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Insect fauna associated with *Cucumis sativus* (Cucurbitales: Cucurbitaceae) in Parakou, A cotton-growing area of central Benin

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ABSTRACT

Cucumber (*Cucumis sativus* L.) is an important vegetable crop in Benin. However, several biotic factors, particularly insects, impede its production. This study aimed to evaluate the entomofaunistic diversity associated with cucumber crops. Insects were collected using moericke and pitfall traps along with a sweep net. Samplings were performed from May to July 2025 in three vegetable gardens. In total, 9 orders, 53 families, and 94 species were recorded. Among them, the cucumber thrips *Thrips tabaci* (6.6%), the leaf miners *Liriomyza trifolii* (2%), the pumpkin beetles *Aulacophora Africana* (1.9%) and *Aulacophora* sp. (1.3%), the leafhopper *Empoasca* sp. (1.7%), the southern green stink bug *Nezara viridula* (1.2%), the corn flea beetle *Chaetocnema pulicaria* (1.1%), the Pumpkin leaf caterpillar *Diphania indica* (1%), the cucumber fly *Dacus ciliatus* (0.9%), the melon fruit flies *Bactrocera cucurbitae* (0.6%), *Bactrocera* sp. (0.9%) and *Bactrocera dorsalis* (0.3%), the grasshopper *Zonocerus variegatus* (0.8%), the ground hopper *Tetrix* sp. (0.6%), the field cricket *Gryllus* sp. (0.3%), the Hadda beetle *Henosepilachn*a sp. (0.3%), the rice stinkbug *Cletus* sp. (0.3%), the lagriid beetle *Lagria villosa* (0.2%) and *Lagria* sp. (0.2%), the cotton stainer *Dysdercus wolkerii* (0.1%) appeared as the most important insect pest species attacking cucumber as reported by previous studies. These pests encountered beneficial insects including natural enemies (predator and parasitoid) and pollinators. However, pest species were more abundant than beneficial insects, regardless of the cucumber's developmental stages. The findings of this study represent an essential reference point for the design and implementation of agroecological strategies for cucumber protection in Benin.

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INTRODUCTION

Cucumber (*Cucumis sativus*) is one of the most important creeping vine plants belonging to the Cucurbitaceae family (Agashi *et al.*, 2020). It comes from Africa and Southwestern Asia where where it has been consumed for over 3,000 years (Gelaye, 2023). It is the third largest vegetable in the world and is grown in more than 80 countries (Rashidi *et al.*, 2024). It is ranked as the fourth-most cultivated vegetable crop, behind tomatoes, cabbage, and onions (Amosun *et al.*, 2025). In 2023, it is expected to be produced in 98 million tons, including gherkins (FAO, 2024). In Benin, this exotic vegetable is one of the main vegetable crops most in demand by the populations for its organoleptic and nutritional quality. Its fruit is a potential agent in cosmetic products (Yêmadjè, 2022). Rich in minerals (potassium, magnesium, calcium, and iron), vitamins (A, C and B6), beneficial nutrients (lycopene and antioxidants) and fiber, cucumber offers several health benefits, particularly in regulating blood pressure, hydration, digestion, and the prevention of certain chronic diseases (Mallick, 2022; dos Santos *et al.*, 2022). An average of 15 kcal of energy, 3.6 g of carbohydrates, 2 to 21% of vitamins, and 2 to 4% of minerals can be provided by a 100 g portion cucumber (Gelaye, 2023).

In West Africa, the low productivity of cucumbers is attributed to several biotic constraints (Zohoungbogbo *et al.*, 2022), such as insect pests that quickly degrade the production and cause significant losses. Damage caused by insect pests can reach 63.65% to 72.08%, especially during the fruiting stage of cucumbers (Assi *et al.*, 2018). In the absence of a control method, yields can drop to 0.71 t/ha (N'Goran *et al.*, 2019). To limit losses associated with insect pests, Beninese cucumber producers use various synthetic pesticides purchased in the bootleg market, and they usually do not follow the recommended doses and application frequencies (Zohoungbogbo *et al.*, 2022). Such use leads most of the time to several negative consequences for growers, consumers, and the environment (Adjogboto *et al.*, 2023). To reduce pesticide abuse, it is essential to develop environmentally friendly pest control methods for cucumber cultivation (Kumar *et al.*, 2024). In an effective program for controlling insect pests, the preliminary step to be addressed is a good understanding of the entomofauna associated with the targeted crop (Chougourou *et al.*, 2012). Indeed, a thorough understanding of the insect fauna associated with cucumber cultivation is crucial (Fondio, 2022). However, in Benin, hardly any studies have focused on the entomofauna associated with the cucumber crop. Current research is restricted to the cataloging of select pests, notably fruit flies (Gnanvossou *et al.*, 2008), or to the assessment of the impact of various treatments on specific pests (Hambada *et al.*, 2021). The current study aimed at filling this gap by conducting an inventory of insect species associated with cucumber crops in Benin to provide useful information for the establishment of an integrated pest management program.

MATERIALS AND METHODS

Study area and experimental sites

The study was conducted in the district of Parakou, located in northern Benin, between 9°13' and 9°27' north latitude and 2°25' and 2°46' east longitude, in the fifth Agroecological Zone (AEZ), named the Central Cotton Zone, which is one of the eight AEZs in Benin (Aholoukpè *et al.*, 2020) (Fig. 1). Parakou's climate is Sudanian (humid tropical), characterized by the alternation of a single rainy season from May to October with an annual rainfall ranging from 800 to 1200 mm (Zohoun *et al.*, 2021). The soil is of the ferruginous tropical type in the French soil classification system, corresponding to Acrisols or Lixisols according to the world. The vegetation is dominated by savannah with all its variants: wooded savannah, tree savannah, and shrubby savannah. Vegetation in the concessions of the urban area has a high species richness with a high dominance of the *Mangifera indica* species (Zohoun *et al.*, 2021).

