Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2024; 12(2): 17-22

Received: 23-01-2024
Accepted: 05-03-2024

Johnson Félicia
Laboratory of Natural Environments and Biodiversity Conservation at Felix Houphouët-Boigny University, Abidjan, Côte d'Ivoire / African

Yokoli Franck
Laboratory of Natural Environments and Biodiversity Conservation at Felix Houphouët Boigny University, Abidjan, Côte d'Ivoire

Kissi Thérèse Appoh Perrine
Laboratory of Natural Environments and Biodiversity Conservation at Felix Houphouët Boigny University, Abidjan, Côte d'Ivoire

Koua Kouakou Hervé
Laboratory of Natural Environments and Biodiversity Conservation at Felix Houphouët Boigny University, Abidjan, Côte d'Ivoire

Corresponding Author:
Johnson Félicia
Laboratory of Natural Environments and Biodiversity Conservation at Felix Houphouët-Boigny University, Abidjan, Côte d'Ivoire / African

Stratification of entomofauna in a fruit Agrosystem: A case study of a soursop orchard (*Annona muricata* L., 1753) in M'Brimbo, South Côte d'Ivoire

Johnson Félicia, Yokoli Franck, Kissi Thérèse Appoh Perrine and Koua Kouakou Hervé

DOI: https://doi.org/10.22271/j.ento.2024.v12.i2a.9293

Abstract
Insects play a crucial role in the stability of agricultural ecosystems. Their vertical distribution and abundance are correlated with their bioecology. Knowledge of the agronomic status of insect species in agriculture allows for the evaluation of pest damage and the ecosystem services provided by beneficial insects. Various insect collection techniques have been implemented based on research or management objectives. This study aimed to investigate the abundance, role, and vertical distribution of insects associated with soursop cultivation. The methodology employed utilized colored traps (yellow, blue, and white) and attractants (wine, beer, and water) placed along delimited transects in the study plot. Additionally, a sweep net was used for rapid capture of flying insects not attracted to the traps. Inventory results revealed the diversity of insects in soursop orchards, with a total of 51 insect species distributed across 8 orders identified. Five insect species were common to all collection levels, while some were specific to a single level. Seven species were found exclusively in ground traps, five in trunk-level traps, and two in foliage traps. The study indicated that insect distribution in this agrosystem is influenced by various parameters such as ecology, diet, and ecological niche. Regarding trap selectivity, yellow was the most attractive color among colored traps for insects, while wine proved more effective for solvent traps in capturing insects. The results showed that traps installed on tree trunks collected more insect species (44 species, 69.05% of individuals) compared to ground traps (28 species, 20.81% of individuals) and foliage traps (16 species, 10.08% of individuals). For a rapid biodiversity inventory in fruit agrosystems, trunk-level collection is recommended as the most effective method.

Keywords: Soursop treesm Insects diversity, Collection level, Types of trap, Côte d'Ivoire

Introduction

The vast diversity of insects makes this zoological class an essential link in maintaining ecological balance [1, 2]. Likewise, their preservation is crucial for the stability of ecosystems. These organisms inhabit a wide variety of habitats and have adapted to all living environments [3, 4]. They play a crucial role by providing numerous ecosystem services to humans. In fact, insects actively contribute to ecosystem development as pollinators, decomposers, predators, prey, and agents of biological control for other organism populations [5, 6]. Additionally, certain insect species have gained the status of pests in agricultural systems [7, 8]. Among cultivated plants, fruit trees are a crucial element in the biological diversity and long-term sustainability of food and agricultural systems [9, 10]. They are grown for their nutritional value, pleasant taste, and various uses [11, 12]. The soursop tree, *Annona muricata*, is commonly cultivated in tropical regions worldwide for its fruits, known as soursops [13]. This plant is renowned for its potential medicinal properties [14, 15]. Some studies suggest that it may have anticancer, anti-inflammatory, and antioxidant properties [16]. Soursop cultivation may face constraints such as climatic conditions, diseases, and insect incidence [17]. Pests like mites, aphids, and caterpillars can damage its leaves and fruits. Additionally, pollination problems can lead to low fruit production. Understanding the insects associated with soursop cultivation will enable the implementation of pest control methods and the protection of beneficial insects to ensure healthy production.

