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Assessment of the Heteroptera entomofauna diversity and their ecological status within cocoa-based agroforestry in contrasting locations in Centre Region of Cameroon

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Abstract
The knowledge of insect biodiversity in general, and heteropteran species in particular under field conditions, which are needed to optimize the preservation of the entomofauna diversity *sensu lato*, especially endangered species in one hand, and the protection of cocoa-based agroforestry systems against their main insect pests on the other hand. For this reason, we are characterized the community of Heteropterans and their ecological status in 12 cocoa farms of three localities (Bokito, Obala and Ngomedgzap) in the Centre Region of Cameroon, using the Chemical Knock Down Method, relevant dichotomous keys and reference insect collections for insect's identification and diversity indices: H' index of Shannon-Weaver, J Equitability index of Pielou and Is Similarity index of Sorensen in 2023. A total of 4904 individuals were collected in all the studied cocoa farms, divided into 137 Heteropteran species, 90 genera and 16 familles. This insect community belong to four ecological groups: 11 (8% in the total) specimens were recognized as cocoa insect pests, 8 (6%) as predators, 13 (9%) as unknown and 105 (74%) as opportunistic. Compared to other ecological groups, insect pests were more abundant with 2664 (54.33%) up to 4904 individuals, followed by unknown 1725(35.17%), opportunistic 483(9,85%), then 32(0.65%) were predators. The abundance of insect pest varied from 2019 (41.17%) individuals for *Sahlbergella singularis* (Miridae) to 1 (0.02%) individual for *Haliomorpha annulicornis* (Pentamidae). The current study provides valuable data regarding heteropteran species biodiversity under field conditions in order to optimize the preservation of the entomofauna diversity *sensu lato*, especially endangered species in one hand; and improve sustainability in the protection of cocoa-based agroforestry systems against their main insect pests via the integrated pest management (IPM) programs in order to increase the annual cocoa farms yield i.e. the cocoa farmers' incomes on the other hand.
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Keys words: Heteropteran biodiversity, ecological status, cocoa farms, Centre region of Cameroon, IPM

INTRODUCTION

Cacao (*Theobroma cacao* Linnaeus, 1753) is an economically important cash crop in its growing area worldwide due to their fruits (beans) which are used in animal nutrition including human, medicine/pharmacology (drug formulation), and cosmetics (Tano Djè *et al*., 2019; Suh and Molua, 2022). In the producing cocoa tree area in the developing countries such as Cameroon, approximatively 600,000 families are directly involved in cocoa cultivation, and this cash crop annually generates about 250 billion CFA (US$ 500,000,000) for cocoa beans exportation; then contributes close to half of the exported products for the country's primary sector (Ngong *et al*., 2019; Bomdzele and Molua, 2023). In West Africa in general and in Cameroon in particular, cacao trees are grown under the multi-complex conditions with other intercropping perennial trees for multiple ecosystem services; this agricultural practice is known as agroforestry systems (Sonwa *et al*., 2007; 2018; Jagoret, 2011; Jagoret *et al*., 2011; Essomba *et al*., 2021; Ndo *et al*., 2023) also called agrisilviculture or silvoarable (Brown *et al.,* 2018). Cocoa-agroforestry systems are known as ecosystems hosting a wide range of biodiversity including the entomofauna or hexapods which negatively affect annual yields of these plantations worldwide, especially in West and Central Africa (Lavable, 1970; Entwistle, 1972; Babin, 2018; Cilas *et al.*, 2018; Cilas and Bastille, 2020). Among the entomofauna taxa inventoried in the cocoa-agroforestry systems, the species belonging to the order Hemiptera particularly were more abundant, diversified and harmful to cocoa compared to the orders Lepidoptera and Coleoptera for example (Lavable, 1970; Entwistle, 1972; Schaefer & Panizzi, 2000; Yede, 2016; Yede *et al.*, 2023). Indeed, more than 37,000 hemipteran species, both generalist and specialist phytophagous taxons, have been overall described, with a further 25,000 probably yet to be described (Shaefer, Com pers). Within the order Hemiptera, the Sub-order Heteroptera is highly diversified and comprises eight Infraorders: Enicocephalomorpha, Dipsocoromorpha, Leptopodomorpha, Gerromorpha, Nepomorpha, Cimicomorpha, Pentatomomorpha and Aradomorpha (Delvare & Aberlenc, 1989). These last five infra-orders, especially the Cimicomorpha and Pentatomomorpha, contain several species of economic interest (Schaefer & Panizzi, 2000) such as species belonging to the family Miridae, which alone includes almost 1,000 genera and 10,000 species, and new species are commonly described particularly in tropical regions such as the Centre Region of Cameroon (Wheeler, 2000; Schuh, 2008). Schaefer and Panizzi (2000) reported that 60% of heteropteran species are described as herbivores. Then, the current knowledge related to the biodiversity of hemipteran species constitutes an essential prerequisite for defining the ecological status of each on-farms species in the study sites, and therefore optimizing the integrated pest management (IPM) against Hemiptera insect pests.

Many heteropteran species prefer the reproductive parts of plants, such as flowers, ovules, ovaries, fruits, seeds, etc.; these plant organs are also solicited by humans for they are sources of nitrogen, basic elements of amino acids. As a result of this convergence of needs between both human and these bugs are in competition, hence the name of pests for the latter (Entwistle, 1972). Plant species damagers, known as phytotoxomiasis, due to the infestations of these organisms towards the plant host have been widely documented (Carter, 1962; Strong, 1970; Entwistle, 1972; Lavabre, 1970; 1977; Tinsley & Pillemer, 1977; Yede, 2016; Babin, 2018; Cilas *et al.*, 2018; Cilas and Bastille, 2020; Mahob *et al.*, 2020; Adeniyi and Asogwa, 2023).

