

ABUNDANCE AND SPECIES RICHNESS OF HEXAPODS ASSOCIATED WITH SOME MEDICINAL PLANTS IN SOUTH-WESTERN PART OF NIGERIA

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Received 3rd March, 2025; accepted 12th July, 2025

ABSTRACT

Plant-insect interaction is a constant action. However, the knowledge of the insects associated with each plant is unlimited and requires regular updates. In this study, the insects associated with five medicinal plants (*Ocimum gratissimum* L., *Chromolaena odorata* (L.), *Spondias mombin* L., *Azadirachta indica* A. Juss. and *Moringa oleifera* Lam.) in southwestern part of Nigeria were investigated. Five stands of each plant were surveyed bi-weekly for five consecutive weeks using hand-picking, standard insect nets and aspirators. Parameters assessed include population fluctuation, relative abundance using SPSS, version 21, while the similarity index and diversity index were estimated for each plant surveyed. Seventeen species belonging to 10 orders of insects were recorded from all the medicinal plants assessed. Hymenopterans recorded the highest population abundance and species richness followed by Dipterans while Orthopterans was the least. The medicinal plants host a diversity of insects which need to be investigated to maintain the nutrients and usage of the medicinal plants.

Key words: Hexapods; medicinal plants; Nigeria; similarity index; diversity index; fluctuation

<https://dx.doi.org/10.4314/njbot.v38i2.1>

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INTRODUCTION

Several associations occur among organisms in the ecosystem including insect-plant relationships (Pilosofo *et al.*, 2017). This relationship includes herbivory, pollination and entomophagy in plants. Krishnaiah *et al.* (2011) reported the benefits of some medicinal plants resulting from the presence of numerous phytochemicals in the barks, leaves and seeds of such plants. These, along with nutrients in these plants, attracted researchers to focus on their relevance to research and therapeutic purposes (Batool *et al.*, 2022). For instance, The World Health Organisation (WHO) reported that 75% of the people in the world depend on medicinal plants for their treatment (Srivastava, 2018). Besides medical treatment, medicinal plants are adopted as beverages (teas) and raw pharmaceutical materials (Altemimi *et al.*, 2017).

Ocimum gratissimum L. is an aromatic plant belonging to the Lamiaceae family majorly found in Africa, Asia and South America (Akara *et al.*, 2021). This plant has the potential to replace synthetic drugs due to its therapeutic properties for various sicknesses (Ugbogu *et al.*, 2021). In some African countries, *Ocimum gratissimum* (Fig. 1) is used to treat ear pains, asthma, cough and respiratory disease (Sofowora *et al.*, 2013). It is also used to treat fevers, hepatitis and diarrhoea (Kpoviessi *et al.*, 2014). Skin diseases and wound infections are also suppressed with the application of *Ocimum gratissimum*. Studies have shown that *Ocimum gratissimum* has anaesthetic properties, anti-stress, anti-inflammatory, anti-mutagenic, anti-ulcerative, gastroprotective and hepatoprotective (Martins *et al.*, 2023). These, along with other results confirmed the fact that *Ocimum gratissimum* is an essential medicinal plant.

Chromolaena odorata L.R.M. King & H. Rob. is a medicinal plant classified in the Asteraceae family (Zahara, 2019). *C. odorata* (Fig. 2) has a maximum height of 6 metres with arrow-like leaves and two branches on both extending the stem (Zahara, 2019). *C. odorata* contains various phytochemicals including acacetin, chalcones, terpenes, terpenoids, pyrrolizidine, saponins and tannins (Sirinthipaporn and Jiraungkoorskul, 2017). Sirinthipaporn and Jiraungkoorskul (2017) reported that *C. odorata* suppressed wounds, burns and skin infections. It is majorly used externally for wound and skin infection, but also possesses some relevant properties such as anti-inflammatory, anti-cancer and anti-diabetic (Sirinthipaporn and Jiraungkoorskul, 2017).

Spondias mombin (Linn) (Fig. 3) is also a medicinal plant distributed in the southwestern part of the world. This plant contains several nutrients; carbohydrates make up more than 60% of total mass; 10% of crude protein; 5% of crude fat and 11% of crude fiber (Igwe *et al.*, 2010). *Spondias mombin* pulp contains sodium, potassium and calcium, while the seeds have ascorbic acid, potassium and calcium (Njoku and Akumefula, 2007).

Azadirachta indica A Juss. (Fig. 4) belongs to the family Meliaceae (Eid *et al.*, 2017). This plant contains tannins, saponins, flavonoids, alkaloids, glycosides, reducing sugars and polyphenols (Atangwho *et al.*, 2009). *Azadirachta indica* can be used to cure malaria, headache and heartburn (Sujarwo *et al.*, 2016). The plant suppresses diabetes and acts as anti-inflammatory, anti-parasitic, anti-bacterial, anti-viral and anti-cancer (Alzohairy, 2016).

Moringa oleifera Lam. (family Moringaceae) is a medicinal plant with several nutrients such as calcium and zinc as well as vitamins such as folic acid and nicotinic acid (Mbikay, 2012; Gopalakrishnan *et al.*, 2016). It contains several phytochemicals like tannins, sterols, terpenoids, flavonoids and saponins (Berkovich, 2013). *Moringa oleifera* (Fig. 5) lowers the reactive oxygen and adjusts the activities of acetylcholine esterase in the brain (Kirisattayakul *et al.*, 2013). Oil extracts of *M. oleifera* are deodorants and lubricants. The seeds are used as coagulant agents, raw materials in cosmetics and as sources of biodiesel (Rockwood *et al.*, 2013).



