International Journal of Agriculture, Environment and Bioresearch

Vol. 5, No. 04; 2020

ISSN: 2456-8643

BIOLOGICAL DIVERSITY OF INVERTEBRATE FAUNA CIRCULATING IN SOME CUCURBIT-BASED MARKET GARDENING AGROSYSTEMS AT MINKO'O (SOUTH REGION, CAMEROON)

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https://doi.org/10.35410/IJAEB.2020.5529

ABSTRACT

Market gardening, one of the predominant activities in developing countries in general and in Cameroon in particular, is nowadays threatened by pests of several animal taxa. These pests cause important yield losses and impose frequent and anarchical applications of large spectrum pesticides that alter product and environment quality. In the perspective of designing a study program on the ecology of major pests of cultivated cucurbit-based agrosystems, the present study aimed at assessing the biological diversity of the invertebrate circulating in these agrosystem. Data were collected at Minko'o, South Region of Cameroon by visual observations in experimental trap gardens from 2015 to 2017. A total of 412 species of 117 families and 20 orders of Invertebrates were identified from a set of 40,741 individuals. This sample comprise Insecta (13 orders), Diplopoda (two orders) and Arachnida (3 orders) and two orders of Gastropoda. The numerically most important orders were Hymenopterans, Hemipterans, Coleopterans, Orthopterans, and Lepidopterans representing 88.67% of the total abundance. The numerically dominant species belonged mainly to these orders. In relation with host plant preferences, all these orders, families and species showed variable level of selectivity as comparisons of their distribution among studied plants appeared different from one taxon to another.

Keywords: Cucurbitaceae, invertebrate, biological diversity, market gardening, inventory.

1. INTRODUCTION

Agriculture is one of the major economic sectors in most developing countries, including Cameroon. Since early 1990's, market gardening is taking an increasing part in this socioeconomic sector in urban and peri-urban areas of these countries as well as in their "gross domestic product" (Nguegang, 2008). It provides fresh vegetables and fruits for an expanding urban population and incomes for the majority of low and medium income African people (Beucher and Bazin, 2012). In Cameroon, market gardening is among the main sources of incomes for countryside dwellers and contributes significantly in the national economy (Kengue

et al., 2008). For instance, Cameroon appears as the major vegetable provider for Central African Countries. In Cameroon, its intensification has drastically increased during the last three decades. It came after the worldwide economic crisis of the late 1980s/early 1990s in various developing countries, related to the decline of traditional cash crops prices on international markets (Nguegang, 2008). Market gardening activities include several plant families among which Solanaceae (Djiéto-Lordon et *al*., 2014, Heumou *et al*., 2015, Elono Azang *et al*., 2016), Malvaceae (Bowombé, 2010) and Cucurbitaceae (Fomekong *et al*., 2008; Mokam *et al*., 2014, 2018). Considering the potential of the Cucurbitaceae as source of vegetable protein, fat and calcium for human population, they are essential in the fight against malnutrition in poor rural and peri-urban as well as refugee populations (Fokou *et al*., 2004). This worldwide plant family comprises about 825 species distributed in 119genus (Dupriez and De Leener, 1987; Jeffrey, 1990). The development and expansion of cucurbit crops are threatened by various constraints (Kumar; 1991, Fomekong *et al*., 2008; Mokam *et al*., 2018), resulting in an increase of production costs and thus of product prices on the market (Adégbola and Singbo, 2001).
Phytophagous insects, especially pests, are among the main threat for crops production in tropical Africa; they affect both the vegetative (leaves, stems, buds, roots) and the reproductive organs (flowers, fruits and seeds) of the plants and induce significant crop losses (Adja *et al*., 2015). This situation is accentuated by poor knowledge of cultural practices in terms of diagnosis of these constraints, and the bioecology of pests on one hand and its consequences the bad choice of the appropriate pesticides on the other. To efficiently address this problem while maintaining high production in quantity and quality, various strategies of integrated pest management, including biological control with the use of auxiliaries (mainly predators, parasitoids or microbial pathogens) and biochemical control (based on plant extract) are heavily encouraged (Lambert, 2010). Moreover, the development of effective integrated crop protection strategies relies on a good knowledge of the diversity, biology and ecology of these pests (Vilardebo, 1979) and their associated natural enemies. Some studies have been conducted on the fauna associated with vegetable in the southern Cameroon. Nevertheless, no study has been carried out on the species composition of invertebrates and their associated natural enemies on leaves, flowers, fruits and stems of domesticated cucurbits. It is in this framework that the present study was carried out in order to complete the former inventories of Invertebrates (pests and natural enemies) of domesticated cucurbits (Mokam *et al*., 2014). It aimed at (i) assessing invertebrate composition per cucurbit plant species/varieties; (ii) determining the most important taxa at three different level (order, family and species) according to numerical abundance, and to (iii) evaluate their preference in host-plants.