In the literature, many studies on the abundance and diversity of insects in cocoa-based agrosystems were focused on the evaluation of the entomofauna biodiversity sensu lato (Adjaloo *et al*., 2012; Thube *et al.*, 2016; Indriati *et al.*, 2020; Adeniyi and Asogwa, 2023 ; Umeh *et al.*, 2023); or the investigation of the impact of some harmful species on cocoa trees (Anikwe, 2009; N'Guessan *et al.*, 2010; Anikwe *et al.* 2009; Anikwe et Outonye, 2015; Adu-Acheampong *et al.,* 2014; Yede *et al.*, 2012; Mahob *et al.*, 2019; 2020; Awudzi *et al.*, 2024; Yede *et al.*, 2024). However, to the best of our knowledge, there is a lack of data regarding the holistic insect diversity of the targeted entomofauna group (i.e. the hemipteran taxa) in the cocoa growing areas worldwide, particularly in the Centre Region of Cameroon. The acquisition of holistic data on the biodiversity of hemipterans in the selected study areas will ultimately set out the targeted insect diversity, the ecological status of each identified taxon, and subsequently optimize the IPM against the main cocoa trees pests, given that the specific richness/diversity of insects vary in time and space (Entwistle, 1972; Adjaloo *et al.*, 2012; Indriati *et al.*, 2020; Adeniyi and Asogwa, 2023; Umeh *et al.*, 2023; Awudzi *et al.*, 2024). The objective of this study was to determine the hemipteran diversity and ecological status of each identified species in our study area. We hypothesized that insect diversity varies between the study locations of the Centre Region of Cameroon.

Materials and methods

Study sites

The study was carried out in cocoa plantations of three contrasting localities, namely Bokito located in the savannah zone (4°34'N and 11°07′E; 508 m a.s.l.), Obala in the transition zone (4°10'N and 11°32'E; 539 m a.s.l.) and Ngomedzap in the forest zone (11°15'N and 11°12'E; 680 m a.s.l.) (Figure 1). The study area is characterized by a subequatorial climate with a bimodal rainfall regime; and its floristic, fauna, pedological composition as well as cultural practices were widely documented (Bisseleua and Vidal, 2008; Bisseleua *et al*., 2011; Jagoret, 2011; Mahob *et al.*, 2020; Yede *et al.*, 2024).

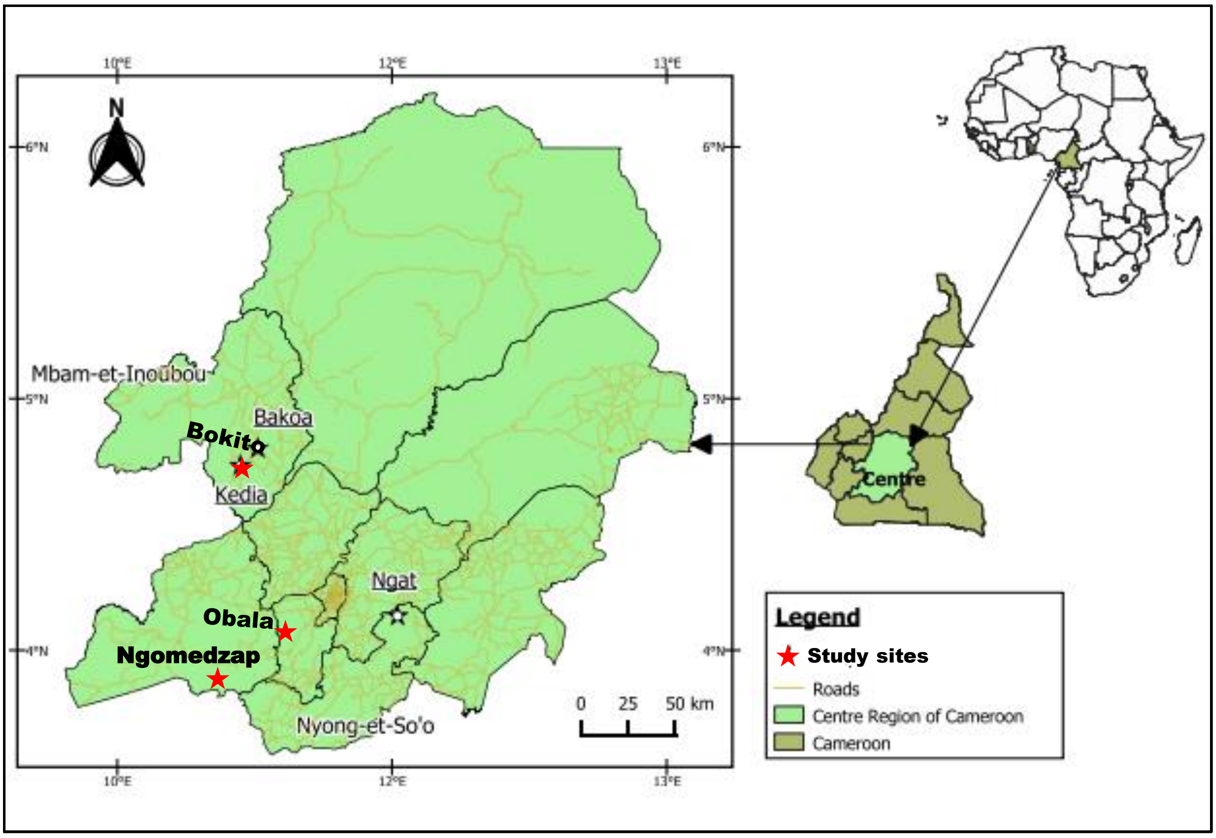

Figure 1. Geographical localization of the Study localities

Experimental plots description

Cacaoculture in the three study locations grown under multiple-complex agroforestry systems characterized by the intercropping cocoa trees with other perennial plant species (Jagoret, 2011; Jagoret *et al.*, 2011). The planting material is mainly the German cocoa also called Forestero or Amelonado (Jagoret, 2011); cocoa trees on and/or between the rows were planted without respect of the agronomic recommendations, 2.5 x 2.5 m or 3 x 3 m for approximately 1200 trees per hectare (Anonymous, 2002). The surface areas of the selected plantations were estimated at 1/2, 3/4 and 1 hectare at Ngomedzap, Obala and Bokito respectively, using the Garmin's Global Positioning System (GPS).