Materials and Methods

Study Area

This study was conducted in the soursop orchards of the Agricultural Company of Bandama (SAB) in M'brimbo, located in the Agneby-Tiassa region, Tiassalé department (5°50'N and 4°50'E). The locality experiences a hot and rainy equatorial climate with four distinct seasons: a major rainy season from April to July; a minor dry season from August to September; a minor rainy season from October to November; and a major dry season from December to March. The average temperature is 28°C, and the average relative humidity is 80%.

Experimental Setup

In a 5-hectare soursop orchard, two plots of 5000 m² (50 m x 100 m) were delineated for insect inventory on the plants. Each plot was subdivided into three transects of 100 m in length and 3 m in width, spaced 15 m apart. Various traps were installed along these transects following the [18].

Insect Collection

Insect collections took place between April and May and lasted four weeks. Three types of traps (solvent attractant traps, colored pans, and colored bowls) along with the sweeping method were employed to collect the majority of insect species.

Capture of Litter Insects

The objective of this study was to identify insects present in the litter of soursop plots. Twelve bowls containing salted water were placed at a depth of 5 cm along the transects. The bowls, spaced 8 m apart, were arranged in a specific order (yellow, blue, and white) [19].

Capture of Understory Insects

This capture aimed to catalog insects colonizing the understory of the soursop plot. Colored pans (yellow, blue, and white) containing soapy water with added salt were used to trap insects, affixed to the trunk at 1.5 m above the ground with a spacing of 15 m along each transect.

Capture of Foliage Insects

The sampling aimed to collect and identify insects colonizing the leaves, flowers, and fruits of the soursop plot. Traps made from 1.5-liter plastic bottles with a funnel were suspended at a height of 2 meters in the foliage. Nine traps per transect, alternating between wine, beer, and water, were used for sampling. In total, three wine traps, three beer traps, and three water traps were arranged.

Sweep netting

Non-selective collections using a sweeping method were carried out with a sweep net across the entire study plot. The objective of this collection was to maximize the inventory of insects so that species not attracted to traps could be identified. The collector would advance at a slow pace along the transect and make rapid lateral back-and-forth movements with the sweep net. Captured insects were asphyxiated in jars containing cotton soaked in ether before preservation in envelopes or vials containing 70% alcohol. These collections were conducted once a week between 7 AM and 10 AM.

Fig 1: Traps Used for Insect Capture A: Colored bowl buried at 5 cm in the soil; B: Colored pan attached to the trunk of a soursop tree at a height of 1.5 m from the ground; C: Attractive trap fixed in the foliage at 2 m above the ground.

Insect Collection, Preservation, and Identification

Insects trapped were collected twice a week, on the 3rd and 6th days of the week. The contents of the traps were renewed weekly. Collected insects were preserved in labeled vials containing 70% alcohol. In the laboratory, insects were grouped based on their morphological characteristics. Insect identification was conducted in the laboratory using a binocular loupe and determination keys [20, 21]. Insects were classified into order, family, genus, and species.

Data Analysis

Relative abundance (Ar), the ratio of the number of individuals of a considered species to the total number of individuals of all species combined, was determined (Noudjoud, 2006). Based on the relative abundance value (Ar), the species was classified as very abundant (Ar > 10%), abundant (5% ≤ Ar < 10%), fairly abundant (1% ≤ Ar < 5%), and scarce (Ar < 1%).

ANOVA analyses between different parameters were conducted, followed by the Newman-Keuls test for variable separation. A Venn diagram illustrating the similarities and dissimilarities in the captured insect populations at each level was constructed. All tests were performed using STATISTICA version 7.1, with a significance threshold of 5%.

