

Diversity, Abundance, Dispersion and Temporal Spread of Arthropods Assemblage Associated with Golden Melon (*Cucumis melo* L.) in Wukari, Nigeria

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Received: 6 May 2026 / Revised: 26 August 2026 / Accepted: 29 September 2026

Abstract

Arthropod community structure of golden melon (*Cucumis melo* L.) was investigated in Wukari, Nigeria wherein arthropods were sampled weekly across the crop growth stages using a modified portable 2-stroke gasoline-powered leaf-blower and vacuum machine (Model number: EBV260E; Power: 0.7KW/7500Min.) with a 5cm diameter inlet cone used to sweep through 4m length of the middle row of 12, 16m² experimental plots at an approximate walking speed of 1m/sec. The relative abundance (RA), frequency of occurrence (FO), diversity indices, spatial dispersion and natural enemy to pest ratio of the specimens were documented. Diversity indices were computed, and spatial distribution patterns of dominant species were determined using Taylor's and Iwao's patchiness regression models. Forty-eight (48) species belonging to 30 families and 10 orders were recorded. Coleopterans and Hymenopterans were the most diverse orders while chrysomelid beetles and sap sucking Hemipterans constituted the major pest groups. Natural enemies; particularly ants, coccinellid beetles, wasps, and spiders were abundant and widely distributed. Dominant pest species (RA≥1.0% and FO≥25.0%) included *Aphis gossypii*, *Asbecesta nigripennis*, *Aulacophora africana*, *Bactrocera cucurbitae* and *Bemisia tabaci*. The population densities of pests and natural enemies largely peaked within the vegetative to flowering. Overall, the spatial distribution computed using Taylor's power law and Iwao's regression models reveals inconsistent results. However, the pest and beneficial arthropods could be said to apparently have an aggregated distribution as comparatively higher R² values tilted more towards aggregation. Community diversity was high (H=3.361) with high species richness (R=6.650) and moderately high evenness (E=0.600). Overall natural enemy to pest ratio was 0.78:1. These findings highlight effective biological regulation and ecological stability of the golden melon agro-ecosystem at Wukari and underscore the potential for conservation based integrated pest management strategies.

Keywords: Buzas and Gibson's Evenness, Golden melon, Iwao's patchiness regression, Shannon-Weiner index, Taylor's power law, Spatial distribution

1. Introduction

Golden melon, also commonly called sweet melon (*Cucumis melo* L.), is an important fruit vegetable crop of the family Cucurbitaceae. It has an extensive rooting system, aerial stem, simple leaves and a trailing, creeping growth habit, and provides essential nutrients including vitamins A and C, minerals and dietary fibre (Olubunmi et al., 2019; Tamer et al., 2010). The crop contributes to food security and rural livelihoods in Nigeria and other tropical and subtropical regions (Filani et al., 2024). Its nutritional and economic value, together with increasing consumer awareness of its health benefits, has stimulated production and consumption in Nigeria, particularly in Wukari, Taraba State (Khalid et al., 2021; Shang et al., 2020).

The productivity of golden melon, however, depends not only on agronomic practices but also on the arthropod community associated with the crop. Arthropods perform contrasting and sometimes interacting ecological functions within agroecosystems. Some are beneficial, particularly pollinators and natural enemies, whereas others are herbivorous pests capable of reducing plant vigour, damaging fruits and foliage, transmitting plant pathogens, or otherwise constraining crop productivity. In golden melon, reported insect associates include pollinators such as bees (Hymenoptera: Apidae) and flies (Diptera: Syrphidae), as well as pest groups such as aphids (Hemiptera: Aphididae), whiteflies (Hemiptera: Aleyrodidae) and fruit flies (Diptera: Tephritidae) (Egbon et al., 2025). Studies conducted in Bauchi and Gombe State of Nigeria has recently highlighted the importance of insect pests in golden melon production (Simon et al., 2026). Consequently, the composition and relative abundance of arthropod guilds may have important implications for crop health and sustainable production.

Despite these ecological and agricultural roles, knowledge of the arthropod community associated with golden melon in Nigeria remains limited. Available studies have tended to emphasize particular pest groups or selected insect taxa rather than characterizing the broader arthropod assemblage occurring on the crop (Egbon et al., 2025). Thus, important information on species richness, diversity, evenness, abundance and the relative representation of pest and beneficial arthropod guilds remains insufficiently documented. This represents a significant research gap because management decisions based only on individual pest species may overlook interactions among pests, pollinators and natural enemies that contribute to the functioning and stability of the crop ecosystem.

Natural enemies, including predatory and parasitic arthropods, are particularly important components of an ecologically based pest-management system because they can contribute to the regulation of pest populations. Similarly, knowledge of pollinator abundance and diversity is relevant to a fruit crop in which successful reproduction and fruit development may depend on insect-mediated pollination. A community-level assessment that distinguishes pest species from natural enemies and other functional groups can therefore provide a more complete ecological basis for determining which arthropods require management and which should be conserved. Such information is especially valuable for integrated pest management (IPM), which seeks to suppress economically important pests while conserving beneficial organisms and reducing unnecessary reliance on synthetic pesticides (Okrikata & Ogunwolu, 2017).

The need for such information is heightened by the fact that arthropod communities are not static. Their diversity, abundance, dispersion and temporal occurrence can vary with agricultural practices, climatic conditions and geographical location. Consequently, observations from one crop, production system or locality cannot necessarily be extrapolated to another. Wukari, located in the Southern Guinea Savanna of Nigeria, provides an important setting for documenting the arthropod fauna associated with golden melon and establishing baseline information for subsequent ecological and pest-management studies. A detailed assessment can reveal the principal pest species, identify potentially important natural enemies, characterize the balance among functional guilds and provide evidence for improving IPM decisions while maintaining ecological balance (Filani et al., 2024).

Against this background, the present study was undertaken to investigate and document the arthropod community associated with golden melon (*C. melo*) in Wukari, Southern Guinea Savanna of Nigeria, with particular emphasis on species composition, diversity, richness, evenness, functional guilds, dispersion and temporal distribution, and to identify the major pest species and associated natural enemies relevant to the development of ecologically sound integrated pest management strategies.

2. Materials and Methods

2.1 Study location

The arthropod observational field survey was conducted in the Research Farm of the Federal University of Wukari, Taraba State, Nigeria which is located in the Southern Guinea savanna zone of the north eastern Nigeria lying within Latitude 7°51'N and Longitude 9°47'E during the planting season of 2025. Wukari has an average annual temperature of 26.8°C. The study area experiences a warm tropical climate characterized by dry and wet seasons with the wet season lasting from April to October peaking in June and September (Okrikata & Yusuf, 2016). Common

weeds in the study area include; *Ipomoea triloba* Linn., *Gomphrena celosoides* Mart., *Imperata cylindrica* L. Raeuschel, *Digitaria horizontalis* Willd., *Rottboellia cochinchinensis* (Lour.) Clayton, *Andropogon gayanus* Kunth, *Tridax procumbens* L., *Commelina benghalensis* L. and *Cyperus rotundus* L.

