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Entomofaunal diversity in cowpea [*Vigna unguiculata* (L.) Walp.] cultivation systems within the cotton-growing zone of central Benin

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ABSTRACT

Cowpea productivity in Benin remains low, largely due to multiple constraints—chief among them, insect infestations. Despite this, few studies have comprehensively examined the insect fauna associated with cowpea, limiting the development of targeted and effective management strategies. This study addresses the gap by investigating the entomofaunal diversity within cowpea cropping systems in the Central Benin cotton zone. Field sampling was conducted during the rainy season, from July to October 2024, across three distinct sites. The methodology included direct observations, insect collection from plants, and the use of buried traps. A total of 79 insect species, spanning 73 genera and 37 families across seven orders, were identified. The most represented were Hemiptera (34%), Coleoptera (25%), Lepidoptera (16%), Diptera (10%), Thysanoptera (6%), Orthoptera (5%), and Hymenoptera (3%). Biodiversity indices—Shannon (2.78 - 2.81), Equitability (0.67 - 0.80), and Simpson (0.91) — indicate a high level of species diversity, with a slight dominance of individuals from a few key families. These included Chrysomelidae, Crambidae, Aphididae, Coreidae, Cicadellidae, Agromyzidae, and Thripidae. Analysis of functional groups across cowpea phenological stages revealed a marked predominance of pest species over beneficial insects throughout the crop cycle. These findings highlighted the rich insect biodiversity within cowpea ecosystems in central Benin, while also underscoring a functional imbalance driven by pest dominance. The results advocate for integrated management strategies that prioritize the conservation of beneficial insects and the continuous monitoring of pest populations to enhance cowpea productivity.

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INTRODUCTION

Cowpea (*Vigna unguiculata* L.), is a grain legume of the Fabaceae family native to Africa (Houenou *et al.*, 2022). It adapts to the climatic and edaphic conditions of most countries in Africa and elsewhere (Gbaguidi *et al.*, 2015). Today, it is grown in almost all tropical and subtropical regions for human food and livestock feed. All parts of the plant are used, including the seeds, green pods, and leaves (Boukar *et al.*, 2019). It is the main legume in Africa, accounting for approximately 94% of the global production, most of which comes from the western and central parts of the continent (FAO, 2017). In Benin, it is the most important grain legume. Its production decreased by 13.6% from 2022 to 2023 and was estimated to be 122,744 tons in 2023 versus 142,002 tons in 2022 (DSA, 2024). It is mainly cultivated for its seeds, rich in proteins (~30%) and carbohydrates (50-60%) (Diouf and Hilu, 2005); its leaves, rich in phosphorus (3.0 to 6.7 mg/g), ascorbic acid (0.3 to 1.5 mg/g), and proteins (27 to 35%) (Ahenkora *et al.*, 1998); its important role in cropping systems and in soil fertility management (Omoigui *et al.*, 2018; Houenou *et al.*, 2022); etc.

Despite these numerous advantages, the cultivation of cowpea faces numerous production constraints that lead to extremely low yields (25 kg/ha) in farmers' fields in Africa (Kamara *et al.*, 2018), with an average yield of about 600 kg/ha across the continent (FAO, 2017). This value is well below the potential yield of 1500-2500 kg/ha for most improved cowpea varieties in Africa (Kamara *et al.*, 2018). In Benin, cowpea yields ranged between 879 and 961 kg/ha from 2018 to 2023 (DSA, 2024), while its potential yield under favorable conditions can reach 2500 kg per hectare (MAEP, 2016). Cowpea low productivity is due to several biotic and abiotic factors (Boukar *et al.*, 2016). Insect pests are the most important constraint affecting cowpea at all stages of its development up to storage (Sodedji *et al.*, 2022). In the absence of effective control, damage from insect pests can reach 80 to 100% (Ahmed *et al.,* 2009; Dugje *et al.,* 2009). These attacks are particularly severe during flowering and pod sets (Ajao *et al.*, 2016). Efficient control of these insect pests can only be achieved through the development of suitable strategies, including combining methods promoting the establishment of more sustainable agroecological systems (Franke *et al.*, 2018).

Knowledge of pests (Choudourou *et al.*, 2012) and auxiliary fauna that participate in pest regulation (Tendeng *et al.*, 2017) and agroecosystem balance (Bello *et al.,* 2018) is the preliminary step to developing sustainable pest management strategies that are eco-friendly and ensure food security (Fatondji *et al.*, 2018). In Benin, very few studies have focused on the cowpea entomofauna's biodiversity. The information provided by these studies unfortunately remains focused on a single municipality (Bello *et al.*, 2018) and needs to be updated for sustainable management of the main cowpea insect pests. In addition, it has been revealed that pest populations and their natural enemies vary over time with changing agricultural practices and environmental conditions, particularly in the current context of climate change (Skendžić *et al.*, 2021; Eigenbrode and Adhikari, 2023). The current study aims to contribute to knowledge on the diversity of entomological fauna of cowpea in Benin. The information generated should be useful in terms of a perspective of biological or integrated control program development.

MATERIALS AND METHODS

Study area and sampled sites

The study was carried out in Agroecological Zone V (AEZ V) named the Central Cotton Zone, which is one of the eight AEZs in Benin (Aholoukpè *et al.*, 2020) (Fig. 1). Located in the center of Benin, AEZ V covers eleven municipalities (Ouessè, Bantè, Glazoué, Dassa-Zoumé, Savè, Bassila, Parakou, Tchaourou, Aplahoué, and Kétou). The region has a Sudano-Guinean climate, which is characterized by two rainy seasons; however, the northern part exhibits a Sudanese tendency and experiences only one rainy season. The rainfall varies from 600 to 1200 mm of water per year in the West and 1000 to 1400 mm of water per year in the East. The average annual temperature is 26.5°C. The soils are of the leached tropical ferruginous type, more or less concreted (Leptosols and Luvisols), ferralitic with a sandy to sandy-clayey texture (Acrisols), and hydromorphic valleys (Fluvisols). The agricultural systems combine food crops (sorghum, yam, cowpea, peanut, maize, and cassava) and cash crops such as cotton (Chevallier *et al.*, 2020).

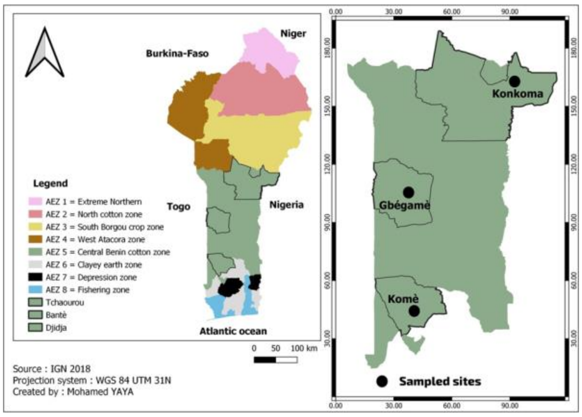

Fig. 1. Map showing the study area and sampled sites

Surveys were carried out in three cowpea cultivation sites located in the municipalities of Tchaorou (Konkoma), Bantè (Gbégamè), and Djidja (Komè), as depicted in Fig. 1. These sites were purposefully selected in collaboration with agriculture extension specialists, based on a set of well-defined criteria: a minimum sown area of 1 hectare, a history of at least three consecutive years of cowpea cultivation, ease of access, absence of phytosanitary treatments, and relative isolation from neighboring crops to reduce external influences.. Specifically, the Konkoma site encompassed 1.80 hectares with four years of continuous cowpea production, Gbégamè covered 1.65 hectares with three years of cultivation, and Komè spanned 1.50 hectares with four years of prior cowpea farming.