Fig. 1: *Ocimum gratissimum*
(Ademiluyi *et al.*, 2022)



Fig. 2: *Chromolaena odorata*
(Vijayaraghavan *et al.*, 2022)

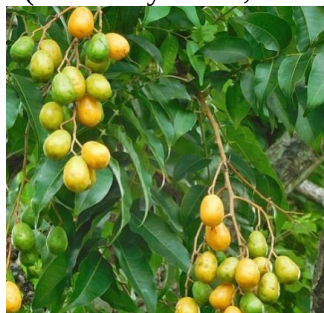


Fig. 3: *Spondias mombin*
(Ogunro *et al.*, 2023)



Fig. 4: *Azadirachta indica*
(Tejesvi *et al.*, 2009)



Fig. 5: *Moringa oleifera* (Islam *et al.*, 2021)

Many medicinal plants possess flowers with bright colour, pleasant smell and sweet tastes which do not only attract insects but also lure them to taste them (Badoni and Arya, 2022). Their roots, stems, leaves and barks are also consumed by several insects including hymenopterans, dipterans, isopterans, coleopterans and lepidopterans (Banjo *et al.*, 2006a). The insects are directly associated with many medicinal plants. The insects do not only harm the medicinal plants but also reduce their therapeutic quality, rendering the plants useless (Rehaman *et al.*, 2018). Banjo *et al.* (2006b) reported that insects associated with *Ocimum gratissimum* are dipterans, orthopterans, hymenopterans, lepidopterans and homopterans in descending order. They also reported hymenopterans, lepidopterans, homopterans and isopterans as insects associated with *Spondias mombin* (Banjo *et al.*, 2006b). In view of the economic importance of these plants, it is necessary to know the insects that are associated with them, as they could cause adverse effects on these beneficial plants (Serdo and Degaga, 2024). This study investigated the insects associated with five medicinal plants (*Moringa oleifera*, *Azadirachta indica*, *Spondias mombin*, *Chromolaena odorata* and *Ocimum gratissimum*) and highlighted the insect-plant relationships that exist amongst them.

MATERIALS AND METHODS

Study Area

This study was carried out in Ago-Iwoye (6.9424° N, 3.9216° E), Ijebu-North LGA of Ogun State, Nigeria. Agriculture is the major economy of this town (Owagboriaye *et al.*, 2022; Oladunjoye *et al.*, 2023). Besides fertile land for agriculture, the town is blessed with several medicinal plants which are consumed by the residents, sold in the market and attracted by the other residents in their neighbouring communities. The survey was carried out fortnightly, starting from May to July, 2024 which

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spanned through the dry season. The number of insects was counted using the direct counting method (Banjo *et al.*, 2000a).

Collection, Identification and Preservation of Insects

Insects were picked from flowers, leaves, stems (branches) and fruits using hands. For flying insects, the standard insect nets were used in the early morning. For the roots, the top soil was dug in about 1 inch down for observation and collection (Aina *et al.*, 2016). The survey was conducted on five separate stands of each plant at bi-weekly intervals for five times (May to July, 2024), namely May, Mid-May, June, Mid-June and July. After collection, the insects were preserved in 70% alcohol using clean standard specimen bottles. Each insect-containing bottle was then tagged with its information (source, date, plant number and plant species). The insects were identified at the Entomology Unit of Department of Zoology and Environmental Biology, Olabisi Onabanjo University, Ago-Iwoye using morphological dichotomous key with the aid of a binocular dissecting microscope (XT-3C 20x & 40x dual light illumination turret step stereoscopic microscope/ Student microscope).

Identification of Plants

Plant identification was done at the Herbarium of the Department of Plant Science, OOU, Ago-Iwoye with the support of a Plant Taxonomist, Dr. Ajoke S. Sanusi.

Data analysis

From the data obtained, the population fluctuation and species richness were illustrated using SPSS version 21 while the diversity indices, which describe the level of dissimilarity of insect incidence on the plants, were estimated. This was done for all the plants surveyed (Banjo *et al.*, 2006a) using Equation 1.

$$D = \frac{\sum [n_i(n_i-1)]}{N(N-1)} \text{ - Equation 1 (Banjo et al., 2006a)}$$

Where,

n_i = Individuals of each species caught, N = Total individuals of all species caught/ seen, D = Simpson diversity index. Also, to evaluate the likeness in the species of insects found on the plants, the Morisita's index of similarity was adopted.

$$C\lambda = \frac{2\sum n_1n_2}{N_1N_2(\lambda_1 + \lambda_2)} \text{ - Equation 2 (Banjo et al., 2006c, Chao et al., 2006)}$$

Where,

λ_1 and λ_2 = Squares of total numbers of individuals in samples 1 and 2, respectively; n_1 and n_2 number of individuals of species in samples 1 and 2. N_1 , N_2 = Total number of individuals in samples 1 and 2, respectively.

RESULTS

Population Fluctuations

From the five biweekly surveillance periods, insect populations associated with the medicinal plants showed varying trends across different orders. Hymenopteran population abundance was high in early May but declined in mid-May. They were absent in June, showed a rapid increase in mid-June, and decreased again in July (Fig. 6). Dipteran populations followed a similar trend as hymenopterans in May, with an initial increase followed by a sharp decline in mid-May. However, in June, dipterans exhibited resurgence, absence in mid-June, and a slight increase in July. Isopterans showed a rapid population increase in May but were absent for the remainder of the surveillance. Blattodeans followed a similar pattern, appearing only in mid-May and absent in all other periods. Orthopterans first appeared in June and experienced a rapid decline that persisted through July.