2.2 Field layout and crop cultural management

The experimental land was ploughed and harrowed after which a 0.034 hectare of land was demarcated into 12 sub-sampling plots each measuring 4 m by 4 m (16m²) during the 2025 cropping season (Figure 1). Seeds of Golden melon (*C. melo*); variety “F1 Delta” was obtained from a reputable agrochemical dealer in Kano, Nigeria. These were sown on raised beds at three seeds/hole to a depth of about 2 cm. The crop spacing was 1 m between rows and 1 m within; thinning to one plant/stand was done at 10 days after planting giving 9 plants/plot (10,000 plants/ha). NPK (15:15:15) fertilizer was applied at the rate of 200kg/ha (Gichimu et al., 2008) at 3 weeks after planting (WAP) using the side band method. Following the standard farming practice in the study area; a residual and systemic fungicide; RiddomilGold® (40g/ha Metalaxyl-M, 640g/ha Mancozeb) was applied at the rate of 2.5 kg/ha at the vegetative, flowering and fruiting stages. The field was subjected to natural arthropod infestation while manual weeding was done when necessary.

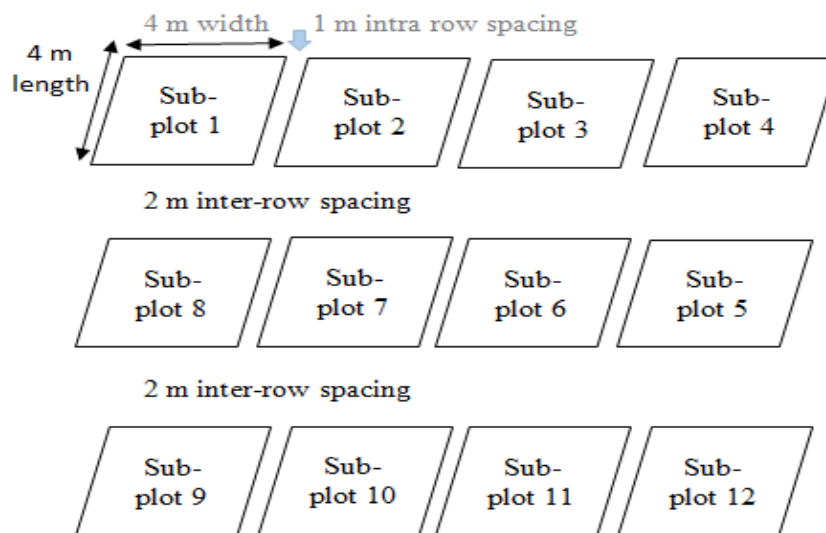


Figure 1. The experimental field layout.

2.3 Arthropod Sampling Procedure

The sampling of arthropod species commenced at the 70% emergence stage [2 WAP] and proceeded at weekly intervals (for 11 weeks) until fruit maturity (a total of 11 samples were taken/sub-sampling plot – a sample/week). Collection was made between 1600 and 1800h but was made between 0700 and 0900hr at the flowering stage for effective sampling of pollinating insects as the melon flowers usually open in the morning and close by noon. A modified *Bragadin Giardinaggio* portable 2-stroke gasoline-powered leaf-blower and vacuum machine (Model number: EBV 260 E; Power: 0.7 KW/7500/Min.) with a 5 cm diameter inlet cone was used to sweep through 4m length of the middle row at an approximate walking speed of 1m/sec (Figure 2). Visual observation complemented suction sampling. The arthropods collected were killed in ethyl acetate killing jar and then preserved in 70% ethanol. Butterflies and moths were dried and preserved in an airtight container containing silica gel to preserve their wing morphology. Immature stages of insects collected were reared to adults in the laboratory for identification. Collected insects were examined and sorted based on external morphological characters using a key- for -insect - identification app supplemented with standard taxonomic keys and references (Gibb & Oseto, 2019; Heinrichs & Barrion, 2004; Triplehorn & Johnson, 2004) for verification after examination under a stereomicroscope. Where

samples could not be identified to the species level, they were reported at the genus level. The identification was further checked by Prof. Emmanuel Okrikata, a specialist in Economic Entomology and Pest Management at Federal University Wukari, Nigeria. The samples were categorized into feeding guilds as described by Okrikata et al. (2019).

Immediately after collection, the arthropods were examined for physical integrity. Damaged specimens were retained if sufficient diagnostic appendages were intact. If present; detached body parts were retained with the corresponding specimen to avoid losing taxonomically important features. Specimens that were dead at the time of collection were also recorded.



Figure 2. Arthropod suction sampling on golden melon plots using a modified *Bragadin Giardinaggio* portable 2-stroke gasoline-powered leaf-blower and vacuum machine during the 2025 cropping season at Wukari.

2.4 Data analysis

The frequency of occurrence (FO) and relative abundance (RA) of arthropods retrieved were computed. As outlined by Okrikata et al. (2019); taxa/species with $FO \geq 25\%$ and $RA \geq 1\%$ were regarded as dominant while, those with $FO < 25\%$ and/or $RA < 1\%$ were regarded as rare. The dominant taxa/species were used to compute the natural enemies to pests' ratio (calculated as the sum of natural enemies divided by the sum of the pests). Temporal spread and weekly fluctuations of dominant arthropods were graphically illustrated.

2.4.1 Diversity indices

Shannon-Weiner diversity index, Margalef's species richness index and, Buzas and Gibson's Evenness index were computed using the Paleontological Statistical Tool –Past₃ (Hammer et al., 2001).

2.4.2 Dispersion indices

The variance to mean ratio (S^2/m) was used to form a tentative opinion on dispersion patterns of the dominant taxa/species. Linear regression models (Taylor's power law and Iwao's patchiness regression) were used to confirm the spatial distribution of the dominant insects (pests and beneficials) as recommended by Mollet et al. (1984) and Okrikata et al. (2019).

The variance to mean ratio (S^2/m) proposed by Myers (1978) is such that; $S^2/m = 1$, <1 and >1 indicate random, regular and aggregated dispersion, respectively.

Taylor's power law states that the variance (S^2) of a population is proportional to the fractional power of the arithmetic mean (m): $S^2 = am^b$

To estimate a and b , the values of $\log(S^2)$ were regressed against $\log(m)$ using the formula:

$$\log(S^2) = \log(a) + b\log(m)$$

Where the intercept (a) is the sampling/computing factor which changes with the sampling unit, and the slope (b) is an index of aggregation that indicates a uniform, random or aggregated dispersion when $b < 1$, $= 1$ or > 1 , respectively (Southwood, 1978; Okrikata et al., 2019).

Iwao's patchiness regression on the other hand, quantifies the relationship between the mean crowding (m^*) and the mean (m) using the formula:

$$m^* = \alpha + \beta m$$

Where m^* is the mean crowding (Lloyd, 1967). The intercept (α) is the index of basic contagion of a population. where;

$\alpha = 0$ (the basic unit of a population is a single individual/random dispersion).

$\alpha > 0$ (there is a positive association between individuals/aggregated dispersion).

$\alpha < 0$ (there is a negative/repulsive association between individuals/regular dispersion).

The slope (β) is the density contagiousness coefficient interpreted in the same manner as b of Taylor's regression (Iwao & Kuno, 1968).

