INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 26, No. 1, p. 119-125, 2025

RESEARCH PAPER OPEN ACCESS

Diversity and abundance of insects found on okra *Abelmonchus esculentus* cultivation in Man, Côte d'Ivoire

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Key words: *Abelmonchus esculentus*, *Amrasca biguttula*, *Brachymyrmex patagonicus*, Auxiliary insects, Insect pests

http://dx.doi.org/10.12692/ijb/26.1.119-125 Article published on January 05, 2025

Abstract

Abelmonchus esculentus is an important source of vitamins and minerals. However, okra plants were damaged by insect pests. This study carried out to evaluate the diversity of insects on okra plants in Man locality, for better pest management. Insects were recorded from 21th to 70th Day After Sowing, on *Clemson spineless* okra sown on March 2nd, 2024. A total of 12 species belonging to 6 orders (Hymenoptera, Hemiptera, Orthoptera, Diptera, Lepidoptera, Coleoptera) were collected. The relative abundances of insect pests, predators, parasitoids and pollinators were 55.13%, 17.95%, 7.26% and 19.66% respectively during the vegetative phase, and 69.34%, 17.33%, 5.78% and 7.55% during the reproductive phase, respectively. The Hemiptera *Amrasca biguttula*, *Podagrica decolorata*, *Dysdercus voelkeri*, *Bemisia tabaci*, Lepidoptera *Plutella xylostella* and, Orthopterans *Oecanthus fultonis*, *Locusta migratoria* and *Criotettix bispinosus* are pests. *Sarcophaga* sp (Diptera) is a parasitoid and *Brachymyrmex patagonicus* (Hymenoptera) is a pollinators. The Coleoptera *Coccinella septempunctata*, *Coccinella cheilomenes* and *Alticini* sp are predators. During the vegetative stage, *B. patagonicus* (42.09%) and *A. biguttula* (29.93%) were the most abundant. During the reproductive stage, the highest number of *A. biguttula* (47.6%), *P. decolorata* (15.13%), *D. voelkeri* (13.57%) and *B. patagonicus* (11.59%) were recorded. Shannon and Margalef indices were higher during the reproductive stage (1.645, 1.602) than those of the vegetative stage (1.589, 1.477). The equitability indices are similar (0.66) for both phases. Knowledge of okra entomofauna will help for integrated pest management.

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Introduction

Okra *Abelmonchus esculentus* accounts for around 1.5% of total vegetable production worldwide (Sathish *et al.*, 2013). It is rich in protein, vitamins and minerals (Krishna *et al.*, 2022). In West Africa, this crop ranks second after tomatoes (Birlouez, 2020). In Côte d'Ivoire, *A. esculentus* production is estimated at 185,800 tonnes per year (Soro *et al.*, 2016).

This crop supplements the population's nutritional needs, which consist exclusively of carbohydrates (Diabaté, 2016). The fruit is rich in calcium, iron, carbohydrates, proteins and vitamins (Khomsug *et al.*, 2010). It is widely consumed in Côte d'Ivoire, particularly in the Tonkpi region. In the Tonkpi region, all parts of the okra except the roots are consumed. It is therefore of vital importance to the people of this region. Okra is also used in traditional medicine and industry (Marius *et al.*, 1997). However, okra is attacked by a large number of insect pests, which limit its production. On the other hand, this crop is home to auxiliary insects that help pollinate the plant and limit the outbreak of insect pests. Insect pests consume okra leaves and leave holes in them, resulting in reduced photosynthesis and lower yields (Soro *et al.*, 2016; Diabaté *et al.*, 2024). These insects also attack okra fruits, reducing their market value and negatively influencing food security (Asare-Bediako *et al.*, 2014 ; Birlouez, 2020 ; Zhussip *et al.*, 2024). Biting-sucking insects, in particular *Amrasca biguttula*, *Bemisia tabaci* and *Aphis gossypii*, are major pests of okra and are responsible for over 17% of yield loss (Mandal *et al.*, 2006; Sarkar *et al.*, 2015). To increase okra yields, farmers use pesticides whose doses and application times are not respected. This has led to the emergence of insect resistance to a wide range of insecticides (Srinivas *et al.*, 2004; Diabaté, 2016; Bade and Bhamare, 2023). Pest management requires a good knowledge of the organisms for targeted control. The general objective of this study was to assess the diversity of insects infested with the okra crop established in the locality of Man, for better pest management. The aim is to determine the insects that are present on okra during the vegetative and reproductive phases.