Results

Distribution of Insects According to Capture Levels

The various capture techniques employed resulted in the collection of a total of 12,525 insects belonging to 8 orders, 36 families, and 51 species. Individuals from all identified insect orders in this study were collected at the trunk level.

Except for the Lepidoptera order, other orders were identified in the understory. However, at the foliage level, three orders were identified: Hymenoptera, Coleoptera, and Diptera. The Coleoptera order is the most diversified with twelve (12) families and eighteen (18) identified species, followed by Hymenoptera with six (6) families and eleven (11) identified species. The Dictyoptera order, with only one family and one identified species, is the least represented. Additionally, individuals from this order were only collected in the understory (Table 1).

Table 1: Distribution and abundance of collected insects according to the capture level in the soursop orchard at M'Brimbo, South Côte d'Ivoire

			Abondance Relative (%)				
Orders	**Families**	**Species**	**Leaves**	**Trunk**	**Soil**	**Plot**	**SA**
Hymenoptera	Formicidae	*Camponotus vagus*	5,30	37,32	10,34	28,52	Pr/O
		Lasius umbratus	0,16	0,93		0,66	O
		Oecophylla smaragdina	3,72	57,69	13,09	43,04	Pr
		Formica sanguinea			11,34	2,34	Pr
		Messor barbarus			9,37	1,93	Pr
	Apidae	*Apis mellifera*	1,58	0,02		0,18	Po
		Bombus hypnorum	1,90	0,01		0,20	Po
	Ichneumonidae	*Stenichneumon culpator*	1,66	0,13		0,26	Po
	Vespidae	*Tricarinodynerus sp*	0,95	0,01		0,10	Po
	Enthophoridae	*Xylocopa violacea*	1,35	0,10		0,21	Po
	Crabronidae	*Trypoxylon figulus*	1,50	0,05		0,18	Pr
Coleoptera	Geotrupidae	*Geotrupes vernalis*			8,44	1,74	D
	Nitidulidae	*Carpophilus maculatus*	39,51			3,99	R
	Meloidae	*Hycleus polymorphus*		0,23		0,16	Po/Pa
	Chrysomelidae	*Orsodacne humeralis*	1,66	0,03		0,19	R
		Trechus obtusus	0,87	0,02		0,10	Pr
		Aspidimorpha quinquefasciata	1,03	0,01		0,11	Po
	Lagriidae	*Lagria villosa*		0,50	0,54	0,46	R
	Curculionidae	*Lixus paraplecticus*		0,13	0,15	0,12	R
	Carabidae	*Bembidion tetracolum*		0,06	0,35	0,11	Pr
		Platynus assimilis		0,05		0,03	Pr
		Platynus longiventris		0,07		0,05	Pr
		Lebia scapularis		0,09	0,31	0,13	Pr
	Coccinellidae	*Vibidia duodecimguttata*	1,03	0,31		0,32	Pr
	Cerambycidae	*Lamia textor*		0,12	0,27	0,14	R
		Saperda cacharias		0,13	0,08	0,10	R
	Staphylinidae	*Staphylinus dimidiaticornis*		0,05		0,03	Pr
	Buprestidae	*Anthaxia nitidula*			0,50	0,10	R
	Elateridae	*Agrypnus murinus*		0,09	0,23	0,11	D
Diptera	Diopsidae	*Diopsis apicalis*	0,95	0,09		0,16	Po
	Drosophilidae	*Drosophila melanogaster*	31,20			3,15	R
	Sarcophagidae	*Sarcophaga africa*	2,30	0,10		0,30	R
	Syrphidae	*Volucella pellucens*	1,11	0,13		0,20	Po/Pa
	Muscidae	*Hydrotaea ignava*	1,19	0,08	0,23	0,22	D
		Stomoxys calcitrans	0,95	0,05	0,12	0,15	R
Homoptera	Cicadidae	*Cicadetta montana*		0,16	0,19	0,15	R
	Membracidae	*Centrotus cornitus*	0,08	0,10		0,08	D
	Cixiidae	*Cixius nervosus*		0,16	0,19	0,15	R
Heteroptera	Pyrrhocoridae	*Dysdercus fasciatus*		0,21	0,46	0,24	R
	Pentatomidae	*Euchistus servus*		0,06	0,04	0,05	R
		Pentatoma rufipes		0,06	0,15	0,07	R
	Reduviidae	*Rhinocoris erytropus*		0,03	0,23	0,07	Pr
		Reduvius sp		0,05	0,12	0,06	Pr
	Coreidae	*Anoplocnemis curvipes*		0,07	0,12	0,07	R
Orthoptera	Gryllidae	*Gryllus assimilis*		0,15	37,90	7,93	O
	Tettigoniidae	*Tettigonia viridissima*		0,10	0,12	0,10	R
	Acrididae	*Omocestus rufipes*		0,05	0,23	0,08	R
	Pygomorphidae	*Zonocerus variegatus*		0,10	0,19	0,11	R
Lepidoptera	Papilionidae	*Papilio sp*		0,03		0,02	R
	Nymphalidae	*Hypolimnas bolina*		0,06		0,04	R
Dictyoptera	Blattidae	*Blatta orientalis*			4,68	0,97	O