Hymenopterans showed a large population abundance in May, which sharply declined in mid-May and remained low through June. A resurgence was noted in mid-June, but the population was absent in July (Fig. 7). Coleopterans and dipterans showed slight increases in May, followed by absence in mid-May. Coleopteran populations reappeared slightly in June and were absent thereafter, while dipterans showed a slight increase in July. Orthopterans and isopods were absent in May and mid-May but showed a slight increase toward July.

Hymenopterans peaked in May, followed by a sharp decline in mid-May that persisted through June. Resurgence was observed in mid-June, but this was followed by another decline (Fig. 8). Dipterans had high populations in May, which decreased in mid-May and were absent in June. They reappeared significantly in mid-July. Lepidopterans were most abundant in May but were absent in mid-May. Slight increases were recorded in June and mid-June, with no lepidopterans observed in July. Both coleopterans and homopterans maintained low populations throughout the surveillance period.

Hymenopteran populations were slightly high in May and increased exponentially in mid-May. A sharp decline occurred in June, but populations resurged in mid-June, peaking in July (Fig. 9). Dipterans increased in May, decreased in mid-May, and were absent in June. They reappeared in mid-June and declined again in July. Isopods appeared briefly in May and mid-June, orthopterans were recorded in mid-May and mid-June, and lepidopterans emerged only in July.

Blattodeans were observed in May, increased in mid-May, disappeared in June and mid-June, and re-emerged in July. Hymenopterans were absent in May but showed a massive increase in mid-May before dropping to zero until July (Fig. 10). Dipterans emerged in May, increased in mid-May, and were absent afterwards. Lepidopterans were present in May, absent in mid-May, and showed a slight increase in June. Their population declined to zero in mid-June before rising again in July.

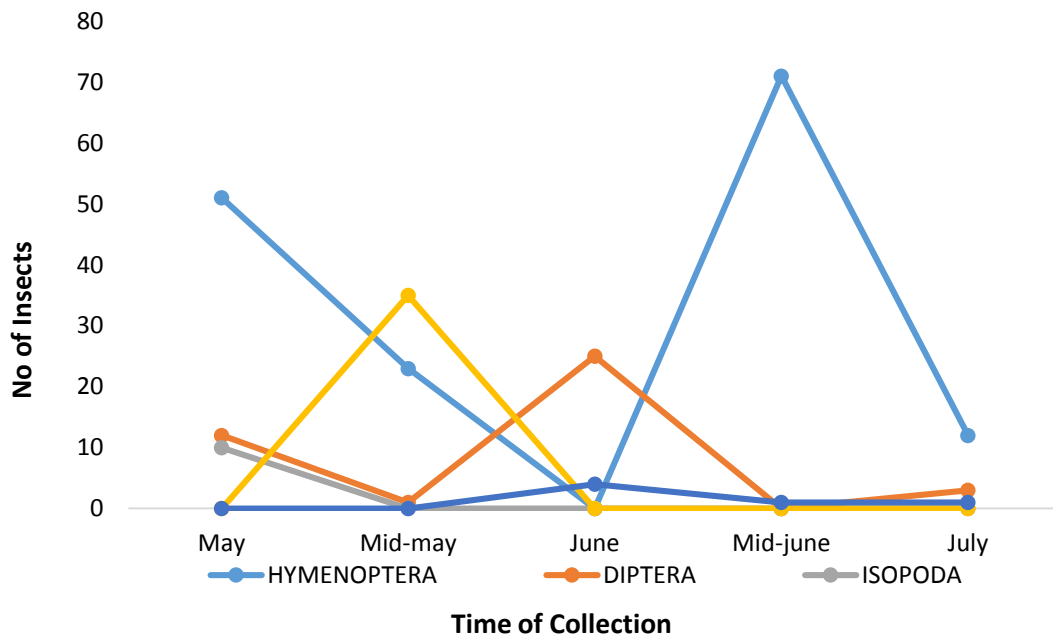


Fig. 6: Fluctuation of insects associated with *Ocimum gratissimum*.