Experimental design and insect diversity assessment

The experiments were completely randomized in each experimental unit (5000 m², i.e. 100 m x 50 m delimited with the help of a decameter, pickets and a string) per study area and conducted twice during the dry season, in the beginning of March and Mid-July 2023, to facilitate data collection (Yede, 2016). A total of 3, 4 and 5 plots were respectively selected for the experiments at Ngomedzap, Obala and Bokito due to the absence of chemical (insecticide) treatments for insects for at least two years before the beginning of our study (Yede *et al.*, 2012; Yede, 2016; Mahob *et al.*, 2019; 2020). Within each sampling unit/experimental plot, 100 cocoa trees, either 300, 400 and 500 at Ngomedzap, Obala and Bokito respectively, were randomly selected per each study period and covered with white plastic tarpaulins (4 m x 5 m) (Figure 2); then the knock down method was used via the application of endosulfan by atomization on each selected trees (Yede, 2016), following the phytosanitary companies recommended dose per chemical product and treatment device. Seven hours' post treatments, insects were collected from the tarpaulins using forceps and brushes; then preserved in pillboxes and/or Eppendorf tubes containing 70% ethanol for their conservation during transportation to the Laboratory of Zoology of the Faculty of Science of the University of Yaounde I for subsequent identification and ecological analyses (Babin, 2009; Jagoret, 2011; Yede, 2016; Yede *et al.*, 2023).

Figure 2: Heteropterans sampling arena using the Chemical Knock Down method

Heteropterans identification

Once the samples were brought back to the laboratory, an initial sorting was carried out to separate heteropteran specimens from the other taxa, using both the identification keys of Delvare & Aberlenc (1989), Dietrich (2005) and Wilson (2005) and a Swift magnifying glass for observations. Firstly, heteropteran taxa were grouped into families; then within families, each specimen was set into genera and species (morpho-species), with the help of relevant documents of Villiers (1943), Entwistle (1972) and Nonveiller (1984), and insect collections from IRAD's Central Entomology Laboratory in Nkolbisson (Yaoundé, Cameroon), collections from various internships Faunistics Laboratory of the Montpellier-France (UMR, CBGP situated to National Institute for Agricultural Research (INRA) and International Cooperation of Agricultural Research for Development (CIRAD) and the Royal Museum for Central Africa (RMCA) in Tervuren (Belgium). To complete the heteropteran identification work, a number of reference documents available on websites such as https:// flow.hemiptera-databases.org/flow/ were consulted.

Heteropteran species ecological status

After the determination of the species richness and abundance, the status of each species, divided into pest, predator, unknown and/or opportunist, was defined using several relevant documents (Wood & Lass 1985; Entwistle 1972; Lavabre 1970; 1977; Schaefer and Panizzi, 2000; Yede, 2016).

Data analysis

Assessment of species richness

Heteropteran species or morphotypes richness noted as "S" (Peet, 1974), and the total absolute abundance of heteropteran species (N) are given per locality, and the entire region. The relative abundance (RA) of a given species is the ratio of its absolute abundance (ni) to the total number of specimens of all species (N) in the locality, Division, and the entire Region, multiplied by 100. Its formula is RA= (Ni/N) x 100 (Dajoz, 1982). The abundance of heteropteran species found on cocoa trees was characterized according to the percentage break down of Dajoz (1982) slightly modified as follows: if RA > 50%, the taxon is very abundant; if 25% ≤ RA ≤ 50%, the taxon is abundant; if RA < 1%, taxon is rare i.e. it exists in very small number.

To determine the main heteropteran species per locality, the relative abundance of each specific case of heteroptera species cocoa trees association was computed in relation to the number of cocoa trees exploited. In addition, the relative frequency (RF) of cocoa trees harboring the targeted group of insects was also characterized as above (Dajoz, 1982). The determination of the main heteropteran species found in cocoa trees in each locality was done considering the relative abundance, the average number of specimens involved, and the percentage of cocoa trees explored.

Heteropteran diversity

Each heteroptera community was characterised via the Shannon diversity index H', Equitability index (E), and the Berger-Parker index calculated using the software Estimate v.8.2 (Colwell, 2006). H'= -∑pilnpi and E= -∑pilnpi/lnS (Kent & Cooker, 1992), with pi = ni/N; ni is the abundance of a given species and N the total number of the different ant species. The similarity or Sorensen quantitative index (Is) between heteropteran communities on cocoa trees of two localities was determined as follow: Is = (2c/(a+b)) x 100, using the software Estimate v.8.2 (Colwell, 2006). In this formula, **a** is the total number of species in locality A, **b** is the total number of species in locality B, and **c** the number of the common species found in both localities.

Determining specific diversity

Values of the diversity indices (Shannon-Weaver, Equitability, Berger-Parker and Sorensen) of different heteroptera communities found on cocoa trees were compared using F-test and Tukey's pairwise comparison, while the mean number of heteropteran specimens per sample size in different localities was compared using the Kruskal Wallis test then the Mann Whitney test for pairwise comparison.

Results

Taxonomic composition, abundance and diversity of Heteroptera species collected on cocoa trees

A total of 4904 individuals divided into 137 morpho-species, 90 genera and 16 families were found on cocoa trees. From the overall community of heteropterans collected for each family level, the Miridae family was the most numerous with 2341 individuals (47.78% of the total), followed in the decreasing order by Lygaeidae, 1385 individuals (28.24%), and Pentatomidae 589 specimens (12.01%) and others 589 (11.97%). Regarding the relative abundance of the different Heteroptera taxa in the study area, 10 families were rare (RA<1%), 04 families revealed less abundant (1% ≤ RA<25%) and 02 families were abundant (25% ≤ RA<50%) (Appendix). However, Reduviidae (22 genera and 32 species), Pentatomidae (18 genera and 26 species and Coreidae (18 genera and 29 species) are showed the very high specific richness/diversity than order families (appendix).