The weekly samples collected for 11 consecutive weeks from each of the 12 sub-sampling plots gave 132 sub-sampling plot-by-week observations (12 sub-sampling plots $\times$ 11 sampling weeks). However, we calculated the mean and variance (Taylor's power-law regression) or mean crowding (Iwao's patchiness regression) for each sampling occasion across the 12 sub-sampling plots. We thus had 11 observations (data points) for the regressions. Zero observations (where present) were retained in the original abundance dataset and were not treated as missing observations and this is because zero values cannot be log transformed. Hence, they were handled at the level of the weekly mean and variance calculations.

3. Results

3.1 Diversity, abundance and feeding guilds of arthropods associated with golden melon at Wukari

A total of 1,174 arthropod samples were sorted into 1 order (Araneae) of the class Arachnida and 6 orders of the class Insecta which made up 48 species, 30 families and 10 orders (Tables 1 and 2). The results show high species diversity (Shannon-Wiener's Index – 3.361), high species richness (Margalef's Richness Index - 6.65), and high evenness (Buzas and Gibson's Evenness Index of - 0.600) of the arthropod community (Table 2). The insect order Coleoptera was the most diverse (16 species, 474 individuals and 2.245 Shannon index), followed by Hymenoptera (10 species, 386 individuals and 1.992 Shannon index). of the 21 dominant (FO $\geq$ 25.0% and RA $\geq$ 1%) taxa, 7 each were Coleoptera and Hymenoptera even though the Coleopterous insects were 1.6x more abundant than hymenopterans. While, Araneae, Blattodea, Dermaptera and Mantodea were made up of a single species each with maximum species evenness values, Diptera; made up of 5 species has the least (0.492) - Table 1.

The dominant arthropod species included the leaf feeding beetles; *Asbecesta nigripennis* Weise, *A. transversa* Allard, *Aulacophora africana* Weise., *Epilachna chrysomelina* Fab. and *Monolepta nigeriae* Bryant. Others included in the list are; *Bracon hebetor* Say., *Apis mellifera* L., *Aphis gossypii* Glover, Ant species, Spiders, *Philanthus triangulum* Fab. and *Rhynocoris nitidulus* Fab. (Tables 3 and 4). Table 3 also shows that, among the Coleoptera, the Chrysomelidae were clearly the most abundant phytophagous family, as species such as *Monolepta nigeriae* (7.08% RA; 90.9% FO), *Aulacophora africana* (6.91% RA; 100% FO), *Asbecesta transversa* (6.48% RA; 90.9% FO), and *Asbecesta nigripennis* (6.31% RA; 90.9% FO) were both numerically dominant and consistently present. A total of 27 (56.25%) of the collections (species/taxa) were rare or scarce (RA $<$ 1.0 % and/or FO $<$ 25.0 %). Of the 21 dominant

species, 8 were herbivores, 3 parasitoids, 9 predators and a pollinator (*A. mellifera*). The approximate natural enemy to pest ratio is 0.78 (Tables 3 and 4).

Tephritidae were represented mainly by *Bactrocera cucurbitae* Coq. (4.95% RA; 72.73% FO) which more abundant and widespread than *Bactrocera invadens* Drew, Tsuruta and White (0.43% RA; 45.45% FO). The economically important pest groups within the Hemiptera such as *Bemisia tabaci* Genn. (3.07% RA; 90.9% FO) and the *A. gossypii* (3.33% RA; 72.73% FO) were frequently encountered which indicates continuous colonization of the crop while their moderate RA suggested chronic rather than outbreak level infestations. Rare and occasional species included several taxa such as *Pseudolynchia canariensis* Macq., and *Lycus corniger* Dalm. (Table 3).

Table 1. Diversity, richness, and evenness of the taxa collected on golden -melon at Wukari in 2025 Cropping Season.

Arachnid/ insect order	S	N	H	R	E
Araneae	1	37	0.000	0.000	1.000
Blattodea	1	5	0.000	0.000	1.000
Coleopteran	16	474	2.245	2.435	0.581
Dermaptera	1	18	0.000	0.000	1.000
Diptera	5	78	0.900	0.918	0.492
Hemiptera	6	115	1.552	1.054	0.787
Hymenoptera	10	386	1.992	1.511	0.733
Lepidoptera	2	16	0.693	0.361	1.000
Mantodea	1	17	0.000	0.000	1.000
Orthoptera	5	28	1.399	1.200	0.810

All species of spiders were treated as a taxon; **S** = Number of species/taxa; **N** = Number of individuals/specimens; **H** = Shannon-Weiner diversity index; **R** = Margalef's species richness index; **E** = Buzas and Gibson's evenness

Table 2. Diversity indices of arthropods collected from golden melon field plots at Wukari in 2025 Cropping Season.

Diversity index	Values	Inference
Shannon-Weiner Index (H)	3.361	Indicates high arthropods diversity, suggesting a complex and stable arthropods community with minimal dominance by a single species
Buzas and Gibson's Evenness Index (E)	0.600	Shows high evenness. Individuals are fairly well distributed among the species present.
Margalef's Richness Index (R)	6.650	Reflects high species richness, indicating the presence of a large number of arthropod species in the golden melon ecosystem.

48 species of arthropods, 30 family and 10 order were collected

Table 3. Relative abundance and frequency of occurrence of arthropod specimens collected on golden-melon at Wukari in 2025 cropping season.

Arachnid/insect Order	Family	Species	RA (%) ¹	FO (%) ²
Araneae	Various families	Spiders	3.16	81.81
Blattodea	Termitidae	<i>Odontotermes</i> sp.	0.43	27.27
Coleoptera	Carabidae	<i>Platymetopus vestitus</i> Dej.	0.60	18.18
		<i>Aphthona whitfieldi</i> Bryant	0.42	36.36
		<i>Asbecesta congoensis</i> Lab.	0.34	27.27
		<i>Asbecesta nigripennis</i> Lab.	6.31	90.90
		<i>Asbecesta transversa</i> Allard	6.48	90.90
		<i>Aulacophora africana</i> Weise	6.91	100.0
		<i>Monolepta goldingi</i> Bryant	0.34	18.18
		<i>Monolepta nigeriae</i> Bryant	7.08	90.90
		<i>Cheilomenes lunata</i> Fab.	2.13	72.73
		<i>Cheilomenes sulphurea</i> Oliv.	2.73	81.81
	Coccinellidae			