2. MATERIALS AND METHODS

2.1 Study site

The study was conducted from November 2015 to June 2017 in the Research Center of Forest and Environment (CEREFEN) (03° 06' N, 012° 21' E, altitude 659 m) of the Institute of Agricultural Research for the Development (IRAD) located at Minko'o (Dja-and-Lobo Subdivision), in the South Region of Cameroon.

The prevailing climate at Minko'o is equatorial humid climate with four seasons: a long dry season running from mid-November to March, a short dry season extending from June to July, a long rainy season from August to November and a small rainy season from March to June (Suchel, 1988). The Landscape of the area was an integral part of the Guineo-Congolese forest (Letouzey, 1968), with floristic components of the evergreen forest.

2.2 Plant material

The plant material included 11 varieties of seven cucurbit species commonly cultivated in the southern forest zone of Cameroon. They were: *Cucumis sativus* Linné commonly called cucumber, *Cucumeropsis mannii* Naudin (white pistachio), *Citrullus lanatus* (Thumberg) Mansfeld with two varieties (watermelon and egusi (yellow pistachio), *Lagenaria siceraria* (Molina) Standley (calabash), *Cucurbita maxima* Duschene (white-seeded melon), *Cucurbita moschata* (Duchesne ex lam.), with four varieties of melon: butternet and three local morphotypes codified var.$_1$, var.$_2$ and var.$_3$ and *Telfaira occidentalis* Hook F. (Fluted squash).

2.3 Experimental design

The experimental garden consisted in a 420 m^2 plot made up with two blocs of nine plates each. Plates were 11 m long x 1.5 m wide, separated by 0.5 m wide furrows. With the exception of the three varieties of *C. moschata* and of *T. occidentalis*, which were grown each on a single ridge; the seven other species were grown on two ridges each. For *T. occidentalis*, distance between plants was 3 m while for the four varieties of *C. moschata* and *C. maxima*, because of their great capacity of expansion, distance between plants was 3.7 m. By this practice invasion of other species was avoided. For *C. sativus* and the two varieties of C. *lanatus*, seeds were sowed on two ridges separated each other by furrows of 1 m while for *C. mannii* and *L. siceraria*, ridges were separated each other by 2.2 m furrows.

To prevent fungal and bacterial infestations of plants and fruits due to the contact of fruits and leaves with soil and breakage of stems under the weight of fruits, individual plants of *C. sativus*, *T. occidentalis* and *C. mannii* were staked.

2.4 Sampling method

Data collecting was done during four successive cropping cycles: (i) from November 2015 to March 2016, (ii) mid-March to August 2016, (iii) September 2016 to January 2017 and (iv) from March to June 2017.

Data collecting was conducted from the rise of the first two true leaves on seedlings until the end of each cropping cycle. This activity consisted of prospecting all organs (leaves, stems, fruits and flowers) of each plant species/variety. Insect net and a mouth aspirator were used to catch a sample of each flying species, while forceps were used to collect immature stage. All samples were taken to the laboratory where immature stages were reared up to imaginal moult, as most of the identification keys are based on adult characters. Adults of each invertebrate species or morphospecies collected were fixed in 70% ethanol, excepted lepidopterans which were kept dry, for further identifications or conformation on voucher collection.

2.5 Samples identifications

Identifications were based on adult morphological characters, observed under a binocular stereomicroscope Leica M80. For this purpose, some identification keys including Delvare and Aberlenc (1989) for insect orders and families Villiers (1948); Villiers (1952); Mestre (1988); Poutouli *et al*. (2011) were used for insects' genera and species determinations. Dichotomous key of Hölldobler and Wilson (1990); Bolton (1994) and Taylor (2010) were used to identify ants. Field determination guides of Bordat and Goudegnon (1991); Michel and Bournier (1997);

Bordat and Arvanitakis (2004) were used to identify many species known taxa as pest insects. The identifications were later confirmed by comparisons with those of the collection of the Laboratory of Zoology, Faculty of Science, University of Yaoundé I.

2.6 Data analysis

After identification, cumulative and relative abundances of invertebrates hosted by each plant species/varieties were computed. For the further analysis, taxa (orders, the families and the species) with ≥ 5%; 5% < relative abundance ≥ 1% were considered dominants and less abundant respectively. While those with abundance < 1%, were considered scare during the study.