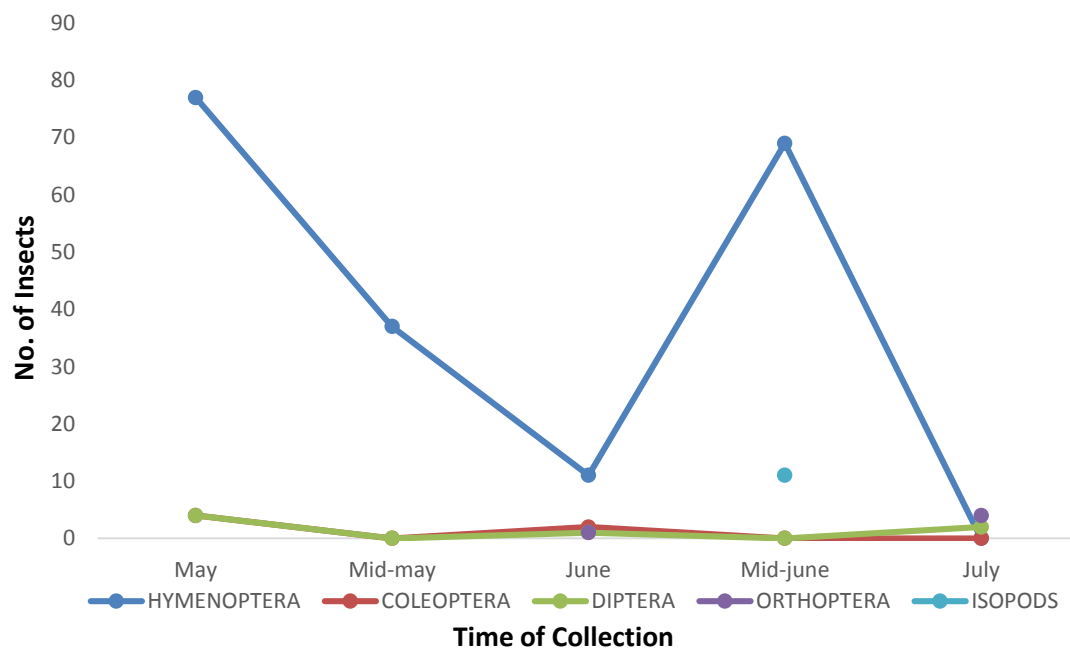


Fig. 7: Fluctuation of insects associated with *Chromolaena odorata*.

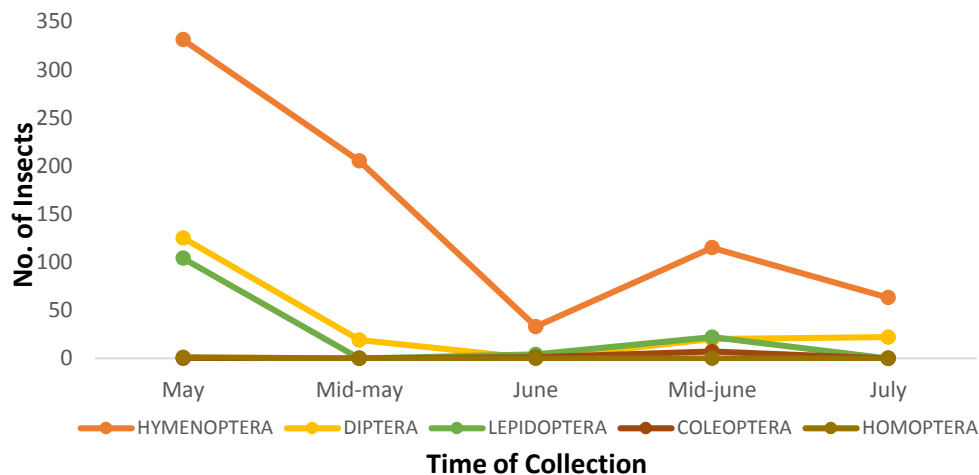


Fig. 8: Fluctuation of insects associated with *Spondias mombin*.

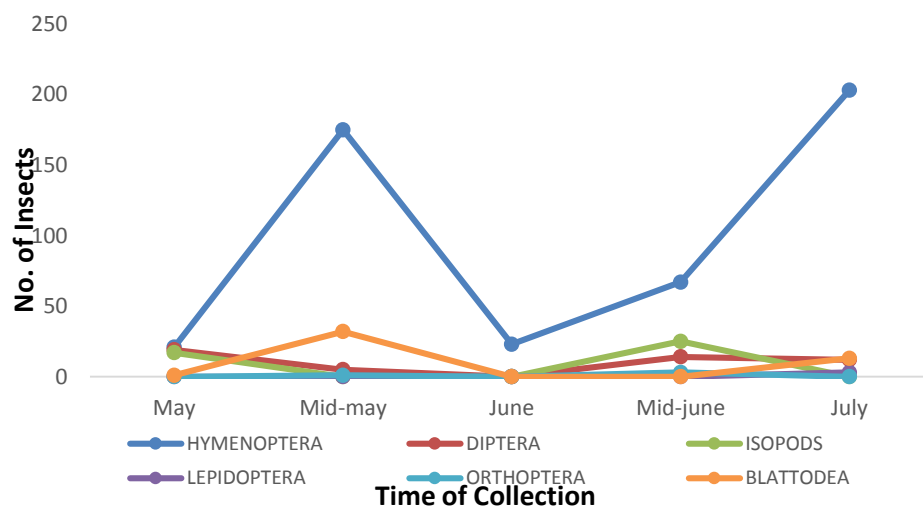


Fig. 9: Fluctuation of insects associated with *Azadirachta indica* (Neem)