At the study site level, Obala (transition zone) showed most specific richness with 91 species inventoried, followed by Bokito (savannah zone) 78 species, then Ngomedzap (forest zone) 59 species (Table 3 and appendix). Within these insect communities recorded in the three contrasting locations, 02 species were numerically predominant (*Sahlbergella singularis* and *Oxycarenus* sp). The distribution frequencies of *Sahlbergella singularis* was very abundant (57.82 %) at Bokito, abundant (35.33%) at Obala and less abundant (22.67%) at Ngomedzap; mean while *Oxycarenus* sp was abundant (46.32%) at Ngomedzap, less abundant (8.28% and 2.69%) respectively at Obala and Bokito (see appendix) according to Dajoz 1982 classification. The equitability index showed that Obala is more diverse than Ngomedzap and Bokito (Table 3); but based on the different index values, pairwise comparaison of the ecological indices between the three study localities, showed the comparable values for species richness S (F=0.95; ddl=2, p=0.41), Shannon index H'(F=1.65; ddl=2, p=0.24) and equitability J (F=0.69; ddl=2, p=0.52) between the sites (Table 1).

Table 1: Biodiversity indices values (mean ± sd) of heteropteran communities found on cocoa trees in the three different study localities of the Centre Region of Cameroon.

	Study locations			
Paramètres	Bokito	Ngomedzap	Obala	**F-test**
Sample sizes _N	18421(460,50±325,05)	1010(252±218,63)	2052(513±395,34)	F= 0,15; ddl= 2; p= 0,85
Taxa_S	78(19,50±1,07)	59(14,75±3,25)	91(22,75±5,02)	F= 0,95; ddl= 2; p= 0,41
Shannon_H'	2,04(1,17±0,13)	2,05(1,70±0,23)	2,07(1,09±0,14)	F= 1,65; ddl= 2; p= 0,24
Equitability_J	0,47(0,27±0,53)	0,5(0,45±0,07)	0,60(0,45±0,14)	F= 0,69; ddl = 2; p=0,52
Berger-Parker	0,58(0,30±0,11)	0,46(0,33±0,05)	0,35(0,23±0,017)	F= 2,21; ddl= 2; p=0,16

Legend: N: abundance; S: specific richness; H': Shannon-Weiver index; E: Pielou index

Similarity

Among the 137 species inventoried, 28 species were common to the three study sites; 18 to Obala and Bokito; 12 to Obala and Ngomedzap and 5 were common to Ngomedzap and Bokito (Figure 3). Nevertheless, 74 species are found only in one study locality as follow: 14 at Ngomedzap, 27 at Bokito and 33 at Obala (Figure 3). The calculation of the Sorensen index showed the high similarity (Is= 53,33%) between Ngomedzap and Obala, Obala and Bokito (Is=54,43%); and fewer high similarity between Ngomedzap and Bokito (Is=48,17%) with regards to the heteropteran communities.

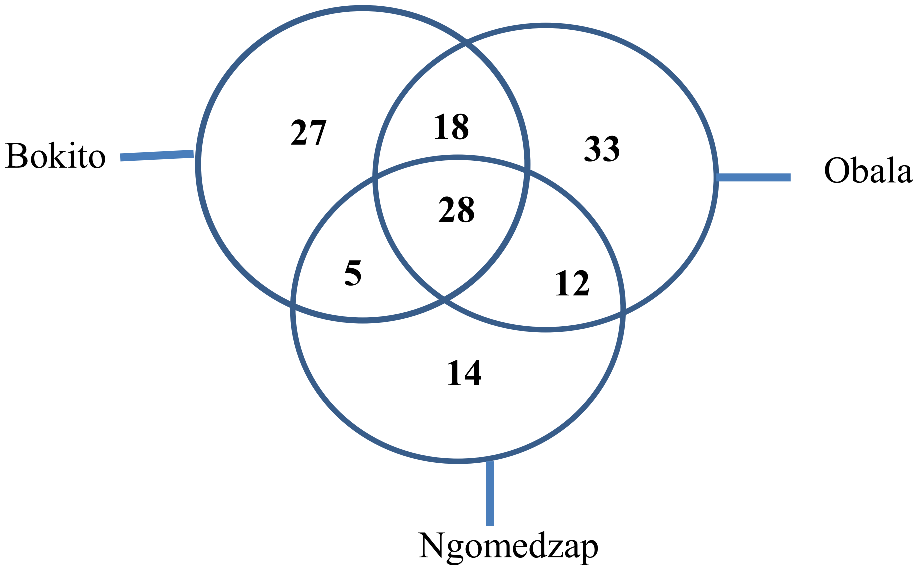

Figure 3: similarity designs of heteropteran communities between the explored localities

Ecological status of cocoa heteropteran species

Overall heteropteran species found in cocoa farms can play many roles in their environment: 11(8%) species up to 137 were recognized as the cocoa insect pests, 8 (6%) as predators, 13 (9%) as unknown and 105 (74%) as opportunists (Appendix). Taking into account the abundance in function of the ecological status of each heteropteran group, values ranged from: 2664 (54.33%) up to 4904 individuals, 1725(35.17%), 483(9,85%) and 32(0.65%) for pests, unknown, opportunistic and predators respectively. In the heteropteran communities recorded in our study area, insect pest species represent in the decreasing order: *Sahlbergella singularis* (41,17%), *Atelocera serrata* (7.89%), *Helopeltis bergrothi* (2.06%), *Homocerus ignotus* (1.43%), *Bathycoelia thalassina* (0.61%), *Atelocera spinulosa* (0.53%), *Helopeltis gerini* (0.43%), *Distantiella theobroma* (0.14%), *Helopeltis* sp. (0.04%), *Haliomorpha annulicornis* (0.02%) and *Helopeltis* sp. (0.02%) (Figure 4).