The study period extended from May to July 2025. According to data from the National Agency of Meteorology in Benin, monthly rainfalls were 65.1 mm in May, 136.1 mm in June, and 371 mm in July.

Monthly temperatures ranged from 23.3°C to 33.9°C in May, 22.5°C to 31.3°C in June, and 21.7°C to 28.3°C in July. Surveys were carried out in three different vegetable gardens located in the city neighborhoods of the district. It is about the vegetable gardens of Swinrou (9°23'38"N; 2°37'13"W), Banikanni (9°19'48"N; 2°38'56"W), and Titirou (9°19'18"N; 2°37'59"W) (Fig. 1). Cucumber cultivation has been practiced in these gardens every year for more than five years. Vegetable producers were facing many difficulties in pest control.

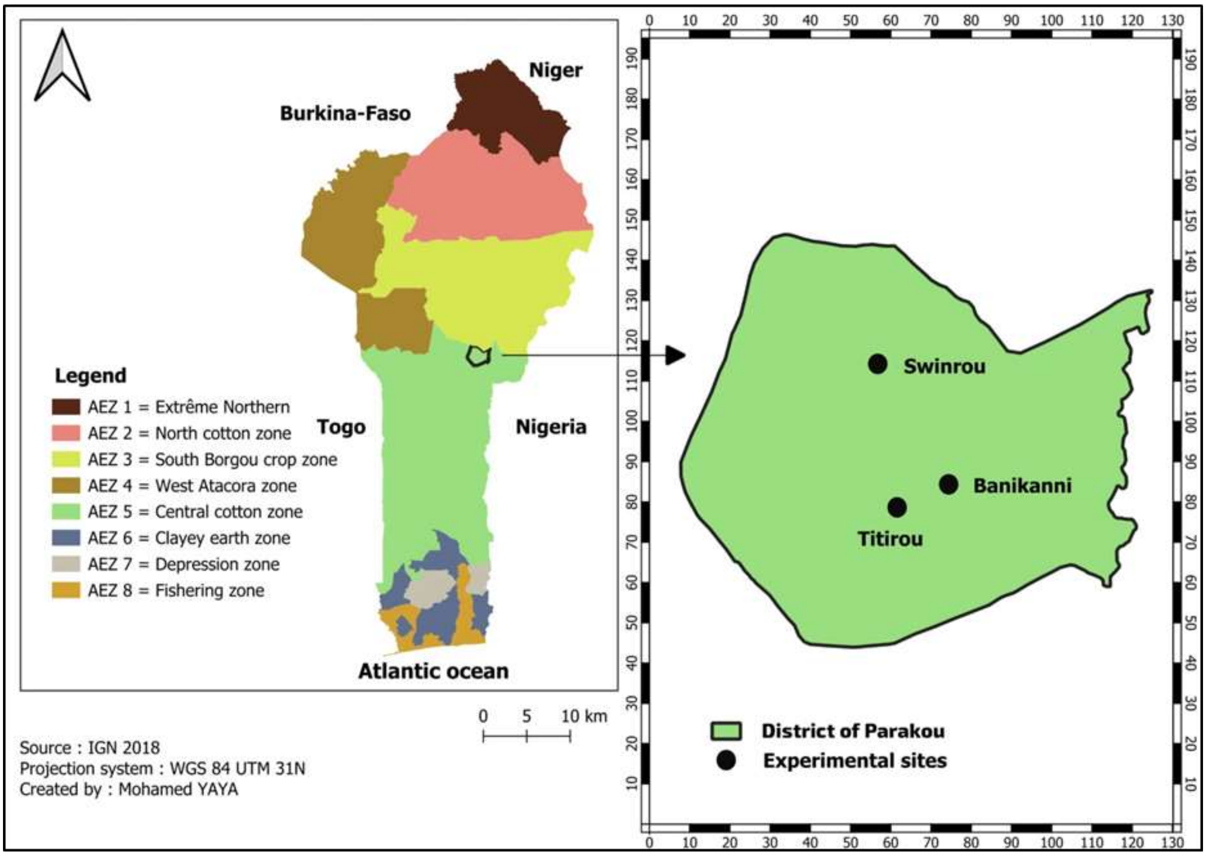

Fig. 1. Map showing study area and experimental sites

Cucumber crop installation

In each vegetable garden, land was cleared manually, and the trash was removed. The plot was divided into 6 beds of 5 m² (2 m x 2.5 m) each. The beds were spaced at 1-meter intervals. Farmers in the study area commonly use the cucumber variety Calypso 41 F1. On May 8, 2025, two seeds were sown per hole. Each bed consisted of 40 plants distributed on 4 rows with a row-to-row spacing of 0.5 m, and the within-row plant spacing was 0.6 cm. The first fertilizer application consisted of NPK (15-15-15) and was applied 3 weeks after sowing at a rate of 7.5 g/hole. It was followed by a second application combining NPK (15-15-15) and urea (46% N) at a rate of 2.1 g/hole and 10.5 g/hole, respectively. The same combination and rate used in the second fertilizer application were also applied for the third fertilizer application, which occurred 7 weeks after sowing. Regular weeding was done to prevent weed invasions. No phytosanitary treatment was applied during the study.