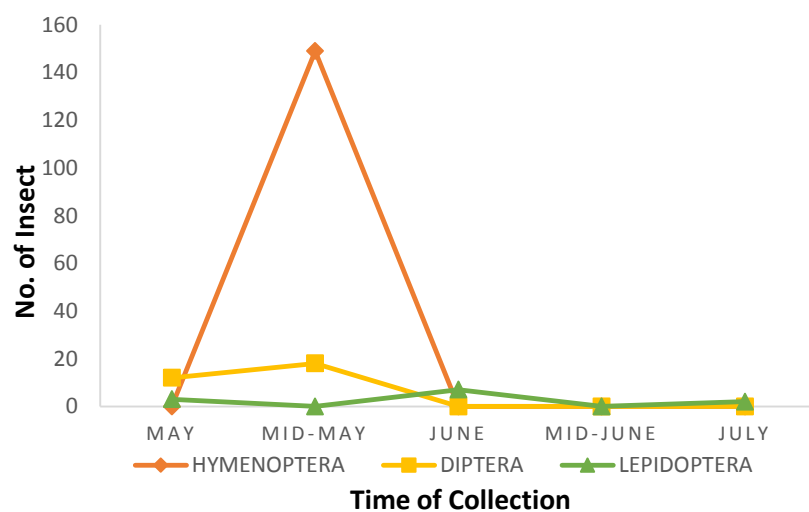


Fig. 10: Fluctuation of insects associated with *Moringa oleifera*

Relative abundance of insects associated with medicinal plants

Through the five-time survey period, *Ocimum gratissimum* hosted a variety of insects, totalling 239 individuals from six major orders: Hymenoptera, Diptera, Isopoda, Blattodea, Orthoptera and Lepidoptera. Hymenopterans made up 65.7% of the total, dominated by *Formica rufa* (66.96%) and *Lasius niger* (3.13%). Dipterans accounted for 13%, all from *Musca* species. Isopods which were represented solely by *Cubaris murina*, constituted 4.20% of the total. Termites in the order Blattodea contributed 14.6%, while Orthoptera (*Caelifera*) represented 1.7%. Lepidopterans which were represented by two individuals, comprised 0.8% of the total insects collected (Fig. 11).

A total of 223 insects from five orders were observed and collected from *Chromolaena odorata*. Hymenopterans were the most abundant, making up 87% of the total, with *Formica rufa* (77.13%) and *Lasius niger* (9.87%). Coleopterans contributed 2.69%, represented by the *Lilioceris merger* (2.24%) and *Platycerus quercus* (0.45%). Dipterans made up 3.14%, including *Tephritis cometa* (1.35%) and *Musca spp.* (1.79%). Orthopterans (grasshoppers) accounted for 2.24%, while isopods (*Cubaris murina*) contributed 4.9% of the total insects (Fig 12).

For *Spondias mombin*, a total of 1,072 insects from five orders were collected: Hymenoptera, Diptera, Coleoptera, Lepidoptera, Homoptera, and maggots. Hymenopterans were the most dominant, making up 69.68%, with *Formica* species (61.95%) and *Lasius niger* (7.74%). Dipterans accounted for 17.35% and were represented by *Musca domestica* (11.29%) and *Coenosia attenuata* (6.34%). Coleopterans (*Platycerus quercus*) contributed 0.75%, while Lepidopterans (butterflies) made up 0.37%. Homopterans accounted for 0.1%, and maggots contributed 11.75% (Fig. 13).

Throughout the five-time monitoring period, *Azadirachta indica* was associated with a total of 635 insects from six orders: Hymenoptera, Diptera, Dictyoptera, Isopoda, Lepidoptera, Orthoptera and Blattodea. Hymenopterans were the most abundant, making up 77%, with *Formica sp.* (77.19%), *Dorylus nigricap* (3.43%) and *Lasius niger* (3.26%). Dipterans (*Musca sp.*) contributed 7.87%, while Dictyoptera (*Mantis religiosa*) accounted for 0.32%. Isopods (*Cubaris murina*) made up 6.61%, Lepidopterans (butterflies) and Orthopterans (*Caelifera*) each contributed 0.63%, and Blattodea (termites) made up 6.93% (Fig. 14).

Insects collected on *Moringa oleifera* during the survey were totalled 191 individuals from three major orders: Hymenoptera, Diptera and Lepidoptera. Hymenopterans dominated with 78.5%, comprising *Formica sp.* (67.54%) and *Lasius niger* (10.47%). Dipterans contributed 15.7%, represented by *Musca sp.* (9.95%) and *Coenosia attenuata* (5.76%). Lepidopterans made up 5.8%, including butterflies (4.71%) and caterpillars (1.57%) (Fig. 15).

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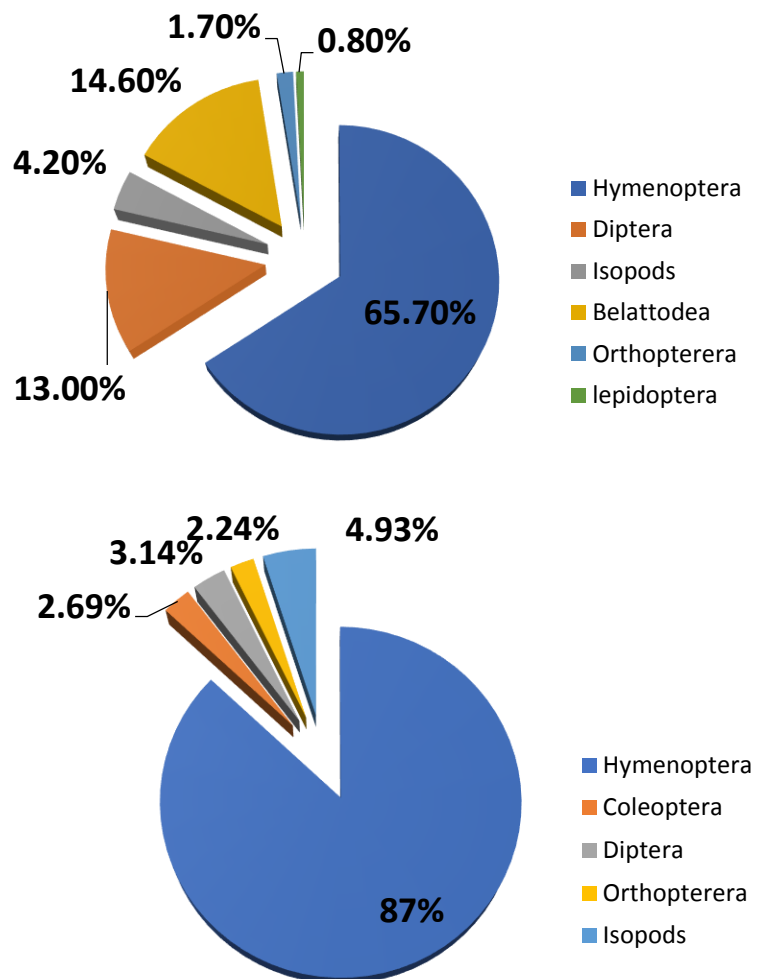


