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Seasonal variation in insect biodiversity in a transitioning sub-urban area

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Abstract
A survey was carried out on the species diversity of insects in the suburban transition area of Patna. The study was conducted over a one-year period of 2021 (January to December). A total of 41 species of insects have been identified in a small area (10 acre), with Lepidopteran order (20) are dominance over the Hemiptera (5), Hymenoptera (5), coleoptera (4), Odonata (3), and Polydesmida, Mantodea, Diptera, and Orthoptera one species each. All of these species are found based on seasonal variation and vegetation as well as the presence of built-up areas. The highest number of insect species was in September, and the lowest were in May and December. Species of *Syntomoides imaon* and *Mylabris flexuosa* were captured during the mating conditions in the months of August and September (rainy season), respectively. These variation indicates the abundance of insect biodiversity and also provides evidence of the abundant food chain of ecosystems.

Keywords: Insect, lepidoptera, hemiptera, hymenoptera, coleoptera, odonata

Introduction
Insects play an important role in our environment by supporting the production of fruits, seeds, vegetables and flowers (James *et al*., 2008) [17], improving the physical condition of the soil, and promoting fertility by burrowing, eating meat. dead animals and plants and act as a bio-degradant of freshwater bodies (van Huis *et al*., 2013) [33]. Some insects also provide us with honey, silk and other products of commercial value, and they serve as food for birds and fish (Chima *et al*., 2013) [10]. Insects are ecologically important because they are at the bottom of the food pyramid and gives impact to both, agroecosystems and human health. However, they are vectors of diseases for many other organisms, including humans (Schowalter *et al*., 2018) [27]. With the exception of primary producers, insects play a role in the functioning of all trophic stages. Thousands of species and billions of individuals play a key role in the processing of organic matter from decomposers, herbivores, carnivores to quaternary consumer levels. Insects can be providers in communities and ecosystems (Miller 1993) [23]. Insects are ecologically related due to their immense diversity and their important role as providers of ecosystem services and for the functioning of ecosystems (Gutiérrez 2020). Examples include pollination and seed dispersal, as well as the degradation and return of nutrients in the soil food web. (Weisser and Siemann 2008). The wide range of life history patterns exhibited by insects reflects the diversity and abundance of individuals of insect species (Hershey *et al*., 2010) [16].

Rapid population growth leads to an increase in human activities, which leads to an increase in habitat change (Wardle, 2002) [34]. Insect populations are affected by changes in habitat composition and seasonal variation (Ayres *et al*., 2009) [5]. They are also influenced by both broad-scale and fine-scale local processes associated with urbanization (Niemelä *et al*. 2002, Bang and Faeth 2011, Egerer *et al*. 2017) [25, 7, 12]. The decline in naturally occurring insect populations has raised awareness of the urge to protect natural habitats and reduce the factors that cause these adverse effects (Gutiérrez 2020). Urban biodiversity has previously been studied, with a focus on factors that operate within cities such as land area, fragmentation, and land cover (Beninde *et al*., 2015) [8]. Related studies examine and show that urbanization reduces species richness (McKinney 2008; Martinson & Raupp 2013) [22, 38] and abundance (Fenoglio *et al*. 2021) [14], but results are limited on whether urbanization has a significant impact on insects form physical features that distinguish cities include a substantial amount of concrete, buildings and vehicles with minimal vegetation rather than more suburban or rural areas (Andersson 2006).

These features contribute to a multitude of environmental changes (Bailey 2021) [6], some of which include rising temperatures (Wouters *et al*., 2017) [37], habitat fragmentation (Weller & Ganzhorn 2004) [36], pollution (Polidori *et al*. 2018) [26], and vegetation disturbance and biodiversity (Bonebrake & Cooper 2014) [9].

Understanding the factors that influence insect abundance and diversity is important because insects provide many ecosystem support functions in urban ecosystems (Thompson and McLachlan, 2007) [32], supporting other insectivores such as birds and bats (Scanlon and Petit, 2008) and are sensitive indicators. The availability of insectivorous birds also indicates an abundance of insects (Kumari *et al*., 2021) [18]. Changes in management practices and habitat characteristics affect overall biodiversity (Scanlon and Petit, 2008). In general, the most insect species are found in areas where vegetation is abundant (Clarke *et al*., 2008) [11]. However, they are also available in a residential area, even in an urban area. At the local scale, there is no existing data or previously studied record of the insect's variation. Accordingly, we conducted a field survey to understand the status of insect species diversity in a changing area of Patna (Bihar), India, which was formerly agricultural land and is rapidly becoming into a residential area. We also take into account seasonal changes in insect communities as urbanization can influence seasonal differences.