Materials and methods

Study site

Okra, Clemson spineless variety was sown on March 2, 2024, in stacks over a quarter-hectare in the entomological plot at the University of Man (7°21'09"N and 7°36'57"W), in the Tonkpi region, west of Côte d'Ivoire. Three seeds were sown in clusters with a distance of 60 cm between rows and 60 cm between plants. After germination, the plants were separated to obtain two plants per cluster. The plot was weeded as required. The climate of this region is tropical, with one dry and one rainy seasons. The average annual temperature and rainfall were 25.0°C and 1,632 mm, respectively. Ferralitic soils of average chemical fertility were predominant (Tiessé, 2020).

Insect sampling, conservation and identification

The insects were recorded on okra plants from the 21st to the 70th day after grains sowing, from 6 a.m. to 11 a.m. weekly on 12 plants per elementary plot. During each observation, the lower and upper of the leaves were checked for the presence or absence of insect pests. Insect larvae were captured using flexible forceps. The numbers of each species were recorded. Specimens of each insect species were then preserved in small plastic jars containing 70% alcohol. Insects were identified on the basis of family recognition keys (Roth, 1974; Delvare and Aberleng, 1989).

Relative abundance (AR) and frequency of occurrence (FO) of insects on okra plants

The relative abundance (RA) of insects on okra plants were calculated according to the following formula:

$$AR\ (\%) = \frac{n * 100}{\mathrm{N}} \quad (1)$$

Where,

n = total number of individuals collected for a given species;

N= total number of individuals collected.

The occurrence frequency (Fo) of insects on okra plants were calculated using the following formula:

$$Fo(\%) = \frac{a * 100}{\mathrm{A}} \quad (2)$$

Where,
a = Number of plants sampled with the given insect;
A = Total number of plants sampled.

The species were then classified according to its frequency of occurrence. It is said to be rare (Fo < 5%), incidental (5% ≤ Fo < 25%), frequent (25% ≤ Fo <50%), constant (50% ≤ Fo < 100%) or ubiquitous (Fo = 100%) (Dajoz, 2006; Akpesse *et al.*, 2022).

Determination of species richness and diversity

Specific richness (S), which is the total number of insect species collected in okra fields, is determined. Biological diversity indices were evaluated by calculating the Shannon (H'), Margalef and equitability indices.

Shannon diversity index

The Shannon index (H') simultaneously takes into account the specific richness and abundance of the different insect families found on a plot. This index is calculated according to the following formula:

Shannon diversity index (H')= - Σ pi ln pi (3)

Where:
pi = probability of encountering family i,
pi=ni/N ; ni = abundance of species i,
and N = total abundance.

Margalef index

The Margalef index is used to determine insect diversity at a given site. It is calculated according to the following formula :

$$d = \frac{(S-1)}{\ln N} \quad (5)$$

Where:
N = total number of individuals of a species
and S = species richness.

Equitability index

The equitability index (E) was used to determine the equitable distribution of individuals. Its aim was to observe the equilibrium of the populations. This index was determined according to the following formula:

$$E = \frac{H'}{\ln S} \quad (4)$$

with : H' = Shannon Diversity Index,
and S = Species Richness.
The value of E varies from 0 (dominance of one species) to 1 (equitable distribution of individuals).

Statistical analysis

The number of insects collected on okra plants was subjected to an analysis of variance (ANOVA main effects, p < 5%) using SPSS Statistic version 20 software. The means were discriminated using XLSTAT 2016 software (Fisher LSD test, p < 5%). Shannon, equitability and Margalef indices were determined using Estimate version 22.0 software (IBM, New York, USA).

Results

Insects diversity on okra plants

A total of 11 insect species with 872 individuals were observed during the vegetative phase and 12 species with 958 individuals during the reproductive phase. The Shannon index is greater than 1.5 during the vegetative and reproductive phases of okra. It is higher during the reproductive stage, with a value of 1.65, than during the vegetative stage (1.59). This insect diversity is confirmed by the Margalef index, which showed a higher value (1.60) during the reproductive stage than during the vegetative stage (1.48). The equitability indices obtained during the vegetative and reproductive stages are equal to 0.66. These values, close to 0.5, show that there is no equitable distribution of okra-infested insects (Table 1).