ST: Agronomic Status; Pr: Predator; O: Omnivore; Pa: Parasitoid; R: Pest; D: Decomposer

Abundance of Collected Insects

The order Hymenoptera, with a relative abundance of 77.63% in the soursop orchard, was the most represented. Insects belonging to this order were predominantly collected at the trunk and ground levels. Among the collected insects, those belonging to the Formicidae family of the Hymenoptera order dominated the population with 76.5% of individuals collected in the soursop orchard. The predominant species in the orchard, constituting 43% of individuals collected, is *Oecophylla smaragdina*. It represents 57.69% of the insects collected at the trunk level. *Camponotus vagus* was abundant at all sampling levels with respective relative abundance values of 5.3% (foliage), 10.34% (ground) and 37.32% at the trunk level. In foliage, two species were predominant: *Carpophilus maculatus* from the order Coleoptera (39.51%) and Drosophila melanogaster from the order Diptera (31.2%). With a relative abundance of 37.9%, the species *Gryllus assimilis* (Orthoptera) was predominant at the ground level.

Agronomic Status of Collected Insect Species

Based on the feeding habits of the insect species identified in this study, insects were grouped into beneficial and harmful species. However, some species, due to their omnivorous diet, can be classified between the two ecological groups. Among the identified species, *Oecophylla smaragdina*, a predatory species, was the most abundant (43.04%) in the soursop orchard. *Camponotus vagus*, a predatory species with an omnivorous diet (28.52%), was abundant at all capture levels. The identified pest insects include defoliators, piercing-sucking insects, and borers (Table I). Pollinators, predators, parasitoids, and decomposers make up the group of beneficial insects.

Specificity of Collected Insects According to Capture Levels

Out of the 51 insect species collected, five (5) are common to all three capture levels. These include *Camponotus vagus*, *Lasius umbratus*, and *Oecophylla smaragdina* (Hymenoptera, Formicidae), *Hydrotea ignava* and *Stomoxys calcitrans* (Diptera, Muscidae). The Venn diagram analysis reveals species common to multiple niches and those isolated from others. When comparing capture levels, fourteen (14) species were common to both foliage and trunk. Similarly, eighteen (18) species were common to both trunk and ground. However, no species collected in litter were found in foliage. Moreover, two species, *Carpophilus maculatus* (Coleoptera, Nitidulidae) and *Drosophila melanogaster* (Diptera, Drosophilidae), were exclusively collected in foliage. As for the trunk, it specifically hosts seven (7) insect species. Five insect species are specifically associated with the understory (Figure 2).