Sampling of insects

Insects were collected via three methods: pitfall traps, moericke traps, and sweep netting (Ndiaye *et al.*, 2023; Zadji *et al.*, 2025). Pitfall traps consisted of plastic containers (H = 8 cm and Ø = 14 cm) buried in the soil so that the edges of the containers were level with the soil surface. Moericke traps were composed of yellow plastic containers (H = 8 cm and Ø = 14 cm) installed on stakes of plant canopy height. In all cases, the plastic containers were filled at 3/5 of their volume with soapy water (10%) to prevent insects from scraping (Mignon *et al.*, 2003). Two traps (one pitfall trap and one Moericke trap), one meter apart, were exposed in each vegetable bed. The traps were set up in the middle of the bed between the central rows on the 14^{th} day after sowing (DAS). The trapped insects were harvested every 3 days, and the soapy water was replaced. For the sweep netting, two sweeps were performed per vegetable bed immediately after trapped insect harvesting.

Identification of insects

After each collection, the samples of insects (captured or trapped) were conserved into transparent plastic sample bottles containing alcohol at 70%. Butterflies and moths were preserved in a handmade triangular envelope to prevent washing off of the scales on contact with alcohol. The samples were taken to the laboratory for identification and counting. The identification was carried out under a binocular microscope using type specimens and based on morphological characteristics described in various entomological classification keys (Delvare and Aberlenc, 1989; Appert and Deuse, 1998; Bordat and Arvanitakis, 2004; Poutouli *et al.*, 2011; Zettler *et al.*, 2016). The identified insects were grouped into functional groups: pests, predators, parasitoids, pollinators, and others.

Data analysis

Data on the number of sightings of all vegetable gardens were pooled per developmental stage, viz., Stage I = sowing to beginning of flowering, Stage II = beginning of flowering to beginning of harvesting, and Stage III = beginning of harvesting to end of harvesting. Relative abundance (Zaime and Gautier, 1989) of each taxon (species, family, and order) was calculated. Data were analyzed by evaluating species richness and diversity. Species richness and diversity were calculated using Margelef's index (Margalef, 1958), the Shannon-Wiener index (Shannon, 1948), and Pielou's evenness (Pielou, 1966). Their formulas are as follows:

Relative abundance (Ra): It refers to the proportion of individuals of a given species relative to the total number of individuals surveyed.

$$\mathrm{Ra}(\%) = \frac{\mathrm{Ni}}{\mathrm{N}} \times 100$$

with Ni = number of individuals for species i, N = total number of individuals surveyed

Margalef richness index (Hm): it is used as a simple measure to quantify species richness within a community.

$$\mathrm{Hm} = \frac{(S-1)}{\ln(N)}$$

with: S = total number of species, N = total number of individuals.

$0 < Hm < 2.0$ = Low species richness

$2.0 < Hm < 3.0$ = Moderate species richness

$3.0 < Hm < 5$ = High species richness

$Hm > 5.0$: Exceptionally high species richness

Shannon-Weaver diversity index (Hs): It measures the diversity of species in a community. The higher the value of Hs, the higher the diversity of species in the community. A value of Hs ranges from 0 to 5. Hs= 0 indicates a community that only has one species.

$$\mathrm{Hs} = -\sum_{i=1}^{s} \frac{\mathrm{Ni}}{\mathrm{N}} * \ln\left(\frac{\mathrm{Ni}}{\mathrm{N}}\right)$$

with Ni = number of individuals for species i and N = Total number of individuals surveyed

Pielou's evenness index (E): It describes the equitability of species abundances within a community.

$$E = \frac{\mathrm{Hs}'}{\ln(S)}$$

with Hs = Shannon – Wiener diversity index and S = total number of species

RESULTS

Taxonomic composition and diversity of entomofauna

A total of 5217 individual insects divided into 9 orders, 53 families, and 94 species of the class Insecta were recorded from the cucumber crop in Parakou, located in the cotton-growing zone of central Benin (Table 1).