Sampling, sorting and conservation of collected samples

Sampling was performed during the cropping season from July to October, 2024. Regular insect captures were carried out starting from twenty-one (21) days after planting and continued at a weekly interval for a total of twelve (12) records. Since insect sampling often requires several techniques to obtain a wide diversity of insects, several techniques were combined to inventory the entomofauna during the cowpea development cycle. The techniques consisted of direct observations and captures on plants (by hand, pliers, sweep net, and mouth aspirator) as well as trapping using buried traps (pitfall traps) (Ndiaye *et al.*, 2023). The collected insects (captured or trapped) were sorted under a binocular loupe and classified according to their orders and families before being preserved in vials containing alcohol at 70°C. The vials were transferred to the laboratory for further insect identification.

Identification of specimens

The specimens were identified in the laboratory down to the species level and counted. Identifications were made using a magnifying glass, identification keys, and illustrated catalogues (Delvare and Aberlenc, 1989; Appert and Deuse, 1998; Bordat and Arvanitakis, 2004; Poutouli *et al.*, 2011; Zettler *et al.*, 2016).

Data analysis

Data on specimen counts (for each order, family, genus, and species) were arranged in an Excel spreadsheet version 2013. Percentages were calculated based on the overall total number of collected specimens. Ecological parameters, including relative abundance (Ra), specific richness (Sr), Shannon-Weaver, Pielou's equitability, and Simpson indexes, were calculated.

Relative abundance Ra (%) refers to the proportion of individuals of a given species (ni) relative to the total individuals (N) recorded across all species. It is calculated using the formula proposed by Dajoz (2006).

$$Ra(\%) = ni * \frac{100}{N}$$

Specific richness Sr (%) represents the proportion of species within a particular taxonomic group (Order or Family), denoted as Ri, relative to the total number of species R observed in the study. This metric is calculated using the formula described by McCarthy (2004).

$$Sr(\%) = Ri * \frac{100}{R}$$

Shannon-Weaver index (H') is a measure of species richness and diversity, commonly used to assess the complexity of insect communities. It assumes that all species present are included in the sample and that individuals are randomly sampled. The index is calculated using the formula provided by Ramade (2009).

$$H' = -\sum_{i=1}^{s} \frac{ni}{N} * \ln(\frac{ni}{N})$$

where ni is the number of individuals for species i and N is the total number of individuals collected for all species.

Pielou's equitability index (E) assesses the evenness of species distribution within the families observed. It reflects how uniformly individuals are spread across species. The index is calculated using the formula described by Weesie and Belemsobgo (1997).

$$E = \frac{H'}{H'max}$$

where H' = Shannon-Weaver index and H' max = maximum diversity. H' max = lnS, with S = total richness expressed in number of families. E ranges from 0 to 1, where 1 indicates perfect evenness (all species equally abundant) and 0 indicates maximum unevenness (one species dominates completely).

Simpson's diversity index (S) quantifies the likelihood that two individuals randomly selected from a sample will belong to different species, thereby reflecting species diversity within a community. The index is calculated using the formula proposed by Simpson (1949).

$$D = 1 - \frac{\Sigma[n_i(n_i - 1)]}{N(N - 1)}$$

where ni is the number of individuals for species i and N is the total number of individuals collected for all species. D ranges from 0 to 1, where high scores (close to 1) indicate high diversity and low scores (close to 0) indicate low diversity.

RESULTS

Composition and general abundance of sampled insects

Table 1 presents the biodiversity of the entomofauna associated with the cowpea crop. In total, 9092 individuals were collected from 79 species, 73 genera, 37 families, and 7 orders. The number of individuals collected is higher in Komè (3183) than in Gbégamè (3098) and Konkoma (2831).

Table 1. Relative abundance of families, genera and species of collected insects

Orders	Families/Genus/Species	Komkoma		Gbégamè		Komè		Total	
		Effectif	%	Effectif	%	Effectif	%	Effectif	%
Coleoptera	Coccinellidae	106	3,74	56	1,82	115	3,61	277	3,05
	Cheilomones sulphurea (Olivier, 1791)	47	1,66	19	0,62	25	0,79	91	1,00
	Epilachna spp. (Dejean, 1837)	59	2,08	37	1,20	90	2,83	186	2,05
	Apionidae	20	0,71	16	0,52	23	0,72	59	0,65
	Apion miniatum (Germar, 1833)	20	0,71	16	0,52	23	0,72	59	0,65
	Scarabaeidae	6	0,21	6	0,19	7	0,22	19	0,21
	Pachnoda cordata (Drury, 1773)	6	0,21	6	0,19	7	0,22	19	0,21
	Tenebrionidae	7	0,25	0	0,00	0	0,00	7	0,08
	Lagria villosa (Fabricius, 1781)	7	0,25	0	0,00	0	0,00	7	0,08
	Chrysomelidae	545	19,25	638	20,73	728	22,87	1911	21,02
	Ootheca mutabulis (Sahlberg, 1829)	69	2,44	35	1,14	42	1,32	146	1,61
	Nisotra uniformis (Jacoby, 1906)	14	0,49	38	1,23	27	0,85	79	0,87
	Psylloïdes chrysocephala (Linnaeus, 1758)	9	0,32	0	0,00	0	0,00	9	0,10
	Oulema melanopus (Linnaeus, 1758)	0	0,00	2	0,06	1	0,03	3	0,03
	Monolepta tenuicornis (Laboissière, 1920)	3	0,11	17	0,55	18	0,57	38	0,42
	Medythia quaterna (Fairmaire, 1880)	22	0,78	28	0,91	17	0,53	67	0,74
	Asbecesta cyanipennis (Halord 1877)	0	0,00	3	0,10	7	0,22	10	0,11
	Lema spp. (Fabricius, 1798)	0	0,00	15	0,49	12	0,38	27	0,30
	Exosoma dalmani (Jacoby, 1897)	2	0,07	12	0,39	18	0,57	32	0,35
	Acantoscelides obtectus (Say, 1831)	166	5,86	175	5,69	191	6,00	532	5,85
	Aulacophora foveicolis (Lucas, 1849)	17	0,60	15	0,49	9	0,28	41	0,45
	Podagrica decolorata (Duvivier, 1892)	16	0,57	8	0,26	19	0,60	43	0,47
	Callosobruchus maculatus (Fabricius, 1775)	133	4,70	192	6,24	262	8,23	587	6,46
	Callosobruchus rhodesianus (Pic, 1902)	94	3,32	98	3,18	105	3,30	297	3,27
	Meloidae	8	0,28	5	0,16	9	0,28	22	0,24
	Mylabris spp. (Fabricius, 1775)	8	0,28	5	0,16	9	0,28	22	0,24