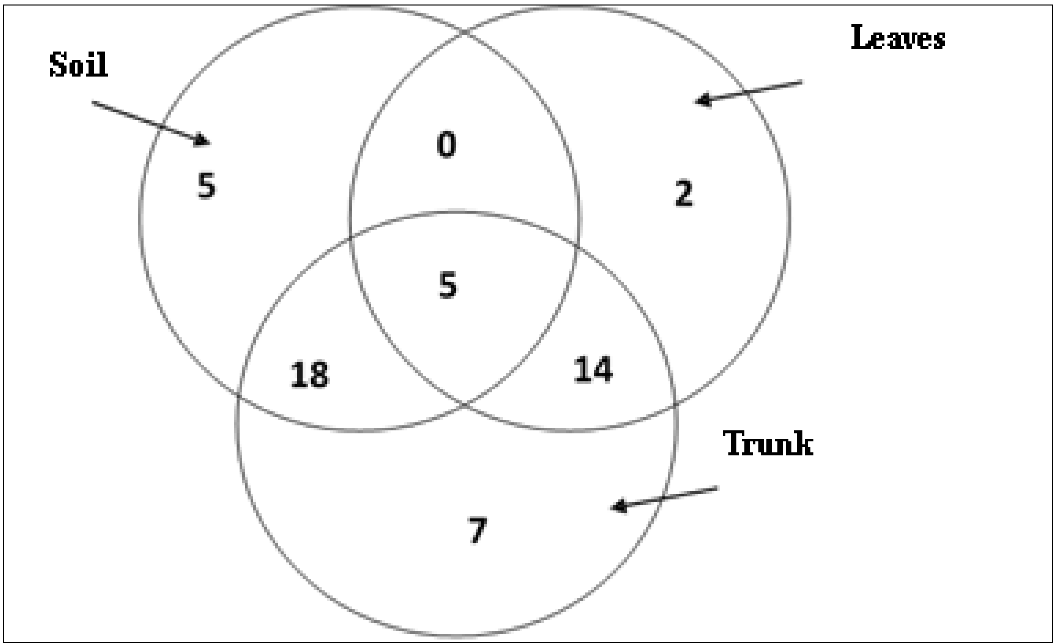

Fig 2: Venn Diagram of Insect Species Collected According to the Capture Level in the Soursop Orchard at M'Brimbo, South Côte d'Ivoire

Structuring and Stratification of Captured Insects Based on the Technique Used

The abundance of collected insects varies depending on the capture level. Thus, the rate of insects collected at the trunk level (69.05%) is statistically higher than those obtained at the ground level (20.81%) and in the foliage (10.08%). Attractive traps have resulted in collecting very few insects (10%) compared to colored traps (Table 2). Few insects were collected at the ground level compared to the trunk with the same type of trap (colored traps).

Table 2: Proportion of sampled insects according to collection levels and traps used in soursop orchards at M'Brimbo, South Côte d'Ivoire

Collection level	Types of traps	Proportion (%) of Collected Insects	Mean Insect Count	P-Value
Soil	Colored traps	20,81	482±40,28 a	0,004
Trunk	Colored traps + Mowing	69,05	1369,33±362,7 b	
Leaf	Attractive traps	10,08	215,5±36,04 a	

ANOVA one-factor test at a 5% significance level followed by Fisher's LSD test. Lowercase letters indicate differences between columns.

Effect of Attractants and Trap Color on Insect Collection

In the foliage, wine traps captured more insects (62.41%) than beer traps (37.5%) and water traps (0.78%). The counting of insects collected in colored traps showed the attractiveness of yellow traps at the trunk level (52.88%) and the ground level (54.63%). Regarding colored pans and bowls, yellow ones captured more insects than the blue ones (41.11% at the trunk level and 30.32% at the ground level), which also captured more insects than the white ones (5.98% at the trunk level and 15.04% at the ground level) (Table 3).