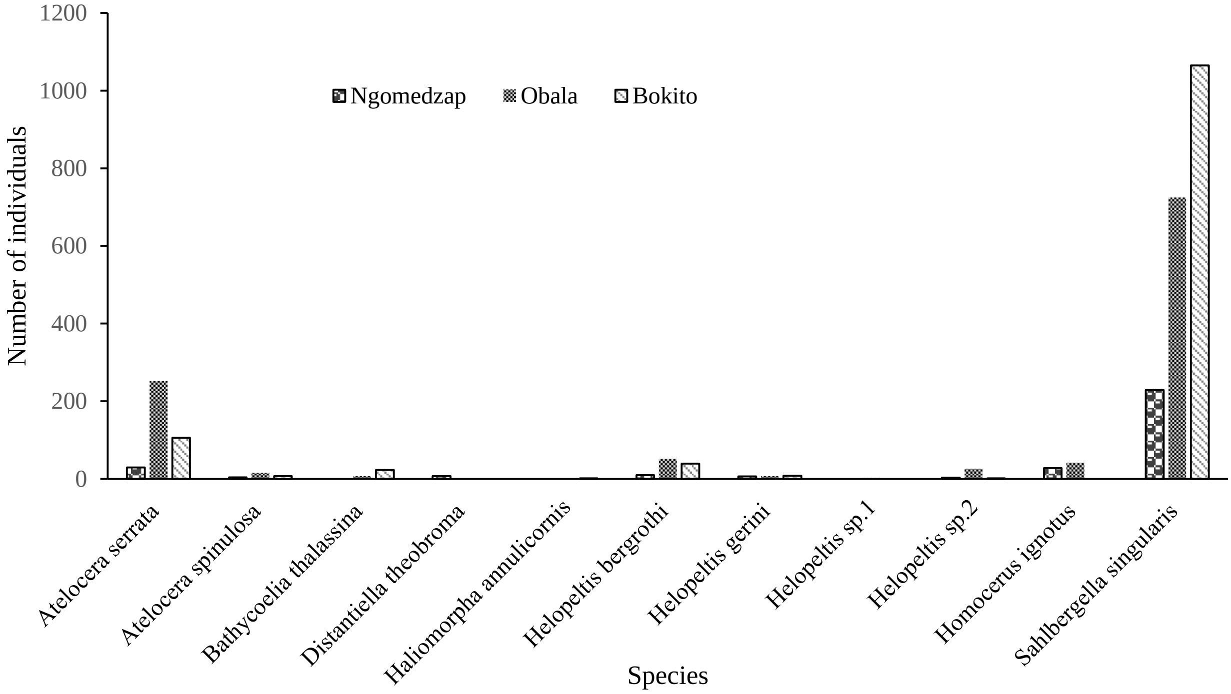

Figure 4: Distribution frequencies of Heteropteran pest species in the study area

Discussion

In this study, 4904 individuals were collected; among them, 137 species were identified. Numeric abundance and specific richness of heteropterans in Centre Region of Cameroon are very important and diversified in cocoa farms. These results could be linked to the high vegetational diversification of plants species in the study area (Sonwa *et al*., 2007; Essomba *et al.*, 2021; Jagoret, 2011; Jagoret *et al.*, 2011; Sonwa *et al*, 2018); it is known that the structure and composition of the flora in a given environment such as cocoa-based agroforestry systems would increase the entomofauna biodiversity of heteropterans (Gidoin, 2013). Our findings support the previous studies of Schroth *et al.* (2004) and Yede (2016), which also reported the high biodiversity in cocoa-based agroforestry systems. In fact, cocoa farms hosted several kind resources (nutrition, habitat, etc.) for many animal species including heteropterans entomofauna due to the niches heterogeneity within the cocoa-agrosystems, which offers environmental conditions close to the natural ecosystems of many species (Schroth *et al.*, 2004). In addition, Adjaloo *et al*. (2012) and yede (2016) have been documented that cocoa farms sheltered a high potential of insect diversity, then justifying the results obtained in the current work.

Concerning the distribution, our study showed high specific richness in the transition zone (Obala) than in both the savannah (Bokito) and the forest (Ngomedzap) zones; and share with them up to 50% of the heteropteran community inventoried. This situation clearly showed that a large range of heteropteran species collected in the study zone were cosmopolites/ubiquitous due to their ability to adapt themselves in the contrasting cocoa-agroforestry systems (Entwistle, 1972; Lavabre, 1970; Hunter, 2002; Yede, 2016). According to Hunter (2002), insects dwell within complex ecosystems and interact with other taxonomic groups and/or abiotic factors of their living environment. Indeed, the presence of entomofauna in general, and heteropterans species in particular, within the cocoa farms was probably due to the favorable factors such as plant hosts species quality (cocoa varieties and associated plant species), microhabitat conditions (i.e. temperature, humidity, light intensity) and suitable food availability (Adjaloo *et al*., 2012; Yede, 2016). Awudzi *et al.* (2024) and Babin *et al*. (2010) reported that agronomic practices of farmers such as pruning and removal of basal shoots/chupons could also influence pest populations in cocoa-based agrosystems due for example to removal of feeding and breeding sites of insects towards the host plants. Moreover, it is known that the diversity of insects in cocoa farms, especially the insect pests (mirid bugs, stink bugs and coreid bugs) varied mainly with the chemicals spraying regimes (Sarfo, 2013, Adu-Acheampong *et al.*, 2015).

From our investigation, the abundance and specific richness varied between the heterapteran groups and the study locality. This result could be explained by the fact that the most abundant species such as *S. singularis* and *A. serrata* are the best adapted compared to the other species inventoried in the studied cocoa agrosystems, confirming thus the observations made by Yede (2016) in the same study area. However, the high abundance of both *S. singularis* and *A. serrata* and/or the high specific richness/diversity of heteroptera were also linked the trophic plasticity of each species, ranged into generalist and specialist phytophagous ones (Schaefer and Panizzi, 2000). Indeed, it is known that, compared to the other species, *S. singularis* and *A. serrata* are polyphagous species with a large range of host plants (Lavabre, 1977; Entwistle, 1972; Yede, 2016); their numerical predominance in the current study seems to be normal, and this result supports findings obtained by Yede (2016) in the same study area.