	Curculionidae	3	0,11	0	0,00	6	0,19	9	0,10
	Myllocerus spp. (Schönherr, 1823)	3	0,11	0	0,00	6	0,19	9	0,10
Orthoptera	Tettigoniidae	12	0,42	18	0,58	10	0,31	40	0,44
	Tettigonia viridissima (Linnaeus, 1758)	12	0,42	18	0,58	10	0,31	40	0,44
	Acrididae	19,00	0,67	13,00	0,42	16,00	0,50	48,00	0,53
	Acrida ungarica (Herbst, 1786)	10	0,35	9	0,29	16	0,50	35	0,38
	Cantantops spp. (Schaum, 1853)	9	0,32	4	0,13	0	0,00	13	0,14
	Pyrgomorphidae	95,00	3,36	139,00	4,52	112,00	3,52	346,00	3,81
	Pyrgomorpha cognata (Charpentier, 1845)	40	1,41	60	1,95	47	1,48	147	1,62
	Zonocerus variegatus (Linné, 1758)	55	1,94	79	2,57	65	2,04	199	2,19
	Gryllidae	13,00	0,46	19,00	0,62	0,00	0,00	32,00	0,35
	Brachytrupes membranaceus (Drury, 1770)	13	0,46	19	0,62	0	0,00	32	0,35
Hymenoptera	Vespidae	6,00	0,21	21,00	0,68	10,00	0,31	37,00	0,41
	Vespula spp. (Thomson, 1869)	6	0,21	21	0,68	10	0,31	37	0,41
	Eulophidae	20,00	0,71	35,00	1,14	23,00	0,72	78,00	0,86
	Entedon senegalensis (Rasplus, 1990)	3	0,11	7	0,23	4	0,13	14	0,15
	Pediobius vignae (Hedqvist, 1978)	13	0,46	23	0,75	16	0,50	52	0,57
	Aprostocetus spp. (Westwood, 1833)	4	0,14	5	0,16	3	0,09	12	0,13
	Eurytomidae	0,00	0,00	21,00	0,68	7,00	0,22	28,00	0,31
	Eurytoma sp (Illiger, 1807)	0	0,00	21	0,68	7	0,22	28	0,31
	Eupelmidae	5,00	0,18	1,00	0,03	9,00	0,28	15,00	0,16
	Eupelmus elongatus (Girault, 1916)	5	0,18	1	0,03	9	0,28	15	0,16
	Apidae	29,00	1,02	29,00	0,94	34,00	1,07	92,00	1,01
	Apis mellifera (Linnaeus, 1758)	27	0,95	15	0,49	34	1,07	76	0,84
	Amegilla spp. (Friese, 1897)	2	0,07	14	0,45	0	0,00	16	0,18
Lepidoptera	Lycaenidae	14,00	0,49	41,00	1,33	54,00	1,70	109,00	1,20
	Euchrysops malathana (Boisduval, 1833)	14	0,49	41	1,33	54	1,70	109	1,20
	Noctuidae	113,00	3,99	22,00	0,71	119,00	3,74	254,00	2,79
	Spodoptera littoralis (Boisduval, 1833)	23	0,81	16	0,52	19	0,60	58	0,64
	Spodoptera exigua (Hubner, 1808)	21	0,74	3	0,10	13	0,41	37	0,41
	Helicoverpa armigera (Hubner, 1808)	69	2,44	3	0,10	87	2,73	159	1,75
	Crambidae	318,00	11,23	336,00	10,92	349,00	10,96	1003,00	11,03
	Syllepta derogata (Fabricius, 1775)	25	0,88	12	0,39	12	0,38	49	0,54
	Maruca vitrata (Fabricius, 1787)	276	9,75	313	10,17	329	10,34	918	10,10
	Maruca testulalis (Fabricius, 1787)	17	0,60	11	0,36	8	0,25	36	0,40
	Pieridae	2,00	0,07	0,00	0,00	0,00	0,00	2,00	0,02
	Eurema sp. (Hübner, 1819)	2	0,07	0	0,00	0	0,00	2	0,02
	Tortricidae	28,00	0,99	19,00	0,62	24,00	0,75	71,00	0,78
	Cydia ptychora (Meyrick, 1922)	28	0,99	19	0,62	24	0,75	71	0,78
Hemiptera	Pentatomidae	85,00	3,00	180,00	5,85	152,00	4,78	417,00	4,59
	Pentatoma sp. (Olivier, 1789)	17	0,60	41	1,33	12	0,38	70	0,77
	Nezara viridula (Linnaeus, 1758)	32	1,13	12	0,39	63	1,98	107	1,18
	Aspavia armigera (Fabricius, 1775)	21	0,74	69	2,24	47	1,48	137	1,51
	Dryadocoris sp. (Kirkaldy, 1909)	10	0,35	31	1,01	17	0,53	58	0,64
	Holcostethus sp. (Fieber, 1860)	5	0,18	27	0,88	13	0,41	45	0,49
	Plataspidae	30,00	1,06	11,00	0,36	25,00	0,79	66,00	0,73
	Coptosoma cribraria (Fabricius, 1798)	17	0,60	4	0,13	4	0,13	25	0,27
	Brachyplatys testudonigra (De Geer, 1774)	13	0,46	7	0,23	21	0,66	41	0,45
	Anthocoridae	1,00	0,04	22,00	0,71	12,00	0,38	35,00	0,38
	Cardiastethus exiguus (Poppius, 1913)	1	0,04	22	0,71	12	0,38	35	0,38
	Alydidae	128,00	4,52	103,00	3,35	66,00	2,07	297,00	3,27
	Riptortus dentipes (Fabricius, 1787)	80	2,83	67	2,18	39	1,23	186	2,05
	Mirperus jaculus (Thunberg, 1783)	48	1,70	36	1,17	27	0,85	111	1,22
	Pyrrhocoridae	14	0,49	5	0,16	8	0,25	27	0,30
	Dysdercus spp. (Guerin-Méneville, 1831)	14	0,49	5	0,16	8	0,25	27	0,30
	Coreïdae	159	5,62	169	5,49	253	7,95	581	6,39
	Anoplocnemis curvipes (Fabricius, 1781)	62	2,19	89	2,89	102	3,20	253	2,78
	Clavigralla tomentosicollis (Stal, 1855)	78	2,76	43	1,40	145	4,56	266	2,93
	Leptoglossus australis (Fabricius, 1775)	19	0,67	36	1,17	6	0,19	61	0,67
	Hydara spp. (Linnaeus, 1758)	0	0,00	1	0,03	0	0,00	1	0,01
	Reduviidae	7	0,25	14	0,45	9	0,28	30	0,33
	Rhinocoris albopilosus (Signoret, 1858)	0	0,00	9	0,29	0	0,00	9	0,10
	Rhinocoris rapax (Stål, 1855)	4	0,14	5	0,16	1	0,03	10	0,11
	Rhinocoris bicolor (Fabricius, 1781)	3	0,11	0	0,00	1	0,03	4	0,04
	Phonoctonus fasciatus (Palisot de	0	0,00	0	0,00	7	0,22	7	0,08

