorus stigma.	263	1	52	13	329
Exochamus sp.	2	0	56	12	70
Henosepilachna reticulate	0	1	77	24	102
Total	571^{a}	2^{b}	192^{c}	99^{d}	864

Values with different superscript for the numerical abundance of Coccinellids between each site is significantly different ($p<0.05$).

Note: Cassava farm (site A), grassy field (site B), bush (site C), and shrubs area (site D)

Table 2: Diversity indices for Coccinellid diversity in four sites of the University of Calabar area

Diversity indices	Site A	Site B	Site C	Site D
Shannon index H'	1.09	0.69	1.23	1.75
Equitability index (E)	0.61	1.00	0.68	0.98
Simpson index (D)	0.35	0.00	0.32	0.17
Species richness index (d)	0.63	1.44	0.84	1.09

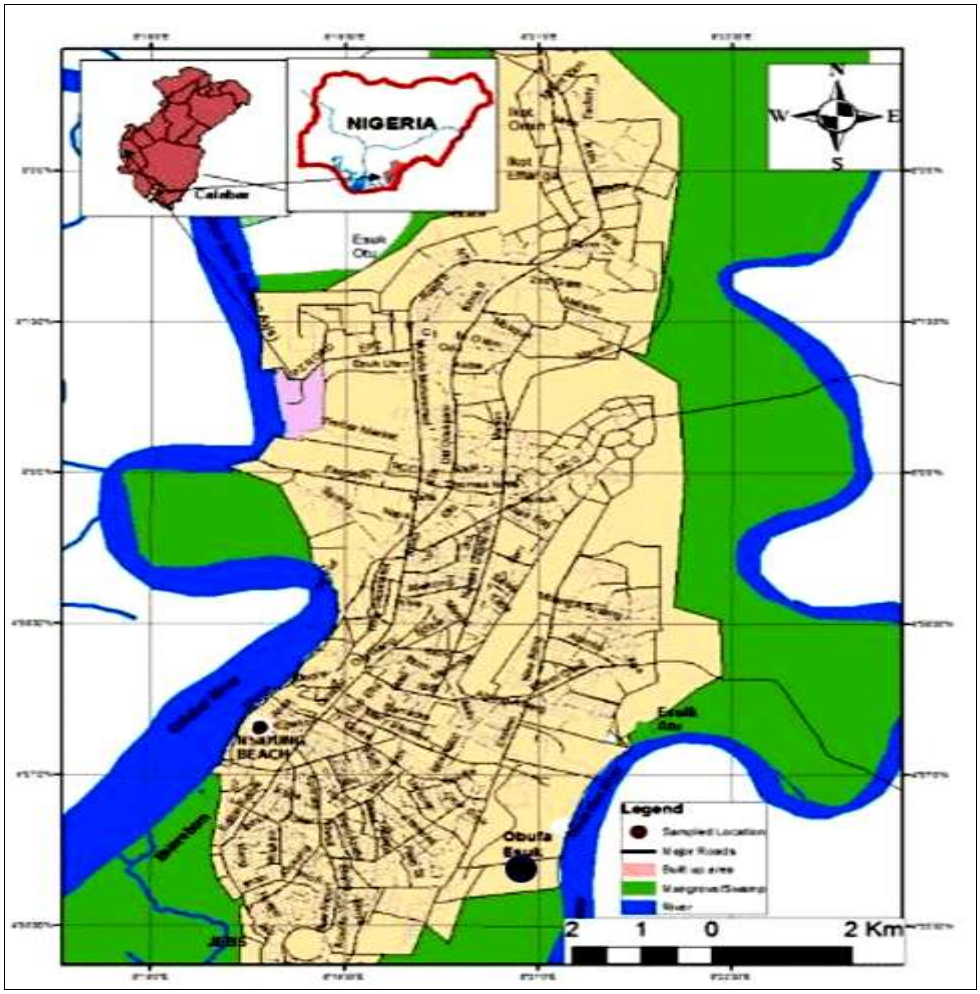

Fig 1: Map of Calabar showing the study area

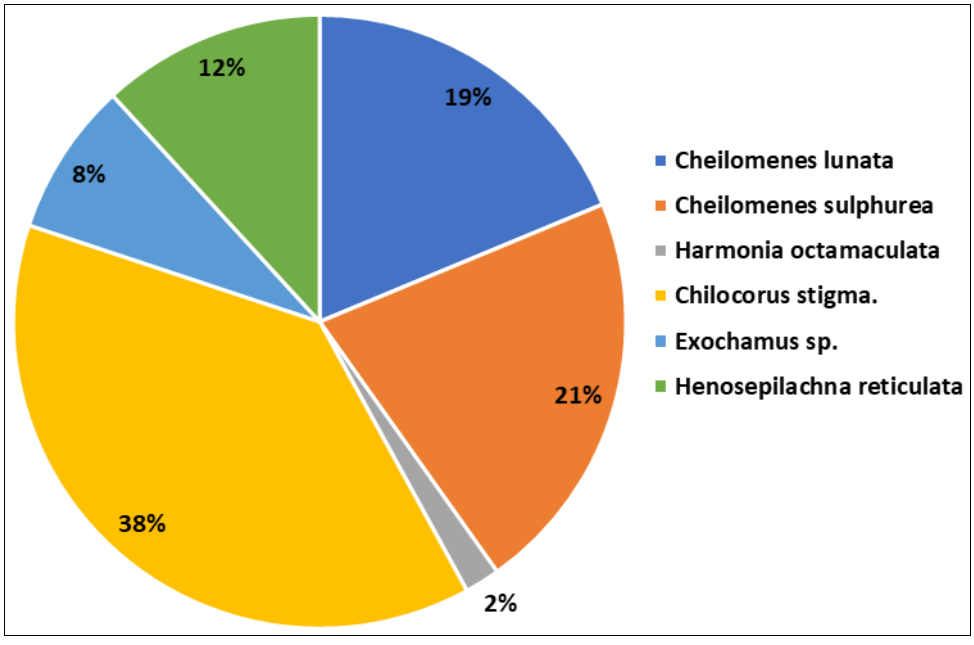

Fig 2: Abundance of Coccinellids species at the University of Calabar area

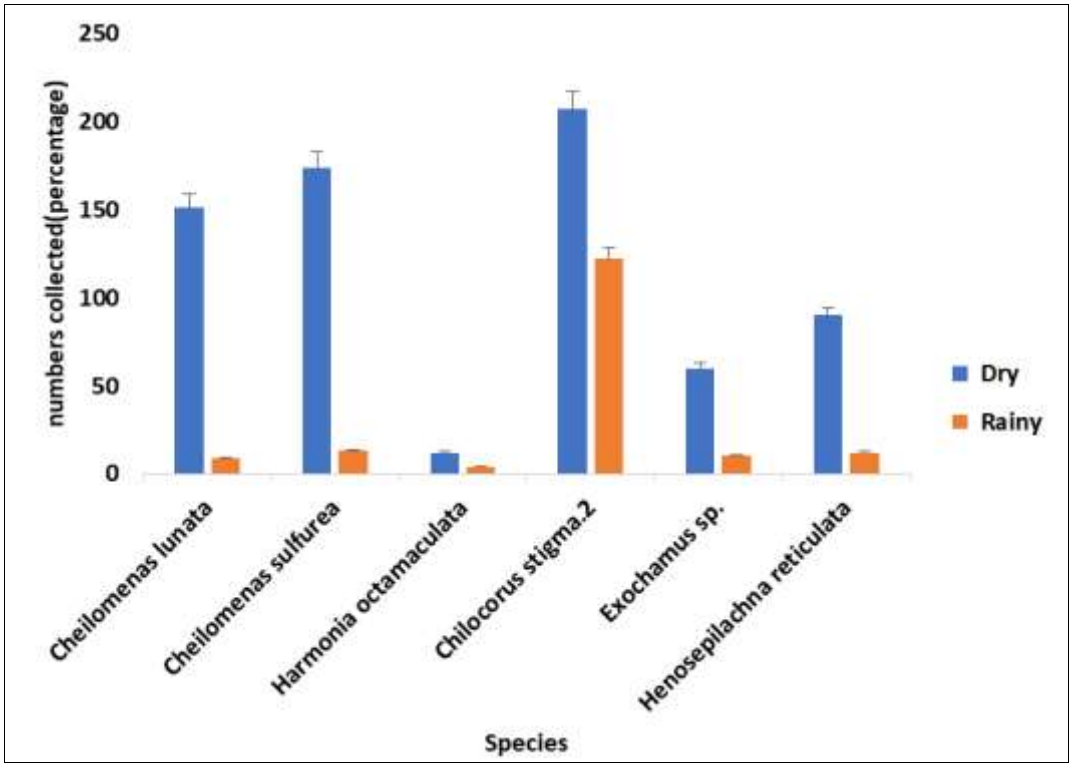

Fig 3: Seasonal variation in the abundance of Coccinellid species at the University of Calabar area

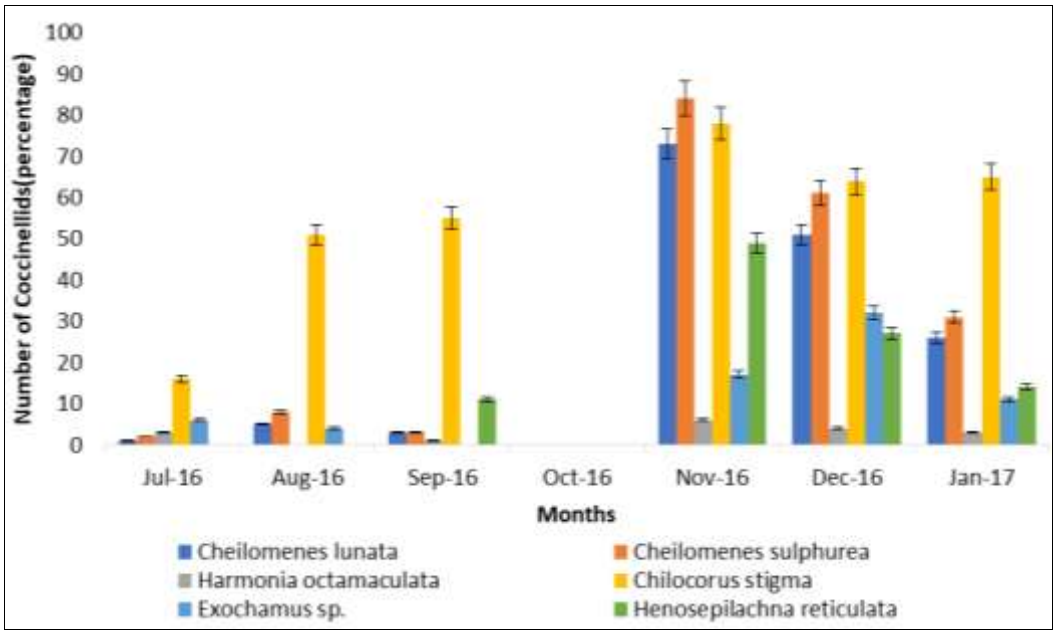

Fig 4: Seasonal variation in the abundance of Coccinellids species at the University of Calabar from July – December 2017

Conclusion

The study investigated for the first time the ecology of lady birds within the bushes of University of Calabar. The population of predatory Coccinellids was significantly higher than that of the herbivorous Coccinellids. Different species of Coccinellids were collected during the study, with *Chilocorus stigma* being the most abundant species. Site A favoured the occurrence of Coccinellids most in general, with *Chilocorus stigma* being the dominant species within the sites. The population of Coccinellids was higher during the dry season.

Declaration of competing interest

We hereby declare that there is no competing interest between the authors.

Ethical approval

Prior to the commencement of the study, an ethical approval was gotten from the relevant Government agency, permitting the use of animals for the study.

