INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print); 2222-5234 (Online)
Website: https://www.innspub.net
Email contact: info@innspub.net
Vol. 27, Issue: 5, p. 147-158, 2025

RESEARCH PAPER OPEN ACCESS

Diversity and abundance of entomofauna associated with the cashew tree (*Anacardium occidentale* L.) and pest damage in the Gbêkê Region (Central Côte d'Ivoire)

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Key words: Cashew, Insect pests, Biodiversity assessment, Stem and fruit borers, *Diastocera trifasciata*, Integrated pest management, Côte d'Ivoire

DOI: https://dx.doi.org/10.12692/ijb/27.5.147-158 Published: November 14, 2025

ABSTRACT

The cashew tree represents a strategic resource in Côte d'Ivoire due to its economic importance and high production. However, the entomological complex associated with this crop is still unexplored. This study has been carried out to characterize the abundance, diversity and types of damage caused by insects associated with the cashew tree. Data were collected from 1 June 2023 to 31 July 2024 in a cashew plantation. Field observations were used to identify insect pests and beneficial insects, as well as visible damage to different parts of the tree. The collection was carried out using various methods: by hand, with sweep nets, wine traps and the knock-down technique. The specimens were preserved in 70° alcohol for identification in the laboratory. A total of 6,587 insects were recorded, with a Shannon diversity index (H') of 3.54 and an evenness index (J) of 0.81. Beneficial insects are dominated by Hymenoptera (54.16%) and Lepidoptera (16.67%). The main pests belong to the orders Hemiptera (43.18%, 19 species) and Coleoptera (38.63%, 17 species), causing damage to the entire tree: young shoots, leaves, inflorescences, fruits and stems. Three functional groups of pests have been identified: stem and root borers (*Apate terebrans*, *Plocaederus ferrugineus*), the girdler (*Diastocera trifasciata*) and sap-sucking insects such as *Helopeltis* sp., *Pseudococcus longispinus*, *Pseudotheraptus devastans*, *Pachnoda* sp. and *Stephanorrhina guttata*. Further research is essential to better understand their biology and implement effective integrated pest management strategies, particularly in West African orchards, especially in Côte d'Ivoire.

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INTRODUCTION

The cashew tree (*Anacardium occidentale* L., 1753) is a perennial plant that contributes to the socioeconomic development of the Ivorian cotton-growing region. Initially used to combat environmental degradation in savanna regions, the cashew tree has now become a genuine cash crop (Koffi and Oura, 2019). For several years now, cashews have been one of Côte d'Ivoire's main export industries, due to growing global demand for its nuts on the international market (Ruf *et al.*, 2019). Between 2006 and 2018, Côte d'Ivoire's production of raw cashew nuts (RCN) increased from 235,000 tons to 761,000 tons, making Côte d'Ivoire the leading producer and exporter of RCN (FIRCA, 2018). The sector employs 1.5 million people and has 250,000 producers in Côte d'Ivoire (FIRCA, 2018). However, many challenges remain. The high national production is mainly linked to the expansion of cultivated areas, which increased from 8,220 hectares in 1970 to around 450,000 hectares in 2008 in the northern and central regions of Côte d'Ivoire. Ivorian orchards are composed of unselected trees of various origins with poorly understood agronomic characteristics. It should also be noted that there is significant pest pressure due to diseases and insect pests.

More advanced research has been conducted in Asia, particularly in India, Vietnam, and China, where the cashew industry is long-established and highly structured (Topper *et al.*, 2001; Zhang *et al.*, 2013). This work has made it possible to better characterize certain specific pests such as the tea mosquito bug (*Helopeltis* spp.), stem borers, and fruit-sucking insects, as well as to develop integrated pest management strategies combining monitoring, cultural practices, biological control, and the judicious use of biopesticides. At the regional level, inventories conducted in other West African countries also reveal a highly diverse entomofauna. For example, 170 insect species have been recorded in Ghana (Dwomoh *et al.*, 2008), 141 in Nigeria (Asogwa *et al.*, 2009), and 262 in Benin (Agboton *et al.*, 2014). These studies show a predominance of Coleoptera and Hemiptera among the major pests, confirming that pest pressure on cashew trees is a phenomenon common to the entire subregion. In Côte d'Ivoire, the few studies conducted on the entomofauna of cashew trees were carried out over a short period (Akessé *et al.*, 2015; N'Dépo *et al.*, 2017). These harmful insects and their control methods, which are little known or poorly understood, significantly affect tree productivity (Diabaté, 2007; Ouali N'Goran *et al.*, 2020). Although currently the world's leading producer of cashew nuts, Côte d'Ivoire still has little systematic data on the diversity and annual dynamics of the populations of several insects that infest cashew trees.