Table 3: Mean number of sampled insects according to trap characteristics in soursop orchards at M'Brimbo, South Côte d'Ivoire

Collection level	Types of traps	Proportion (%) of Collected Insects	Mean Insect Count	P-Value
Soil	Yellow bowl	54,63	263,33±12,52 a	0,001
	Blue bowl	30,32	146,17±20,23 b	
	White bowl	15,04	72,5±12,95 c	
Trunk	Yellow tray	52,88	724,17±206 a	0,04
	Blue tray	41,11	563±216,59 ab	
	White tray	5,98	82,17±16,81 b	
Leaf	Wine trap	62,41	134,5±21,74 a	0,001
	Beer trap	37,5	80,83±15,13 b	
	Water trap	0,78	0,17±0,17 c	

ANOVA one-factor test at a 5% significance level followed by Fisher's LSD test. Lowercase letters indicate differences between columns

Discussion

The study of the stratification of the entomofauna in the soursop orchard in M'Brimbo, southern Côte d'Ivoire, identified 8 orders and 51 insect species associated with this crop. The high diversity recorded could be explained both by the age of the orchard and the capture methodology used. Indeed, this 10-year-old orchard has a dense canopy, which could favor insect proliferation. The specific diversity obtained in this study is higher than that recorded by [17] in soursop orchards in Mexico. These authors identified 20 insect species associated with soursop cultivation. This difference may be explained by different geographical areas and also by the method used. In this study, insects were collected by trapping, while [17] used direct capture on plants. Similarly, [22] identified 25 insect species on Shea trees through tree collection. The high diversity obtained in the soursop orchards in M'Brimbo could be explained by factors external to the orchard. Indeed, since the soursop orchard is close to other monocultures (rubber cultivation, mango trees, cocoa cultivation), insects specific to other crops may have been found in the study orchard.

This study demonstrated the structuring of insects in a given orchard. The abundance of collected insects was related to the capture level. Thus, colored pans placed at the trunk level allowed for the collection of nearly 70% of the sampled insects. This indicates that in soursop plantations, insect populations predominantly occupy this part.

The collection of insects with colored traps in the litter and at the trunk level revealed that yellow traps captured more individuals. The abundance of collected insects is thus influenced by the color of the trap and its position. Some studies have shown that the effectiveness of colored traps lies in the ability of insects to detect them [23, 24]. Also showed that yellow traps are more attractive to the majority of insects due to their trichromatic vision. However, these authors showed that yellow is much more attractive to certain orders of insects. Thus, in their work on pine pests in Algeria, yellow traps were more attractive to Diptera and Coleoptera.

In order to capture insects in the foliage, attractive traps made from 1.5-liter bottles with volatile substances were used. The work of [25] showed that wine and beer are used as baits to capture *Eupotosia mirifica*, an insect inaccessible by conventional collection methods. These traps predominantly captured Diptera and Coleoptera. These results are similar to those obtained by [26] in Bordeaux, France. These authors showed that insects belonging to these two orders are most attracted to this type of trap. The wine trap was the most effective compared to beer and water traps in this study. This observation could be explained by the composition of wine. Composed of alcohols, esters, and acids, it can attract certain types of insects, such as Hymenoptera and Coleoptera. Also, the slower evaporation of ethanol in wine can extend the effectiveness of the attractant over a longer period [27]. Although beer contains attractive compounds, including sugars and yeasts, its effectiveness duration may be shorter due to its lower alcohol content.

Conclusion

The study of the entomofauna of the soursop tree *Annona muricata* in M'Brimbo using different sampling methods revealed a great diversity of insects associated with this crop. The four techniques used captured a total of 51 insect species distributed across three capture levels (foliage, trunk, and ground). According to this stratification, insects were more abundant at the trunk level of soursop trees. Also, yellow-colored traps proved to be more effective than blue and white traps. Finally, among the attractants used for insect capture in the foliage, wine was more effective than beer and water.