	Beauvois, 1805)								
	Aleyrodidae	143	5,05	111	3,61	168	5,28	422	4,64
	Bemisia tabaci (Gennadius, 1889)	143	5,05	111	3,61	168	5,28	422	4,64
	Aphididae	278	9,82	254	8,25	187	5,87	719	7,91
	Aphis crassivora (Koch, 1854)	236	8,34	208	6,76	146	4,59	590	6,49
	Aphis gossypi (Glover, 1877)	42	1,48	37	1,20	22	0,69	101	1,11
	Macrosyphom euphorbiae (Thomas, 1878)	0	0,00	9	0,29	19	0,60	28	0,31
	Cicadellidae	128	4,52	222	7,21	164	5,15	514	5,65
	Cicadella spp. (Latreille, 1817)	23	0,81	55	1,79	75	2,36	153	1,68
	Empoasca spp. (Walsh, 1862)	105	3,71	167	5,43	89	2,80	361	3,97
	Miridae	4	0,14	2	0,06	19	0,60	25	0,27
	Lygus spp. (Hahn, 1833)	4	0,14	2	0,06	19	0,60	25	0,27
Thysanoptera	Thripidae	237	8,37	149	4,84	189	5,94	575	6,32
	Megalurothrips sjostedti (Trybom, 1908)	222	7,84	127	4,13	186	5,84	535	5,88
	Thrips tabaci (Lindeman, 1889)	15	0,53	22	0,71	3	0,09	40	0,44
Diptera	Agromyzidae	160	5,65	284	9,23	162	5,09	606	6,67
	Melanogromyza bonavistae (Madden, 2009)	3	0,11	24	0,78	7	0,22	34	0,37
	Ophiomyia spencerella (Greathead, 1969)	15	0,53	44	1,43	21	0,66	80	0,88
	Melanogromyza vignalis (Spencer, 1959)	0	0,00	5	0,16	16	0,50	21	0,23
	Liriomyza spp. (Mik, 1894)	142	5,02	211	6,86	118	3,71	471	5,18
	Tachinidae	31	1,10	54	1,75	27	0,85	112	1,23
	Tachina spp. (Meigen, 1803)	31	1,10	54	1,75	27	0,85	112	1,23
	Dolichopodidae	56	1,98	41	1,33	87	2,73	184	2,02
	Dolichopus sp. (Latreille, 1796)	56	1,98	41	1,33	87	2,73	184	2,02
	Syrphidae	1	0,04	22,00	0,71	0,00	0,00	23,00	0,25
	Episyrphus spp. (Matsumura & Adachi, 1917)	1	0,04	22	0,71	0	0,00	23	0,25
	Total	2831	100	3078	100	3183	100	9092	100

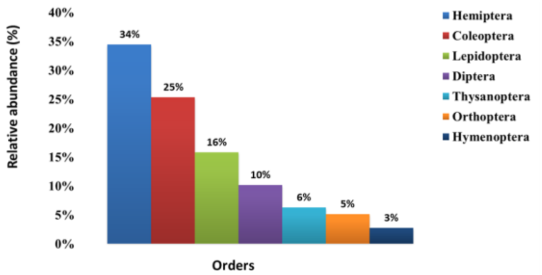

Fig. 2. Relative abundance of orders

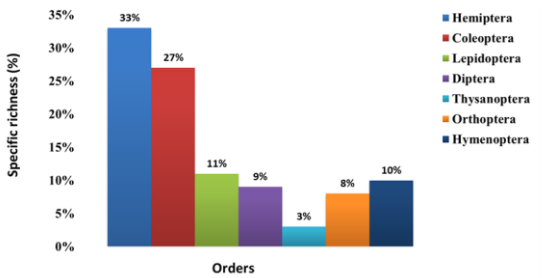

Fig. 3. Specific richness of orders

Relative abundance and specific richness of orders

Fig. 2 presents the overall relative abundance of the orders. It appears that Hemiptera were the most abundant, with 34% of the total number of collected individuals, followed by Coleoptera (25%), Lepidoptera (16%), Diptera (10%), Thysanoptera (6%), Orthoptera (5%), and Hymenoptera (3%). As for the overall specific richness of the orders, the analysis of the Fig. 3 shows that Hemiptera were also the richest with 32.91% of the total number of recorded species, followed by Coleoptera (27%), Lepidoptera (11%), Hymenoptera (10%), Diptera (9%), Orthoptera (5%), and Thysanoptera (3%).

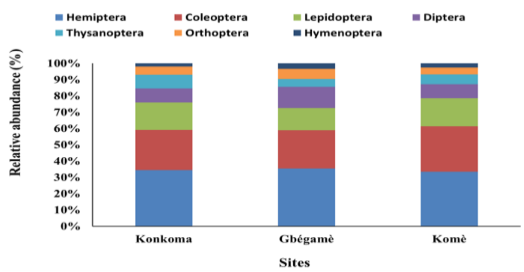

Fig. 4. Relative abundance of orders according to sampled sites

Fig. 4 presents the overall relative abundance of insects according to sampled sites. Regardless of the sampled site, Hemiptera were the most represented, followed by Coleoptera, Lepidoptera, and Diptera. Hymenoptera remains the least abundant order.

Relative abundance and specific richness of families

In general, among the 37 insect families recorded in the study area, the Chrysomelidae (21.02%) were the most abundant, followed by the Crambidae (11.03%), Diptera (10.17%), Aphididae (7.91%), Agromyzidae (6.67%), Coreidae (6.39%), Thripidae (6.32%), and Cicadellidae (5.65%); the remaining families recorded less than 5% of abundance (Table 1).

Furthermore, Konkoma represented all the recorded families, except for Eurytomidae. Komè did not represent the families of Tenebrionidae, Gryllidae, Peridae, and Syrphidae. Similarly, Gbégamè did not represent the families of Tenebrionidae, Curculionidae, and Peridae (Table 1).

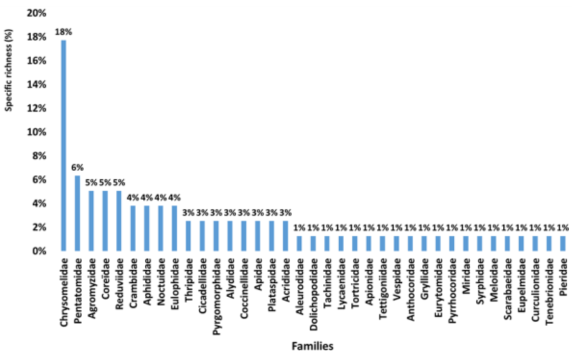

Fig. 5. Specific richness of families

Fig. 5 displays the species richness of the 37 recorded families. The Chrysomelidae exhibited the highest species richness (18%) among all other families, with the Pentatomidae following closely at 6%. The families of Agromizydae, Coreïdae, and Reduividae recorded 5% species richness; those of Crambidae, Aphididae, Noctuidae, and Eulophidae, 4%. Thripidae, Cicadellidae, Pyrgomorphidae, Alydidae, Coccinellidae, Apidae, Plataspidae, and Acrididae hosted 3% of species richness, and the remaining families harvested the lowest species richness (1%).

Relative abundance of species

Fig. 6 shows the relative abundance of 38 out of the 79 species recorded. The 38 species are those that recorded at least 1% of relative abundance. It was about: *Maruca vitrata* (10%), *Aphis crassivora* (6%), *Callosobruchus maculatus* (6%), *Megalurothrips sjostedti* (6%), *Acantoscelides obtectus* (6%), *Liriomyza* spp. (5%), *Bemisia tabaci* (5%), *Empoasca* spp. (4%), *Callosobruchus rhodesianus* (3%), *Clavigralla tomentosicollis* (3%), *Anoplocnemis curvipes* (3%), *Zonocerus variegatus* (2%), *Epilachna* spp. (2%), *Riptortus dentipes* (2%), *Dolichopus* sp. (2%), *Helicoverpa armigera* (2%), *Cicadella* spp. (2%), *Pyrgomorpha cognata* (2%), *Ootheca mutabulis* (2%), *Aspavia armigera* (2%), *Tachina* spp. (1%), *Mirperus jaculus* (1%), *Euchrysops malathana* (1%), *Nezara viridula* (1%), *Aphis gossypi* (1%), *Cheilomones sulphurea* (1%), *Ophiomyia spencerella* (1%), *Nisotra uniformis* (1%), *Apis mellifera* (1%), *Cydia ptychora* (1%), *Pentatoma* sp. (1%), *Medythia quaterna* (1%), *Leptoglossus australis* (1%), *Apion miniatum* (1%), *Spodoptera litt*oralis (1%), *Dryadocoris* sp. (1%), *Pediobius vignae* (1%), *Syllepta derogata* (1%). The rest of the species recorded less than 1% of relative abundance (Fig. 6).