This lack of taxonomic and ecological knowledge limits the implementation of effective integrated pest management programs. Hence the need for studies covering the complete annual cycles of cashew trees in order to harmonize pest monitoring and management approaches. The objective of this study is therefore to determine the abundance and diversity of insect populations associated with cashew cultivation. Specifically, it aims to identify insect pests and the damage they cause, as well as beneficial insects, over the plant's annual cycle.

MATERIALS AND METHODS

Presentation of the study area

The study was conducted in the town of Brobo, located in central Côte d'Ivoire. It is located 20 km east of Bouaké on the Bouaké-M'Bahiakro road. This area belongs to the Sudano-Guinean zone, which is characterized by four seasons: a long dry season (November to February), a long rainy season (March to June), a short dry season (July to August), and a short rainy season (September to October). Rainfall varies between 1,200 and 1,500 mm, but is erratic (FAO, 2005).

The climate is transitional equatorial, with average temperatures ranging from 20°C to 27.5°C. Relative humidity varies from 57% to 85% (FAO, 2005). In this locality, a 3-hectare peasant cashew plantation was chosen as the study site (07°36.598N, 004°49.590W and 234 m altitude). The studies were conducted from June 1, 2023, to July 31, 2024.

Materials

Sampling of cashew tree pests and beneficial insects was carried out using wine traps and sweep nets. Individuals within reach were also captured and visual observations of damage were made. The studies were conducted from June1, 2023, to July 31, 2024. Photographs of certain insect specimens and the damage they caused were taken using a NIKON COOLPIX B700 digital camera manufactured by NIKON (Nikon Canada Inc. 1366 Aerowood Drive Mississauga, Ontario L4W 1C1 (905) 625-9910).

Description and construction of traps

The type of trap used in this study is the one described by Allemand and Aberlenc (1991). The container used to make the traps is a 1.5-liter modified plastic (PVC) bottle. The bottle is cut at the base of the upper conical section and the neck. The diameter of the entrance hole must be small to limit evaporation and the entry of rainwater. After fitting the conical section into the lower section, two diametrically opposed holes are drilled to allow the trap to be hung. Two other holes, also opposite each other, are drilled in the same plane, above the lower level of the neck, to prevent the trap from filling with rainwater. The device for hanging the trap in trees is made of soft wire twisted to form an inverted Y, with the branches curved at the ends to hold the container and the other end curved into a hook perpendicular to the Y. The curved part used for hanging on trees must be well bent into a semicircle to prevent it from falling (Fig. 1).

Fig. 1. Wine trap used to collect insects

A : Trap before installation on the cashew tree; B : Trap hung on a cashew tree branch

Setting and checking traps

Each bottle contains a mixture of 300 ml of palm wine and a teaspoon of salt (sodium chloride). The insects are attracted to the drink. Adding salt to the mixture limits fermentation by the insects, prevents the growth of bacteria, and thus allows for longer intervals between replacements of up to 15 days (Allemand and Aberlenc, 1991). The trapping device consists of 30 traps hung on cashew tree branches with wire, to which solid grease (used in mechanics) is applied. This grease repels predators and thus prevents the insects caught in the traps from being eaten by *Oecophylla longinoda (*Latreille, 1802) weaver ants. Surveys were conducted during the first and last week of each month from June1, 2023, to July 31, 2024.

The captured insects were rinsed several times with water before being stored in labeled plastic jars containing 70° alcohol. They were then taken to the laboratory for identification using keys.

Identification of samples

The following guides were used to identify the specimens:

1. Roth (1980) for the orders Lepidoptera and Isoptera,
2. Delvare *et al.* (1989) for orders Diptera Tephritidae and Isoptera;
3. Rigout (1989) for species of the tribe Cetoniini, *Pachnoda*;
4. Allard (1993) for species of the Sternotomini tribe such as *Zographus* and *Sternotomis*; -Poutouli *et al.* (2011) for Heteroptera such as Coreidae and Reduviidae;
5. Yéboué *et al.* (2012) for *Anoplocnemis curvipes* species;
6. Bouchard *et al.* (2016) for beetles of the genera *Cetnonia* and *Pachnoda*.