3 RESULTS AND DISCUSSION

3.1 Biological diversity of invertebrates associated with cucurbits

During the study, a total of 412 species of invertebrates belonging to two phyla, 20 orders and 117 families of invertebrates was identified from a set of 40,741 individuals collected on the 11 species/varieties of cucurbits studied. They belonged into two phyla. The phylum of Arthropoda was the most speciose (18 orders, 112 families and 406 species) and the most abundant numerically (40197 individuals or 98.66%) than the phylum of Mollusca with two orders, 5 families and 6 species (544 individuals or 1.34%). Arthropod comprised Arachnida with 3 orders, 6 families and 6 species; Diplopoda with two orders, two families and two species and Insecta with 13 orders, 104 families and 398 species. This community appeared more diversified Fomekong *et al.* (2008) who collected on the same area on *Cucumeropsis mannii* (Cucurbitaceae) at Yaoundé (Cameroon), eight orders and 37 families of insects and from that of Adja *et al.*, (2015) who obtained on *Lagenaria siceraria* and *Citrullus lanatus* (Cucurbitaceae), 71 species of insects belonging to 41 families and 10 orders at Yamoussoukro (Côte d'Ivoire). These differences could be due either to the number of host plants (sampling material), to the sampling effort, to the extension of the study period, or to geographical variations of the study sites. This result reveals that, in addition to insects, other classes of arthropods namely Arachnida (represented by Acari), Diplopoda (Spirotreptida, Polydesmida) and even some individual of the phylum Mollusca namely Gastropoda (Caenogastropoda, Stylommatophora) can also feed on different organs of cucurbits, that may in certain circumstances particularly on seedling or during the aggregation phase of their larvae cause serious damages to host plant production.

3.2 Biological diversity at the level of orders

Among invertebrates, five orders Insecta dominated the community, each with higher species richness representing 88.67% of the sample. They included orders Hymenoptera (21 families and 89 species) with 11,381 individuals representing 27.94% of the total individuals collected, Hemiptera (20 families and 95 species) with 11,293 individuals (27.72 %), Coleoptera (20 families and 102 species) with 8,299 individuals (20.37 %) and Orthoptera (7 families and 58 species) with 3,646 individuals (8.95 %) and to a lesser extent Lepidoptera (8 families and 10 species) with 1505 individuals (3.69 %) (Table1).These observations were also mentioned by Vayssières *et al.* (2001) on market crops at Réunion Island, by Fomekong *et al.* (2008) on *Cucumeropsis mannii* (Cucurbitaceae), and by Chougourou *et al.*, (2012) on *Lycopersicon esculentum* Mill in common of Djakotomey in Benin. Our results are similar to those of Assi *et al.*, (2018); these authors showed that the main insect orders in cucumber culture were Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera respectively. These results are

ISSN: 2456-8643

different from those of Koné *et al*., (2019) obtained on zucchini in Northern Côte d'Ivoire. According to these authors, the main orders of insects colonizing zucchini plots are Homoptera, Hymenoptera and Diptera. This difference could be explained by the fact that both studies were conducted at different seasons. The climate of Korhogo is characterized by two seasons while ours by four seasons. Besides Koné *et al.*, (2019) has thought that the season has an influence on the entomofauna of Cucurbits. Moreover, five other orders, each less species and less abundant numerically were also observed. They were orders of Aranea, Thysanoptera, Diptera, Polydesmida, and Spirostreptida (Table1).In relation with host plant selection, all these orders showed variable level of selectivity; their distribution among studied plants appeared different from one order to another.