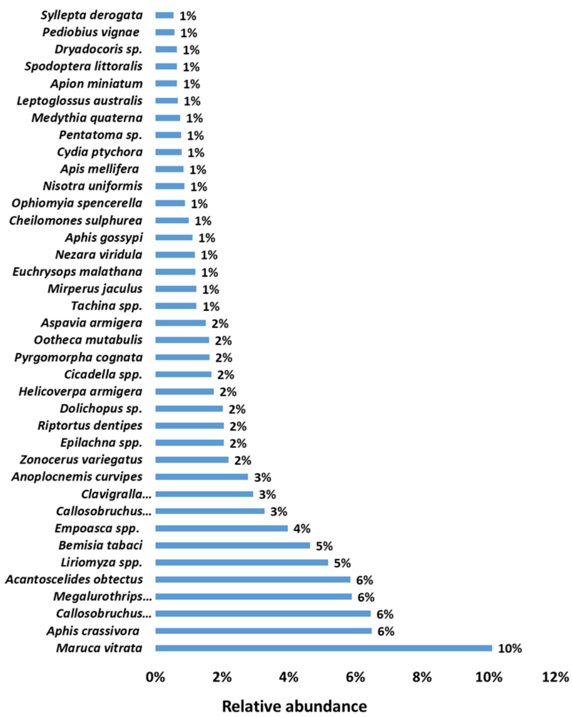

Fig. 6. Relative abundance of species

Index of Shannon-Wiener diversity (H'), Piélou equitability (E) and Simpson of captured insects by sampled site

Fig. 7 illustrates the values of the Shannon-Weaver diversity index (H'), Pielou's equitability index (E), and Simpson's diversity index (D) across the three sampling sites. The Shannon index values were relatively consistent among the sites: Konkoma (2.81), Gbégamè (2.78), and Komè (2.78), indicating comparable species richness. Equitability values varied slightly, with Gbégamè (0.79) and Komè (0.80) exhibiting higher evenness in species distribution, while Konkoma showed a lower equitability value (0.67), suggesting a more uneven distribution of individuals among species. The Simpson index remained constant across all sites at 0.91, reflecting a uniformly high level of species diversity (Fig. 7).

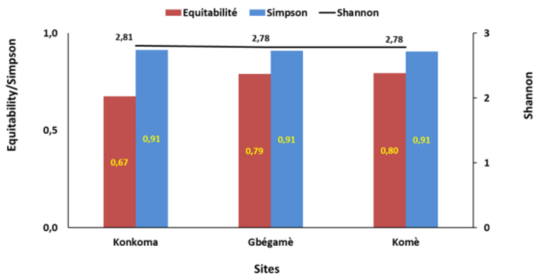

Fig. 7. Specific diversity of the insect fauna according to sampled sites

Functional groups: Composition and dynamics

Collected insects are composed of pests, which are the most abundant (89.98%), and auxiliaries (10.29%). The insect pests are grouped in 26 families, including Apionidae, Scarabaeidae, Tenebrionidae, Chrysomelidae, Meloidae, Curculionidae, Tettigoniidae, Acrididae, Pyrgomorphidae, Gryllidae, Lycaenidae, Noctuidae, Crambidae, Pieridae, Tortricidae, Pentatomidae, Plataspidae, Alydidae, Pyrrhocoridae, Coreïdae, Miridae, Aleyrodidae, Aphididae, Cicadellidae, Thripidae, and Agromyzidae. Beneficial insects are distributed across 11 families, of which 6 are consisted of predators (6.45%)—Coccinellidae, Vespidae, Anthocoridae, Reduviidae, Dolichopodidae, and Syrphidae- 4 families are parasitoids (2.56%- Eulophidae, Eurytomidae, Eupelmidae, and Tachinidae- and one family composed of pollinators (1.01%- Apidae).

The functional group of pest families is marked by a high abundance of Chrysomelidae (21.02%) and Crambidae (11.03%). In the functional group of predator families, the most represented families are Coccinellidae (3.05%) and Dolichopodidae (2.02%). Regarding the functional group of parasitoid families, Tachinidae (1.23%) and Eulophidae (0.86%) are the most dominant.

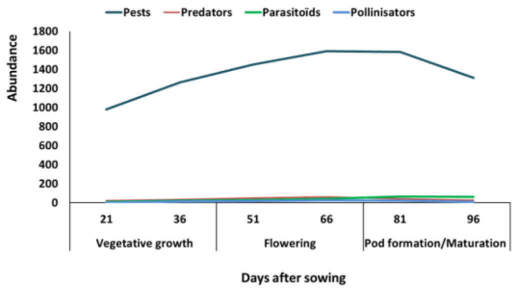

Fig. 8. Dynamic of populations of different insect functional groups

Fig. 8 presents the dynamics of insect populations in the different functional groups during the development cycle of the cowpea crop. It is clear from the figure that the dynamic of pest populations reveals greater abundance of pests compared to all the other functional groups during the different phenological stages (vegetative, flowering, and pod formation/maturation). The pest population significantly increased from the vegetative stage to pod formation stage before decreasing slightly during the maturation stage.

DISCUSSION

Our study identified a total of 79 species, 73 genera, 37 families, and 7 orders associated with cowpea crops. The insect community was dominated by two orders: Hemiptera, followed by Coleoptera, with additional representation from Lepidoptera, Diptera, Thysanoptera, Orthoptera, and Hymenoptera. These findings align with previous studies conducted in similar agroecological contexts. For instance, Mohammadou *et al.* (2023), in their investigation of pest diversity in cowpea fields in Bockle and Dang Localities (North-Cameroon), reported six major orders, with Hemiptera being the most abundant, followed by Coleoptera, Hymenoptera, Lepidoptera, Heteroptera and Orthopera. Similarly, Bello *et al.* (2018) documented eight insect orders with cowpea in Northwestern Benin, where Coleoptera was the most dominant, followed by Hemiptera (including both Homoptera and Heteroptera), Lepidoptera, Diptera, Hymenoptera, Thysanoptera, and Orthoptera. In Cuba, Santana-Baños *et al.* (2023) recorded five orders in cowpea agroecosystems, with Coleoptera and Hemiptera showing the highest dominance. Collectively, these early studies corroborate our findings, emphasizing the consistent predominance of Hemiptera and Coleoptera in cowpea-associated insect communities across diverse geographic regions. Furthermore, while Bello *et al.* (2018) reported 27 insect families in cowpea fields in Djougou (Northwestern Benin), our study identified 37 families, thereby contributing additional insights into the entomofaunal diversity of cowpea ecosystems in Benin.