Distinctive characteristics were observed using a Euromex (Holland) Model BMK 31162 binocular microscope (Euromex Microscopen bv, Typograaf 8, 6921 VB Duiven, The Netherlands) to facilitate identification.

Data analysis

The data collected during this study were analyzed using ecological indices. Four measures of diversity were used: the Shannon-Wiener diversity index (H'), relative frequency (Fr), frequency of occurrence (FO), and the evenness index (J).

The Shannon-Wiener diversity index (H') was calculated using the formula provided by Ramade (1984):

$$H' = -\sum_{i=1}^{s} qi \ln(qi)$$

qi is the relative abundance of each species. It is the ratio of the number of individuals of a given species (*ni*) to the total number of individuals in the community (*N*).

Relative frequency (Fr) is a concept that allows a species, category, class, or order (*ni*) to be evaluated in relation to the total animal population of all species combined (*N*) in a faunal inventory (Faurie *et al.*, 1980). It was calculated using the following formula :

$$Fr = ni/N$$

ni: sum of all contacts with species *i* at each stage of counting; N: ∑ni: sum of contacts with all species observed at each stage.

The Frequency of Occurrence (FO) is the ratio expressed as a percentage of the number of surveys containing the species studied, relative to the total number of surveys (Dajoz, 1982). It is calculated using the following formula:

$$FO\ (\%) \frac{Pi}{P} x100$$

Pi: number of surveys containing the species studied; P: total number of surveys conducted.

Depending on the FO value, the following categories are distinguished: omnipresent species if FO = 100%; constant species if 75% ≤ FO < 100%; regular species if 50% ≤ FO < 75%; accessory species if 25% ≤ FO < 50%; accidental species if 5% ≤ FO < 25%; rare species if FO < 5%.

RESULTS

Specific composition of insects

All of the capture methods used in this study resulted in the recording of 79 species divided into 8 orders and 34 families. The orders Coleoptera and Hemiptera were the most diverse, accounting for 32.91% and 27.85% of the insects collected, respectively. The least represented orders were Blattodea (3.80%), Mantodea (3.80%) and Orthoptera, with 2.53% of the recorded insect population (Table 1). The distribution of insects by family showed that the most represented were Cerambycidae and Cetoniidae with 10 species each, followed by the Coreidae family with 6 species. Sixteen families were less represented (Table 1).

Abundance of the insect population

A total of 6,587 individuals of insects associated with the cashew tree were collected at the study site, with a Shannon diversity index (H') of 3.54 and an evenness index (J) of 0.81 . The results of the occurrence frequencies identified 2 ubiquitous species (2.53%), 17 constant species (21.52%), 26 regular species (32.91%), 24 accessory species (30.38%) and 10 accidental species constituting 12.66% of all species recorded (Table 1).

Distribution of species according to status

The classification of species according to their impact on cashew trees shows that 42 species are harmful, representing 53% of the species inventoried. Twenty-two species are beneficial insects, representing 28% of the entomofauna, and fifteen species, or 19%, have not been identified. The latter have been classified in the "other" category. Among the insects that are pests of the cashew tree, the orders Hemiptera and Coleoptera comprise 19 (43.18%) and 17 species (38.63%) respectively. Furthermore, the major pests were recorded in these two insect orders. Beneficial insects are mainly represented by species belonging to the order Hymenoptera, with 54.16%, and Lepidoptera, with 16.67% of the insect population (Fig. 2).

Table 1. Insect species collected on the cashew ochard from June 1, 2023 to July 31, 2024