Table 1. Distribution and relative abundance of insect species and families

Orders	Families/Genus/Species	Stage I		Stage II		Stage III		Total	
		No Ind	Ra (%)	No Ind	Ra (%)	No Ind	Ra (%)	No Ind	Ra (%)
Dermaptera	Forficulidae	0	0.0	0	0.0	5	0.1	5	0.1
	Forficula sp.	0	0.0	0	0.0	5	0.1	5	0.1
Thysanoptera	Thripidae	0	0.0	0	0.0	630	16.8	630	12.1
	Thrips tabaci	0	0.0	0	0.0	345	9.2	345	6.6
	Frankliniella occidentalis	0	0.0	0	0.0	285	7.6	285	5.5
Hemiptera	Pentatomidae	0	0.0	25	2.5	50	1.3	75	1.4
	Nezara viridula	0	0.0	20	2.0	40	1.1	60	1.2
	Aspavia armigera	0	0.0	5	0.5	10	0.3	15	0.3
	Reduviidae	0	0.0	5	0.5	5	0.1	10	0.2
	Rhynocoris sp.	0	0.0	0	0.0	5	0.1	5	0.1
	Zelus sp.	0	0.0	5	0.5	0	0.0	5	0.1
	Cicadellidae	35	7.9	20	2.0	35	0.9	90	1.7
	Empoasca sp.	35	7.9	20	2.0	35	0.9	90	1.7
	Coreidae	0	0.0	0	0.0	15	0.4	15	0.3
	Cletus sp.	0	0.0	0	0.0	15	0.4	15	0.3
	Lygaeidae	0	0.0	5	0.5	0	0.0	5	0.1
	Dysdercus voelkeri	0	0.0	5	0.5	0	0.0	5	0.1
	Geocoridae	0	0.0	0	0.0	35	0.9	35	0.7
	Geocoris sp.	0	0.0	0	0.0	35	0.9	35	0.7
	Membracidae	0	0.0	5	0.5	0	0.0	5	0.1
	Oxyrhachis sp.	0	0.0	5	0.5	0	0.0	5	0.1
	Aphrophoridae	5	1.1	0	0.0	15	0.4	20	0.4
	Aphrophora sp.	5	1.1	0	0.0	15	0.4	20	0.4
	Miridae	0	0.0	25	2.5	25	0.7	50	1.0
	Creontiades sp.	0	0.0	5	0.5	15	0.4	20	0.4
	Creontiades pallidus	0	0.0	5	0.5	0	0.0	5	0.1
	Helopeltis schoutedeni	0	0.0	15	1.5	5	0.1	20	0.4
	Nesidiocoris sp.	0	0.0	0	0.0	5	0.1	5	0.1
Hymenoptera	Apidae	5	1.1	90	8.9	230	6.1	325	6.2
	Apis mellifera	5	1.1	90	8.9	205	5.5	300	5.8
	Xylocopa sp.	0	0.0	0	0.0	25	0.7	25	0.5
	Eulophidae	0	0.0	15	1.5	5	0.1	20	0.4
	Aprostocetus sp.	0	0.0	5	0.5	5	0.1	10	0.2
	Diglyphus isaea	0	0.0	10	1.0	0	0.0	10	0.2
	Halictidae	15	3.4	5	0.5	70	1.9	90	1.7
	Halictus sp.	0	0.0	0	0.0	25	0.7	25	0.5
	Lasioglossum sp.	15	3.4	5	0.5	45	1.2	65	1.2
	Pompilidae	5	1.1	0	0.0	0	0.0	5	0.1
	Anoplius sp.	5	1.1	0	0.0	0	0.0	5	0.1
	Ichneuminidae	15	3.4	0	0.0	0	0.0	15	0.3
	Campoletis sp.	15	3.4	0	0.0	0	0.0	15	0.3
	Vespidae	60	13.5	60	5.9	100	2.7	220	4.2
	Vespula sp.	0	0.0	15	1.5	10	0.3	25	0.5
	Vespula vulgaris	50	11.2	35	3.5	55	1.5	140	2.7
	Delta sp.	0	0.0	0	0.0	10	0.3	10	0.2
	Ropalidia spp.	5	1.1	5	0.5	15	0.4	25	0.5
	Polistes sp.	5	1.1	5	0.5	10	0.3	20	0.4
	Formicidae	20	4.5	70	6.9	140	3.7	230	4.4
	Pheidole megacephala	5	1.1	40	4.0	25	0.7	70	1.3
	Pheidole spp.	15	3.4	15	1.5	100	2.7	130	2.5
	Camponotus sp.	0	0.0	0	0.0	5	0.1	5	0.1
	Solenopsis geminata	0	0.0	15	1.5	10	0.3	25	0.5
Diptera	Chironomidae	0	0.0	5	0.5	0	0.0	5	0.1
	Chironomus transvaalensis	0	0.0	5	0.5	0	0.0	5	0.1

	Diopsidae	5	1.1	15	1.5	20	0.5	40	0.8
	Diopsis apicalis	0	0.0	5	0.5	0	0.0	5	0.1
	Diopsis sp.	5	1.1	10	1.0	20	0.5	35	0.7
	Stratiomyidae	0	0.0	5	0.5	60	1.6	65	1.2
	Hermetia illucens	0	0.0	5	0.5	60	1.6	65	1.2
	Limoniidae	0	0.0	0	0.0	5	0.1	5	0.1
	Limonia sp.	0	0.0	0	0.0	5	0.1	5	0.1
	Tephritidae	5	1.1	57	5.6	95	2.5	157	3.0
	Bactrocera cucurbitae	0	0.0	10	1.0	20	0.5	30	0.6
	Bactrocera sp.	5	1.1	15	1.5	25	0.7	45	0.9
	Bactrocera dorsalis	0	0.0	7	0.7	10	0.3	17	0.3
	Dacus sp.	0	0.0	0	0.0	10	0.3	10	0.2
	Dacus ciliatus	0	0.0	25	2.5	20	0.5	45	0.9
	Myiopardalis pardalina	0	0.0	0	0.0	10	0.3	10	0.2
	Calliphoridae	5	1.1	0	0.0	430	11.4	435	8.3
	Chrysoma sp.	5	1.1	0	0.0	430	11.4	435	8.3
	Culicidae	0	0.0	95	9.4	280	7.4	375	7.2
	Culex sp.	0	0.0	95	9.4	280	7.4	375	7.2
	Micropezidae	0	0.0	10	1.0	5	0.1	15	0.3
	Micropeza sp.	0	0.0	10	1.0	5	0.1	15	0.3
	Muscidae	0	0.0	60	5.9	145	3.9	205	3.9
	Musca domestica	0	0.0	60	5.9	145	3.9	205	3.9
	Sarcophagidae	35	7.9	25	2.5	425	11.3	485	9.3
	Sarcophaga carnaria	35	7.9	25	2.5	425	11.3	485	9.3
	Drosophilidae	5	1.1	20	2.0	30	0.8	55	1.1
	Drosophila melanogaster	5	1.1	20	2.0	30	0.8	55	1.1
	Ephydridae	5	1.1	0	0.0	0	0.0	5	0.1
	Discomyza sp.	5	1.1	0	0.0	0	0.0	5	0.1
	Syrphidae	10	2.2	0	0.0	5	0.1	15	0.3
	Episyrphus sp.	10	2.2	0	0.0	5	0.1	15	0.3
	Limoniidae	0	0.0	0	0.0	5	0.1	5	0.1
	Limonia sp.	0	0.0	0	0.0	5	0.1	5	0.1
	Agromyzidae	35	7.9	10	1.0	60	1.6	105	2.0
	Liriomyza trifolii	35	7.9	10	1.0	60	1.6	105	2.0
Lepidoptera	Crambidae	5	1.1	0	0.0	65	1.7	70	1.3
	Diphania indica	5	1.1	0	0.0	45	1.2	50	1.0
	Spoladea recurvalis	0	0.0	0	0.0	20	0.5	20	0.4
	Geometridae	0	0.0	15	1.5	0	0.0	15	0.3
	Scopula minorata	0	0.0	15	1.5	0	0.0	15	0.3
	Hesperidae	0	0.0	0	0.0	5	0.1	5	0.1
	Hesperia comma	0	0.0	0	0.0	5	0.1	5	0.1
	Nymphalidae	50	11.2	45	4.4	165	4.4	260	5.0
	Hypolimnas misippus	0	0.0	0	0.0	10	0.3	10	0.2
	Acraea acerata	0	0.0	5	0.5	25	0.7	30	0.6
	Acraea encedon	50	11.2	40	4.0	130	3.5	220	4.2
	Noctuidae	10	2.2	0	0.0	60	1.6	70	1.3
	Spodoptera sp.	10	2.2	0	0.0	35	0.9	45	0.9
	Helicoverpa armigera	0	0.0	0	0.0	25	0.7	25	0.5
Coleoptera	Carabidae	35	7.9	35	3.5	25	0.7	95	1.8
	Pheropsophus sp.	0	0.0	20	2.0	0	0.0	20	0.4
	Pterostichus melanarius	0	0.0	0	0.0	10	0.3	10	0.2
	Harpalus sp.	35	7.9	15	1.5	15	0.4	65	1.2
	Scarabaeidae	5	1.1	0	0.0	10	0.3	15	0.3
	Adoretus sp.	5	1.1	0	0.0	10	0.3	15	0.3
	Elateridae	0	0.0	0	0.0	5	0.1	5	0.1
	Agriotes sp.	0	0.0	0	0.0	5	0.1	5	0.1
	Chrysomelidae	20	4.5	65	6.4	200	5.3	285	5.5