Arachnid/insect Order	Family	Species	RA (%) ¹	FO (%) ²
Dermaptera Diptera	Lycidae	<i>Epilachna chrysomelina</i> F.	4.35	72.73
		<i>Exochomus flavipes</i> Thumb.	0.85	45.45
		<i>Lycus corniger</i> Dalm.	0.34	9.09
	Tenebrionidae	<i>Gonocephalum</i> sp.	0.34	27.27
		<i>Omotrachelus togoanus</i> Mshl.	0.60	36.36
		<i>Carpophilus dimidiatus</i> F.	0.60	36.36
	Chelisochidae	<i>Chelisoches flavipennis</i> Fab.	1.54	72.73
		<i>Pseudolynchia canariensis</i> Macq.	0.17	9.09
	Muscidae	<i>Morellia prolectata</i> Walk.	0.43	27.27
		<i>Musca domestica</i> L.	0.68	36.36
		<i>Bactrocera cucurbitae</i> Coq.	4.95	72.73
	Tephritidae	<i>Bactrocera invadens</i> Drew, Tsuruta and White	0.43	45.45
		<i>Bemisia tabaci</i> Genn.	3.07	90.9
Hemiptera	Aleyrodidae	<i>Riptortus</i> sp.	0.77	63.64
	Alydidae	<i>Aphis gossypii</i> Glover	3.33	72.73
	Pentatomidae	<i>Agonoscellis versicolor</i> F.	0.51	36.36
	Pyrhocoridae	<i>Odontopus nigricornis</i> Stal.	0.68	45.45
	Reduviidae	<i>Rhynocoris nitidulus</i> Fab.	1.45	63.64
Hymenoptera	Apidae	<i>Apis mellifera</i> L.	4.27	63.64
		<i>Apanteles syleptae</i> Fer.	0.77	54.55
	Braconidae	<i>Bracon hebetor</i> Say	2.30	81.81
		<i>Cardiochiles niger</i> W&H.	2.30	63.64
		<i>Chrysis convexifrons</i> Mocs.	0.68	36.36
	Chrysididae	<i>Philanthus triangulum</i> Fab.	1.54	63.64
		<i>Camponotus</i> spp.	7.68	90.9
		<i>Crematogaster</i> sp.	4.18	63.64
	Vespidae	<i>Pheidole</i> sp.	8.36	100
		<i>Antodynerus</i> sp.	0.85	63.64
		<i>Nymphalidae</i>	0.68	63.64
	Lycaenidae	<i>Zizeeria</i> sp.	0.68	45.45
		<i>Miomantis</i> sp.	1.45	54.55
Mantodea Orthoptera	Acrididae	<i>Acrida bicolor</i> Thunberg	0.77	63.64
		<i>Gastrimargus amplus</i> Sjost.	0.26	27.27
		<i>Oedaleus nigeriensis</i> Uvarov	0.17	18.18
	Gryllidae	<i>Gymnogryllus</i> sp.	0.26	36.36
		<i>Pyrgomorpha</i> sp.	0.94	63.64
	Pyrgomorphidae			

Spider species were treated as a single taxon; RA (%)¹ – Relative abundance; FO (%)² – Frequency of occurrence

Table 4. Feeding guilds of the dominant arthropods collected on golden melon at Wukari in 2025 cropping season.

Guild	Species	Plant part attacked	Host/Prey
Hb	<i>Aphis gossypii</i> Glover	Le, Vi, Fr	-
	<i>Asbecesta nigripennis</i> Lab.	Le,	-
	<i>Asbecesta transversa</i> Allard	Le,	-
	<i>Aulacophora africana</i> Weise	Le, Fl, Fr	-
	<i>Bactrocera cucurbitae</i> Coq.	Le, Fl,	-
	<i>Bemisia tabaci</i> Genn.	Le, Vi, Fr	-
	<i>Epilachna chrysomelina</i> F.	Le	-
	<i>Monolepta nigeriae</i> Bryant	Le, Fl, Fr	-
	<i>Bracon hebetor</i> Say	-	Lepidopteran larvae
	<i>Cardiochiles niger</i> W&H.	-	Lepidopteran larvae
Pa	<i>Cheilomenes lunata</i> Fab.	-	Aphids and whiteflies

Guild	Species	Plant part attacked	Host/Prey
Po	<i>Apis mellifera</i> L.	-	Nectar/pollen
Pr	<i>Camponotus</i> sp.	-	Insects, honeydew
	<i>Crematogaster</i> sp.	-	Small arthropods
	<i>Cheilomenes sulphurea</i> Oliv.	-	Aphids and whiteflies
	<i>Chelisoches flavipennis</i> Fab.	-	Eggs and larvae
	<i>Miomantis</i> sp.	-	Various insects
	<i>Pheidole</i> sp.	-	Small insects
	<i>Philanthus triangulum</i> Fab.	-	<i>Apis</i> spp.
	<i>Rhynocoris nitidulus</i> Fab.	-	Polyphagous
	Spiders	-	Insects

Hb — Herbivore (include defoliators, sap suckers, flower/ fruit feeders)

Pr — Predator

Pa — Parasitoid

Po — Pollinator

Fr = Fruit;

Vi = vine.

Arthropod taxa with frequency of occurrence ≥ 25.0 % and relative abundance ≥ 1 %.

Le – Leaf; Fl – Flower; Fr – Fruit; Vi – Vine.

3.2 Temporal distribution of dominant arthropods associated with golden melon at Wukari

The temporal spread of the dominant arthropods associated with golden melon shown in Figures 3, 4 and 5 revealed that the leaf-eating beetles commenced infestation from the seedling stage, except *E. chrysomelina* which commenced at the vegetative stage, and they all spanned through to the fruiting stage, peaking (0.67 – 0.83/4m-row) largely during the late-vegetative to flowering period. The dominant pollinator, *A. mellifera*, commenced visits at the vegetative stage (3rd week after planting) in low densities, peaking during the flowering period and terminating with a sharp decline in number during the mid-fruiting period. The hemipterous, sap-sucking insects (*A. gossypii* and *B. tabaci*) were visible commencing from the 2nd week after planting spanning into the 11th week after planting, peaking within the late-flowering into the early-fruiting period. Aside from *B. hebetor*, *C. lunata* and *C. flavipennis* which commenced visits at the vegetative stage, all other dominant natural enemy species were in the crop agro-ecosystem during the seedling stage in comparatively lower densities (0.17 – 0.75/4m-row).

Figure 5 shows that, the trend in weekly fluctuation of natural enemy species generally followed that of the pest species as they both appeared in comparatively lower densities during the seedling stage (0.83 – 2.50/4m-row); peaked during the flowering stage (3.83 – 5.25/4m-row), and declined during the fruiting stage (3.25 – 4.92/4m-row). Overall, the natural enemy to pest ratio was 0.78:1.