Materials and Methods

Selection of site: For the study of insect species diversity we have selected a changing area of Patna India, [23^0 32'21"N 85^0 02'18"E] (figure – 1) which is a sub-urban area that was previously completely farmland and is rapidly being converted into a residential area. The study site was situated in an area with sparse vegetation and a variety of herbs and shrubs. The abundance of fields and flowering plants provide an ideal environment for insects to thrive. Both vegetated ecosystems and human-dominated residential areas can be found in this area. For the study, three types of habitats were chosen: farmland, constructed areas, and some vegetated areas with herbs and shrubs. A total area of approximately 10 acres was covered for this study.

Fig 1: Study area at Patna, (Bihar) India [Google Earth Image]

Search of insects in study area: Insect searches were conducted on a regular and random basis, and the spotted insects were photographed with a camera. There was not a single insect picked up or disturbed during the study. All photographs were taken on the spot. The research was conducted over a year, from January 2021 to December 2021, with seasonal variations.

Identification of insect species: Insects have been identified using morphological characteristics such as color appearance, wing size, and so on, and their order and families have been listed.

Result and Discussion

The diversity and abundance of insect species observed in the selected habitats are shown in images (figure 2 and 3**)**. During the study period from January to December 2021, 41 insectspecies from 24 families and 09 orders were recorded (Table-1).