References

1. Akpan E, Ekpe U, Ibok J. Heavy metal trends in the Calabar River, Nigeria. Environmental Pollution. 2002;42:47-51.
2. Dixon AF. Insect predator-prey dynamics: ladybird beetles and biological control. New York: Cambridge University Press; c2000.
3. Elmira A, Jafari R, Afrogheh RV. Biodiversity and distribution of predaceous ladybird (Coleoptera:

Coccinellidae). International Research Journal of Applied and Basic Sciences. 2013;5(6):705-709.
4. Hacker S, Bertness M. Morphological and physiological consequences of a positive plant interaction. Ecology. 1995;76:2165-2175.
5. Hodek I, Honek A, Van E, Helmut F. Ecology and behaviour of the ladybird beetles. Wiley-Blackwell; c2012.
6. Honek A, Martinkova Z, Pekar S. Aggregation characteristics of three species of Coccinellidae (Coleoptera) at hibernation sites. European Journal of Entomology. 2007;104(1):51-56.
7. Horowitz AR, Antignus Y, Gerling D. Management of *Bemisia tabaci* whiteflies. In: The whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) interaction with geminivirus-infected host plants. Netherlands: Springer; c2011.
8. Horowitz R, Denholm I, Morin S. Resistance to insecticides in the TYLCV vector, *Bemisia tabaci*. In: Insecticide resistance and mechanisms. Netherlands: Springer Dordrecht; c2007.
9. Iperti G, Paoletti M. Biodiversity of predaceous coccinellidae in relation to bioindication and economic importance. Agriculture, Ecosystems and Environment. 1999;74:323.
10. Judy A, Tudor H. Are you a ladybug? Kingfisher; c2000.
11. Maredia K, Gage S, Landis D, Scriber J. Habitat use patterns by the seven-spotted lady beetle (Coleoptera: Coccinellidae) in a diverse agricultural landscape. Biological Control. 1992;2:159-165.
12. Ofuya TI. Studies on the capability of *Cheilomenas lunata* (Fabricius) (Coleoptera: Coccinellidae) to prey on cowpea aphid, *Aphis craccivora* Koch (Homoptera: Aphididae) in Nigeria. Agriculture, Ecosystem and Environment. 1991;52(1):35-38.
13. Ohashi KY, Sakuratani N, Osawa S, Takafuji A. Thermal microhabitat use by the ladybird beetle, *Coccinella septempunctata* (Coleoptera: Coccinellidae), and its life cycle consequences. Environmental Entomology. 2005;34:432-439.
14. Pearson SA. Post embryonic development survival rate and predation potential of *Coccinella septempunctata* L. In relation to the mustard aphid (*Lipaphis erysimi* Kalt.). Columbia, U.S.A: Pearson Educational Publisher; c2004.
15. Pielou EC. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology. 1966;13:131-144.
16. Seago AE, Giorgi JA, Li J, Ślipińskia A. Phylogeny, classification and evolution of ladybird beetles (Coleoptera: Coccinellidae) based on simultaneous analysis of molecular and morphological data. Molecular Phylogenetics and Evolution. 2011;60:137-151.
17. Shah Z. Ladybird beetles (Coccinellidae: Coleoptera) of Peshawar region. Agriculture University, Department of Entomology. Peshawar: NWFP; c1985.
18. Shannon CE, Weiner W. The mathematical theory of communication. Urbana: University of Illinois Press; c1949.
19. Sharma S, Sudha D, Rajendra C, Vibha D. Macro-invertebrate community diversity in relation to water quality status of Kunda River (M.P.), India. Discovery. 2013;3(9):40-46.
20. Sheppard SK, Henneman ML, Memmott J, Symondson WO. Infiltration by alien predators into invertebrate food webs in Hawaii: a molecular approach. Molecular Ecology. 2004;13:2077-2088.
21. Simpson EH. Measurement of diversity. Nature. 1949;163:688.
22. Vandenberg NJ. Coccinellidae Latreille 1807. In: American Beetles. Arnett JM, editor. Boca Raton: CRC Press; c2002.
23. Wetzler RA, Risch SJ. Experimental studies on beetle diffusion in simple and complex crop habitats. Journal of Animal Ecology. 1984;53:1-19.