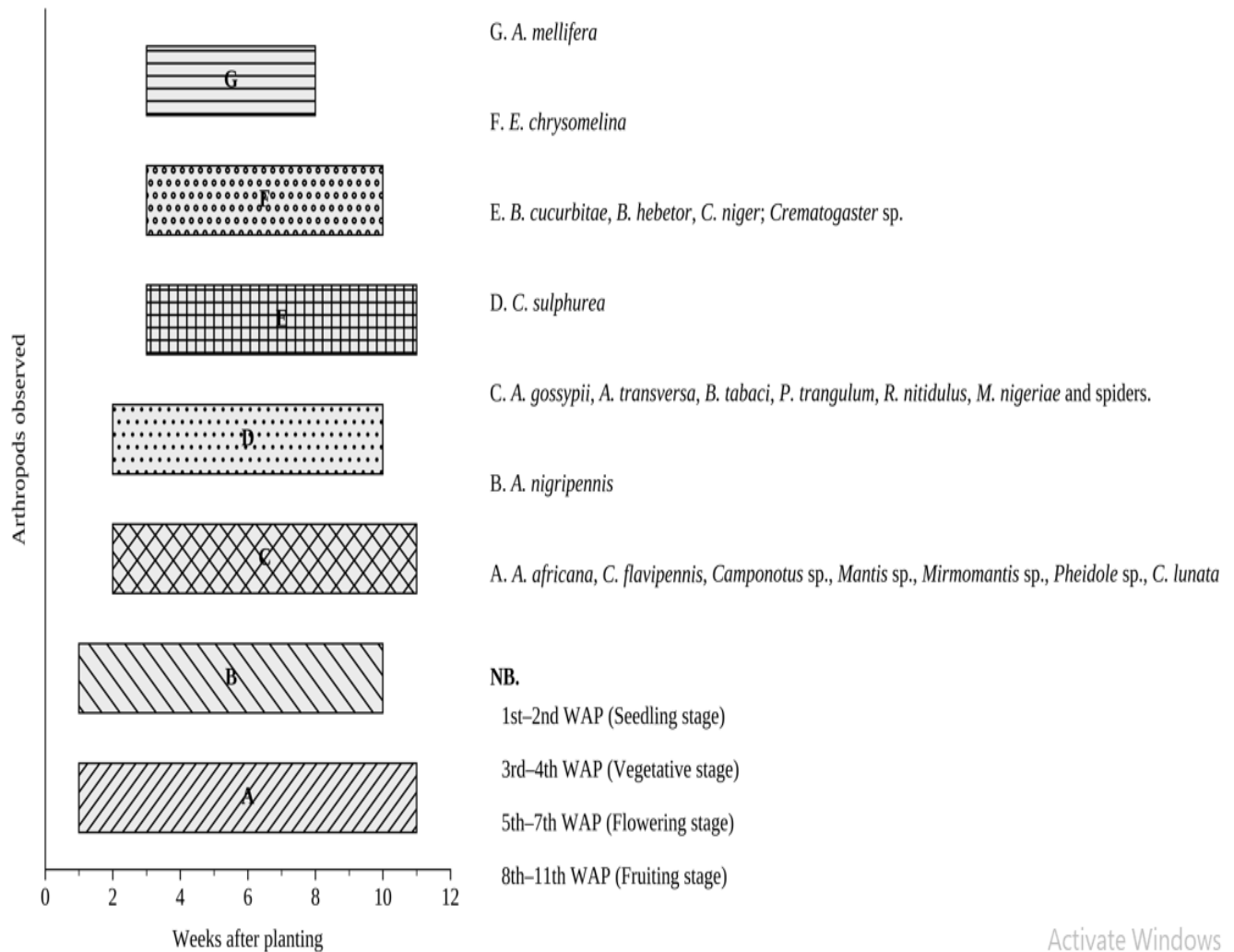


Figure 3. Temporal spread of dominant arthropods associated with golden melon during the 2025 cropping season at Wukar.

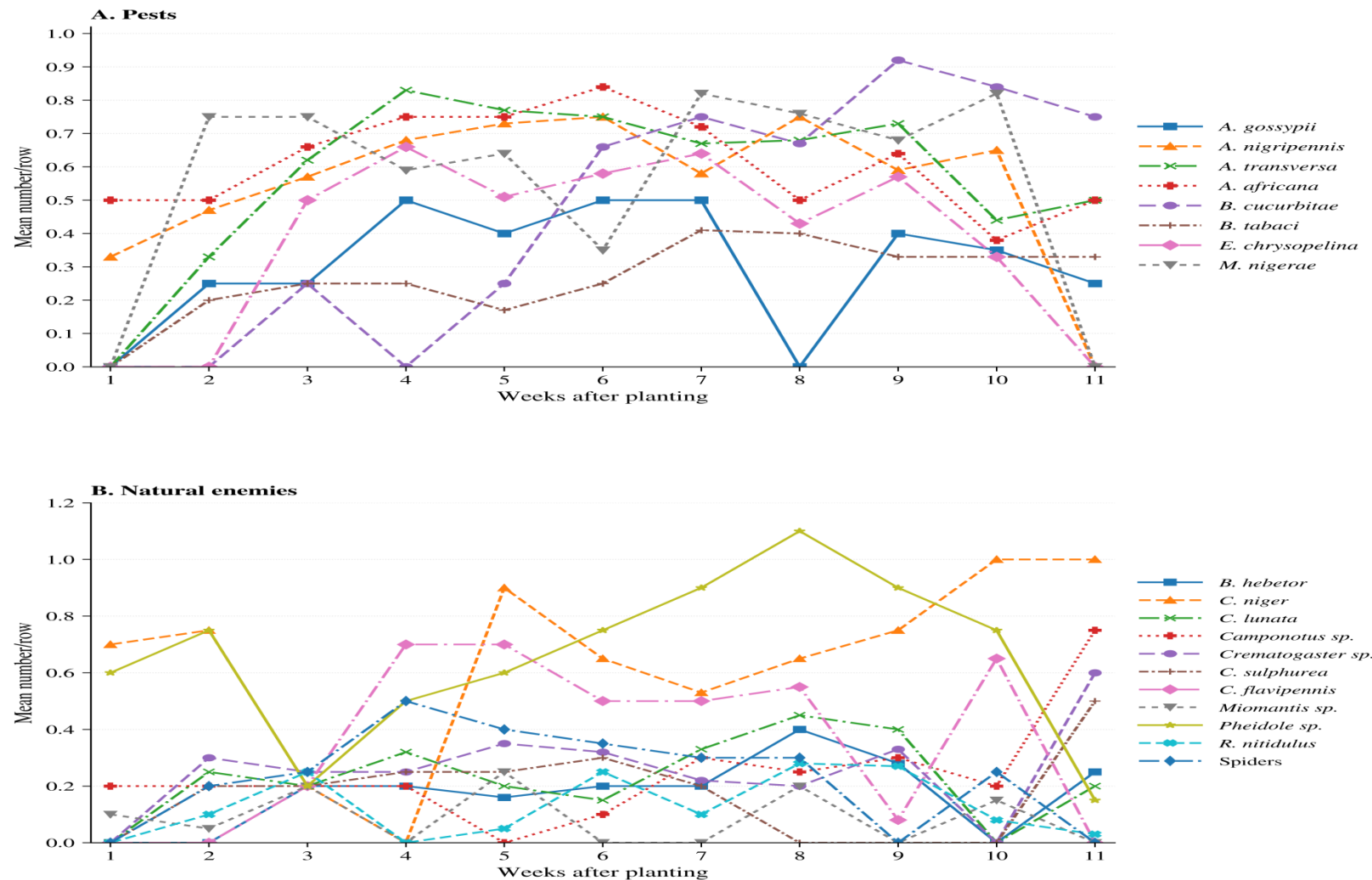


Figure 4. Weekly fluctuations in density of dominant arthropod species collected from golden melon at Wukari in 2025 cropping season. **A.** Pest **B.** Natural Enemy.