	Nisotra sp.	0	0.0	0	0.0	20	0.5	20	0.4
	Chaetocnema pulicaria	5	1.1	25	2.5	25	0.7	55	1.1
	Aulacophora sp.	0	0.0	5	0.5	65	1.7	70	1.3
	Aulacophora africana	15	3.4	15	1.5	70	1.9	100	1.9
	Monolepta sp.	0	0.0	20	2.0	5	0.1	25	0.5
	Cassida sp.	0	0.0	0	0.0	10	0.3	10	0.2
	Diacantha kraatzi	0	0.0	0	0.0	5	0.1	5	0.1
	Coccinellidae	10	2.2	135	13.3	185	4.9	330	6.3
	Exochomus nigromaculatus	0	0.0	5	0.5	5	0.1	10	0.2
	Parexochomus nigromaculatus	5	1.1	15	1.5	20	0.5	40	0.8
	Cheilomenes sulphurea	5	1.1	110	10.9	35	0.9	150	2.9
	Cheilomenes propinqua	0	0.0	0	0.0	115	3.1	115	2.2
	Henosepilachna sp.	0	0.0	5	0.5	10	0.3	15	0.3
	Tenebrionidae	0	0.0	5	0.5	15	0.4	20	0.4
	Lagria sp.	0	0.0	0	0.0	10	0.3	10	0.2
	Lagria villosa	0	0.0	5	0.5	5	0.1	10	0.2
	Staphylinidae	5	1.1	0	0.0	0	0.0	5	0.1
	Paederus sp.	5	1.1	0	0.0	0	0.0	5	0.1
	Erotylidae	0	0.0	0	0.0	5	0.1	5	0.1
	Triplax sp.	0	0.0	0	0.0	5	0.1	5	0.1
	Bostrichidae	0	0.0	5	0.5	20	0.5	25	0.5
	Xylothrips sp.	0	0.0	5	0.5	20	0.5	25	0.5
Orthoptera	Tetrigidae	25	5.6	0	0.0	5	0.1	30	0.6
	Tetrix sp.	25	5.6	0	0.0	5	0.1	30	0.6
	Tettigoniidae	0	0.0	5	0.5	0	0.0	5	0.1
	Conocephalus sp.	0	0.0	5	0.5	0	0.0	5	0.1
	Gryllidae	5	1.1	45	4.4	35	0.9	85	1.6
	Gryllus bimaculatus	0	0.0	40	4.0	30	0.8	70	1.3
	Gryllus sp.	5	1.1	5	0.5	5	0.1	15	0.3
	Gryllotalpidae	0	0.0	0	0.0	5	0.1	5	0.1
	Gryllotalpa africana	0	0.0	0	0.0	5	0.1	5	0.1
	Acrididae	5	1.1	30	3.0	20	0.5	55	1.1
	Oedaleus senegalensis	0	0.0	0	0.0	10	0.3	10	0.2
	Zonocerus variegatus	5	1.1	30	3.0	10	0.3	45	0.9
Odonata	Libellulidae	5	1.1	0	0.0	10	0.3	15	0.3
	Crocothemis sp.	5	1.1	0	0.0	10	0.3	15	0.3
Total		445	100	1012	100	3760	100	5217	100

Ra= Relative abundance; Stage I= sowing to beginning of flowering; Stage II= beginning of flowering to beginning of harvesting; Stage III= beginning of harvesting to end of harvesting

The largest number of families has been recorded among the Diptera (15), with a predominance of the Sarcophagidae followed by the Calliphoridae, Culicidae, Muscidae, Tephritidae, Agromyzidae, Stratiomyidae, and Drosophilidae. Coleoptera came in second place along with Hemiptera with 9 families. The predominant family in Coleoptera was Coccinellidae followed by Chrysomelidae and Carabidae, and the predominant family in Hemiptera was Cicadellidae, followed by Pentatomidae and Miridae. Hymenoptera comprised 7 families, with Apidae predominating, followed by Formicidae, Vespidae, and Halictidae. Lepidoptera, along with Orthoptera, comprised five families. Nymphalidae was the most abundant in Lepidoptera, followed by Noctuidae and Crambidae. Gryllidae was the most abundant in Orthoptera, followed by Acrididae. The remaining orders, Dermaptera, Thysanoptera, and Odonata, comprised only one family, including Forficulidae, Thripidae, and Libellulidae, respectively (Table 1).