In this study, the ecological status of the heteropteran species recorded were divided into four homogeneous groups, namely pests, predators, opportunistic and unknown. This result indicates that there are too many taxa of insect in the cocoa-based agroforestry systems; and each taxon has a different impact on the targeted host plant, *Theobroma cacao* Linneaus. Considering the percentage of insect pests (54.33%), compared to unknown (35.17%), opportunistic (9,85%) and predator (0.65%), our study clearly showed that this group of insects is predominant in term of abundance; then the annual cocoa losses in Centre Region of Cameroon is correlated to the high abundance of heretopteran insect pest species, which are also known as the main insect pest groups for the targeted host plant in the cocoa growing area worldwide (Lavable, 1970; 1977; Entwistle, 1972; Schaefer & Panizzi, 2000; Yede, 2016; Yede *et al.*, 2023). The cocoa trees infestations by the heteropteran insect pests such as *S. singualris*, *Distantiella theobroma*, *Helopeltis* sp. cause yield losses up to 100%, in case of strong selection pressures and without chemical treatments (Entwistle, 1972; Lavabre, 1977; Yede, 2016; Mahob et al., 2018; 2019; Yede *et al.*, 2012; 2024). Beside the taxa qualified as abundant, we also recorded rare (RA<1%) insect species (Appendix). Therefore, knowledge of biodiversity of insects in general, and heteropteran species in particular, are needed under field conditions to optimize the preservation of the entomofauna diversity *sensu lato*, especially endangered species in the one hand, and the protection of the cocoa-based agroforestry systems against the main insect pests via the integrated pest management (IPM) programs in order to increase the annual cocoa farms yield i.e. the cocoa farmers' incomes in the other hand.

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Conclusion

In our study area and experimental conditions, the heteropteran species associated with cocoa trees are very diversified and abundant; this biodiversity varies between the three studied agroecosystems (Forest, Savannah and Transition Zone). Compared to the Forest (Ngomedzap) and the Savannah (Bokito) zones, the Transition (Obala) zone sheltered more heteropteran species. The similarity is high in cocoa plantations from adjacent study localities and lower in cocoa farms geographically distant, due to the mixing/sharing of insect species between adjacent plantations. The community of Heteroptera species inventoried in the selected cocoa farms (137 specimens in total) was divided into four categories with regard of the ecological status: opportunistic, pests, predators and unknown species. Belong these four categories, insect pests appear as less diversified in term of specific richness compared to opportunistic, predators and unknown species but very abundant in term of individuals in the studied plantations. The current study provides valuable data regarding heteropteran species biodiversity under field conditions in the study area in order to optimize the preservation of the entomofauna diversity *sensu lato*, especially endangered species. However, it will be interesting to capitalize our results by organizing awareness campaign to the smallholders to upgrade their knowledge of heteroptera cocoa pest species, with the ultimate goal to improve sustainability the protection of the cocoa-based agroforestry systems against the main insect pests via the integrated pest management (IPM) programs in order to increase the annual cocoa farms yield i.e. the cocoa farmers' incomes.

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Appendix

Familly	Species	Ecological status On cocoa tree	Number of individuals per study area Ngomedzap	Obala	Bokito	Total
	Mirperus jaculus Thunberg, 1783	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
	Riptortus acantharis Dallas, 1852	Opportunistic	0(0)	0(0)	22(1.94)	22(0.45)
	Riptortus dentipes Fabricius, 1787	Opportunistic	2(0.2)	1(0.04)	4(0.21)	7(0.14)
Alydidae	*Stenocoris apicalis* Westwood, 1842	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Stenocoris elegans Blöte,1937	Opportunistic	0(0)	0(0)	15(0.81)	15(0.30)
	Stenocoris sp.	Opportunistic	0(0)	3(0.15)	7(0.38)	10(0.20)
	Tupalus maculatus Distant, 1901	Opportunistic	0(0)	0(0)	4(0.21)	4(0.08)
Aradidae	*Mezira rugosa* Signoret, 1858	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Acanthomia hystrix Dallas, 1852	Opportunistic	0(0)	2(0.09)	1(0.05)	3(0.06)
	Alleoerhynchus plebejus Reuter and Popius, 1909	Opportunistic	1(0.09)	9(0.43)	1(0.05)	11(0.22)
	Anoplocnemis gracilicornis Stäl., 1865	Opportunistic	0(0)	1(0.04)	1(0.05)	2(0.04)
	Anoplocnemis tristator Fabricius, 1803	Opportunistic	2(0.2)	1(0.04)	3(0.16)	6(0.12)
	Chaerommatus farinosus Amyot & Audinet-Seville, 1843	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Clavigralla hystrix Dallas,1852	Opportunistic	2(0.2)	0(0)	2(0.10)	4(0.08)
	Clavigralla sp.1	Opportunistic	0(0)	2(0.09)	0(0)	2(0.04)
	Clavigralla sp.2	Opportunistic	0(0)	1(0.04)	1(0.05)	2(0.04)
	Clavigralla tomentosicollis Stäl., 1855	Opportunistic	0(0)	2(0.09)	0(0)	2(0.04)
	Cletus apicicornis Horv.,1905	Opportunistic	2(0.2)	1(0.04)	0(0)	3(0.06)
	Cletus sp.1	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Cletus unifasciatus Villiers, 1950	Opportunistic	1(0.09)	3(0.15)	3(0.16)	7(0.14)
	Dasynus sp.	Opportunistic	1(0.09)	0(0)	1(0.05)	2(0.04)
Coreidae	*Homocerus ignotus* Schouteden, 1938	Pest	28(2.77)	42(2.05)	0(0)	70(1.43)
	Homocerus pallens Fabricius, 1781	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Homocerus sp.	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Hydara tenuicornis Westwood, 1842	Opportunistic	2(0.2)	1(0.04)	4(0.21)	7(0.14)