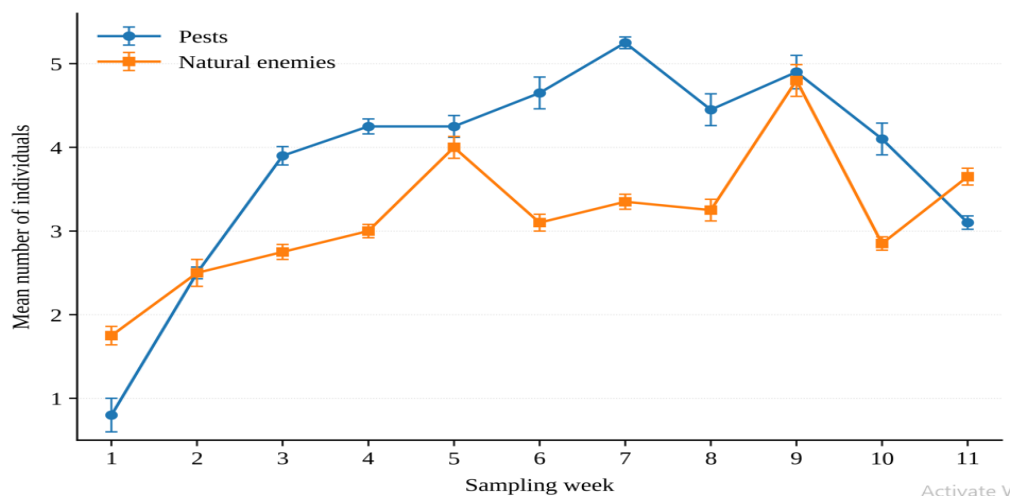


Figure 5. Pooled mean weekly fluctuations in density of dominant pest and natural enemy species on golden melon at Wukari in 2025 cropping season (**Pooled Ratio of Natural enemy to Pest Abundance = 0.78:1**).

3.3 Spatial distribution of dominant arthropods associated with golden melon at Wukari

Table 5 shows an inconsistent pattern of fluctuation of population density and dispersion across the growth stages of the crop in the study area. The population densities of some dominant pest (*A. gossypii*, *A. nigripennis*, *A. africanus*, *B. tabaci*, *E. chrysomelina*) and beneficial (*A. mellifera*, *C. sulphurea*, *C. flavipennis* and *Crematogaster* sp.) species progressively increased across the growth stages with a decline at the fruiting stage. This trend, however, was not observed in these pest – *A. transversa*, *B. cucurbitae*, *M. nigeriae*), and beneficial (*B. hebetor*, *Camponotus* sp., *C. niger*, *C. lunata*, *Miomantis* sp., *Pheidole* sp., *R. nitidulus* and spiders in which cases population densities did not follow a defined order across the crop growth stages.

The variance to mean ratio (S^2/m) which gave us a tentative opinion of the spatial distribution of the dominant arthropods indicates aggregated dispersion (>1) at the seedling stage for all the dominant arthropods except for *B. cucurbitae* and *Crematogaster* sp. which were absent at that crop growth stage. The arthropods, however, largely assumed a regular/uniform distribution (<1) during the vegetative stage except for *A. gossypii*, *B. cucurbitae*, *E. chrysomelina*, *A. mellifera*, *Camponotus* sp., *C. lunata*, *Crematogaster* sp. and *R. nitidulus* which maintained aggregated dispersion (Table 5). Of interest is that while *A. transversa*, *A. africanus*, *B. tabaci*, *B. hebetor* and *Pheidole* sp. Maintained the same dispersion pattern (regular) during the vegetative, flowering and fruiting stage; *R. nitidulus* correspondingly maintained aggregated distribution (Table 5).

Regression analyses (Taylor's power law and Iwao's patchiness models) were used to buttress the dispersion patterns of the dominant arthropods. Taylor's power law showed aggregation ($b > 1$) of all the dominant arthropods (pest and beneficial) except for *A. gossypii*, *B. cucurbitae*, *A. mellifera*, *B. hebetor*, *C. lunata*, *C. flavipennis*, *Miomantis* sp. and *R. nitidulus* which showed uniform dispersion ($b < 1$). All arthropods with a uniform pattern in Taylor's model showed the same in Iwao ($\beta < 1$). Conflicting outcomes were however seen as all arthropods that were aggregated ($b > 1$) by Taylor's model appeared uniform ($\beta < 1$) in Iwao's model. However, because the R^2 values of Taylor's model were higher in *A. nigripennis*, *A. transversa*, *B. tabaci*, *M. nigeriae*, *Camponotus* sp. and *Crematogaster* sp., they were classified as aggregated. Of interest however, is that, the Iwao's intercept (α) values were > 0 in all the dominant arthropods except in *A. africanus* and *Pheidole* sp. which indicated that the populations largely had a group of individuals as their basic unit which inferred a positive association between individuals and a tendency to crowding/aggregation (Table 6).

Table 5. Population density ($m \pm SE$)/4m-row and variance to mean ratio (S^2/m) of dominant arthropods collected on golden melon at Wukari in 2025 cropping season.

Species	Seedling Stage		Vegetative Stage		Flowering Stage		Fruiting Stage	
	$m \pm SE$	S^2/m	$m \pm SE$	S^2/m	$m \pm SE$	S^2/m	$m \pm SE$	S^2/m
Pest								
<i>Aphis gossypii</i> Glover	0.08±0.08	3.000	0.31±0.16	2.820	0.50±0.05	0.170	0.32±0.13	1.760
<i>Asbecesta nigripennis</i> Lab.	0.47±0.07	2.650	0.67±0.05	0.130	0.69±0.06	0.160	0.52±0.13	2.050
<i>Asbecesta transversa</i> Allard	0.33±0.19	6.930	0.75±0.05	0.110	0.72±0.03	0.040	0.60±0.06	0.380
<i>Aulacophora africana</i> Weise	0.56±0.06	2.000	0.72±0.03	0.040	0.78±0.03	0.040	0.55±0.07	0.580
<i>Bactrocera cucurbitae</i> Coq.	0.00±0.00	0.000	0.0±0.08	3.000	0.78±0.16	1.55	0.78±0.04	0.140
<i>Bemisia tabaci</i> Genn.	0.17±0.10	3.460	0.25±0.05	0.330	0.28±0.07	0.700	0.37±0.02	0.070
<i>Epilachna chrysomelina</i> F.	0.17±0.17	12.00	0.56±0.06	1.333	0.58±0.05	0.140	0.04±0.12	2.020
<i>Monolepta nigeriae</i> Bryant	0.50±0.25	9.000	0.67±0.05	0.130	0.61±0.15	1.270	0.77±0.03	0.080
Beneficial								
<i>Apis mellifera</i> L.	0.11±0.11	4.000	0.64±0.17	1.610	0.78±0.10	0.460	0.28±0.13	3.620
<i>Bracon hebetor</i> Say	0.11±0.11	4.000	0.25±0.05	0.330	0.19±0.03	0.140	0.27±0.04	0.370
<i>Camponotus</i> spp.	0.81±0.10	3.600	0.64±0.32	5.780	0.72±0.10	0.500	0.70±0.09	0.630
<i>Cardiochiles niger</i> W&H	0.11±0.11	4.000	0.31±0.03	0.090	0.19±0.10	1.860	0.27±0.09	1.630
<i>Cheilomenes lunata</i> Fab.	0.22±0.03	1.000	0.08±0.08	3.000	0.08±0.08	3.000	0.28±0.02	0.090
<i>Cheilomenes sulphurea</i> Oliv.	0.19±0.10	3.600	0.28±0.28	0.100	0.31±0.07	0.640	0.22±0.06	1.080
<i>Chelisoches flavipennis</i> Fab.	0.08±0.04	1.730	0.19±0.06	0.570	0.28±0.03	0.100	0.10±0.06	2.250
<i>Crematogaster</i> sp.	0.00±0.00	0.000	0.47±0.24	4.290	0.58±0.10	0.570	0.45±0.12	1.910
<i>Miomantis</i> sp.	0.14±0.07	2.650	0.28±0.03	0.100	0.11±0.11	4.010	0.08±0.05	2.000
<i>Pheidole</i> sp.	0.67±0.04	1.000	0.58±0.05	0.140	0.67±0.05	0.130	0.88±0.06	0.260
<i>Rhynocoris nitidulus</i> Fab.	0.14±0.07	2.650	0.08±0.08	3.000	0.11±0.06	1.000	0.17±0.06	1.250
Spiders	0.19±0.10	3.600	0.42±0.05	0.200	0.39±0.03	0.070	0.25±0.07	1.170

Table 6. Comparison of dispersion of dominant arthropods collected on golden melon at Wukari in 2025 cropping season using Taylor's power law ($\log S^2 = \log a + b \log m$) and Iwao's regression ($m^* = \alpha + \beta m$) models.