Abundance, species richness and diversity of insect orders

Diptera outnumbered the other eight groups in terms of abundance, as seen in Fig. 2, with 1972 insect individuals accounting for 37.8% of the of the total number collected. It was followed by the orders of Hymenoptera with 905 insect individuals (17.3%), Coleoptera with 785 insect individuals (15%), Thysanoptera with 630 insect individuals (12.1%), Lepidoptera with 420 insect individuals (8.1%), Hemiptera with 305 insect individuals (5.8%), Orthoptera with 180 insect individuals (3.5%), Odonata with 15 insect individuals (0.3%), and Dermaptera with 5 insect individuals (0.1%). Coleoptera had the most species (23.40%), followed by Diptera (22.34%), Hymenoptera (18.09%), Hemiptera (14.89%), Lepidoptera (9.57%), Orthoptera (7.45%), and Thysanoptera (2.13%). Odonata and Dermaptera had a comparable number of species (1.06%).

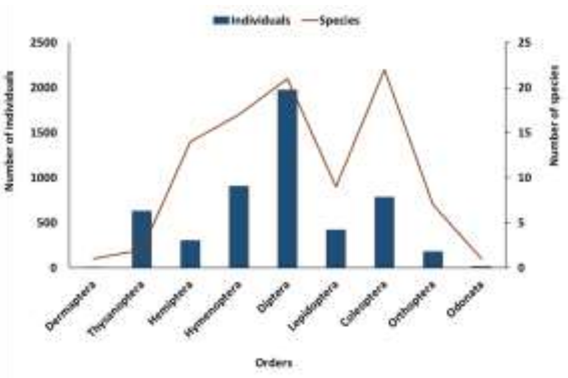

Fig. 2. Abundance and species richness of insect orders

The values of the different diversity indices calculated varied significantly among insect orders (Table 2). The order of Coleoptera recorded the highest value of te Margalef index (Hm = 2.45), followed by Diptera (Hm = 2.34), indicating moderate species richness. However, Margalef index values of the remaining orders were less than 2, i.e., varying between 0 and 1.87, suggesting lower species richness. Likewise, as for species diversity, Coleoptera exhibited again the highest species diversity (Hs = 2.58) as compared to the Hymenoptera (Hs = 2.18), the Hemiptera (Hs = 2.17), the Diptera (Hs = 2.15), the Orthoptera (1.58), and the Thysanoptera (0.69). No diversity was observed for the orders Dermaptera and Odonata. According to the evenness index, Dermaptera and Odonata were composed of only one species. Individuals are more evenly distributed among species in Thysanoptera (E = 0.99) than in Coleoptera (E = 0.84), Hemiptera (E = 0.82), Orthoptera (E = 0.81), Hymenoptera (E = 0.77), Lepidoptera (E = 0.73), and Diptera (E = 0.71) (Table 2).

Table 2. Diversity indexes of insect orders

Orders	Margalef (Hm)	Shannon (Hs)	Evenness (E)
Dermaptera	0.00	0.00	-
Thysanoptera	0.12	0.69	0.99
Hemiptera	1.52	2.17	0.82
Hymenoptera	1.87	2.18	0.77
Diptera	2.34	2.15	0.71
Lepidoptera	0.93	1.59	0.73
Coleoptera	2.45	2.58	0.84
Orthoptera	0.70	1.58	0.81
Odonata	0.00	0.00	-

Abundance, species richness and diversity of insect families

Thirty-nine out of the 53 identified insect families have recorded at least 10 insect individuals and were used to construct Fig. 3. Among these families, the Thripidae were the most abundant, with 630 insect individuals representing 12.1% of the collected insect individuals, followed by the Sarcophagidae, Calliphoridae, Culicidae, Coccinellidae, Apidae, Chrysomelidae, and Nymphalidae, with 485, 435, 375, 330, 325, 285, and 260 insect individuals representing 9.3%, 8.3%, 7.2%, 6.3%, 6.2%, 5.5%, and 5% of the collected insect individuals, respectively. The remaining families recorded less than 5% of abundance (Fig. 3).

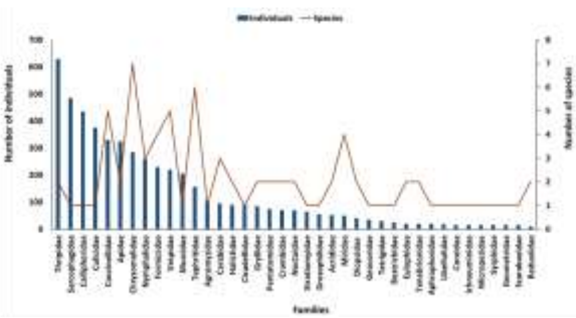

Fig. 3. Abundance and species richness of insect families

However, as for species richness, the rich families were Chrysomelidae (7 species), followed by Tephritidae (6 species), Coccinellidae and Vespidae (5 species), Formicidae and Miridae (4 species), and Nymphalidae and Carabidae (3 species). The remaining families recorded no more than 2 species (Fig. 3).