Table 1. Biodiversity index for okra insects

Diversity indices	Vegetative stage	Reproductive stage
Individuals	872	958
Taxa_S	11	12
Shannon_H	1.59	1.65
Margalef	1.48	1.60
Equitability_J	0.66	0.66

Frequency of occurrence of okra insects

In the course of this study, 6 insect orders were sampled. These were the orders Hymenoptera, Hemiptera, Orthoptera, Diptera, Lepidoptera and Coleoptera. Lepidoptera were rare (Fo < 5%),

Diptera and Orthoptera were accessory (5% ≤ Fo < 25%), and Coleoptera and Hemiptera were frequent (25% ≤ Fo <50%) on okra plants. Their frequencies of occurrence were respectively 35.04% and 38.67% for Coleoptera, 3.85% and 3.11% for Lepidoptera, 7.26% and 5.75% for Diptera, 12.36% and 12% for Orthoptera and 21.8% and 32.89% for Hemiptera during the vegetative and reproductive stages (Fig. 1A).

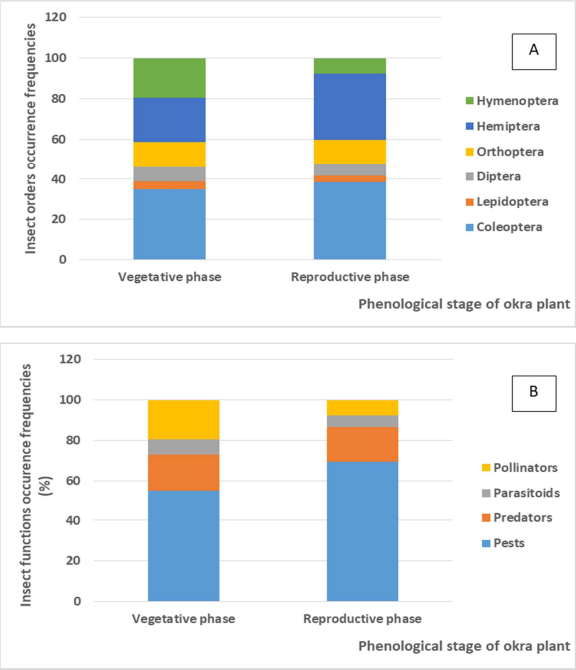

Fig. 1. Occurrence frequencies of insect orders (A) and their functions (B) recorded on okra plant

The insects collected were grouped into 4 categories: pests, predators, parasitoids and pollinators. The frequencies of insect pests, predators, parasitoids and pollinators are 55.13%, 17.95%, 7.26% and 19.66% respectively during the vegetative phase, and 69.34%, 17.33%, 5.78% and 7.55% during the reproductive phase (Fig. 1B). The insects *Amrasca biguttula* (Hemiptera: Cicadellidae) (Fig. 2a), *Podagrica decolorata* (Hemiptera: Chrysomelidae) (Fig. 2b), *Dysdercus voelkeri* (Hemiptera: Pyrrhocoridae) (Figs 2c,d), *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), *Plutella xylostella* L. (Lepidoptera: Plutellidae) (Fig. 2e), *Oecanthus fultonis* (Orthoptera: Gryllidae), *Locusta migratoria* (Ortoptera: Acrididae) and *Criotettix bispinosus* (Orthoptera: Tettrigidae) are pests. Hemipterans attached to okra are sucking, biting insects. They sting leaves and stems and inject viruses, resulting in loss of raw and processed sap, reduced photosynthesis, disease outbreaks and lower yields. *Sarcophaga* sp (Diptera: Sarcophagidae) is a parasitoid and *Brachymyrmex patagonicus* (Hymenoptera: Formicidae) is a pollinator (Fig. 2f). In addition, *Coccinella septempunctata* (Coleoptera: Coccinellidae), *Coccinella cheilomenes* (Coleoptera: Coccinellidae) (Fig. 2g) and *Alticini* sp (Coleopera: Chrysomelidae) (Fig. 2h) are predators. Parasitoids, predators and pollinators help increase okra yields. Parasitoids and predators attack insect pests, reducing their numbers and attacks.