Species	Taylor's Power Law				Iwao's Patchiness Regression			
	A	b'	SE_b	R^2	α	β'	SE_β	R^2
Pest								
<i>Aphis gossypii</i> Glover	-0.185	0.668	0.932	0.019 ^{NS}	2.948	0.444	0.217	0.677 ^{NS}
<i>Asbecesta nigripennis</i> Lab.	-3.870	3.659	3.261	0.413 ^{NS}	5.221	0.274	0.986	0.037 ^{NS}
<i>Asbecesta transversa</i> Allard	-4.065	3.696	1.160	0.860*	26.786	-2.290	0.828	0.793 ^{NS}
<i>Aulacophora africana</i> Weise	-6.158	5.405	1.754	0.860 ^{NS}	-0.306	0.923	0.062	0.992 ^{NS}
<i>Bactrocera cucurbitae</i> Coq.	-0.027	0.551	0.864	0.001 ^{NS}	2.428	0.672	0.064	0.991*
<i>Bemisia tabaci</i> Genn.	-2.984	1.562	1.231	0.746 ^{NS}	2.203	0.237	0.290	0.251 ^{NS}
<i>Epilachna chrysomelina</i> F.	-1.849	1.774	0.891	0.683 ^{NS}	48.835	-6.191	1.728	0.865 ^{NS}
<i>Monolepta nigeriae</i> Bryant	-9.251	8.680	2.354	0.885*	52.325	-5.270	2.779	0.643 ^{NS}
Beneficial								
<i>Apis mellifera</i> L.	0.063	0.847	0.435	0.010 ^{NS}	3.853	0.553	0.052	0.983**
<i>Bracon hebetor</i> Say	-1.843	0.761	1.541	0.417 ^{NS}	4.973	-0.930	0.765	0.425 ^{NS}
<i>Camponotus</i> spp.	-9.585	9.856	4.927	0.654 ^{NS}	137.369	-14.089	9.297	0.534 ^{NS}
<i>Cardiochiles niger</i> W&H	-1.818	1.110	1.683	0.368 ^{NS}	21.467	-5.427	1.890	0.805 ^{NS}
<i>Cheilomenes lunata</i> Fab.	-2.003	0.468	0.172	0.985**	11.879	-3.151	0.743	0.900*
<i>Cheilomenes sulphurea</i> Oliv.	-3.074	1.680	3.125	0.326 ^{NS}	6.448	-1.075	0.953	0.389 ^{NS}
<i>Chelisoches flavipennis</i> Fab.	-1.051	0.274	0.801	0.463 ^{NS}	3.232	-0.339	1.205	0.038 ^{NS}
<i>Crematogaster</i> sp.	-5.117	4.976	4.086	0.611 ^{NS}	10.071	-0.463	1.643	0.074 ^{NS}
<i>Miomantis</i> sp.	-1.858	0.633	0.928	0.667 ^{NS}	3.019	-0.169	0.744	0.025 ^{NS}
<i>Pheidole</i> sp.	2.749	-2.415	0.751	0.870 ^{NS}	-1.167	1.039	0.013	1.000 ^{NS}
<i>Rhynocoris nitidulus</i> Fab.	-0.084	0.356	0.824	0.005 ^{NS}	2.835	-0.448	1.076	0.080 ^{NS}
Spiders	-2.867	1.762	1.122	0.765 ^{NS}	2.230	0.358	0.096	0.874*

NS = Non-significant, * = significant at 5% level, ** = significant at 1% level. Hypothesis $H_0: b = 1$ (random distribution), $H_1: b \neq 1$

4. Discussion

The arthropods assemblage was highly diverse revealing that Golden melon agro-ecosystems in the study area support a complex arthropod community. This level of diversity agrees with earlier studies on cucurbits in the tropical agro-ecosystem where crop structural complexity and continuous availability of plant resources promote arthropod colonization (Alao et al., 2017; Okrikata et al., 2019). Among herbivorous taxa, Chrysomelid leaf-feeding beetles dominated both in RA and FO, particularly *A. africana*, *A. transversa*, *A. nigripennis* and *M. nigeriae* posing a sustained threat throughout the cropping season. Their high RA (6.31 – 7.08%) and very high FO (> 90%) reflect strong host adaptation and continuous availability of suitable feeding site on the crop's foliage. Similar dominance of chrysomelid beetles on cucurbits has been reported across sub-Saharan Africa where leaf beetles are consistently identified as key defoliators of cucurbit crops (Ofuya et al., 2023). This observation also agrees with the findings of Haber et al. (2021) who reported Chrysomelid beetles as the most destructive insect pests of cucurbits. The relative abundance (RA) indicates the numerical dominance of each species within the total arthropod community while the frequency of occurrence (FO) reflects the temporal consistency of the species across the sampling periods.

The relatively moderate abundance of *A. gossypii* and *B. tabaci* in this study is at variance with the report of Aleem et al. (2025) which showed that aphids are the most dominant cucurbit pest. This discrepancy may be attributed to seasonal variation, planting date, or differences in rainfall regime, which strongly influence aphid population dynamics. Their persistence across sampling periods is typical of phloem feeders with rapid reproductive cycles and strong dispersal ability, particularly under warm tropical conditions (Li et al., 2023; Liu et al., 2021). Their presence is specifically significant because of their role as sap-suckers and vectors of plant pathogens. Tephritidae were represented mainly by *B. cucurbitae* (4.95% RA; 72.73% FO) which was more abundant and widespread than *B. invadens* (0.43% RA; 45.45% FO). This identifies *B. cucurbitae* as the primary fruit fly pest of golden melon in the study area with direct implications for fruit damage and yield loss as widely documented in recent cucurbit IPM studies (Opoku et al., 2025).

Ant (*Camponotus* sp., *Crematogaster* sp. and *Pheidole* sp.) dominance in tropical agro-ecosystem is increasingly recognized as an indicator of tropical complexity and ecological stability (Diamé et al., 2018). They likely exploited food resources like honeydew from sap-sucking insects. Their dominance implied indirect effects on pest population dynamics through predation. Spiders were among the dominant arthropods retrieved and recent studies confirm spiders as key stabilizers of pest populations in low-input vegetable systems (Rao & Kanaujia, 2023). The arthropods were functionally diverse comprising herbivores, predators, parasitoids and pollinators indicating a well-structured food web. Herbivores constituted the most species rich guild attacking leaves, vines, flowers and fruits with foliar feeders being dominant. This pattern aligns with cucurbit crop phenology and the expansive leaf area which supports early and mid-season herbivores (Theis et al., 2014).