Table 1. List of the orders of invertebrates collected during the study

Orders (species richness)	Abundance of Invertebrates per Cucurbit species / varieties											Total
	A	B	C	D	E	F	G	H	I	J	K	
						Arachnida						
Acari (3)	0(0)	0(0)	0(0)	0(0)	0(0)	15(93.75)	0(0)	1(6.25)	0(0)	0(0)	0(0)	16(0.04)
Aranea(2)	146(12.64)	10(8.92)	167(14.46)	68(5.89)	79(6.84)	73(6.32)	105(9.09)	87(7.53)	88(7.62)	166(14.37)	73(6.32)	1155(2.83)
Opilion (1)	29(93.55)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(6.45)	0(0)	0(0)	31(0.08)
						Diplopoda						
Polydesmida (1)	79(13.93)	45(7.94)	68(11.99)	36(6.35)	31(5.47)	20(3.53)	61(10.76)	9(1.59)	32(5.64)	99(17.46)	87(15.34)	567(1.39)
Spirostreptida (1)	102(19.92)	48(9.38)	92(17.96)	34(6.64)	15(2.93)	38(7.42)	27(5.27)	10(1.95)	23(4.49)	63(12.30)	60(11.72)	512(1.26)
						Insecta						
Coleoptera (102)	933(11.24)	617(7.43)	869(10.47)	446(5.37)	402(4.84)	760(9.16)	880(10.60)	43(5.19)	570(6.87)	2168(26.12)	223(2.69)	8299 (20.37)
Collembola (1)	0(0)	1(25.00)	0(0)	0(0)	0(0)	0(0)	3(75.00)	0(0)	0(0)	0(0)	0(0)	40.01)
Dermaptera (2)	7(8.64)	1(1.23)	7(8.64)	2(2.47)	12(14.81)	7(8.64)	15(18.52)	4(4.94)	2(30.86)	0(0)	1(1.23)	81(0.2)
Diptera (31)	2(0.34)	5(0.85)	7(1.19)	18(3.07)	56(9.56)	131(22.35)	109(18.60)	15(2.56)	59(10.07)	18 (3.07)	0(0)	586(1.44)
Dictyoptera (3)	25(7.84)	24(7.52)	46(14.42)	8(2.51)	12(3.76)	31(9.72)	6(1.88)	8(2.51)	13(4.08)	114(35.74)	32(10.03)	319(0.78)
Hemiptera (95)	944(8.36)	402(3.56)	835(7.39)	2048(18.14)	717(6.35)	852(7.54)	681(6.03)	379(3.36)	597(5.29)	3625(32.10)	213(1.89)	11293 (27.72)
Hymenoptera (89)	1412(12.41)	1020(8.96)	1152(10.12)	718(6.31)	571(5.02)	1271(11.17)	1096 (9.63)	828(7.28)	718(6.31)	2051(18.02)	544(4.78)	11381 (27.94)
Lepidoptera (10)	82(5.45)	15(1.00)	33(2.19)	75(4.98)	19(1.26)	32(2.13)	29(1.93)	9(0.60)	26(1.73)	1181(78.47)	4(0.27)	1505 (3.69)
Neuroptera (3)	14(15.38)	5(5.49)	7(7.69)	7(7.69)	8(8.79)	17(18.68)	12(13.19)	0(0)	2(2.20)	19(20.88)	0(0)	91(0.22)
Orthoptera (58)	512(14.04)	311(8.53)	490(13.44)	255(6.99)	256(7.02)	311(8.53)	221(6.06)	128(3.51)	217(5.95)	638(17.50)	307 (8.42)	3646 (8.95)
Plecoptera (1)	6(6.90)	3(3.45)	18(20.69)	0(0)	5(5.74)	8(9.20)	2(2.30)	0(0)	5(5.75)	17(19.54)	23 (26.44)	87(0.21)
Psocoptera (1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(100)	0(0)	0(0)	0(0)	1(0)
Thysanoptera (2)	200(32.10)	88(14.13)	1(0.16)	120(19.26)	27(4.33)	26(4.17)	13(2.09)	28(4.49)	17(2.73)	103(16.53)	0(0)	623 (1.53)
						Gastropoda						
Caenogastropoda (4)	39(11.89)	19 (5.79)	51(15.55)	16(4.88)	19(5.79)	48(14.63)	45(13.72)	14(4.27)	18(5.49)	19(5.79)	40(12.20)	328(0.81)
Stylommatophora (2)	29(13.43)	19(8.80)	41(18.98)	42(19.44)	13(6.02)	14(6.48)	14(6.48)	2(0.93)	15(6.94)	17(7.87)	10(4.63)	216(0.53)
Total	4561(11.20)	2726(6.69)	3884(9.53)	3893(9.56)	2242(5.50)	3654(8.97)	3319(8.15)	1954(4.80)	2427(5.96)	10464(25.68)	1617(3.97)	40741 (100.00)

Legend: Figures represent the abundance per plant species/variety in brackets are the relative abundance according to the plant species; A: *Citrullus lanatus* var. egusi; B: *Citrullus lanatus* var. watermelon; C: *Cucumeropsis mannii*; D: *Cucumis sativus*; E: *Cucurbita maxima*; F: *Cucurbita moschata* var.$_1$; G: *Cucurbita moschata* var.$_2$; H: *Cucurbita moschata* var.3; I: *Cucurbita moschata* var. butternet; J: *Lagenaria siceraria*; K: *Telfairao ccidentalis*

3.3. Biological diversity at the level of families for the most abundant orders

Without consideration of plant species/varieties, among the 117 families of invertebrates identified during the present survey, only five families within Insecta showed relative abundance ≥ 5% (Table 2). Then, the community was dominated by families Formicidae (representing 24.58% of the total fauna), Chrysomelidae (12.66%), Aphididae (9.66%), Miridae (6.27%) and Aleyrodidae (5.84%). Moreover 13 families, namely Acrididae (4.10 %), Pyrgomorphidae (3.52%), Aranea Fm2 (2.66%), Pterophoridae (2.75%), Apidae (2.62%), Nutidulidae (2.13%), Tenebrionidae (2.08%), Coccinellidae (2.02%), Thripidae (1.53%), Coreidae (1.43%), Paradoxosomatidae (1.39%), Odontopygidae (1.26%) and Ciccadellidae (1.25%) were also numerically important, with relative abundance ≥ 1% (Table 2).The activity of the species belonging to these families greatly affects the development and the growth of the plant. The main insect families collected during the present study differed to a certain extent from those observed on *L. siceraria* and *C. lanatus* by Adja *et al.*, (2015) in Ivory Coast. For instance, the pest community described by these authors included especially the families of Chrysomelidae, Coccinellidae and Meloidae, whose larvae and adults are mainly leaf eaters.