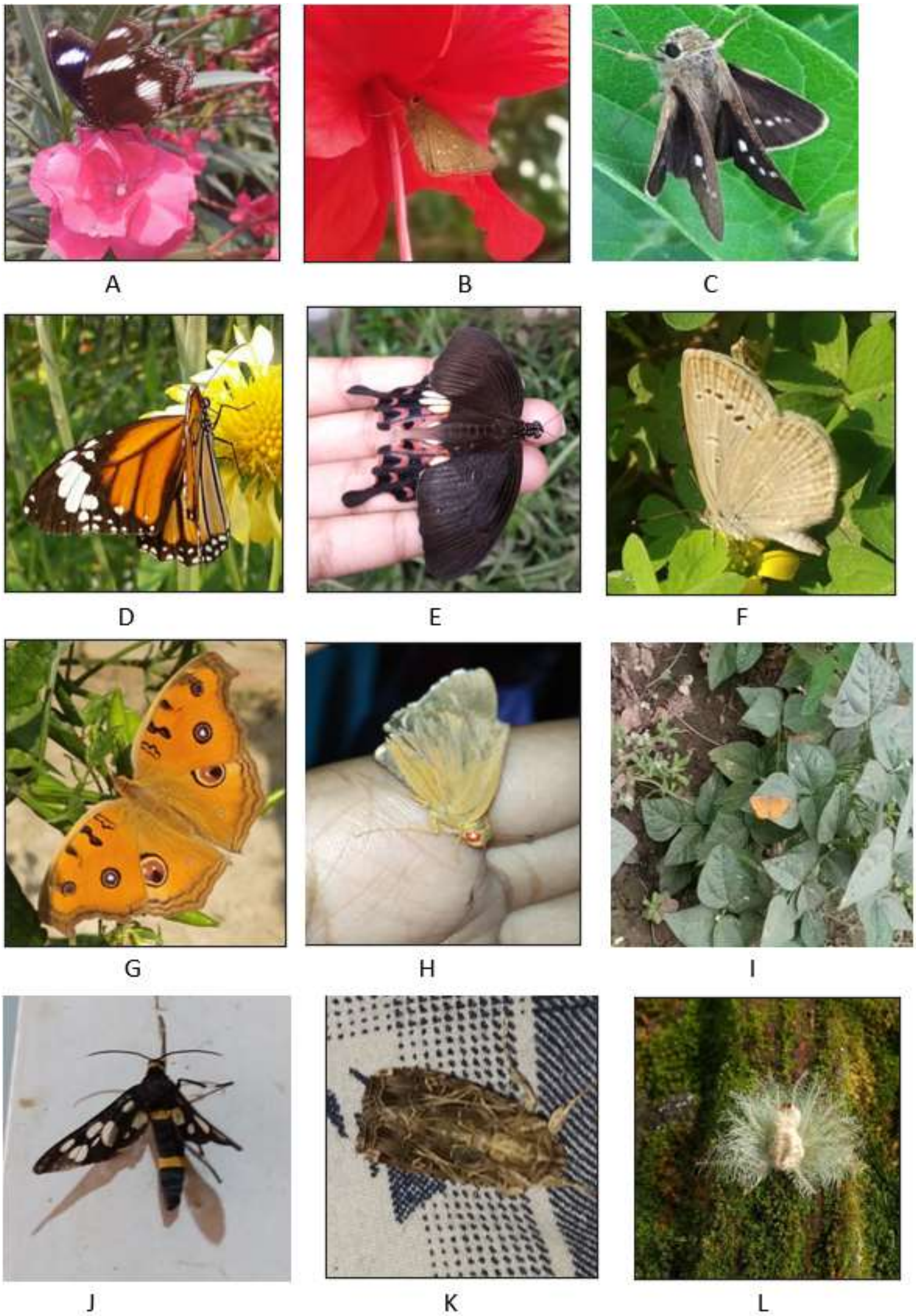

Fig 2: Different species of Insect of Order: Lepidoptera: [A: *Hypolimnas bolina;* B: *Pelopidas mathias;* C: *Borbo cinnara*; D: *Danaus genutia*; E: *Papilio polytes*; F: *Pseudozizeeria maha*; G: *Junonia almana*; H: *Atalopedes campestris*; I: *Ariade marione*; J: *Syntomoides imaon*; K: *Spodoptera litura*; L: *Lophocampa caryae]*