The analysis of the Shannon diversity index (2.78 - 2.81), Pielou's equitability index (0.67 - 0.80) and Simpson's index (0.91) reveals a high level of family-level diversity within the insect community, accompanied by a moderate dominance of individuals from a limited subset of families. The most represented families included Chrysomelidae (Coleoptera), followed by Crambidae (Lepidoptera), Aphididae, Coreidae and Cicadellidae (Hemiptera), as well as Agromyzidae (Diptera) and Thripidae (Thysanoptera). Several species within these families are well-documented pests of cowpea, contributing to significant crop damage and yield reduction (Gopalakrishnan, 2007; Ali, 2009; Aktar *et al.*, 2009; Dzeme *et al.*, 2010; Sharma *et al.*, 2010; Yadav *et al.*, 2017). These findings emphasize the ecological value of monitoring dominant pest families to inform targeted management strategies in cowpea agroecosystems.

The abundance of functional groups recorded at different phenological stages showed pests were significantly more abundant throughout the cowpea cycle compared to beneficial insects (predators, parasitoids and pollinators). This evidence indicates that the higher pest density could be facilitated by lower natural enemy populations (Atuo and O'Connell, 2017). Many factors, including the ecological characteristics of the environment, could explain this low density of natural enemies (Holling, 1961). Indeed, climate change could modify abiotic conditions such as temperature, precipitation, humidity, and wind, which can alter the life cycles of certain predatory insect species and their prey, leading to changes in their behaviors and interactions (Traill *et al.*, 2010; Tylianakis *et al.*, 2014).

Among identified insect pests, several species pose a significant threat to cowpea cultivation. Key among these were the legume flower and pod borer *Maruca vitrata* (Singh *et al.*, 1990); pod-sucking bugs such as *Clavigralla tomentosicollis*, *Mirperus jaculus*, *Riptortus dentipes*, *Nezara viridula* and *Anoplocnemis curvipes* (Dabiré, 2001; Pitan and Odebiyi, 2001); the flower thrips *Megalurothrips sjostedti* (Dabiré, 2001); and the leaf beetle *Ootheca mutabilis* (Mukendi, 2010). Additionally, seed-feeding insects, including *Callosobruchus maculatus*, *C. rhodesianus*, *Acanthoscelides obtectus*, *Melanagromyza vignalis* and *Ophiomya spencerella* (Lienard and Seck, 1994), contribute to post-harvest losses. Sap-sucking pests, notably the shiny black aphid *Aphis craccivora* (Alavo, 2010), *Medythia quaterna* and *Monolepta tenuicornis*, are particularly damaging; the latter two are known vectors of "Cowpea Mottle Virus" (CMeV) on cowpea (Tia, 1987). These findings suggest that the low cowpea yields observed in the country may be largely attributed to the diverse assemblage of insect pests that infest the crop throughout its entire phenological stages. From seedling emergence to pod maturation, these pests exert continuous pressure on cowpea plants, leading to significant damage and substantial yield losses (Yadav *et al.*, 2017).

Regarding beneficial insects, predatory insect species have been recorded. These include *Cheilomones sulphurea* and *Episyrphus* spp., which are predators of aphids (Soro *et al.*, 2021); *Vespula* spp., *Rhinocoris* sp., *Phonoctonus fasciatus*, *Dolichopus* sp., and *Cardiastethus exiguous* feed on a wide range of insect pests belonging to various taxa (Abdurahiman *et al.*, 1982; Donovan, 2003; Sahayaraj and Balasubramanian, 2016).

Concerning parasitoids, our study revealed the census of species such as *Entedon senegalensis*, strictly subjugated to Apions of *Vigna* (Bapfubusa *et al.*, 1990); *Pediobius vignae*, whose larvae are parasitoids of cowpea seed-feeder *Melanagromyza* *vignalis* (Bapfubusa *et al.*, 1990); *Eupelmus elongatus*, an ectoparasitoid attacking immature or adult stages of many host insects (Noyes and Valentine, 1989); *Eurytoma* sp., known to parasitize Coleoptera that are pests of cowpea pods and seeds (Bapfubusa *et al.*, 1990); and *Aprostocetus* spp., a parasite of various insects, including cowpea weevils (Vongpa *et al.*, 2016).

CONCLUSION

The study reveals that cowpea cropping systems in Central Benin harbor a rich and diverse insect fauna, encompassing 79 species across 73 genera, 37 families, and seven orders. However, the functional composition of these communities is imbalanced, with a pronounced dominance of pest species over beneficial insects throughout all phenological stages of the crop. This pest prevalence poses a significant threat to cowpea productivity. The findings point out the need to implement integrated pest management strategies that emphasize the conservation of beneficial insect populations and the continuous monitoring of pest dynamics to mitigate yield losses and improve crop performance.

REFERENCES

Abdurahiman UC, Mohamed UVK, Remadevi OK. 1982. Studies on the biology of a predator, *Cardiastethus* sp. (Hemiptera: Anthocoridae) found in the galleries of *Nephantis serinopa* meyr. (Lepidoptera: Xylorictidae). Current Science **51**(11), 574-576. http://www.jstor.org/stable/24086337

Ahenkora K, Adu Dapaah HK, Agyemang A. 1998. Selected nutritional components and sensory attributes of cowpea (*Vigna unguiculata* [L.] Walp) leaves. Plant foods for human nutrition **52**(3), 221-229. https://doi.org/10.1023/a:1008019113245

Ahmed BI, Onu I, Mudi L. 2009. Field bioefficacy of plant extracts for the control of post flowering insect pests of cowpea (*Vigna unguiculata* (L.) Walp.) in Nigeria. Journal of Biopesticides **2**(1), 37-43. https://doi.org/10.57182/jbiopestic.2.1.37-43

Aholoukpè HSN, Amadji GL, Koussihouèdé HKI. 2020. Stocks de carbone dans les sols des zones agro-écologiques du Bénin. In Chevallier T, Razafimbelo TM, Chapuis-Lardy L, Brossard M, Eds. Carbone des sols en Afrique. Impacts des usages des sols et des pratiques agricoles. FAO : IRD Éditions, 101-112). https://doi.org/10.4000/books.irdeditions.34917.

Ajao FO, Osipitan AA, Pitan OR, Lawal OI. 2016. Effect of Plant Spacing on Abundance of Major Insect Pests of Cowpea [*Vigna unguiculata* (L.) Walp] and Crop Yield. Journal of Organic Agriculture and Environment **4**(1), 24-33. DOI: 10.5923/j.ijaf.20140401.04

Aktar MW, Sengupta D, Chowdhury A. 2009. Impact of pesticides use in agriculture: their benefits and hazards. Interdisciplinary Toxicology **2**(1), 1-12. DOI: 10.2478/v10102-009-0001-7

Alavo TBC. 2010. Effet répulsif du kaolin contre les populations *d'Aphis craccivora* (Homoptera : Aphididae) sur le niébé (*Vigna unguiculata*). International Journal of Biological and Chemical Sciences **4**(2), 407-414. https://www.ajol.info/index.php/ijbcs/article/view/58138

Ali SA. 2009. Occurrence and distribution of insect pest attacking some vegetative plants at five localities of EL Qassin province, Saudi Arabia. Pakistan Entomologist **31**(2), 148-154.

Appert J, Deuse J. 1982. Les Ravageurs des Cultures Vivrières et Maraîchères sous les Tropiques. Paris: Maisonneuve et Larose, p 420.