According to the selectivity of these invertebrate opposite host plant species/varieties, Formicidae, Chrysomelidae and Miridae showed similar distribution model within plant species with the highest abundance on *L. siceraria* and the lowest on *T. occidentalis* while Aphididae was the most abundant on *L. siceraria* (50.34%) and on *Cucumis sativus* (35.36%). Occurrence of invertebrate families varied according to cucurbit species/varieties; so, the family Aphididae was not encountered on *Cucurbita moschata* var.$_2$. The family of Aleyrodidae was not encountered on *T. occidentalis* and on *Citrullus lanatus* var. watermelon, meanwhile, this family appeared mostly abundant on *Cucurbita maxima* (17.23%) (Table 2). Specificity was shown between individuals from the family Pterophoridae and the plant species *L. siceraria*, as its abundances were higher only on this plant species (98.84%). The same trend was observed among the less frequent families (relative abundance below 5%) (Table 2).

Table 2. List of the main families of invertebrates (relative abundance above 1%) collected during the study

Families	Abundance of Invertebrates per Cucurbit species / varieties											total
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	
Acrididae	206(12.32)	134(8.01)	214(12.80)	159(9.51)	97(5.80)	145(8.67)	115(6.88)	56(3.35)	72(4.31)	321(19.20)	153(9.15)	1672(4.10)
Aleyrodidae	355(14.92)	0(0)	166(6.97)	286(12.02)	410(17.23)	295(12.39)	255(10.71)	153(6.43)	210(8.82)	250 (10.50)	0(0)	**2380(5.84)**
Aphididae	110(2.79)	171 (4.34)	85(2.16)	1392(35.36)	12(0.30)	47(1.19)	0(0)	35(0.89)	102(2.59)	1982(50.34)	10(0.03)	**3937(9.66)**
Apidae	116(10.86)	148(13.86)	68(6.37)	143(13.39)	98(9.18)	112(10.49)	146(13.67)	54(5.06)	78(7.30)	105(9.81)	0(0)	1068(2.62)
Fm.$_{2}$	139(12.82)	103(9.50)	153(14.11)	68(6.27)	68(6.27)	64(5.90)	88(8.12)	77(7.10)	88(8.12)	164(15.13)	72(6.64)	**5156(12.66)**
Chrysomelidae	808(15.67)	497(9.64)	633(12.28)	237(4.60)	224(4.34)	499(9.68)	497(9.64)	282(5.47)	230(4.46)	1175(22.79)	74(1.44)	509(1.25)
Ciccadellidae	71(13.95)	40(7.86)	60(11.79)	73(14.34)	33(6.48)	21(4.13)	15(2.95)	7(1.38)	15(2.95)	151(29.67)	23(4.52)	829(2.03)
Coccinellidae	2(0.24)	10(1.21)	17(2.05)	125(15.08)	8(0.97)	48(5.79)	60(7.24)	12(1.45)	144(17.37)	403(48.61)	0(0)	582(1.43)
Coreidae	85(14.61)	17(2.92)	63(10.82)	48(8.25)	23(3.95)	91(15.64)	126(21.65)	27(4.64)	29(4.98)	73(12.54)	0(0)	1084 (2.66)
Formicidae	1275(12.73)	860(8.59)	1071(10.69)	568(5.67)	469(4.68)	1124(11.22)	929(9.28)	771(7.70)	624(6.23)	1804(18.01)	521(5.20)	**10016(24.58)**
Miridae	171(6.69)	100(3.92)	234(9.16)	156(6.11)	202(7.91)	275(10.77)	178(6.97)	116(4.54)	184(7.20)	931(36.45)	7(0.27)	**2554 (6.27)**
Nutidulidae	1(0.12)	1(0.12)	0(0)	2(0.23)	103(11.87)	108(12.44)	94(10.83)	35(4.03)	77(8.87)	447(51.50)	0(0)	868(2.13)
Odontopygidae	102(19.92)	48(9.38)	92(17.97)	34(6.64)	15(2.93)	38(7.42)	27(5.27)	10(1.95)	23(4.49)	63(12.30)	60(11.72)	512(1.26)
Paradoxo somatidae	79(13.93)	45(7.94)	68(11.99)	36(6.35)	31(5.47)	20(3.53)	61(10.76)	9(1.59)	32(5.64)	99(17.46)	87(15.34)	567(1.39)
Pterophoridae	0(0)	0(0)	8(0.71)	0(0)	0(0)	1(0.09)	0(0)	2(0.18)	2(0.18)	1106(98.84)	0(0)	1119 (2.75)
Pyrgomorphidae	250(17.43)	132(9.21)	211(14.71)	79(5.51)	122(8.51)	120(8.37)	71 (4.95)	47(3.28)	99(6.90)	215(14.99)	88(6.14)	1434 (3.52)
Tenebrionidae	93(10.95)	61(7.18)	129(15.19)	64(7.54)	43(5.06)	51(6.01)	69(8.13)	60(7.07)	54(6.36)	106(12.49)	119(14.02)	849(2.08)
Thripidae	200(32.10)	88(14.13)	1(0.16)	120(19.26)	27(4.33)	26(4.17)	13(2.09)	28(4.49)	17(2.73)	103(16.53)	0(0)	623(1.53)
Others families	498(10.00)	271(5.44)	611(12.26)	303(6.08)	257(5.16)	569(11.42)	575(11.54)	173(3.47)	347(6.97)	966(19.40)	412(8.27)	4982 (12.23)
Total	4561(11.20)	2726(6.69)	3884(9.53)	3893(9.56)	2242(5.50)	3654(8.97)	3319(8.15)	1954(4.80)	2427(5.96)	10464(25.68)	1617(3.97)	40741 (100)