Orders	Famillies	Species	Total	Frequencies (%)	Categories
Blattodea (3,80 %)	Ectobiidae	*Blattela* sp.	20	0,30	Accessory
	Termitidae	*Anoplotermes* sp.	13	0,20	Accessory
		Macrotermes bellicosus (Smeathman, 1781)	93	1,41	Constant
Coleoptera (32,91 %)	Bostrichidae	*Apate monachus* Fabricius, 1775	15	0,23	Regular
		Apate terebrans (Pallas, 1772)	74	1,12	Regular
	Cerambycidae	*Ancylonotus tribulus* (Fabricius, 1775)	2	0,03	Accidental
		Ceroplesis analeptoides Lepesme, 1950	31	0,47	Regular
		Diastocera trifasciata (Fabricius, 1775)	815	12,37	Constant
		Mallodon downesi Harold, 1879	3	0,05	Accidental
		Neoplocaederus ferrugineus (Linnaeus, 1758)	10	0,15	Accessory
		Paranaleptes reticulata (Breuning, 1937)	89	1,35	Regular
		Philematium festivum (Fabricius, 1775)	26	0,39	Accessory
		Prosopocera bipunctata (Drury, 1773)	162	2,46	Constant
		Tithoes confinis (Castelnau, 1840)	1	0,02	Accidental
		Zographus regalis (Brown, 1776)	97	1,47	Regular
	Cetoniidae	*Chlorocala* sp.	57	0,87	Regular
		Chlorocala africana (Drury, 1773)	160	2,43	Constant
		Diplognatha gagates (Forster, 1771)	53	0,80	Constant
		Eudicella aethiopica (Müller, 1941)	35	0,53	Regular
		Lophorrhina quinquelineata (Fabricius, 1781)	75	1,14	Accessory
		Pachnoda babaulti (Bourgoin, 1921)	1073	16,29	Constant
		Pachnoda cordata (Drury, 1773)	175	2,66	Constant
		Pachnoda marginata (Drury, 1773)	102	1,55	Regular
		Phonotaenia balteata (De Geer, 1778)	236	3,58	Regular
		Phonotaenia scalaris (Gory & Percheron, 1833)	136	2,06	Constant
	Elateridae	*Pachyderes* sp.	4	0,06	Accessory
	Meloidae	*Mylabris bifasciata* (De Geer, 1778)	15	0,23	Accessory
	Scarabaeidae	*Scarabaeus sacer* (Linnaeus, 1758	11	0,17	Accessory
	Tenebrionidae	*Lagria villosa* (Fabricius, 1781)	5	0,08	Accidental
Diptera (7,59 %)	Drosophilidae	*Drosophilla* sp.	56	0,85	Regular
	Calliphoridae	*Chrysomya megacephala* (Fabricius, 1794)	19	0,29	Accessory
	Syrphidae	*Ischiodon* sp.	2	0,03	Accidental
	Tephritidae	*Bactrocera dorsalis* (Hendel, 1912)	266	4,04	Constant
		Bactrocera invadens (Drew, Tsuruta & White, 2005)	94	1,43	Regular
		Ceratitis capitata (Wiedemann, 1824)	26	0,39	Regular
Hemiptera (27,85 %)	Alydidae	*Mirperus jaculus* (Thunberg, 1783)	133	2,02	Accessory
		Riptortus dentipes (Fabricius, 1787)	81	1,23	Constant
	Aphididae	*Aphis aurantii* (Boyer de Fonscolombe, 1841)	84	1,28	Accessory
		Aphis gossypii (Glover, 1877	98	1,49	Regular
	Aphrophoridae	*Aphrophora alni* (Fallén, 1805)	8	0,12	Accidental
	Coccidae	*Udinia catori* (De Lotto, 1963	145	2,20	Regular
	Coreidae	*Anoplocnemis curvipes* (Fabricius, 1781)	100	1,52	Constant
		Clavigralla tomentosicollis (Stål, 1855)	66	1,00	Constant
		Cletus sp.	55	0,83	Accessory
		Homoeocerus pallens (Fabricius, 1781)	21	0,32	Regular
		Leptoglossus occidentalis (Heidemann, 1910)	23	0,35	Regular
		Pseudotheraptus devastans (Distant, 1917)	211	3,20	Constant
	Miridae	*Helopeltis schoutedeni* (Reuter, 1906)	90	1,37	Regular
	Pentatomidae	*Boerias ventralis* (Dallas, 1851)	87	1,32	Regular
		Nezara viridula (Linnaeus, 1758)	68	1,03	Regular
		Pseudatelus sp.	27	0,41	Regular
		Pseudatelus spinulosa (Palisot de Beauvois)	17	0,26	Accessory
	Pseudococcidae	*Paracoccus spinulosus* (De Lotto, 1961)	12	0,18	Accessory
	Pyrrhocoridae	*Dysdercus voelkeri* (Schmidt, 1932)	197	2,99	Constant
	Reduviidae	*Dinocleptes inops* (Stål, 1865)	5	0,08	Accessory
		Rhynocoris albopilosus (Signoret, 1858)	23	0,35	Accessory
		Rhynocoris bicolor (Fabricius, 1781)	13	0,20	Regular
Hymenoptera (16,46 %)	Apidae	*Apis mellifera* (Linnaeus, 1758)	188	2,85	Ubiquitous
		Bombus sp.	5	0,08	Accessory