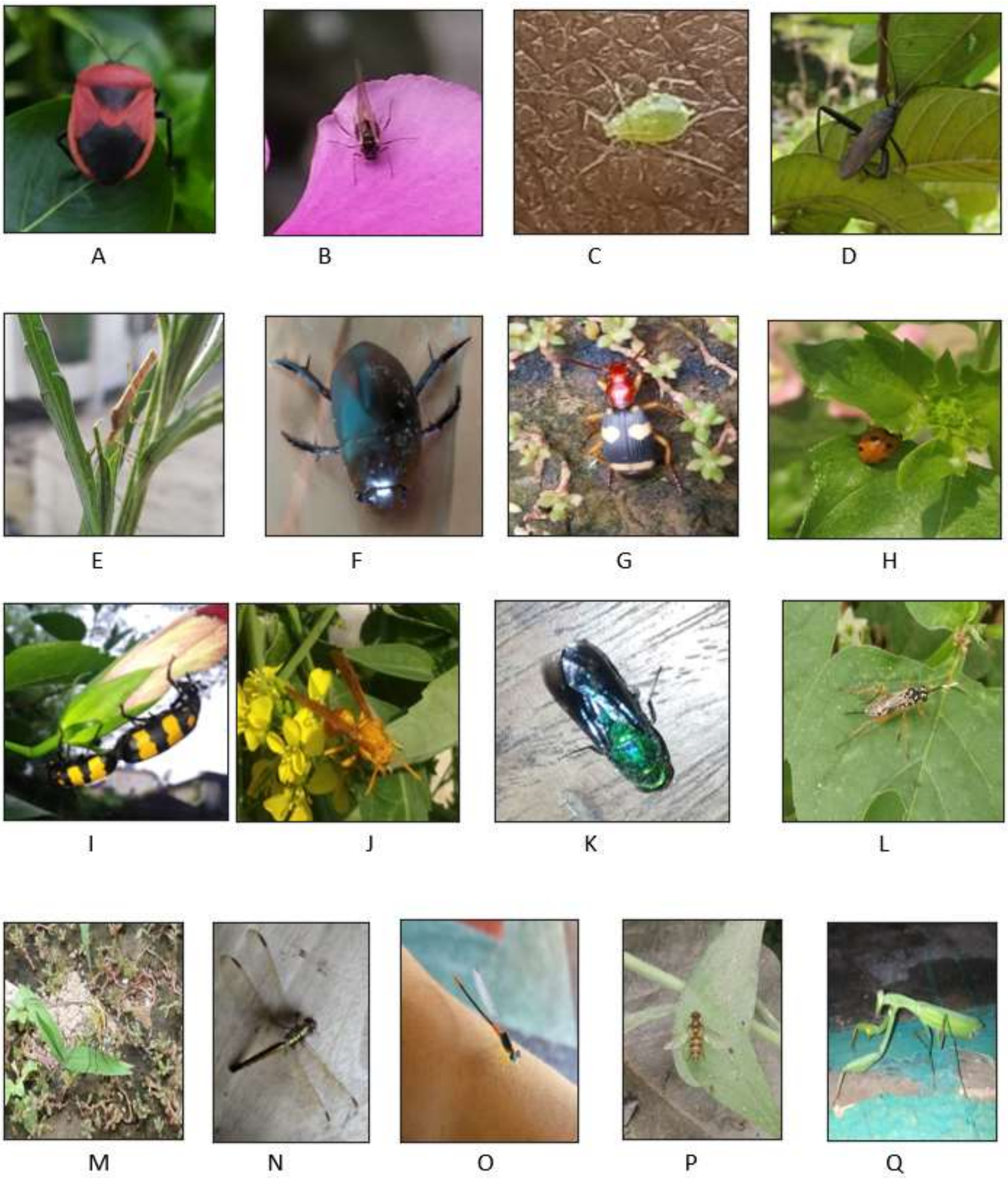

Fig 3: Different species of Insect [order Hemiptera: A: *Coridius janus*; B: *Tuberolachnus salignus*; C: *Lipaphis erysimi*; D: *Acanthocephala terminalis*; E: *Leptocorisa oratorius*] [order Coleoptera: F: *Hydrophilus piceus*; G: *Pheropsophus jessoensis*; H: *Harmonica axyridis*; I: *Mylabris flexuosa*] [order Hymenoptera: J: *Polistes versicolor*; K: *Chrysura refulgens;* L: *Cryptanura spinaria*] [order Odonata: M: *Diplacodes trivalis*; N: *Potamarcha congener*; O: *Ceriagrion cerinorubellum*] [order Diptera: P: *Episyrphus balteatus*] [order Mantodea: Q: *Mnatis religiosa*]

Table 1: List of insects which were available around study area at Patna, (Bihar) India. [arranged in alphabetical order with species as per order]

S. No.	Insect name	Scientific name	Order	Family
1.	Blue moon butterfly	*Hypolimnas bolina*	Lepidoptera	Nymphalida
2.	Blue mormon	*Papilio polymnestor*	Lepidoptera	Papilionidae
3.	Boisduval's blue butterfly	*Icaricia icaioides*	Lepidoptera	Lycaenidae
4.	Cabbage looper	*Trichoplusia ni*	Lepidoptera	Noctuidae
5.	Common castor butterfly	*Ariadne merione*	Lepidoptera	Nymphalidae
6.	Common evening brown	*Melanitis leda*	Lepidoptera	Nymphalida
7.	Common mormon	*Papilio polytes*	Lepidoptera	Papilionidae
8.	Common tiger butterfly	*Danaus genutia*	Lepidoptera	Nymphalida
8.	Cotton leafworm	*Spodoptera litura*	Lepidoptera	Noctuidae
10.	Dark evening brown	*Melanitis phedima*	Lepidoptera	Nymphalida
11.	Dark small branded swift	*Pelopidas mathias*	Lepidoptera	Hesperiidae
12.	Eupterote caterpillar	*Eupterote mollifera*	Lepidoptera	Eupterotidae
13.	Handmaiden moth	*Syntomoides imaon*	Lepidoptera	Erebidae