	Latimbus punctiventris Signoret, 1858	Opportunistic	0(0)	5(0.24)	0(0)	5(0.10)
	Leptoglossus membranaceus Fabricius, 1781	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Leptoglossus sp.	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Mevaniomorpha annulipes Reuter,1884	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Mydonia sp.	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Mydonia tuberculosa Signoret, 1851	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
	Myla hoploxys Dallas, 1852	Opportunistic	0(0)	1(0.04)	1(0.05)	2(0.04)
	Pseudopendulinus longicornis Schouteden, 1939	Unknown	0(0)	28(1.36)	7(0.38)	35(0.71)
	Pseudotheraptus sp.	Unknown	6(0.59)	73(3.56)	4(0.21)	83(1.69)
	Sericocoris sp.	Opportunistic	3(0.29)	0(0)	0(0)	3(0.06)
	Therapus africanus Burmeister, 1935	Opportunistic	0(0)	2(0.09)	1(0.05)	3(0.06)
	Therapus distinctii Stäl., 1865	Opportunistic	0(0)	8(0.38)	1(0.05)	9(0.18)
Cydnidae	*Onalips cribratus* Schiodte, 1881	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
Enycocephalidae	*Embolorrhinus cornifrons* Bergroth and Schouteden; 1905	Opportunistic	2(0.2)	8(0.38)	1(0.05)	11(0.22)
	Physopelta festiva Fabricius, 1803	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
Largidae	*Physopelta melanoptera* Distant, 1904	Opportunistic	2(0.2)	1(0.04)	0(0)	3(0.06)
Ledridae	*Petalocephala* sp.	Opportunistic	1(0.09)	1(0.04)	0(0)	2(0.04)
	Dieuches abondans Eyles, 1973	Unknown	17(0.68)	78(3.80)	93(5.04)	188(3.83)
	Dieuches africanus Eyles, 1973	Unknown	11(1.08)	99(4.82)	91(4.94)	201(4.10)
	Dinomachus africanus Bergroth, 1894	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Dinomachus grandis Distant, 1908	Unknown	2(0.2)	49(2.39)	3(0.16)	54(1.10)
Lygaeidae	*Hyginus guinensis* Scudder, 1959	Unknown	11(1.08)	35(1.70)	35(1.90)	81(1.65)
	Metadieuches dispar Haglund, 1895	Unknown	36	71(3.46)	13(0.70)	120(2.45)
	Myodocha serripes Distant, 1882	Unknown	1(0,09)	7(0.34)	42(2.28)	50(1.02)
	Oxycarenus sp.	Unknown	467(46.32)	170(8.28)	51(2.69)	688(14.03)
	Pachygrontha bipunctata Stäl, 1865	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
	Distantiella theobroma Distant, 1909	Pest	7	0(0)	0(0)	7(0.14)
	Helopeltis bergrothi Signoret, 1858	Pest	10(0.99)	52(2.53)	39(2.12)	101(2.06)

	Helopeltis gerini Carayon, 1948	Pest	6	7(0.34)	8(0.43)	21(0.43)
	Helopeltis sp.1	Pest	0(0)	2(0.09)	0(0)	2(0.04)
	Helopeltis sp.2	Pest	3(0.29)	26(1.27)	1(0.05)	30(0.61)
Miridae	*Lygus coffeae* China, 1935	Unknown	7(0.69)	42(2.05)	55(2.98)	104(2.12)
	Lygus sp.1	Opportunistic	10(0.99)	2(0.09)	2(0.10)	14(0.28)
	Lygus sp.2	Opportunistic	2(0.2)	0(0)	0(0)	2(0.04)
	Physophoropterella denticolis Reuter and Poppius, 1911	Unknown	0(0)	36(1.75)	0(0)	36(0.73)
	Sahlbergella singularis Haglund, 1895	Pest	229(22.67)	725(35.33)	1065(57.82)	2019(41.17)
	Tinginotum bipuncticolli Poppius, 1915	Opportunistic	0(0)	5(0.24)	0(0)	5(0.10)
Myodochidae	*Pamera horvathi* Reuter, 1831	Opportunistic	1(0,09)	0(0)	3(0.16)	4(0.08)
	Acrosternum sp.	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Acrosternum varicornis Dallas, 1851	Opportunistic	0(0)	2(0.09)	0(0)	2(0.04)
	Actuaris variams Villiers	Opportunistic	2(0.2)	0(0)	2(0.10)	4(0.08)
	Agaeus pivamentalis Distant, 1901	Opportunistic	0(0)	1(0.04)	3(0.16)	4(0.08)
	Asopinia platynopus Schouteden, 1907	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Aspavia hastator Fabricius, 1794	Opportunistic	0(0)	0(0)	13(0.70)	13(0.26)
	Aspavia sp.1	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Aspavia sp.2	Opportunistic	0(0)	0(0)	4(0.21)	4(0.08)
	Atelocera serrata Fabricius, 1803	Pest	29(2.87)	252(12.28)	106(5.75)	387(7.89)
	Atelocera spinulosa Palisot, 1805	Pest	4(0.39)	15(0.73)	7(1.38)	26(0.53)
	Bathycoelia sp.	Opportunistic	0(0)	1(0.04)	1(0.05)	2(0.04)
	Bathycoelia thalassina Herrich-Schäffer, 1844	Pest	0(0)	7(0.34)	23(1.25)	30(0.61)
Pentatomidae	*Carbula carbula* Distant, 1887	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Carbula melacantha Fabricius, 1794	Opportunistic	0(0)	1(0.04)	5(0.27)	6(0.12)
	Carbula sp.	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Coenomorpha schioedtei Haglund, 1894	Unknown	49(4.85)	2(0.09)	0(0)	51(1.04)
	Glypsus bouvieri Dallas, 1851	Opportunistic	0(0)	1(0.04)	0(0)	2(0.04)
	Haliomorpha sp.	Opportunistic	0(0)	5(0.24)	1(0.05)	6(0.12)