Acknowledgments

The acknowledgments of the funding body, institutional head, co-workers, field assistants, local people etc. should be briefed and declaration of any conflict of interest related to the work.

References

1. Hiba D, Adjami Y, Ghanem R, Viñolas A, Ouakid M, Tahraoui A. Coleoptera inventory in cork oak stands of North-Eastern Algeria. Turkish Journal of Forestry. 2016;17:11-7.
2. Mathieu Q. Des insectes pour sauver l'agriculture et l'alimentation mondiales. In: Le Déméter 2023 [Internet]. IRIS éditions; 2023 [cité 8 janv 2024]. p. 169-83. Disponible sur: https://www.cairn.info/le-demeter-2023--0011662119-page-169.htm
3. Mercken K, Boisson S, Lebeau J, Mahy G. Carrières et zones agricoles: Une synergie pour le biodiversité. 2019 [cité 8 Jan 2024]; Disponible sur: https://orbi.uliege.be/handle/2268/240505
4. Kissi P, Akpesse A, Coulibaly T, Koua K. Influence of cocoa cultivation on the diversity and density of termites in the Azaguié zone (South of Côte d'Ivoire). Entomologie faunistique-Faunistic Entomology. 2022;
5. Kouonon LC, Yao YEP, Goba KAE, Koffi KA, Koffi KG, Gourene AAB. Évaluation de la diversité morphologique d'Apis mellifera L. adansonii (Latreille, 1804) dans le district du Bas-Sassandra, Sud-Ouest de la Côte d'Ivoire. Afrique Science. 2020;17(4):139-52.
6. Soro K, Seguena F, Yeo NE, Konate ML. Identification des espèces de plantes arborescentes dans les agroécosystèmes et leur rôle dans l'espace de la réserve naturelle scientifique de Lamto : cas du terroir du village.