Atuo FA, O'Connell TJ. 2017. The landscape of fear as an emergent property of heterogeneity: Contrasting patterns of predation risk in grassland ecosystems. Ecology and Evolution **7**(13), 4782-4793. https://doi.org/10.1002/ece3.3021

Bapfubusa B, Rasplus JY, Fabres G. 1990. L'entomofaune Associée aux Gousses des Légumineuses du Genre *Vigna* dans Différents Habitats de la Zone Forestière du Centre-Cameroun. Annales de la Société entomologique de France **26,** 203-210.

Bello S, Babalakoun AO, Zoudjihékpon J, Coulibaly KA. 2018. Diversité de l'entomofaune du niébé (*Vigna unguiculata* (L.) Walpers) au Nord-Ouest du Bénin. Journal of Applied Biosciences **132**(1), 13424-13438. https://dx.doi.org/10.4314/jab.v132i1.4

Bordat D, Arvanitakis L. 2004. Arthropodes des cultures légumières d'Afrique de l'Ouest, centrale, Mayotte et Réunion. Montpellier, France : CIRAD/FLHOR, p 291.

Boukar O, Belko N, Chamarthi S, Togola A, Batieno J, Owusu E, Haruna M, Diallo S, Umar ML, Olufajo O, Fatokun C. 2019. Cowpea (*Vigna unguiculata*): Genetics, genomics and breeding. Plant Breeding **138,** 415-424. https://doi.org/10.1111/pbr.12589

Boukar O, Fatokun CA, Huynh BL, Roberts PA, Close TJ. 2016. Genomic tools in cowpea breeding programs: status and perspectives. Frontiers in Plant Science **7,** 757. https://doi.org/10.3389/fpls.2016.00757

Chevallier T, Razafimbelo TM, Chapuis-Lardy L, Brossard M. 2020. Carbone des Sols en Afrique. FAO: IRD Éditions, p 272. DOI: https://doi.org/10.4000/books.irdeditions.34867

Chougourou DC, Agbaka A, Adjakpa JB, Koutchika RE, Kponhinto UG, Adjalian EJN. 2012. Inventaire préliminaire de l'entomofaune des champs de tomates (*Lycopersicon esculentum* Mill) dans la Commune de Djakotomey au Bénin. International Journal of Biological and Chemical Sciences **6**(4), 1798-1804. https://doi.org/10.4314/IJBCS.V6I4.34

Dabiré C. 2001. Étude de quelques paramètres biologiques et écologiques de *Clavigralla tomentosicollis* STAL., (Hemiptera : Coreidae) punaises suceuses des gousses du niébé (*Vigna unguiculata* (L.)) dans une perspective de lutte durable contre l'insecte au Burkina Faso. PhD thesis, Université de Cocody, p 179.

Dajoz R. 2006. Précis d'écologie (8ème edn). Paris : Dunod.

Delvare G, Aberlenc HP. 1989. Les insectes d'Afrique et d'Amérique tropicale. Clés pour la reconnaissance des familles. Montpellier : CIRAD-GERDAT, p 302.

Diouf D, Hilu KW. 2005. Microsatellites and RAPD Markers to Study Genetic Relationships Among Cowpea Breeding Lines and Local Varieties in Senegal. Genetic Resources and Crop Evolution **52,** 1057-1067. https://doi.org/10.1007/s10722-004-6107-z

Donovan BJ. 2003. Potential manageable exploitation of social wasps, *Vespula* spp. (Hymenoptera: Vespidae), as generalist predators of insect pests. International Journal of Pest Management **49**(4), 281-285. https://doi.org/10.1080/0967087031000123698

DSA (Direction de la Statistique Agricole). 2024. Les chiffres définitifs de la campagne agricole 2023-2024 au Bénin. MAEP. Cotonou, Bénin. Available Source: https://dsa.agriculture.gouv.bj. March 19, 2025.

Dugje IY, Omoigui LO, Ekeleme F, Kamara AY, Ajeigbe H. 2009. Farmers' Guide to Cowpea Production in West Africa. International Institute of Tropical Agriculture, Ibadan, Nigeria: IITA, p 20.

Dzeme WD, Niba AS, Asiwe JAN. 2010. Effects of insecticide spray application on insect pest infestation and yield of cowpea (*Vigna unguiculata* (L.) Walp) in the Transkei, South Africa. African Journal of Biotechnology **9**(11), 1673-1679. https://doi.org/10.5897/AJB2010.000-3018

Eigenbrode SD, Adhikari S. 2023. Climate change and managing insect pests and beneficials in agricultural systems. Agronomy Journal **115,** 2194-2215. https://doi.org/10.1002/agj2.21399

FAO (Food and Agricultural Organizations of the United Nations). 2017. FAOSTAT. Available Source: http://www.fao.org/faostat/en/#data/QC. January 22, 2024.

Fatondji D, Martius C, Vlek PLG. 2018. Gestion durable des ravageurs du niébé. Agriculture, Ecosystems & Environment **256,** 12-20.

Franke AC, van den Brand GJ, Vanlauwe B, Giller KE. 2018. Sustainable intensification through rotations with grain legumes in Sub-Saharan Africa: A review. Agriculture Ecosystems & Environment **261,** 172-185. https://doi.org/10.1016/j.agee.2017.09.029

Gbaguidi AA., Assogba P, Dansi M, Yedomonhan H, Dansi A. 2015. Caractérisation Agromorphologique Des Variétés de Niébé Cultivées Au Bénin. International Journal of Biological and Chemical Sciences **9**(2), 1050-1066. https://doi.org/10.4314/ijbcs.v9i2.40.

Gopalakrishnan TR. 2007. Vegetable crops, Vol. IV. New Delhi: New India Publishing, 181-187.

Holling CS. 1961. Principles of insect predation. Annual Review of Entomology **6,** 163-182. https://doi.org/10.1146/annurev.en.06.010161.001115

Houenou A, Hinnou CL, Maliki R, Tede S. 2022. Analyse genre de la sélection participative des cultivars locaux de niébé cultivés au centre du Bénin. Annales De l'Université De Parakou - Série Sciences Naturelles Et Agronomie **12**(1), 43-60. https://doi.org/10.56109/aup-sna.v12i1.12

Kamara AY, Omoigui LO, Kamai N, Ewansiha SU, Ajeigbe HA. 2018. Improving Cultivation of Cowpea in West Africa. In: Sivasankar S, Bergvinson D, Gaur P, Kumar S, Beebe S, Tamò M, Eds. Achieving Sustainable Cultivation of Grain Legumes, Vol II. Cambridge, UK: Burleigh Dodds Science Publishing, 235-252. http://dx.doi.org/10.19103/AS.2017.0023.30

Lienard V, Seck D. 1994. Revue des Methodes de Lutte Contre *Callosobruchus Maculatus* (F.) (Coleoptera: Bruchidae), Ravageur des Graines de Niebe (*Vigna Unguiculata* (L.) Walp) en Afrique Tropicale. International Journal of Tropical Insect Science **15,** 301-311. https://doi.org/10.1017/S1742758400017616

MAEP. 2016. Catalogue Béninois Des Espèces Et Variétés Végétales (CaBEV), 2nd Edition. Ministère De L'Agriculture De l'Elevage Et De La Pêche; INRAB/DPVPPAAO/ ProCAD/MAEP & CORAF/WAAPP, Bibliothèque Nationale Du Bénin, 4ème Trimestre Dépôt Légal No. 8982 Du 21 Octobre 2016.