Legend: Figures represent the abundance per plant species/variety in brackets are the relative abundance according to the plant species; A: ***Citrullus lanatus*** var. egusi; B: *Citrullus lanatus* var. watermelon; C: *Cucumeropsis mannii*; D: *Cucumis sativus*; E: *Cucurbita maxima*; F: *Cucurbita moschata* var.$_1$; G: *Cucurbita moschata* var.$_2$; H: *Cucurbita moschata* var.$_3$; I: *moschata* var. butternet; J: *Lagenaria siceraria*; K:*Telfaira occidentalis*.

3.4. Biological diversity at the level of species

The order Hemiptera was the most speciose, with 95 species belonging to 20 families. Among them *Aphis gossypii* Glover, 1877 (Aphididae) with 9.66% of the total fauna, followed by *Bemisia tabaci* (Gennadius) (Aleyrodidae) (5.84%), *Halticus* sp. (Miridae) (4.45%), *Leptoglossus australis* Fabricius, 1775 (Coreidae) (1.38%) and *Nesidiocoris* sp. (Miridae) (1.60%) were the most abundant.

According to cucurbit species/varieties, a relative selectivity in host plants was observed as *A. gossypii* was most abundant on *L. siceraria* (50.38%) of the individuals followed by *C. sativus* (35.37%), while *B. tabaci* was most abundant on *C. maxima* (17.23%) and *C. lanatus* var. egusi (14.92%) (Table 3). Similar trend was observed for the other species (Table 3).

The order of Hymenoptera was represented by 89 species belonging to 21 families. The ants (Formicidae) *Pheidole megacepahala* Fabricius, 1793 (7.79%), *Myrmicaria opaciventris* Emery, 1893 (6.32%), *Camponotus flavomarginatus* Mayr, 1862 (2.50%), *Lepisiota guineensis* Mayr, 1902 (1.24%), *Odontomacus troglodytes* André, 1887 (1.21%), the bee *Apis mellifera* Linné, 1758(1.35%) and the unidentified bee species Gen.$_{142}$ sp. (1.21%) appeared the most abundant. Concerning host plant selectivity, *P. megacephala*

M. opaciventris were more frequent on *L. siceraria* while *C. flavomarginatus* was more represented on *C. lanatus* var. egusi. Similar trend was observed on the other species (Table 3).

The order of Coleoptera was represented by 102 species belonging to 21 families. The family of Chrysomelidae which was represented by *Lamprocopa occidentalis* Weise, 1895 (4.95%), *Leptaulaca fissicollis* Thomson, 1858 (3.66%) and *Monolepta intermedia* Ritsema, 1875 (1.16%); the family of Nutidulidae with *Epuraea* sp. (2.11%), *Henosepilachna reticulata* Olivier, 1791 (Coccinellidae) (1.82%), *Lagria villosa* Fabricius, 1783 (Tenebrionidae) (1.41%) were the most abundant. In relation to host plant selectivity, the same trend was observed with preference for *L. siceraria* for almost all species with exception of *L. villosa*, most abundant on *C. mannii* (Table 3).

The order Orthoptera was represented by 58 species belonging to seven families. Among them, two species, *Atractomorpha acutipennis* Bolivar, 1884 (Pyrgomorphidae) (1.80%) and *Oxycatantops spissus* Walker, 1870 (Acrididae) (2.42%) were numerically dominant. (Table 3). Concerning the selectivity in host plant, these two species were most frequent respectively on *C. lanatus* var. egusi for *Atractomorpha acutipennis* and on *L. siceraria* for *O. spissus* (Table 3).

The Lepidoptera contained 10 species belonging to eight families but a single specie most abundant, *Sphenarches anisodactylus* Walker, 1864. This species belonging to the family Pterophoridae was recorded with a relative abundance of 2.75%. This species was mostly abundant on *L. siceraria* (98.84%) (Table 3).