	Haliomorpha annulicornis Signoret, 1858	Pest	0(0)	0(0)	1(0.05)	1(0.02)
	Lerida punctata Palisot, 1805	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
	Menida villosa Linnavouri, 1975	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Parantestia eburnea Roche,1979	Opportunistic	0(0)	2(0.09)	0(0)	2(0.04)
	Planopsis sylvatica Distant, 1890	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Platynopiellus reichii Signoret, 1858	Opportunistic	2(0.2)	2(0.09)	0(0)	4(0.08)
	Pseudatelus excurrens Bergroth ,1853	unknown	1(0.09)	22(1.07)	11(0.59)	34(0.69)
	Tripanda longiceps Villiers ,1967	Opportunistic	0(0)	2(0.09)	0(0)	2(0.04)
Pyrrhocoreidae	*Antilochus boerhaviae* Fabricius, 1794	Opportunistic	0(0)	1(0.04)	6(0.32)	7(0.14)
	Dysdercus haemorrhoidalis Signoret,1858	Opportunistic	0(0)	1(0.04)	0(0)	3(0.06)
	Dysdercus melanoderes Karsch ,1892	Opportunistic	1(0.09)	1(0.04)	0(0)	2(0.04)
	Oncopeltus famelicus Fabricius, 1781	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Oncopeltus sp.	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Scanthius sp.	Opportunistic	0(0)	1(0.04)	4(0.21)	5(0.10)
	Acanthaspis bilineolata Palisot,1805	Opportunistic	0(0)	1(0.04)	1(0.05)	2(0.04)
	Carcinomma astrologus Bergroth, 1894	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Cethera musiva Germar,1837	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Cetheromma telescopus Jeannel, 1917	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Dulichius gemellus Haglund, 1895	Opportunistic	0(0)	3(0.15)	0(0)	3(0.06)
	Ectrichodia barbicornis Audinet-Serville, 1825	Predator	0(0)	2(0.09)	0(0)	2(0.04)
	Ectrichodia distincta Signoret,1782	Predator	1(0.09)	11(0.53)	3(0.16)	15(0.30)
	Endochus sp.	Opportunistic	1(0.09)	1(0.04)	0(0)	2(0.04)
	Hoplopium spinulosum Bergroth, 1910	Opportunistic	0(0)	0(0)	4(0.21)	4(0.08)
	Lisarda sp.	Opportunistic	0(0)	41(1.99)	8(0.43)	49(1.00)
	Microvarus conradti Jeannel, 1917	Opportunistic	0(0)	3(0.15)	0(0)	3(0.06)
	Peirates sp.	Opportunistic	1(0.09)	7(0.34)	0(0)	8(0.16)
	Peprius nodulipes Signoret, 1858	Opportunistic	3(0.29)	5(0.24)	0(0)	8(0.16)
	Petalocheirus rubiginosus Palisot de Beauvois, 1805	Opportunistic	0(0)	0(0)	5(0.27)	5(0.10)

	Petalocheirus variegatus Palisot de Beauvois, 1805	Opportunistic	0(0)	0(0)	5(0.27)	5(0.10)
Reduviidae	*Pisilus ripuliformis* Fabricius ,1794	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Polytoxus flavescens Villiers, 1943	Opportunistic	10(0.99)	7(0.34)	14(0.76)	31(0.63)
	Rhinocoris Bituberculatus Stäl., 1858	Predator	0(0)	1(0.04)	0(0)	1(0.02)
	Rhinocoris acutus Stäl., 1858	Predator	1(0.09)	2(0.09)	0(0)	3(0.06)
	Rhinocoris bicolor Fabricius, 1781	Predator	0(0)	3(0.15)	0(0)	3(0.06)
	Rhinocoris carmelita Stäl., 1859	Predator	0(0)	3(0.15)	1(0.05)	4(0.08)
	Rhinocoris hutsebauti Schouteden,1932	Predator	1(0.09)	0(0)	0(0)	1(0.02)
	Rhinocoris sp.	Predator	0(0)	3(0.15)	0(0)	3(0.06)
	Santosia sp.	Opportunistic	1(0.09)		0(0)	1(0.02)
	Santosia trimaculata Palisot,1805	Opportunistic	0(0)	2(0.09)	0(0)	2(0.04)
	Sastrapadra elegantula Villiers,1943	Opportunistic	1(0.09)	5(0.24)	0(0)	6(0.12)
	Thodelmus sp.	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
	Tribelocephala curticornis Villiers, 1943	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Tribelocephala dahomeyensis Villiers, 1943	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Vestula lineaticeps Signoret, 1858	Opportunistic	15(1.48)	9(0.43)	1(0.05)	25(0.51)
	Vestula sp.	Opportunistic	1(0.09)	0(0)	1(0.05)	2(0.04)
	Zostus acutus Palisot,1805	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Leptocoris aethiops Distant, 1901	Opportunistic	1(0.09)	1(0.04)	1(0.05)	3(0.06)
	Leptocoris apicalis Hahn, 1833	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Leptocoris exophtalma Thumb, 1837	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
Rhopalidae	*Leptocoris* sp.1	Opportunistic	0(0)	1(0.04)	0(0)	1(0.02)
	Leptocoris sp.2	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
	Leptocoris sp.3	Opportunistic	1(0.09)	1(0.04)	1(0.05)	3(0.06)
Tasplastidae	*Cantharodes Jaspideus* Fairmaire, 1858	Opportunistic	1(0.09)	0(0)	0(0)	1(0.02)
	Cantacader afzelii Stäl., 1873	Opportunistic	0(0)	0(0)	2(0.10)	2(0.04)
Tingidae	*Copium ornatella* Stal., 1855	Opportunistic	0(0)	0(0)	1(0.05)	1(0.02)
	Teleonemia nigerrima Schouteden, 1923	Opportunistic	0(0)	3(0.15)	0(0)	3(0.06)