		Meliponula bocandei (Spinola, 1853)	15	0,23	Accessory
		Trigona sp.	33	0,50	Regular
	Braconidae	*Bracon* sp.	2	0,03	Accidental
		Iphiaulax sp.	13	0,20	Regular
	Eumenidae	*Belonogaster juncea* (Fabricius, 1781)	22	0,33	Regular
		Synagris cornuta (Linnaeus, 1758)	5	0,08	Accessory
	Formicidae	*Camponotus* sp.	12	0,18	Accessory
		Crematogaster africana (Mayr, 1895)	54	0,82	Constant
		Dorylus nigricans (Illiger, 1802)	10	0,15	Accessory
	Vespidae	*Polistes* sp.	16	0,24	Accessory
		Ropalida sp.	10	0,15	Accidental
Lepidoptera (5,06 %)	Arctiidae	*Euchromia lethe* (Fabricius, 1775)	4	0,06	Accidental
	Gracillaridae	*Eteoryctis syngramma* (Meyrick, 1914)	128	1,94	Constant
	Nymphalidae	*Charaxes fulvescens* (Aurivillius, 1891)	144	2,19	Constant
		Charaxes jasius (Linnaeus, 1767)	150	2,28	Regular
Mantodea (3,80 %)	Mantidae	*Mantis religiosa* (Linnaeus, 1758)	50	0,76	Regular
		Sphodromantis lineola (Burmeister, 1838)	11	0,17	Accessory
	Tarachodidae	*Tarachodes afzelii* (Stal, 1871)	9	0,14	Accessory
Orthoptera (2,53 %)	Pyrgomorphidae	*Zonocerus variegatus* (Linnaeus, 1758)	86	1,31	Ubiquitous
	Tettigoniidae	*Phaneroptera sparsa* (Stål, 1857)	5	0,08	Accidental

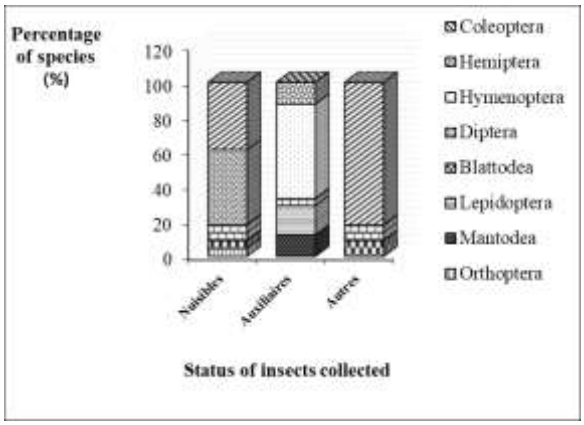

Fig. 2. Distribution of species according to status

Typology of insect pests identified according to the organs attacked

The insect pests captured were classified into three categories according to the organ attacked. Thus, a distinction is made between pests of branches and/or trunks, pests of fruit, and pests of leaves (defoliators):

Main pests of branches, trunks, roots, and the damage they cause

There are three species, all belonging to the order Coleoptera. Two species, the girdler *Diastocera trifasciata* and the trunk and root borer *N. ferrugineus*, belong to the Cerambycidae family. The last identified species, A. *terebrans*, from the Bostrichidae family, is a borer of cashew tree trunks and branches.

In the case of *D. trifasciata*, only the adults are responsible for the damage. Observations show that attacks first appear as small areas of bark gnawed away by an adult pair (male and female). This area is then gradually consumed in a circular pattern, from the outer layers towards the heartwood of the branch or tree trunk. When the attack is severe, the branch is weakened and breaks instantly. The attack surface then looks like a branch cut with a carpenter's saw (Fig. 3). The branches and/or stems attacked have circumferences between 8.1 and 30 cm, with an average of 17.63 ± 2.86 cm. Their lengths range from 1.50 to 3.25 cm, with an average length of 2.4 ± 0.54 cm. These measurements were taken on 407 branches cut by the species. An orchard attacked by this species is characterized by a multitude of cut branches, some of which remain hanging on the trees and others littering the orchard floor.