Fig. 12: Relative abundance of insects associated with *Chromoleana odorata*

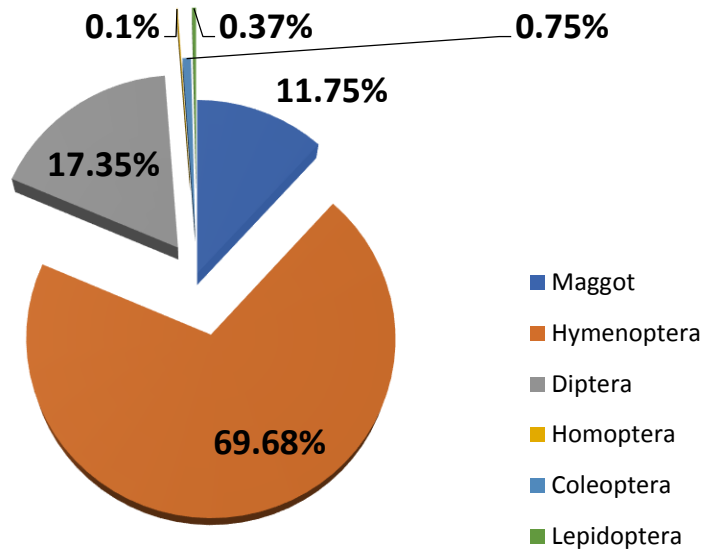


Fig. 13: Relative abundance of insects associated with *Spondias mombin*

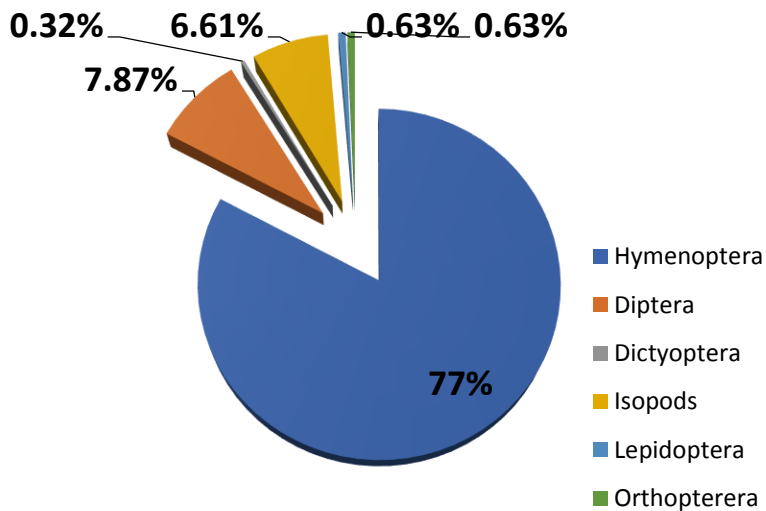


Fig. 14: Relative abundance of insects associated with *Azadirachta indica*

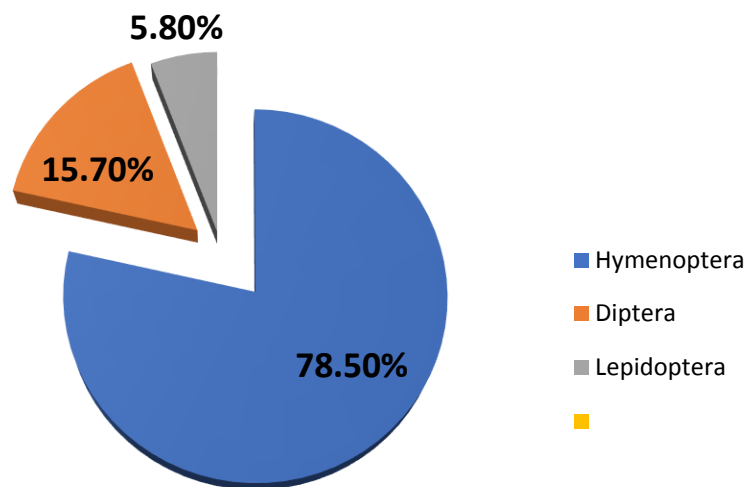


Fig. 15: Relative abundance of insects associated with *Moringa oleifera*

Similarity index of insects among the medicinal plants

Table 1 shows the similarity index between each pair of plant species surveyed based on the insect data recorded on them. The similarity indices between *Ocimum gratissimum*, *Chromolaena odorata*, *Spondias mombin*, *Azadirachta indica* and *Moringa oleifera* were 0.959, 0.971, 0.984 and 0.970, respectively. *Chromolaena odorata* had similarity indices of 0.979, 0.976, 0.993 and 0.983 with *Ocimum gratissimum*, *Spondias mombin*, *Azadirachta indica* and *Moringa oleifera*, respectively. The similarity indices between *Spondias mombin* and other plants were 0.971, 0.976, 0.982 and 0.996. While for *Azadirachta indica*, similarity indices with other plants were 0.984, 0.993, 0.982 and 0.984. On *Moringa oleifera*, the similarity indices compared to *Ocimum gratissimum*, *Chromolaena odorata*, *Spondias mombin* and *Azadirachta indica* were 0.970, 0.983, 0.996 and 0.984, respectively.