14.	Monarch butterfly	*Danaus plexipus*	Lepidoptera	Nymphalida
15.	Olepa moth	*Olepa ricini*	Lepidoptera	Erebidae
16.	Pale grass blue butterfly	*Pseudozizeeria maha*	Lepidoptera	Lycaenidae
17.	Peacock Pansy	*Junonia almana*	Lepidoptera	Nymphalida
18.	Rice swift butterfly	*Borbo cinnara*	Lepidoptera	Hesperiidae
19.	Small grass skipper butterfly	*Atalopedes campestris*	Lepidoptera	Hesperiidae
20.	Tussock moth	*Lophocampa caryae*	Lepidoptera	Erebidae
21.	Musturd aphid	*Lipaphis erysimi*	Hemiptera	Aphididae
22.	Giant willow aphid	*Tuberolanchnus salignus*	Hemiptera	Aphididae
23.	Cucurbit stink bug	*Coridius janus*	Hemiptera	Dinidoridae
24.	Leaf footed bug	*Acanthocephla terminalis*	Hemiptera	Coreide
25.	Rice ear bug	*Leptocorisa oratorius*	Hemiptera	Alydidae
26.	Emerald wasp	*Chrysura refulgens*	Hymenoptera	Chysididae
27.	Yellow paper wasp	*Polistes versicolor*	Hymenoptera	Vespidae
28.	Mud dauber	*Sceliphron caementarium*	Hymenoptera	Sphecidae
29.	Black garden ant	*Lasius niger*	Hymenoptera	Formicidae
30.	Ichneumon wasps	*Cryptanura spinaria*	Hymenoptera	Ichneumonidae
31.	Blister beetle	*Mylabris flexuosa*	Coleoptera	Meloidae
32.	Scavanger beetle	*Hydrophilus piceus*	Coleoptera	Hydrophilidae
33.	Asian bombardier beetle	*Pheropsophus jessoensis*	Coleoptera	Carabidae
34.	Asian lady beetle	*Harmonica axyridis*	Coleoptera	Coccinellidae
35.	Swampwatcher dragonfly	*Potamarcha congener*	Odonata	Libellulidae
36.	Ground skimmer	*Diplacodes trivalis*	Odonata	Libellulidae
37.	Orange tailed Marsh Dart	*Ceriagrion cerinorubellum*	odonata	Coenagrionidae
38.	Marmalade hoverfly	*Episyrphus baltetus*	Diptera	Syrphidae
39.	Praying mantis	*Mnatisreligiosa*	Mantodea	Mantidae
40.	Yellow spotted millipede	*Harpaphe haydeniana*	Polydesmida	Xystodesmida
41.	Oxya grasshopper	*Oxya sp.*	Orthoptera	Acrididae

The dominant order was lepidoptera (20 species) followed by Hemiptera and Hymenoptera (05 species each), Coleoptera (04 species), Odonatan (03species), Diptera, Mantodean, Polydesmida and Orthoptera having 01 species each. The highest number of insect species was found in a vegetated area, where trees and shrubs were found. Most of them were butterfly and from Lepidoptera order. The fewest species were found in the constructed area. Farmland has a moderate number of insect species, which could be attributed to open farmland with a strong food chain. Farmland should have maximum species but the moderate number of species were found due to the use of chemical fertilizers and pesticides. When only locally adapted, nonnative plants are present, cultivating native plant gardens at the scale of a yard does not always positively influence insect diversity (Matteson and Langellotto 2011) [20]. Few species were common and have been recorded in all three habitats. They are usually everywhere. Insects are also affected by seasonal changes. The study sites usually have three seasons: summer, rainy and winter. The maximum number of species found in the rainy season, i.e. in August and September, includes 06 species and 07 species respectively (Table-2).

Table 2: Visibility of Insect's species variation during study period of different months of 2021

Months	**Insects**						
JAN	Peacock pansy	Rice swift butterfly					
FEB	Giant willow aphid	Mustard aphid	Yellow paper wasp	Common mormon			
MAR	Marmalade hoverfly	Small grass skipper butterfly	Asian lady beetle	Blue moon butterfly	Common tiger butterfly	Monarch butterfly	Common caster
APR	Black garden ant	Cotton leaf worm					
MAY	Mud dauber						
JUNE	Praying mantis	Ichneumon wasps					
JULY	Pale grass blue butterfly	Orange tailed Marsh Dart					
AUG	Handmaiden moth	Tussock moth	Asian bombardier beetle	Yellow spotted millipede	Ground skimmer		
SEPT	Blue mormon	Cucurbit stink bug	Leaf footed bug	Emerald wasp	Blister beetle	Dark small branded swift	Scavenger beetle
OCT	Oxya grasshopper	Dark evening brown	Eupterote caterpillar	Swamp watcher dragonfly	Rice ear bug		
NOV	Boisduval's blue butterfly	Common evening brown	Olepa moth				
DEC	Cabbage looper						

After the rainy season from October to December, species were recorded in decline each month as 5,3 and 1 species respectively. In general, October and November are the mild season and post rainy season. But many species have been recorded in similar numbers. December was winter and having least recorded 01 insect species, while in January there were only 02 species (Table 2). The lowest number of species was recorded in the month of May (only 01 species.) Generally rainy seasons are breeding season for the insect. Species of *Syntomoides imaon* (figure -4 'A') and *Mylabris flexuosa* (figure -3 'I') were captured during the mating conditions in the months of August and September, respectively in the rainy season of the study area. While *Danaus plexipus* was captured during its emergence from the pupal stage (figure -4'B') in March (moderate). The majority of the butterflies were seen in March, which is also known as the spring season and the flowering season in the study area.