Taking into account the three development stages of cucumber considered in this study, the calculated Margalef index value was higher for stage III (Hm = 5.2) as compared to the first two stages that exhibited similar values, Hm = 4.4 for stage I and Hm = 4.5 for stage II. The Shannon index value for stage I (Hs = 2.9) was slightly smaller than those of stages II and III, which were both equal (Hs = 3). Regarding the evenness index, it decreases over cucumber developmental stages, running from E = 0.88 (stage I) to E = 0.87 (stage II) and E = 0.78 (stage III) (Fig. 4).

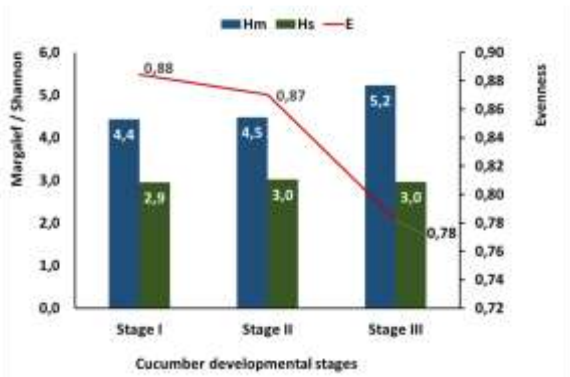

Fig. 4. Specific diversity of the insect families according to developmental stages

Stage I = sowing to beginning of flowering; Stage II = beginning of flowering to beginning of harvesting; Stage III = beginning of harvesting to end of harvesting

Functional groups

Functional groups are composed of pests, predators, parasitoids, pollinators, and visitors. As depicted by Fig. 5, pest populations show greater abundance of insect individuals and species richness compared to all the other functional groups. Out of the 94 (100%) insect species identified from the 5217 (100%) insect individuals collected, 49 (52.13%) species were identified as pests from 2164 (41.48%) individuals, 11 (11.70%) species were identified as visitors from 1605 (30.76%) individuals, 24 (25.53%) species were identified as predators from 958 (18.36%) individuals, 6 (6.38%) species were identified as parasitoids from 75 (1.44%) individuals, and 4 (4.5%) species were identified as pollinators from 415 (7.95%) individuals (Fig. 5).

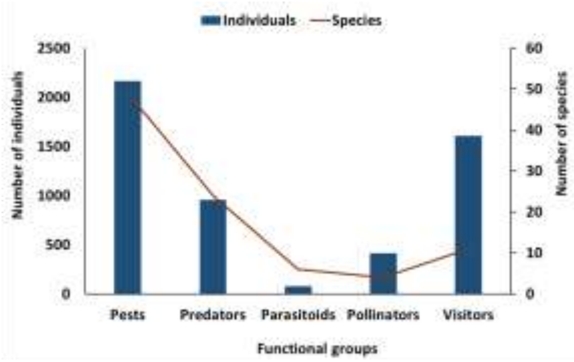

Fig. 5. Abundance and species richness of insect according to their functional groups

Across all developmental stages, pest populations were the most abundant, followed by visitor insects and then the other functional groups. From stage I to stage II, the number of pests and visitors grew slowly (from 210 to 284 and from 25 to 200, respectively). From stage II to stage III, however, the number of pests and visitors rose sharply (from 284 to 1,579 individuals and from 200 to 1,360, respectively). These increases were much more pronounced than those observed in auxiliary insects such as predators and parasitoids.

DISCUSSION

Along with the competition for energy, fertile land, and water, one bottleneck to lifting vegetable production in SSA is high exposure to pests (Waterfield and Zilberman, 2012). Knowledge of the insects associated with cucumber reported by the present study is the starting point for developing methods to control insect pests of this vegetable crop (Dagba *et al.*, 2024). The data recorded in the present investigation revealed that the cucumber plant attracted a wide variety of insects belonging to 9 orders, 53 families, and 94 species. Our results agree with many other studies carried out in Africa. For instance, in Ivory Coast, 11 orders, 29 families, and 46 species have been revealed in Dabou by Assi *et al.* (2018); Ouali N'Goran *et al.* (2019) obtained 9 orders, 27 families, and 42 species in Bonoua; and Fondio *et al.* (2020) identified 7 orders, 37 families, and 61 species in Daloa. Surveys conducted in Nigeria allowed the identification of 8 orders, 10 families, and 12 species at Ibadan and Abeokuta (Pitan and Filani, 2013) and 7 orders, 15 families, and 23 species at Ekiti State University Teaching and Research Farm Ado-Ekiti (Falade, 2022). A study conducted by Atibita *et al.* (2020) at Bamunka-Ndop in the Northwest Region of Cameroon permitted the recording of 4 orders, 6 families, and 10 species. Variations observed in terms of the number of taxa in these studies could be explained by the variation of climatic parameters in the study areas, the number of replicates, or sampling techniques (Severgnini *et al.*, 2019; Fondio *et al.*, 2020).

Early reports were largely based on a global literature search for insects related to cucumber cultivation, without field verification that the stated species exist in Benin.