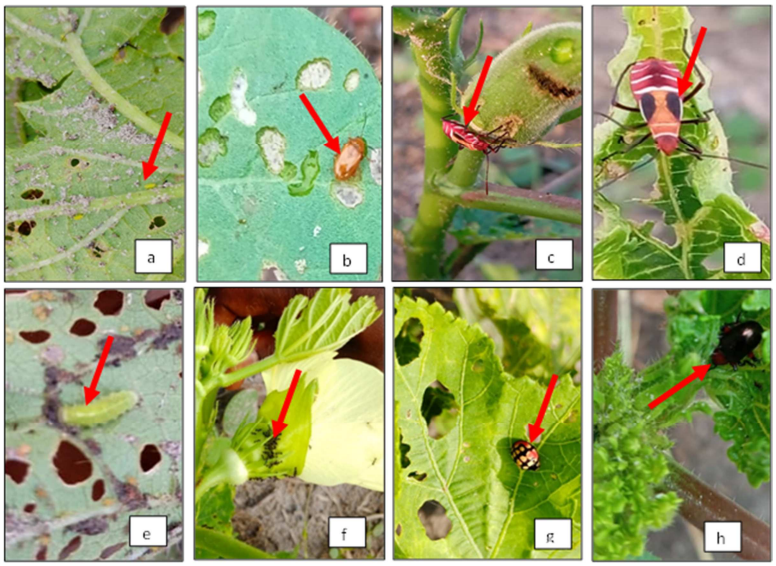

Fig. 2. Some insects associated with okra plant (a : *Amrasca biguttula*, b : *Podagrica decolorata*, c & d : *Dysdercus voelkeri*, e : larve de *Plutella xylostella*, f : *Brachymyrmex patagonicus*, g : *Coccinella cheilomenes*, h : *Alticini* sp).

Table 2. Relative abundance and insects collected functions in the okra plants during the vegetative and reproductive phases

Insects recorded	Insect status	Vegetative phase		Reproductive phase	
		N	AR (%)	N	AR (%)
Podagrica decolorata	R	20 ± 2.82^{c}	9.18	36.25 ± 9.25^{b}	15.13
Coccinella septempunctata	Pre	5.50 ± 1.73^{d}	2.52	4.75 ± 0.95^{c}	1.98
Coccinella cheilomenes	Pre	17.75 ± 3.94^{c}	8.14	1.75 ± 0.5^{c}	0.73
Plutella xylostella	R	2.25 ± 0.95^{d}	1.03	1.75 ± 0.5^{c}	0.73
Sarcophaga sp	Par	4 ± 2.58^{d}	1.83	3.75 ± 2.21^{c}	1.57
Oecanthus fultonis	R	3 ± 1.41^{d}	1.38	3 ± 1.15^{c}	1.25
Locusta migratoria	R	1.75 ± 0.95^{d}	0.8	1.75 ± 0.95^{c}	0.73
Criotettix bispinosus	R	3 ± 2.30^{d}	1.38	2.75 ± 1.70^{c}	1.15
Brachymyrmex patagonicus	P	91.75 ± 12.68^{a}	42.09	27.75 ± 14.38^{b}	11.59
Amrasca biguttula	R	65.25 ± 12.8^{b}	29.93	114 ± 22.46^{a}	47.6
Dysdercus voelkeri	R	0 ± 0^{d}	0	32.50 ± 14.79^{b}	13.57
Alticini sp	R	0 ± 0^{d}	0	9.50 ± 5.26^{c}	3.97
Bemisia tabaci	R	3.75 ± 2.21^{d}	1.72	0 ± 0^{c}	0
F		118.495	-	48.767	-
p		0.000	-	0.000	-

AR = relative abundance, N = number of insects recorded, P = pollinators, Par = parasitoids, Pre = predators, R= pests. Means with the same letter in the same column do not differ statistically from each other (Fisher LSD test, $p < 0.05$).