Fig 4: A: *Syntomoides imaon,* B: *Danaus plexippus* emerges out from cocoun

We have also observed mud nest which was built by Mud dauber/ mud wasps (*Sceliphron caementarium*) inside the constructed/residential area (Figure - 5 A, B, C & D). These nests were found in a built outdoor area with a roof, with plenty of light and air, but no direct sunlight. They build intricate structures from the mud where they lay their eggs, providing their young with a safe and comfortable place to begin their lives. They collect mud from a nearby source and shape into balls or dumplings with their front legs and lower jaw. Usually these pellets are the size of a wasp's head, but they can fly to their preferred nesting site, often meters above the ground.

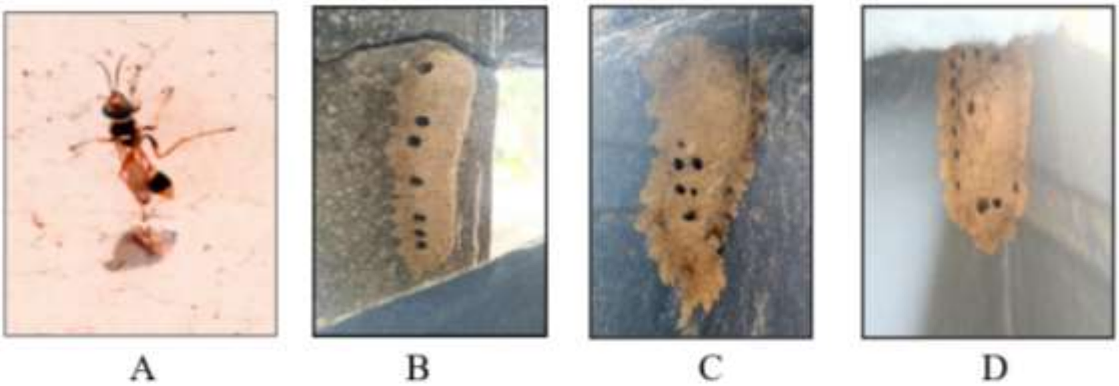

Fig 5: A: *Sceliphron caementarium* (Mud dauber); B to D: Nest of Mud dauber/Mud wasp

In the present study; Lepidoptera is the most dominant order with 50%, followed by Hemiptera and Hymenoptera with (12%) (Fig- 1). This is in contrast to the works of Naman *et al*., (2019) [24] who recorded Odonata were the most dominant Order with (22.92%) followed by Order Lepidoptera and Hymenoptera with (20.83%) each respectively at Kaduna State University, Nigeria while, Adeduntan and Olusola (2013) [2] noted Orthoptera as the insect order. The most dominant of the forest vegetation types in Ondo State. The differences in species richness in different locations may be due to relationships between insect diversity and environmental (local and landscape) habitat features that varied across insect orders, though insect diversity often increased with habitat heterogeneity and edge density in both urban and rural ecosystems (Theodorou *et al*., 2020) [31]. In general, the richness of insect species decreases in more urbanized areas (McIntyre 2000) [21]. However, total insect abundance frequently increases in urban greenspaces compared to natural landscapes due to greater abundance of generalist urbanophiles (including nonnative species) or resource concentration (Shochat *et al*. 2010, Faeth *et al*. 2011) [29, 13]. The focal taxa determine whether native plants play an important role in supporting urban insect diversity. Bees, adult butterflies, and wasps, for example, frequently rely on nonnative, locally adapted plants for alternative food sources (Shapiro 2002) [28] and are generally unaffected by enhancing urban landscapes with native vegetation (Matteson and Langellotto 2011) [20].