Fig. 3. Attacks and damage caused by the chisel beetle *Diastocera trifasciata* on cashew trees

A: pair of *D. trifasciata* attacking a cashew tree branch; B : branch cut by a pair of *D. trifasciata*; C : attack surface of a cut branch

Fig. 4. Damage caused by the borer *Neoplocaederus ferrugineus* on cashew trees

A : Sawdust resulting from the activity of larvae in the tree; B : Cashew tree damaged by *N. ferrugineus* larvae

Unlike *D. trifasciata, N. ferrugineus* attacks are carried out by larvae that generally live and feed at the base of trees, specifically in the root zone. They thus divert most of the nutrients intended for the cashew tree. Severe attacks cause trees to decline and eventually die (Fig. 4).

The damage caused by adult *A. terebrans* is visible from the outside of the trees through the holes from which their droppings and sawdust escape. The attack begins with an individual perforating the trunk and/or branches. Gradually, the various holes made by the individuals join together inside the tree, thus forming large tunnels or galleries. These passages grow larger and larger as the adults feed. This disrupts the tree's vascular system and stunts its growth. A severe attack on the tree, characterized by multiple holes, leads to a drastic decline in production or death. When the attack is localized on the branches, they become fragile and break (Fig. 5).

Fig. 5. Damage caused by the borer *Apate terebrans* to cashew trees

A : Entry hole resulting from larval activity in the tree; B : Sawdust characteristic of damage caused by *Apate terebrans* larvae; **C** : Galleries caused by the feeding activity of *Apate terebrans* larvae

Main fruit pests and the damage they cause

The major pests identified belong mainly to the Hemiptera order (19 species). These different species belong to the Miridae, Coreidae, Pentatomidae, and Pyrrhocoridae families. The larvae and adults of the species belonging to these different families bite and suck the sap from immature fruit and young shoots.

Fig. 6. Attacks and damage caused by Hemiptera *P. devastans* on developing fruit

A: early attack on immature apples and necrosis caused by *P. devastans* bites; B : necrosis caused by *P. devastans* bites on an immature cashew nut; C : nuts destroyed by *P. devastans* attacks.

Fig. 7. Attacks and damage caused by *Dysdercus voelkeri* Hemiptera on developing nuts

A : early attack on immature apples; B : apple destroyed after attacks by *D. voelkeri*

Their activities cause deformation and leave blackish spots on the developing nuts (Fig. 6A). When these necrotic spots occur, the growth of the nut and apple stops, causing them to dry out, fall off, or rot on the panicles (Fig. 6B and C). Of all these sap-sucking, the species *Pseudotheraptus devastans, Helopeltis schoutedeni*, *Anoplocnemis curvipes,* and *Dysdercus*

voelkeri cause the most damage to immature fruit in the study plantation (Fig. 7 and 8). In addition to these species, there are also pests of ripe apples belonging to the order Coleoptera of the family Cetoniidae (Fig. 9) and to the order Orthoptera with the family Pyrgomorphidae.

Fig. 8. Attacks and damage caused by Hemiptera *Anoplocnemis curvipes* on developing apples
A : Female *A. curvipes* attacking an immature apple; B : Male *A. curvipes* attacking an immature apple; C : Apple destroyed by attacks from *A. curvipes*.

Fig. 9. Attacks and damage caused by species of the Cetoniidae family on cashew apples
A : colony of *Pachnoda cordata* feeding on a cashew apple; B : *Pachnoda babaulti* attacking a cashew apple.

Fig. 10. Leaves mined by *Eteoryctis gemoniella* Stainton

Main leaf pests and the damage they cause

The defoliators encountered are species belonging to the Gracillariidae (Lepidoptera) and Pyrgomorphidae (Orthoptera) families. The most common species is *E. gemoniella*. These insects consume the leaves entirely or partially during the plant's vegetative growth phase (Fig. 10).