Four orders, although relatively represented, contained only species with weak abundances. These included Thysanoptera, Aranea, Polydesmida and Spirostreptida. The Thysanoptera, in the majority represented by *Thrips* sp., occurred with a relative abundance of 1.50%. The Aranea were represented by several unidentified species belonging to the genus codified Aranea-Gen.$_3$ sp..The Polydesmida were represented by the species *Habrodesmus falx* Cook, 1896 (family Paradoxosomatidae) while the Spirostreptida were represented by the species *Trichochalopuncus* sp. (family Odontopygidae) (Table 3). At a lesser extent, these species also were unequally distributed among studied plant species.

To certain extent, these observations differed from those of Adja *et al*., (2015) who reported that *Lamprocopa occidentalis*, *Aulacophora foveicolis*, *Aulacophora africana*, *Asbecesta cyanipennis*, *Ootheca mutabilis*, *Lilioceris livida*, *Henosepilachna elaterii*, *Henosepilachna reticulate* and *Mylabrisholosericea* (Coleoptera) were the main pests on *L. siceraria* and *C. lanatus* (Cucurbitaceae). This finding is also different from that of Vinutha *et al*., (2017) who, in India showed that *Aulacophora foveicollis* Lucas (Chrysomelidae), *Thrips tabaci* Lindeman (Thripidae), *Eurybrachys tomentosa* (Fabricius) (Eurybrachidae), *Liriomyza trifolli* Burgess (Agromyzidae), *Bactocera cucurbitae* Coq. (Tephritidae), *Spilostethus pandurus* (Scopoli) (Lygaeidae), *Spilostethus hospes* (Fabricius) and *Coccinella transversalis* (Fabricius) (Coccinellidae) were commonly found on oriental pickling melon, *Cucumis melo* var. conomon.

The majority of species observed during this study were represented in a fair manner on cucurbit species although some of them were highly abundant on some plant species. This can be explained by the fact that the species of the fauna observed have the same capacity for colonization of the species of cucurbits. However, some species showed a great preference for some cucurbit species.

Table 3. List of the main species of invertebrates (relative abundance above 1 %) collected during the study

	Cucurbits species and varieties studied											
Species	A	B	C	D	E	F	G	H	I	J	K	Total
						Aranea						
Gen.$_3$sp.	139(12.82)	103(9.5)	153(14.11)	68(6.27)	68(6.27)	88(8.12)	64(5.9)	88(8.12)	77(7.1)	164(15.13)	72(6.64)	1084(2.66)
						Coleoptera						
Epuraea sp.	1(0.12)	1(0.12)	0(0)	0(0)	103(11.96)	73(8.48)	108(12.54)	94(10.92)	35(4.07)	446(51.8)	0(0)	861(2.11)
Henosepilachna Reticulate	0(0)	1(0.13)	3(0.4)	98(13.23)	5(0.67)	142(19.16)	44(5.94)	53(7.15)	10(1.35)	385(51.96)	0(0)	741(1.82)
Lagria Villosa	55(9.6)	45(7.85)	90(15.71)	42(7.33)	24(4.19)	43(7.5)	40(6.98)	47(8.2)	45(7.85)	69(12.04)	73(12.74)	573(1.41)
Lamprocopa Occidentalis	267(13.23)	140(6.94)	96(4.76)	102(5.05)	152(7.53)	125(6.19)	245(12.14)	322(15.96)	90(4.46)	453(22.45)	26(1.29)	2018(4.95)
Leptaulaca Fissicollis	291(19.52)	210(14.08)	234(15.69)	60(4.02)	43(2.88)	57(3.82)	80(5.37)	76(5.1)	85(5.7)	344(23.07)	11(0.74)	1491(3.66)
Monolepta Intermedia	99(20.97)	56(11.86)	88(18.64)	16(3.39)	8(1.69)	13(2.75)	40(8.47)	12(2.54)	36(7.63)	99(20.97)	5(1.06)	472(1.16)
						Hemiptera						
Aphis gossypii	110(2.79)	171(4.34)	85(2.16)	1392(35.37)	12(0.3)	102(2.59)	47(1.19)	0(0)	35(0.89)	1982(50.36)	0(0)	3936(9.66)
Bemisia tabaci	355(14.92)	(0)	166(6.97)	286(12.02)	410(17.23)	210(8.82)	295(12.39)	255(10.71)	153(6.43)	250(10.5)	(0)	2380(5.84)
Halticus sp.	157(8.66)	98(5.41)	218(12.03)	151(8.33)	195(10.76)	169(9.33)	246(13.58)	168(9.27)	115(6.35)	295(16.28)	0(0)	1812(4.45)
Leptoglossus australis	83(14.72)	16(2.84)	60(10.64)	43(7.62)	23(4.08)	28(4.96)	89(15.78)	125(22.16)	26(4.61)	71(12.59)	0(0)	564(1.38)
Nesidiocoris sp.	12(1.84)	1(0.15)	1(0.15)	0(0)	4(0.61)	0(0)	2(0.31)	0(0)	0(0)	632(96.93)	0(0)	652(1.60)
						Hymenoptera						
Apis mellifera	108(19.71)	134(24.45)	65(11.86)	132(24.09)	0(0)	4(0.73)	0(0)	0(0)	0(0)	105(19.16)	0(0)	548(1.35)
Camponotus flavomarginatus	209(20.51)	77(7.56)	100(9.81)	72(7.07)	29(2.85)	46(4.51)	70(6.87)	106(10.4)	119(11.68)	133(13.05)	58(5.69)	1019(2.5)
Gen.$_{142}$sp.	8(1.62)	14(2.84)	3(0.61)	0(0)	98(19.88)	74(15.01)	112(22.72)	146(29.61)	38(7.71)	0(0)	0(0)	493(1.21)
Lepisiota guineensis	143(28.89)	3(0.61)	11(2.22)	48(9.7)	10(2.02)	3(0.61)	109(22.02)	55(11.11)	28(5.66)	42(8.48)	43(8.69)	495(1.21)
Myrmicaria opaciventris	282(10.95)	242(9.4)	311(12.08)	197(7.65)	155(6.02)	185(7.18)	134(5.2)	230(8.93)	94(3.65)	577(22.41)	168(6.52)	2575 (6.32)
Odontomacus troglodytes	74(14.6)	38(7.5)	52(10.26)	18(3.55)	17(3.35)	30(5.92)	94(18.54)	37(7.3)	46(9.07)	97(19.13)	4(0.79)	507(1.24)