According to species richness and diversity index values, the majority of insect species captured belong to six major insect groups: Coleoptera, Diptera, Hymenoptera, Hemiptera, Lepidoptera, and Orthoptera. Coleoptera was mostly represented by pest species of the families of Scarabaeidae (*Adoretus* sp.), Elateridae (*Agriotes* sp.), Chrysomelidae (*Nisotra* sp., *Chaetocnema pulicaria*, *Aulacophora* sp., *Aulacophora africana*, *Monolepta* sp., *Cassida* sp., and *Diacantha kraatzi*), Coccinellidae (*Henosepilachna* sp.), Tenebrionidae (*Lagria* sp. and *Lagria villosa*), and Bostrichidae (*Xylothrips* sp.); followed by predator species of the families of Coccinellidae (*Exochomus nigromaculatus*, *Parexochomus nigromaculatus*, *Cheilomenes sulphurea,* and *Cheilomenes propinqua*) and Staphylinidae (*Paederus* sp.). Similarly, the order of Hemiptera consisted mostly of pest species of the families of Pentatomidae (*Nezara viridula* and *Aspavia armigera*), Cicadellidae (*Empoasca* sp.), Coreidae (*Cletus* sp.), and Lygaeidae (*Dysdercus voelkeri*); and predator species of the families of Reduviidae (*Rhynocoris* sp. and *Zelus* sp.), Geocoridae (*Geocoris* sp.), and Miridae (*Nesidiocoris* sp.). Diptera was mostly represented by visitor species belonging to the families of Chironomidae (*Chironomus transvaalensis*), Stratiomyidae (*Hermetia illucens*), Limoniidae (*Limonia* sp.), Calliphoridae (*Chrysoma* sp.), Culicidae (*Culex* sp.), Micropezidae (*Micropeza* sp.), Muscidae (*Musca domestica*), Sarcophagidae (*Sarcophaga carnaria*), Ephydridae (*Discomyza* sp.) and Limoniidae (*Limonia* sp.); followed by pest species of the families of Tephritidae (*Bactrocera cucurbitae*, *Bactrocera* sp., *Bactrocera dorsalis*, *Dacus* sp., *Dacus ciliates* and *Myiopardalis pardalina*), Drosophilidae (*Drosophila melanogaster*) and Agromyzidae (*Liriomyza trifolii*), and some predator species of the families of Diopsidae (*Diopsis apicalis* and *Diopsis* sp) and Syrphidae (*Episyrphus* sp.). Therefore, only a few pest species were represented in the order of Lepidoptera, which included species from the families Crambidae (*Diphania indica* and *Spoladea recurvalis*), Geometridae (*Scopula minorata*), Hesperiidae (*Hesperia comma*), Nymphalidae (*Hypolimnas misippus*, *Acraea acerata*, and *Acraea encedon*), and Noctuidae (*Spodoptera* sp. and *Helicoverpa armigera*). The same is true for the order of Orthoptera, which includes the pest families Tetrigidae (*Tetrix* sp.), Tettigoniidae (*Conocephalus* sp.), Gryllidae (*Gryllus bimaculatus* and *Gryllus* sp.), Gryllotalpidae (*Gryllotalpa africana*), and Acrididae (*Oedaleus senegalensis* and *Zonocerus variegatus*). Hymenoptera was only represented by beneficial insects such as pollinators of the families of Apidae (*Apis mellifera* and *Xylocopa* sp.), Halictidae (*Halictus* sp. and *Lasioglossum* sp.), parasitoids of the families of Eulophidae (*Aprostocetus* sp. and *Diglyphus isaea*), Pompilidae (*Anoplius* sp.), Ichneumonidae (*Campoletis* sp.), and Vespidae (*Delta* sp. and *Ropalidia* spp.), and predators of the families of Formicidae (*Pheidole megacephala*, *Pheidole* spp., *Camponotus* sp., and *Solenopsis geminata*) and Vespidae (*Vespula* sp., *Vespula vulgaris,* and *Polistes* sp.). Among the aforementioned species, some have previously been identified as the most important cucumber bug pests, causing serious harm. The field cricket *Gryllus* sp., the ground hopper *Tetrix* sp., the grasshopper *Zonocerus variegatus,* the pumpkin leaf caterpillar *Diphania indica,* the cucumber thrips *Thrips tabaci*, or the corn flea beetle *Chaetocnema pulicaria*, the pumpkin beetles *Aulacophora* sp. and *Aulacophora africana,* the Hadda beetle *Henosepilachn*a sp., the lagriid beetle *Lagria villosa,* and *Lagria* sp. feed on cucumber leaves or fruits, reducing the photosynthetic leaf area; The southern green stink bug *Nezara viridula*, the leafhopper *Empoasca* sp., the leaf miners *Liriomyza trifolii,* the rice stink bug *Cletus* sp., and the cotton stainer *Dysdercus wolkerii* (Pitan and Filani, 2013; Assi *et al*., 2018; Fondio *et al*., 2020; Khadka *et al*., 2025). Melon fruit flies *Bactrocera cucurbitae*, *Bactrocera* sp., and *Bactrocera dorsalis*, as well as the cucumber fly *Dacus ciliates,* lay eggs on the fruits, and the larvae that feed on them dig galleries in the fruits, reducing their quality (Sapkota *et al*., 2010; Pitan and Filani, 2013; Kumar *et al*., 2024).

Some insect pest species previously reported that deserve attention were not found in this study. However, the presence of these insect pest species on cucumber crops significantly threatens the production of cucumbers in Benin. Their presence may hinder cucumber producers' efforts, affect their income, and compromise nutritional security.

CONCLUSION

This study provides information on the entomofauna related to cucumber crops in central Benin's Parakou region, which is part of the cotton-growing zone. Because the survey was not conducted throughout two cropping seasons or in various agroecological zones, the absence of pest prevalence cannot be interpreted as proof that the pest did not exist in the region. Complementary surveys are required and should be conducted during the rainy season, in other parts of the country, and on several cucumber varieties to broaden knowledge of insect pests associated with this crop in Benin, allowing effective management measures to be developed to keep population densities of these pest species below the economic threshold level. Furthermore, incorporating agroecological techniques such as crop diversification and habitat modification into farming practices is crucial to building more resilient agricultural systems, as the widespread and ongoing use of chemical pesticides is harmful to both human health and the environment.

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