The dominance of *A. mellifera* (4.27% RA; 63.64% FO) starting from the vegetative stage highlights the availability of pollinators within the golden melon field. This is ecologically important as cucurbits are pollinator dependent crops and the presence of honey bees likely contributes directly to the fruit set and quality. However, the abundance of *P. triangulum* (a key parasitoid of bees) highlights the need to devise a management strategy as highlighted by Sarwar (2016) and Okrikata et al. (2019) as it has been shown to have the capacity to reduce local bee population. Several taxa including *Pseudolynchia canariensis*, *Lycus corniger* and some orthopterans recorded low RA and FO, and were categorized as rare/occasional species, and as such are transient or opportunistic visitors, with minimal direct impact on golden melon production. Recent literature emphasizes that maintaining such functional diversity enhances yield stability and ecosystem resilience (Steffan-Dewenter et al., 2024).

RiddimilGold® is a systemic fungicide formulation for the management of fungal and oomycete diseases. While it is not targeted at arthropod pests, its applications in this study can influence arthropod communities through both direct and indirect pathways; some of which are potentially complex. Unlike insecticides; fungicides are generally expected to have less direct toxicity to insects and spiders. However, fungicide exposure may affect non-target arthropods directly in some circumstances such as alteration of microbial communities, reduction of entomopathogenic fungi, modification of plant–microbe interactions, or changes in the availability and quality of prey and other food resources. In particular, suppression of naturally occurring entomopathogenic fungi may

reduce an important source of biological regulation of herbivorous arthropods and thereby potentially favour some pest populations (Klotioloma et al., 2022).

The presence of parasitoids within Braconidae notably *B. hebetor* and *C. niger* with dominant status confirms the existence of a functional parasitoid guild capable of regulating lepidopteran and other insect pests. Generally, the natural enemies showed density increases that lagged behind pest densities, indicating a numerical response. The pest populations were followed by substantial increases in natural enemy populations with a natural enemy to pest population ratio of 0.78:1 suggests that the pest populations are partially regulated by biological control agents. This agrees with classical predator–prey theory (Solomon, 1949) and field observations by Hawkins et al. (1993) and supports the adoption of IPM rather than indiscriminate chemical.

The arthropod population density largely increased progressively from the seedling to the vegetative and flowering stages with population decline in the later part of the fruiting stage coinciding with increased vegetative biomass and reproductive structures. This trend is in agreement with Okrikata et al. (2019) who reported that pest abundance peaks during flowering and fruiting due to increased food availability. Variance to mean ratios indicated predominantly aggregated distributions especially during early growth stages. Aggregated distributions are characteristic of phytophagous insects due to localized oviposition and clumped host resources (Southwood & Henderson, 2000). The shift towards near random distributions during later stages suggests dispersal as population pressure increases, consistent with findings by Taylor (1984).

Overall, Taylor's power law and Iwao's regression apparently revealed predominantly aggregated spatial patterns for pests and beneficial arthropods. Previous studies have shown that, where conflicting results are observed between the regression models, the interpretation should lean more on the model with the highest R^2 value (Mollet et al., 1984; Moradi-Vajargah et al., 2011; Taylor, 1984). Aggregation is ecologically advantageous allowing insects to exploit patchy resources efficiently (Iwao, 1968; Taylor, 1961). Significant departures from randomness observed in *A. africana* and *E. chrysomelina* align with observations by Fenemore and Prakash (1992,) on beetle spatial behavior. The agreement between Taylor's and Iwao's models for some species strengthens confidence in the dispersion interpretations. However, the lack of significance for certain taxa contrasts with findings by Okrikata et al. (2019), possibly due to differences in sampling intensity and spatial scale.

Coleoptera and Hymenoptera exhibited the highest diversity and richness reflecting their ecological versatility. Similar dominance of these orders in vegetable systems has been reported by Perfecto et al. (2009). Moderate to high evenness values indicate limited dominance by single species suggesting community stability as described by Cuza et al. (2026). The Shannon–Wiener index ($H = 3.361$) indicates high arthropod diversity comparable to values reported for stable tropical agro-ecosystems (Magurran, 2004). The evenness value ($E = 0.600$) reflects moderately equitable species distribution, agreeing with Rajabpour and Yarahmadi (2024) who suggested that such values indicate resilience against pest outbreaks. However, this value is lower than those reported by Okrikata et al. (2019) in unmanaged vegetable fields a difference that may be attributed to sampling technique and intensity.

5. Limitations

The arthropod observational survey on Golden melon was conducted for one season and at one location. This limits the generalizability of our results across years, climatic conditions, and agro-ecological contexts. This is because inter-annual variability in weather, pest pressure, and community composition may not be captured by a one season survey. Crop damage or yields were not measured in this particular study as it wasn't a focus as such conclusions about the functional or economic consequences of the observed arthropod community for crop production cannot be drawn. Since predation and parasitism were not quantified; inferences about trophic interactions are limited. Sampling was conducted between 1600 and 1800h and between 0700 and 0900hr at the flowering stage. This may introduce sampling-time bias, as arthropod activity and detectability can vary with time of day. While the effectiveness of vacuum sampling may vary with arthropod size, mobility, position within the canopy, and attachment to plant surfaces; small, weakly mobile arthropods may be efficiently collected. Also, while vacuum sampling can cause physical damage to specimens, potentially complicating morphological identification, particularly for delicate insects and spiders; it still provides an efficient and relatively standardized method for collecting arthropods from crop canopies. Finally, while the use of a systemic fungicide

(RiddomilGold®) as part of the field management regime may not have a direct effect on the arthropods, indirect effects cannot be completely excluded. Future studies should therefore, incorporate multi-season, multi-site designs, multi-sampling techniques, direct measures of crop damage and yield, functional assays of predation and parasitism to help address these limitations.

6. Conclusions

This study demonstrates that golden melon in the study area supports a highly diverse, functionally rich arthropod community dominated by coleopteran herbivores and hymenopteran natural enemies. The pest population was strongly influenced by crop phenology with peaks largely during the vegetative and/or flowering stages. The dominant natural enemies exhibited close temporal and spatial coupling with their prey as spatial analyses revealed predominantly aggregated distributions reflecting resource heterogeneity and trophic interactions. Diversity indices confirmed a stable and resilient ecosystem characterized by high species richness and moderately high evenness. The pest-natural enemy balance observed throughout the season indicates substantial potential for conservation, biological control, and reducing reliance on chemical pesticides. These findings provide rich ecological evidence to support IPM strategies that prioritize habitat conservation and natural enemy enhancement in the golden melon production system in the study area.

Acknowledgements

The study is funded by the Nigerian Government's Tertiary Education Trust Fund (TETFund) under its Institutional Based Research (IBR) programme. The authors gratefully acknowledge the management of Federal University Wukari (FUW), Nigeria for recommending the proposal for TETFund's approval with an award letter: FUW/REG/T.5/Vol.5/T019 on 26th June, 2025. Many thanks to Mr. Ahmed Mohammed of the Research Farm of FUW for his support during the field work. Sincere thanks to Dr. Ogunmola Adeniyi of the Statistics Department of FUW for his assistance in statistical analyses.

Conflict of Interest

The authors declare no conflict of interest.

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Publication Ethic

The manuscript has not been submitted nor under consideration in any print or online journal or source.

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