Relative abundance of insects associated with okra cultivation

The Coleoptera species *C. septempunctata*, *C. cheilomenes* and *Alticini* sp, the Lepidoptera *P. xylostella*, the Diptera *Sarcophaga* sp, the Orthoptera *O. fultonis*, *L. migratoria*, *C. bispinosus*, the Hymenoptera *B. patagonicus* and the Hemiptera *A. biguttula*, *P. decolorata*, *D. voelkeri*, and *B. tabaci* were collected from okra plants. The Hemipterans *D. voelkeri* and the Coleoptera *Alticini* sp were not observed during the vegetative stage. During the reproductive phase, *B. tabaci* was not observed. Then, during the vegetative stage, *B. patagonicus* and *A. biguttula* were the most abundant, with frequencies of 42.09% (91.75 individuals) and 29.93% (65.25 individuals), respectively. They were followed by *P. decolorata* (9.18% or 20 individuals), *C. cheilomenes* (8.14% or 17.75 individuals), *C. septempunctata* (2.52% or 5.5 individuals), *Sarcophaga* sp (1.83% or 4 individuals), *B. tabaci* (1.72% or 3.75 individuals), *O. fultonis* (1.38% or 3 individuals), *C. bispinosus* (1.38% or 3 individuals), *P. xylostella* (1.03% or 2.25 individuals), *L. migratoria* (0.8% or 1.75 individuals) ($F = 118.495$; $p = 0.000$). During the breeding stage, *A. biguttula, P. decolorata, D. voelkeri* and *B. patagonicus* were the most abundant, with frequencies of 47.6%, 15.13%, 13.57% and 11.59%, respectively. The insects *Alticini* sp. (3.97%), *C. septempunctata* (1.98%), *Sarcophaga* sp (1.57%), *O. fultonis* (1.25%) and *C. bispinosus* (1.15%) were sparsely observed on okra plants during the reproductive stage. The numbers of *C. cheilomenes*, *P. xylostella* and *L. migratoria* were very low, below 1% on the plants. Their frequencies are identical and equal to 0.73%, i.e. 1.75 insects ($F = 48.767$; $p = 0.000$) (Table 2).

Discussion

The insects collected on okra plants belong to 6 orders which were the orders of Hymenoptera, Hemiptera, Orthoptera, Diptera, Lepidoptera and Coleoptera. In the vegetative phase 872 insects were recorded from 11 insect species, while the reproductive phase 958 individuals were recorded from 12 species. Similar results were obtained by Boateng *et al.* (2019) in Ghana. According to these authors, the orders Coleoptera, Hemiptera, Lepidoptera, Hymenoptera, Orthoptera and Mantodea are all related to okra cultivation. In addition, the families Coccinellidae, Cicadellidae, Formicidae, Chrysomelidae, Aleyrodidae and Acrididae were the most abundant. These insects belong to the pest, parasitoid, predator and pollinator groups. The insect pest *A. biguttula* was

the most numerous during the vegetative and reproductive phases. These results are in line with those of Challa *et al.* (2020), who showed that jassid numbers ranged from 3.5 jassids/6 leaves on day 44 after sowing to 4 jassids/leaf on day 47 after sowing. The four Hemiptera *A. biguttula, P. decolorata, D. voelkeri* and *B. tabaci* are insect pests of okra. *A. biguttula, D. voelkeri* and *B. tabaci* are sucking biters. They bite the leaves and stems of plants and inject disease-causing viruses (Ugwoke and Onyishi, 2009; Ojiako *et al.*, 2018; Krishna *et al.*, 2022). *P. decolorata* and orthopterans consume okra leaves, reducing leaf area and lowering yield (Ugwoke and Onyishi, 2009; Soro *et al.*, 2016; Diabaté *et al.*, 2024). Work by Mandal *et al.* (2006), Sarkar *et al.* (2015) and Ojiako *et al.* (2018) has shown that *Podagrica* spp., *Dysdercus* spp. and *B. tabaci* are the major insect pests that infest leaves and considerably reduce yield. Yield losses can reach 18%. Orthopterans sometimes cut young plants, reducing plant density. These defoliating insects destroy the plant and cause its death (Zhussip *et al.*, 2024). According to Krishna *et al.* (2022), these insect pests are responsible for major yield losses in okra.

Conclusion

Six insect orders comprising 12 species were collected from okra plants. These were Hymenoptera (*B. patagonicus*), Hemiptera (*A. biguttula, P. decolorata, D. voelkeri, B. tabaci*), Orthoptera (*O. fultonis, L. migratoria and C. bispinosus*), Diptera (*Sarcophaga* sp.), Lepidoptera (*P. xylostella*) and Coleoptera (*C. septempunctata, C. cheilomenes* and *Alticini* sp.). The insects collected were divided into four groups: pests, predators, parasitoids and pollinators. During the vegetative stage, *B. patagonicus* and *A. biguttula* were the most abundant. During the reproductive stage, *A. biguttula, P. decolorata, D. voelkeri* and *B. patagonicus* were the most numerous. The Shannon and Margalef indices are 1.65 and 1.60 during the breeding stage and 1.59 and 1.48 during the vegetative stage. Equitability indices were equal to 0.66 for both phases.

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