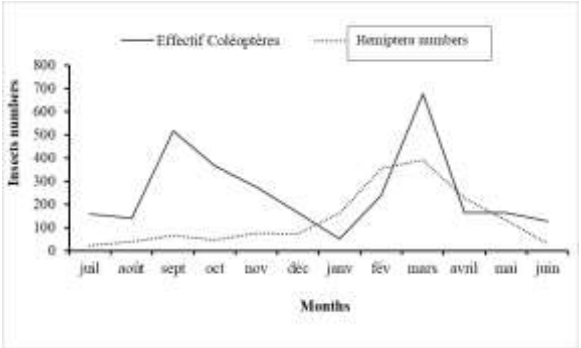

Fig. 11. Monthly variations in the population of Coleoptera and Hemiptera insects from June 1, 2023, to July 31, 2024

Monthly changes in the population of Coleopteran and Hemipteran pests

The curves based on the "insect population/month" matrix show a variation in insect populations throughout the year (Fig. 11). The curve showing the evolution of beetle populations shows two peaks (two maxima), one in September and the other, larger one, in March. The insect population collected during this study shows four main trends over the course of the year. The population begins to increase from August to September, then decreases until January. From that month until March, the population increases, finally declining from April to August (Fig. 11). For Hemiptera, the population curve shows a single peak (maximum) in March. The population of insects collected during this study shows a gradual increase from the first month of captures (July) until February and March, when the maximum number of individuals are captured. This is followed by a decline in numbers until June.

Identified beneficial insects

The rate of beneficial insects is 30.38%. The predators identified belong to the orders Hymenoptera, Orthoptera, Dictyoptera, and Hemiptera (Fig. 12). The main ones are *O. longinoda, Camponotus* sp, D. *nigricans, D. inops,*

R. albopilosus, R. bicolor, and M. religiosa. The pollinators recorded are the species A. *mellifera* of the order Hymenoptera and the Lepidoptera C. *jasius* and C. *fulvescens*, which were observed on cashew inflorescences.

Fig. 12. Quelques espèces prédatrices de la famille des Reduviidae observées en cajouculture

DISCUSSION

This study is the first of its kind in Côte d'Ivoire to provide information on the entomofauna over an annual cycle of the cashew tree. It has identified 79 species divided into 8 orders and 34 families. These results show that the data obtained on entomofauna represent a significant improvement over previous inventories of insects associated with cashew trees in Côte d'Ivoire. The orders Coleoptera and Hemiptera are the most diverse, accounting for 32.91% and 27.85% of the insect population collected, respectively. Previous studies on the inventory of cashew tree entomofauna have obtained results with different numbers of species from one author to another. Thus, Dwomoh *et al.* (2008) stated that of the 170 species found on cashew trees in Ghana, 35.29% are Coleoptera, followed by Hemiptera at 18.23%. In Benin, Agboton *et al.* (2014) recorded 36% Hemiptera and 25% Coleoptera out of 262 insect species.

Coleoptera are the most numerous at all sampling sites, but this number is lower than that obtained by Dwomoh *et al.* (2008) and Agboton *et al.* (2014). The predominance of Coleoptera once again demonstrates their importance within the insect class. With 400,000 species described, Coleoptera are among the most numerous and diverse groups of animals.

According to Bouchard *et al.* (2016), one in five species is a Coleoptera. The ranking of Hemiptera could be explained by the period during which this study took place. The study covered the different stages of cashew tree development, including flowering, fruit set, and fruiting, which occur between December and April. These phases of the plant's life cycle provide nutrition for piercing-sucking insects such as Hemiptera due to the presence of immature fruits and sap-filled leaves (Obodji, 2017). The distribution of species by family shows that Cetoniidae, Coreidae, and Cerambycidae occupy first (10 species), second (9 species), and third (8 species) place, respectively. This result is justified by the sampling period. Between August and April, the pre-floral vegetative growth, flowering, and fruiting phases occur. Cetoniidae and Hemiptera Coreidae, which feed on fruit, are attracted by the substances emitted by plants during flowering and fruiting. As for Cerambycidae, their favorable period in orchards is between April and January (Akessé *et al.*, 2018). As for pests that attack branches and stems, they all belong to the order Coleoptera, in the families Cerambycidae and Bostrichidae. The longhorn beetle *Diastocera trifasciata* and the borer *Apate terebrans* have been recorded as the most harmful to cashew trees. This observation was also made in Côte d'Ivoire by Brunck and Fabre (1964), Akessé *et al.* (2015), N'Dépo *et al.* (2017), Aliko *et al.* (2019), and Ouali N'Goran *et al.* (2020). In other African countries that produce cashew nuts, attacks by these species have been recorded. Dwomoh *et al.* (2008) made the same observation in Ghana. In Nigeria, the increase in *Diastocera trifasciata* infestation poses a serious threat to cashew cultivation (Asogwa *et al.*, 2011). In Benin, the borer *Apate terebrans* Pallas is one of the most important insect species attacking cashew nuts (Agboton *et al.*, 2014). These results show the degree of damage caused by these two beetles to cashew cultivation in the West African sub-region. The most harmful sap-sucking insects recorded during this study were the Coreidae *P. devastans*, *A. curvipes*, and *H. schoutedeni*. These insects pierce and suck the sap contained in the plant's tender fruits and buds, thereby exposing the plant to disease (Appert and