Species richness

The species richness of Hymenoptera on *Ocimum gratissimum* was 2, while Diptera, Isopoda, Blattodea, Orthoptera and Lepidoptera recorded a richness of 1 each (Table 2). On *Chromolaena odorata*, Hymenoptera, Coleoptera and Diptera, each had a species richness of 2, while Orthoptera and Isopoda had a richness of 1 (Table 3). For *Spondias mombin*, Hymenoptera had a species richness of 2, Coleoptera 1, Diptera 2, Lepidoptera 1 and Homoptera 1 (Table 4). Species richness of Hymenoptera was 3,

Dictyoptera 1, Diptera 1, Lepidoptera 1, Blattodea 1 and Orthoptera 1 on *Azadirachta indica* (Table 5). Species richness on *Moringa oleifera* was 2 for Hymenoptera, 2 for Diptera and 1 for Lepidoptera (Table 6).

Diversity Indexes

On *O. gratissimum*, the diversity indexes of the insect orders were: hymenopterans was 0.914, dipterans, isopods, blattodea, orthopterans and lepidopterans was 1, respectively. On *Chromolaena odorata*, the diversity indexes of the insect orders were: hymenopterans was 0.79787, coleopterans was 0.6666, dipterans was 0.42857, orthopterans and isopods were 1. On *Spondias mombin*, the diversity indexes of the insect orders were: dipterans was: 0.54287 and hymenopterans was 0.8022. On *Azadirachta indica*, the diversity index for Hymenopterans was 0.84973. On *Moringa oleifera*, the diversity indexes for the insect orders were: Dipterans was 0.51954 and the Hymenopterans was 0.76601.

Table 1: Similarity index of insects among the medicinal plants

Medicinal Plant	<i>Ocimum gratissimum</i>	<i>Chromolaena odorata</i>	<i>Spondias mombin</i>	<i>Azadirachta indica</i>	<i>Moringa oleifera</i>
<i>Ocimum gratissimum</i>	1.000	0.979	0.971	0.984	0.970
<i>Chromolaena odorata</i>	0.959	1.000	0.976	0.993	0.983
<i>Spondias mombin</i>	0.971	0.976	1.000	0.982	0.996
<i>Azadirachta indica</i>	0.984	0.993	0.982	1.000	0.984
<i>Moringa oleifera</i>	0.970	0.983	0.996	0.984	1.000

Values closer to 1 indicate a higher similarity, while values closer to 0 would indicate lesser similarity.

Table 2: Diversity of insects associated with *Ocimum gratissimum*

Insects	Sum	Mean	SD	SE	Diversity index	Species richness
HYMENOPTERA						2
<i>Formica rufa</i>	150	30	26.916	12.037	0.914	
<i>Lasius niger</i>	7	1.4	2.608	1.1662		
DIPTERA						1
<i>Musca sp.</i>	31	6.2	10.569	4.7267	1	
ISOPOD						1
<i>Cubaris murina isopods</i>	10	2	4.4721	2	1	
BLATTODEA						1
<i>Macrotermes bellicosus</i>	35	7	15.6525	7	1	
ORTHOPTERA						1
<i>Caelifera</i>	4	0.8	1.304	0.584	1	
LEPIDOPTERA						1
<i>Acraea serena</i>	2	0.4	0.548	0.245	1	

Samples surveyed from 5 stands of *Ocimum gratissimum*

Table 3: Diversity of insects associated with *Chromoleana odorata*

Insects	Sum	Mean	SD	SE	Diversity index	Species richness
HYMENOPTERA						2
<i>Lasius niger</i>	22	4.4	8.764	3.9192	0.798	
<i>Formica rufa</i>	172	34.4	29.997	13.415		
COLEOPTERA						2
<i>Lilioceris merdigera</i>	5	1	1.414	0.633	0.667	
<i>Platycerus quercus</i>	1	0.2	0.447	0.2		
DIPTERA						2
<i>Tephritis cometa</i>	3	0.6	0.894	0.4	0.429	
<i>Musca sp.</i>	4	0.8	1.304	0.583		
ORTHOPTERA						1
<i>Junonia oenone</i>	5	1	1.732	0.775	1	
ISOPODS						1
<i>Cubaris murina isopods</i>	11	2.2	4.919	2.2	1	

Samples surveyed from 5 stands of *Chromoleana odorata*

Table 4: Diversity of insects associated with *Spondias mombin*

Insects	Sum	Mean	SD	SE	Diversity index	Species richness
Maggots	126	25.2	45.069	20.1554	1	1
HYMENOPTERA						2
<i>Formica rufa</i>	664	132.8	105.87	47.349	0.802	
<i>Lasius niger</i>	83	16.6	23.671	10.586		
DIPTERA						2
<i>Musca domestica</i>	121	24.2	30.768	13.760	0.543	
<i>Coenosia attenuate</i>	65	13	20.905	9.3488		
HOMOPTERA						1
<i>Aphis cracivora</i>	1	0.2	0.447	0.2	1	
COLEOPTERA						1
<i>Platycerus quercus</i>	8	1.6	3.0496	1.364	1	
LEPIDOPTERA						1
<i>Junonia oenone</i>	4	0.8	1.789	0.8	1	