Pheidole megacephala	301(9.49)	280(8.83)	398(12.55)	155(4.89)	125(3.94)	249(7.85)	222(7)	322(10.15)	309(9.74)	660(20.81)	151(4.76)	3172(7.79)
Lepidoptera												
Sphenarches anisodactylus	0(0)	0(0)	8(0.71)	0(0)	0(0)	2(0.18)	1(0.09)	0(0)	2(0.18)	1106(98.84)	0(0)	1119(2.75)
Orthoptera												
Atractomorpha acutipennis	144(19.65)	50(6.82)	127(17.33)	40(5.46)	51(6.96)	40(5.46)	63(8.59)	32(4.37)	28(3.82)	114(15.55)	44(6)	733(1.80)
Oxycatantops spissus	140(14.18)	92(9.32)	135(13.68)	79(8)	53(5.37)	50(5.07)	77(7.8)	60(6.08)	43(4.36)	182(18.44)	76(7.7)	987(2.42)
Polydesmida												
Habrodesmus falx	79(13.93)	45(7.94)	68(11.99)	36(6.35)	31(5.47)	32(5.64)	20(3.53)	61(10.76)	9(1.59)	99(17.46)	87(15.34)	567(1.39)
Spirostreptida												
Trichochalopuncus sp.	102(19.92)	48(9.38)	92(17.97)	34(6.64)	15(2.93)	23(4.49)	38(7.42)	27(5.27)	10(1.95)	63(12.3)	60(11.72)	512(1.26)
Thysanoptera												
Thrips sp.	199(32.46)	88(14.36)	0(0)	120(19.58)	27(4.4)	11(1.79)	24(3.92)	13(2.12)	28(4.57)	103(16.8)	0(0)	613(1.50)
Total	3358(11.22)	1953(6.53)	2564(8.57)	3189(10.66)	1658(5.54)	1799(6.01)	2264(7.57)	2329(7.78)	1461(4.88)	8471(28.31)	878(2.93)	29924(73.45)

4. CONCLUSION

The present study shows that the invertebrate fauna associated with Cucurbitaceous at Minko'o (southern Cameroon) is highly diversified, with a total of 40,741 individuals arranged into 20 orders, 117 families and 412 species. The main organisms collected were from the class Insect represented by orders Hymenoptera, Hemiptera, Coleoptera Orthoptera and Lepidoptera. The most abundant families were Formicidae, Aphididae, Chrysomelidae, Miridae and Aleyrodidae while the most abundant species were *Epuraea* sp., *H. reticulata*, *L. villosa*, *L. occidentalis*, *L. fissicollis*, and *M. intermedia* (Coleoptera); *A. gossypii*, *B. tabaci*, *Halticus* sp., *L. australis* and *Nesidiocoris* sp. (Hemiptera); Apidae-Gen.$_{142}$ sp., *A. mellifera*, *C. flavomarginatus*, *L. guineensis*, *M. opaciventris*, *O. troglodytes* and *P. megacephala* (Hymenoptera), *A. acutipennis* and *O. spissus* (Orthoptera) and *S. anisodactylus* (Lepidoptera). Looking at the high level of biological diversity on cucurbits, the future study may have stated on the specific diversity of entomofauna and their functional statute on the host plant, to clearly define this pest states or importance as biological control of the pest species population. Despite the high number of unidentified species, the present studies provide baseline data for ecological studies, prior to an implementation of a potential integrated pest management strategy.

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ISSN: 2456-8643

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