Deuse, 1982). These results are similar to those of Dwomoh *et al.* (2008, 2013), who reported that the most economically important Hemiptera pests of cashew trees in Ghana are *H. schoutedeni, P. devastans, A. curvipes, D. superstiosus*, and *R. dentipes*. The temporal distribution of harmful species belonging to the order Coleoptera varied somewhat, but high numbers were recorded in September (517 individuals) and March (678 individuals). The abundance of beetles in September is thought to be due to the strong presence of the species *Diastocera trifasciata* and *Pachnoda babaulti* in cashew plantations. The high number of *Diastocera trifasciata* in September is consistent with the findings of Akessé *et al.* (2018). According to these authors, the maximum number of individuals of this species is recorded from September to October in cashew orchards, corresponding to their breeding season.

In addition to all the harmful species identified during this study, several beneficial insects (30.38% of the insect population) were also captured. The beneficial insects encountered have been reported by several authors who have conducted studies on entomofauna (Agboton *et al.*, 2014; Akessé *et al.*, 2016). The presence of these species adds value to the crop because predators could be used as alternatives to synthetic pesticides for the protection of cashew nuts and almonds (Hashemi *et al.,* 2009). According to Dejean (1991), Peng *et al.* (2004) and Dwomoh *et al.* (2009), species such as *O. longinoda* ants are effective agents for the biological control of insect pests.

However, the impact of these red ants on cashew trees remains unclear, as they use the leaves to build their nests, thereby reducing the tree's photosynthetic activity. In addition, these leaves sometimes cover buds and developing nuts. These organs eventually die, thereby reducing the productivity of cashew trees (Agboton *et al.*, 2014).

CONCLUSION

The results obtained highlight the great diversity and abundance of the entomofauna associated with cashew orchards in Côte d'Ivoire. This specific richness, dominated by the orders Coleoptera and Hemiptera, reflects both the ecological complexity of this agroecosystem and the strong pressure exerted by insect pests (53% of the total population) on production. While certain species, such as the girdler beetles *Diastocera trifasciata,* the stem borers *Apate terebrans,* the *Pseudotheraptus devastans* bugs, and the *Helopeltis schoutedeni* mirids, pose a major threat to crops, the presence of beneficial insects (28% of the total population), particularly predatory Hymenoptera and pollinating Lepidoptera, paves the way for more ecological and sustainable control strategies. From an integrated pest management perspective, it is imperative to promote biological control by utilizing identified natural enemies such as *Oecophylla longinoda* ants, predatory reduviids (*Dinocleptes inops, Rhynocoris albopilosus, Rhynocoris bicolor)*, etc., and plant-based biopesticides. Such approaches will reduce dependence on synthetic chemicals, limit pest resistance, and preserve useful biodiversity in cashew orchards. Furthermore, this study highlights the need to deepen taxonomic and ecological knowledge of the species identified. Accurate identification of pests and their natural enemies, supported by morphological and molecular analyses, remains essential to understanding their interactions, life cycles, and periods of proliferation. This information will provide the scientific basis needed to develop effective monitoring and control programs. Finally, the implementation of these strategies requires synergy between research, extension services, and cashew nut producers. Strengthening the technical capacities of stakeholders in the sector, environmental education, and the creation of participatory pest monitoring networks will promote sustainable and integrated orchard management. Thus, preserving the productivity and sustainability of the cashew sector in Côte d'Ivoire will require a balanced combination of science, innovation, and farmers' knowledge, within a comprehensive agroecological approach. Already, the incineration of branches after attacks by the branch borer is helping to break the species' development cycle and thus significantly reduce its attacks.

ACKNOWLEDGEMENTS

We would like to thank the Cotton and Cashew Council for its financial support and all cashew nut producers for their collaboration.

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