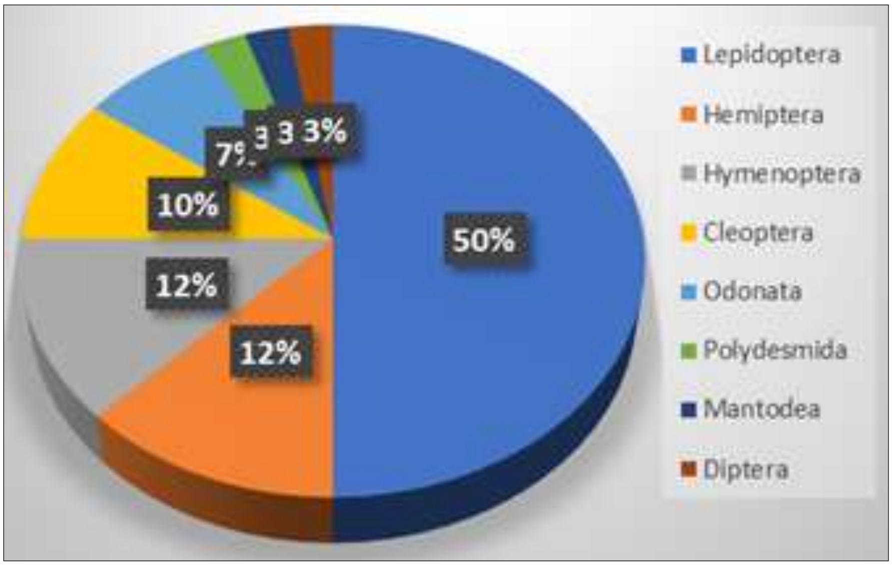

Fig 6: Percentage (%) of Insect species in different order available at the study area

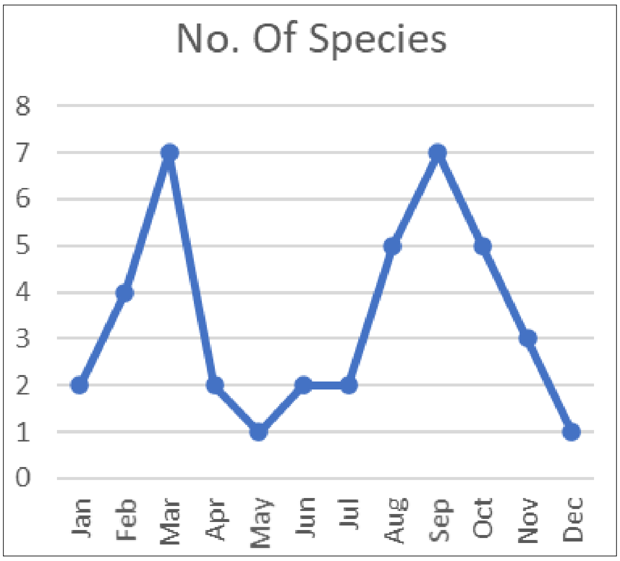

Fig 7: Availability of number of insect species in different months of the year of 2021

The current study indicates that the rainy season has the highest insect diversity than the dry and hot seasons (Fig-2), but Aranda *et al.*, (2021) discovered that the highest number of insect species was recorded in November (moderate season), and Adams *et al.*, (2020) discovered that insect species richness and abundance were highest in drier and hotter sites, but the magnitude of local environmental effects varied with the degree of urbanization. These findings show that seasonal fluctuations in insect species richness and abundance have the greatest impact on local insect diversity throughout the year. Local habitat and local microclimatic differences played important roles in shaping local insect communities after seasonal differences were taken into account (Adams *et al.*, 2020)

Conclusion

The intensity of environmental variations is multiplied by erosion of natural habitats, urbanization, pollution, and chemical use in agroecosystems. Abiotic (temperature, humidity, light) and biotic (host, vegetative biodiversity, crowding, and diets) stresses all have an impact on insect population dynamics. We predicted that more urbanized areas would have lower overall species richness but more diverse insect assemblages (Faeth *et al.*, 2011) [13]. These variation indicates the abundance of insect biodiversity and also provides evidence of the abundant food chain of ecosystems. Because no previous research has been done, this study report serves as a baseline. The current data being analyzed will be useful in determining the future state of the ecosystem. However, as the area is changing from farmland to residential land, conservation of these insect species is needed for a better ecosystem in the future.

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