McCarthy BC. 2004. Review of Measuring Biological Diversity, by A. E. Magurran. The Journal of the Torrey Botanical Society, **131**(3), 277-278. https://doi.org/10.2307/4126959

Mohammadou M, Fouelifack-Nintidem B, Adamou M, Taïmanga KD, Tsekane SJ, Ngamaleu-Siewe B, Laure Kenne EL, Yomon AK, Martin Kenne M. 2023. Diversity and Abundance of Pest Insects Associated with *Vigna unguiculata* (L.) Walp., 1843 (Fabales: Fabaceae) in Bockle and Dang Localities (North-Cameroon). American Journal of Entomology **7**(2), 38-61. https://doi.org/10.11648/j.aje.20230702.12

Mukendi R. 2010. Évaluation de l'efficacité de biopesticides botaniques contre l'insecte ravageur (*Ootheca mutabilis* Sahlb. Coleoptera: Chrysomelidae) des feuilles de niébé (*Vigna unguiculata* (L.) Walp.). Mémoire de DEA, Université de Kinshasa, République Démocratique du Congo.

Ndiaye A, Mbow B, Diallo I, BA I, Faye M, Diome T, Brevault T, Sembene M. 2023. Inventory of the entomofauna associated with the cultivation of sweet corn in Senegal: Report of the fall armyworm *Spodoptera frugiperda*. Journal of Entomology and Zoology Studies **11**(3), 9-23. https://doi.org/10.22271/j.ento.2023.v11.i3a.9194

Noyes JS, Valentine EW. 1989. Mymaridae (Insecta: Hymenoptera)-introduction, and review of genera. Fauna of New Zealand **17,** 1-100. https://doi.org/10.7931/J2/FNZ.17

Omoigui LO, Kamara AY, Batieno J, Iorlamen T, Kouyate Z, Yiizagla J, Diallo S, Garba U. 2018. Guide to Cowpea Production in West Africa. Ibadan, International Institute of Tropical Agriculture (IITA), p 52.

Pitan OOR, Odebiyi JA. 2001. Crop losses in cowpea due to the pod-sucking bugs *Riptortus dentipes*, *Mirperus jaculus*, *Anoplocnemis curvipes* and *Nezara viridula*. International Journal of Tropical Insect Science **21**(3), 237-241. https://doi.org/10.1017/S1742758400007633

Poutouli W, Silvie P, Aberlenc HP. 2011. Hétéroptères phytophages et prédateurs d'Afrique de l'Ouest. Wageningen (NLD) ; Versailles : CTA ; Quae, p 79.

Ramade F. 2009. Eléments d'écologie : Ecologie fondamentale - 4e édition. France : Dunod, p 704.

Sahayaraj K, Balasubramanian R. 2016. Reduviid: An Important Biological Control Agent. In: Sahayaraj K, Balasubramanian R, Eds. Artificial Rearing of Reduviid Predators for Pest Management. Singapore: Springer, 1-28. https://doi.org/10.1007/978-981-10-2522-8_1

Santana-Baños Y, Carrodeguas-Díaz S, Rodríguez-Espinosa FL, Pupo-Pérez RA, Díaz-Barrio M, del Busto-Concepción A. 2023. Insects associated with cowpea in agroecosystems of Pinar del Río, Cuba. Revista De Protección Vegetal **38,** 1-4.

Sharma HC, Srivastava CP, Durairaj C, Gowda CLL. 2010. Pest management in grain legumes and climate change. In: Yadav S, Redden R, Eds. Climate Change and Management of Cool Season Grain Legume Crops. Dordrecht: Springer, 115-139. https://doi.org/10.1007/978-90-481-3709-1_7

Simpson EH. 1949. Measurement of diversity. Nature **163,** 688. https://doi.org/10.1038/163688a0

Singh SR, Jackai lEN, Dos Santos JHR, Adalla CB. 1990. Insect pests of cowpea. In: Singh SR, Ed. Insect Pests of Tropical Food Legumes. Chichester, UK: John Wiley and Sons Ltd., 43-89.

Skendžić S, Zovko M, Živković IP, Lešić V, Lemić D. 2021. The impact of climate change on agricultural insect pests. Insects **12**(5), 440. https://doi.org/10.3390/insects12050440

Sodedji FAK, Ryu D, Choi J, Agbahoungba S, Assogbadjo AE, N'Guetta SPA, Jung JH, Nho CW, Kim HY. 2022. Genetic Diversity and Association Analysis for Carotenoid Content among Sprouts of Cowpea (*Vigna unguiculata* L. Walp). International Journal of Molecular Sciences **23**(7), 3696. https://doi.org/10.3390/ijms23073696

Soro L, Soro S, Coulibaly T, Fondio D. 2021. Effect of three synthetic chemical insecticides on *Cheilomenes sulphurea* (Coleoptera: Coccinellidae), a predatory insect in cotton field in Ferkéssedougou, northern Côte d'Ivoire. IOSR Journal of Agriculture and Veterinary Science **14**(2), 14-20. https://doi.org/10.9790/2380-1402021420

Tendeng E, Labou B, Djiba S, Diarra K. 2017. Actualisation de l'entomofaune des cultures maraîchères en Basse Casamance (Sénégal). International Journal of Biological and Chemical Sciences **11**(3), 1023-1028. https://dx.doi.org/10.4314/ijbcs.v11i3.7

Tia E. 1987. Modalités de la transmission du virus de la marbrure du niébé (Cowpea Mottle virus (CMeV)) en Côte d'Ivoire. Mémoire de DAA (Diplôme d'Agronomie Approfondie), ENSEA (Ecole Nationale Supérieure de Statistique et d'Economie Appliquée), Abidjan, p 53.

Traill LW, Lim MLM, Sodhi NS, Bradshaw C. 2010. Mechanisms driving change: altered species interactions and ecosystem function through global warming. Journal of Animal Ecology **79**(5), 937-947. https://doi.org/10.1111/j.1365-2656.2010.01695.x

Tylianakis JM, Binzer A. 2014. Effects of global environmental changes on parasitoid–host food webs and biological control. Biological Control **75,** 77-86. https://doi.org/10.1016/j.biocontrol.2013.10.003

Vongpa V, Amornsak W, Gordh G. 2016. Development, reproduction and longevity of *Aprostocetus* sp. (Hymenoptera: Eulophidae), an egg parasitoid of the Brown Planthopper, *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae), Agriculture and Natural Resources **50**(4), 291-294. https://doi.org/10.1016/j.anres.2016.10.001

Weesie PDM, Belemsobgo U. 1997. Les rapaces diurnes du Ranch de gibier de Nazinga (Burkina Faso). Alauda **65,** 263-278.

Yadav GR, Srivastava P, Mishra VK, Rajveer, Chauhan D. 2017. Diversity of insect fauna associated with cowpea crop ecosystem. Environment and Ecology **35**(2), 630-637.

Zettler JA, Mateer SC, Link-Pérez MA, Bailey J, Demars G, Ness T. 2016. To Key or Not to Key: A New Key to Simplify and Improve the Accuracy of Insect Identification. The American Biology Teacher **78**(8), 626-633. https://doi.org/10.1525/abt.2016.78.8.626