Samples surveyed from 5 stands of *Spondias mombin*

Table 5: Diversity of insects associated with *Azadirachta indica*

Insects	Sum	Mean	SD	SE	Diversity index	Species richness
HYMENOPTERA						3
<i>Formica rufa</i>	450	90	78.807	35.243	0.850	
<i>Dorylus nigricap</i>	20	4	8.396	3.755		
<i>Lasius niger</i>	19	3.8	5.495	2.457		
DIPTERA						1
<i>Musca sp.</i>	50	10	7.517	3.362	1	
DICTYOPTERA						1
<i>Mantis religiose</i>	2	0.4	0.548	0.245	1	
ISOPODS						1
<i>Cubaris murina isopod</i>	42	8.4	11.845	5.297	1	
LEPIDOPTERA						1
<i>Junonia oenone</i>	4	0.8	1.304	0.583	1	
ORTHOPTERA						1
Caelifera	4	0.8	1.303	0.583	1	
BLATTODEA						1
<i>Macrotermes bellicosus</i>	44	8.8	13.971	6.248	1	

Samples surveyed from 5 stands of *Azadirachta indica*

Table 6: Diversity of insects associated with *Moringa oleifera*

Insects	Sum	Mean	SD	SE	Diversity index	Species richness
HYMENOPTERA					0.766	2
<i>Formica rufa</i>	129	25.8	57.691	25.8		
<i>Lasius niger</i>	20	4	8.944	4		
DIPTERA					0.519	2
<i>Musca sp.</i>	19	3.8	5.495	2.457		
<i>Coenosia attenuata</i>	11	2.2	4.919	2.2		
LEPIDOPTERA	11	2.2	4.919	2.2	1	1
<i>Acraea serena</i>						

Samples surveyed from 5 stands of *Moringa oleifera*

DISCUSSION

The population of insects associated with five medicinal plants (*Ocimum gratissimum*, *Chromolaena odorata*, *Spondias mombin*, *Azadirachta indica* and *Moringa oleifera*) for five weeks of bi-weekly surveillance in this study showed diverse fluctuation for each plant and specified times. Ten insect orders containing 17 species were reported from all the medicinal plants surveyed. These plants are famous sources of drugs, pharmaceutical products and treatment of wounds, using the leaves, roots, bark and flowers (Abdallah *et al.*, 2023). Hymenopterans were the most abundant on all the medicinal plants followed by dipterans. However, both orders consistently rose and fell throughout the surveillance period, probably due to the fluctuation of rainfall at the time of the survey. In contrast, other orders showed varying attendance at different weeks of the surveillance period.

Of course, each plant possesses distinct qualities to accommodate varieties of insects at specified times of their life-cycle and seasons of the year. As a means of reproduction, plants employ pollination, the transfer of pollen from anther to the stigma of the same or different plants using different insects (Haas and Lortie, 2020). While Hymenopterans are insectivorous pollinators, hosted by many plants, they concurrently feed on other insects visiting the plants. The stems and flowers of many medicinal plants possess sweet sap and nectars, which attract dipterans, homopterans and lepidopterans. Also, dictyopterans are predators of other insects on medicinal plants (Banjo *et al.*, 2006a; Banjo *et al.*, 2006c).

The abundance of insects associated with each plant showed that hymenopterans are the most abundant of all the medicinal plants while orthopterans are the least. Hymenopterans are insectivorous pollinators hosted in all medicinal plants; dipterans and lepidopterans are nectar suckers; dictyopterans are predators of other insects (Banjo *et al.*, 2006a). On *Ocimum gratissimum*, hymenopterans and dipterans are most abundant showing the diversity of these two orders. In addition, these orders are ecologically linked with several medicinal plants (Warren *et al.*, 1988). Chakraborty *et al.* (2021) also reported that hymenopterans had the highest values of the insects associated with some medicinal plants. In other studies by Banjo *et al.* (2006a), hymenopterans were the most abundant in 80% of the medicinal plants (Banjo *et al.*, 2006a; Banjo *et al.*, 2006b). However, Badoni and Arya (2022) reported the dominance of the Order Lepidoptera followed by Order Diptera from insects that visited *Berberis* spp. This differs from the present study due to the colourful nature of the flowers produced by *Berberis* spp.

The results showed that these medicinal plants hosted several insects from different orders which feed on their parts and nutrients. To further resolve this scenario, more research is needed to unravel the extent of damages these insects might have caused the plants. Studies should be carried out to find out which

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insecticides or natural enemies could be employed to reduce or terminate insects on the plants without adversely disrupting the process of pollination.

CONCLUSION

The vast knowledge of phytochemicals and nutrients in plants has attracted researchers to focus on their current use as alternative source of medication. Some associated insects have been observed to have some effect on these plants, thereby reducing the beneficial qualities. This study was aimed to identify the insects associated with five of the medicinal plants. Hymenopterans and dipterans were observed to be the most abundant. It is necessary to regularly survey the insect pests in order to determine when to reduce, terminate or maintain them without compromising the process of pollination.

Authors' contributions

The experiment was designed and the manuscript was prepared by SAA, GAR, DO and AAO. SAA, DO, AAO, KML, BIY and HAA carried out the morphological identification and surveillance. JAA, AOO and DO handled the statistical analysis. AAO, AOO, DO, AAO and SAA contributed to the final preparation of the manuscript DO, GAR and SAA administered the project.

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