Agronomie Africaine. 2020;32(1):75-90.
7. Gnago JA, Danho M, Agneroh TA, Fofana IK, Kohou AG. Efficacité des extraits de neem (Azadirachta indica) ET DE papayer (Carica papaya) dans la lutte contre les insectes ravageurs du gombo (*Abelmoschus esculentus*) ET DU Chou (*Brassica oleracea*) en Côte d'Ivoire. International Journal of Biological and Chemical Sciences [Internet]. 2010 [cité 8 Jan 2024];4(4). Disponible sur: https://www.ajol.info/index.php/ijbcs/article/view/63035
8. Akesse EN, Ouali-N'Doran SWM, Tano Y. Insectes ravageurs du piment Capsicum Chinense Jacq. (Solanaceae) à Port-Bouët (Abidjan-Côte d'Ivoire): Pratiques de lutte par les pesticides chimiques. Journal of Applied Biosciences. 2015;93:8667-74.
9. Kone SL, Soro K, Amon DEA, Dogbo OD. Etat de conservation de la phytodiversite dans les agrosystemes a base de cultures perennes a la peripherie du Parc National de Tai (sud-ouest de la Cote D'ivoire). Agronomie Africaine. 2022;34(1):33-44.
10. Adji BI, Yao KAG, Gorebi BN, Kadio GA, Gbotto AA, Assiri AA, *et al.* Identification des pratiques et types de systemes agroforestiers a base de cacaoyers (*Theobroma cacao* L.) dans les trois principales zones de production de cacao en Cote D'Ivoire. Agronomie Africaine. 2020;32(3):323-42.
11. Ambé GA. Les fruits sauvages comestibles des savanes guinéennes de Côte-d'Ivoire: état de la connaissance par une population locale, les Malinké. BASE [Internet]. 2001 [Cité 8 Jan 2024]; Disponible sur: https://popups.uliege.be/1780-4507/index.php?id=15005&gathStatIcon=true&lang=es
12. Diarra N, Togola A, Denou A, Willcox M, Daou C, Diallo D. Etude ethnobotanique des plantes alimentaires utilisées en période de soudure dans les régions Sud du Mali. International Journal of Biological and Chemical Sciences. 2016;10(1):184-97.
13. Ndjoumoui CA, Augustin M, Christian MA, Cedric CD. Effets de la durée de conservation ET DU prétraitement sur les paramètres de germination des graines du corossolier (*Annona muricata* L.) au Cameroun. Journal of the Cameroon Academy of Sciences. 2022;18(1):285-94.
14. Marc A. Évaluation sensorielle de jus mixtes à base de jus de gingembre (Zingiber officinale) ET DE corossol (*Annona muricata* L.). Sciences des Structures et de la matière [Internet]. 2022 [Cité 8 Jan 2024];6(2). Disponible sur: http://publication.lecames.org/index.php/mat/article/view/4443
15. Moreau D, Huchot E, Gazaille V, Rossanaly-Vasram R, Andre M. Automédication par *Annona muricata* L. (corossol) à visée anticancéreuse à la Réunion. Revue des Maladies Respiratoires. 2018;35(9):948-55.
16. Gajalakshmi S, Vijayalakshmi S, Devi RV. Phytochemical and pharmacological properties of *Annona muricata*: A review. International Journal of Pharmacy and Pharmaceutical Sciences. 2012;4(2):3-6.
17. Cham AK, Esquivel LG, Bermúdez RA, Velasco RC, Blanco CJM, Campos COJ. Insects associated with the soursop (*Annona muricata* L.) crop in Nayarit, Mexico. Florida Entomologist. 2019;102(2):359-65.
18. Mandelik Y, Roll U. Diversity patterns of wild bees in almond orchards and their surrounding landscape. Israel Journal of Plant Sciences. 2009;57(3):185-91.
19. Leong JoaNM, Thorp RW. Colour-coded sampling: the pan trap colour preferences of oligolectic and nonoligolectic bees associated with a vernal pool plant. Ecological Entomology. août 1999;24(3):329-35.
20. Jiri Z, Milan C, Milos L, Cuisin M. La grande encyclopedie des insectes. Paris, France: Librairie Gründ; c1989.
21. Mignon J, Haubruge E, Francis F. Clé d'identification des principales familles d'insectes d'Europe. Liège: Presses agronomiques de Gembloux; c2016.
22. Kambou SF, Ilboudo ME, Kientega DH, Sanon A, Ilboudo Z. Inventory and Biodiversity of the Entomofauna Associated with Shea Fruits (*Vitellaria paradoxa* CF Gaertn), an Important Non-Timber Forest Product in the Ziro Province of Burkina Faso. Advances in Entomology. 2022;11(1):18-37.
23. Campbell JW, Hanula JL. Efficiency of Malaise traps and colored pan traps for collecting flower visiting insects from three forested ecosystems. J Insect Conserv. déc 2007;11(4):399-408.
24. Sukovata L, Dziuk A, Parratt M, Bystrowski C, Dainton K, Polaszek A, *et al.* The importance of trap type, trap colour and capture liquid for catching Dendrolimus pini and their impact on by-catch of beneficial insects. Agri and Forest Entomology. nov 2020;22(4):319-27.
25. Aberlenc HP, Curletti G, Dutto M, Tassi F. Eupotosia mirifica, joyau menacé du patrimoine naturel européen (Coleoptera, Cetoniidae). In Compagnia delle Foreste; 2003 [Cité 8 Jan 2024]. Disponible sur: https://agritrop.cirad.fr/526463
26. Dauphin P, Thomas H. Quelques données sur le contenu des pièges à frelons asiatiques posés à Bordeaux (Gironde) en 2009. Bulletin de la Société linnéenne de Bordeaux. 2009;144(3):287-97.
27. Silva V, Igrejas G, Falco V, Santos TP, Torres C, Oliveira AM, *et al.* Chemical composition, antioxidant and antimicrobial activity of phenolic compounds extracted from wine industry by-products. Food control. 2018;92:516-22.