E-ISSN: 2708-0021
P-ISSN: 2708-0013
www.actajournal.com
AEZ 2024; 5(2): 01-09
Received: 03-04-2024
Accepted: 08-05-2024

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Entomofauna of tomato (*Lycopersicon esculentum* Mill.) in 4 production basins in the West-Cameroon region

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DOI: https://doi.org/10.33545/27080013.2024.v5.i2a.146

Abstract
Because of insect damage, tomato yields are low in relation to the area under cultivation. The aim of this study was to identify the entomofauna of four tomato agroecosystems in Western Cameroon during the dry and rainy seasons 2020 and 2021. Insects were collected using yellow traps, an entomological net and a mouth aspirator, preserved in 70% ethanol and identified at the Universities of Dschang and Yaoundé I. A total of 25321 insects from 7 orders of 66 families were collected and 17 Arachnida-Araneidae. 16437 individuals and 8884 were collected respectively in the dry and rainy season. Using yellow traps, 14209 individuals were collected and 11112 using net. Here, Hemiptera represented 72.56%, Diptera 14.61%, Lepidoptera 9.42%, Hymenoptera 2.34%. Hemiptera Aleyrodidae, Aphididae, Cicadellidae and Miridae, Diptera-Drosophillidae, Lepidoptera-Gelechiidae, Hymenoptera-Formicidae and Orthoptera-Acrididae are the families with the most individuals. Hemiptera-Aleyrodidae account for 51.49% of all invertebrates. More insects were collected in the dry season (64.91%). District of Bangangté, Nkong-Ni and Foumbot were the most attacked. Beneficial insects include Hymenoptera Formicidae, Halictidae and Figitidae, Odonata and Arachnida-Araneidae. This work is an essential step in setting up integrated pest management strategies.

Keywords: IPM, tomato agroecosystems, entomofauna, pests, natural enemies

Introduction
Tomato (*Lycopersicon esculentum* Mill) is grown in many countries around the world and in a variety of climates, including relatively cold regions thanks to the development of crops under cover (Mensah *et al.* 2016) [27]. It is the most widely produced vegetable worldwide, ahead of watermelon and cabbage, but behind potatoes and sweet potatoes, the latter two being considered more as starchy foods (FAO, 2010) [15]. According to statistics from the Food and Agriculture Organisation of the United Nations, global tomato production in 2018 was 182,256,458 tonnes, making the tomato the second most widely grown vegetable in the world (FAO, 2018) [17]. Tomatoes are very important in the human diet, providing a good reservoir of antioxidants, such as lycopene, ascorbic acid, carotenoids, flavonoids and phenolic compounds (Arab and Steck, 2014) [2]. It is rich in carbohydrates, proteins, lipids, vitamins (A, B, C, E) and trace elements (potassium). Its skin and seeds are rich in fibre (Sawadogo *et al.* 2015) [31]. Numerous epidemiological studies have shown that consumption of fruit and vegetables such as tomatoes plays a role in the prevention of chronic diseases, and reduces mortality from cancer and cardiovascular disease (Lecerf, 2006) [24]; Chanforan, 2010) [5]. Cameroon is ranked 6th in Africa in terms of tomato consumption. Cameroon ranks 6th in Africa with an estimated fresh tomato production of about 1.3 million tonnes in 2017, for a total cultivated area of 105561 ha, i.e. a yield of 12.1 t/ha (FAO 2017) [16]. It is therefore an important fruiting vegetable in Cameroonian agriculture. The western region, particularly the Bangangté, Foumbot, Mbouda and Dschang areas contribute 39% of national tomato production (Boum, 2015) [4]. One of the major constraints to increasing tomato production in this region is pest control. The entomofaunal biodiversity of tomato ecosystem is varied: some insects act as pests, causing damage to different parts of the plant (Leaves, stems, fruit) and thus reducing yields. Other insects, on the other hand, are pollinators and natural enemies. Unfortunately, tomato pests and their natural enemies are little known to producers, as is the entomofauna in general, which

abounds in addition to the above-mentioned pollinators. This lack of knowledge leads to a poor choice of chemical products to limit pest damage and improve production (Kanda *et al.*, 2013; Mondedji *et al.*, 2015) [23, 28]. But the problems associated with their use still remain: pest resistance and the impact on beneficials, the impact of pesticides. Thus, one efficient alternative method is to get farmers to identify insects while highlighting the role of each insect in the production system. In this way, decisions are taken on the basis of the pest and not on the basis of the producer's friends (pollinators and natural enemies). As far as biodiversity is concerned, studies carried out in different agro-ecological zones of Cameroon reveal a high entomofaunal diversity. These studies showed that in the Sahelian agro-ecological zone, mainly in the Meskine locality in the Far North region of Cameroon, the insect pests associated with tomatoes in the field were whiteflies, aphids, leafhoppers, mirids, noctuid moths and locusts. Ladybird beetles and syrphid flies were also found to be predators (Patouma *et al.* 2020) [31]. The work of Ndounking *et al.* (2022) [29] in Dschang, West Cameroon, the highland agro-ecological zone, showed that the main pests of tomatoes were whiteflies, aphids, leafminers and fruit flies. Spiders and ants were observed as predators. But those carried out on sweet pepper, a plant in the same family as tomato, by Dzokou *et al.* (2021a) [13] in the localities of Zaah Seeh, Tetop, Lepeh and Lac Municipal in the Ménoua department, West Cameroon region, identified whiteflies, aphids, mirids, leafhoppers, psyllids, leafminers and noctuid moths as pests, and wasps and ants as predators and bees as pollinators. The aim of this work is to make an inventory of the faunal biodiversity in the tomato agroecosystem and to highlight the role of each insect in order to provide information on pests and diseases that can be controlled.

Materials and Methods

Presentation of the study environment

Study sites: This study was conducted during the dry and rainy seasons of 2020 and 2021, in 4 departments of the West Cameroon region: Ménoua, Bamboutos, Ndé and Noun (Figure 1). In each department, 8 plots were sampled for a total of 32 plots per season.

In the western region, the original forest vegetation (Olivry, 1986) [30] has been progressively degraded by large-scale plantations of coffee trees and other crops (market gardening and food crops). This activity has led to the development of savannah formations and gallery forests occupying almost all uncultivated land. The western region is characterised by a tropical mountain climate with two seasons (unimodal rainfall): a long rainy season lasting about nine months from March to November and a short dry season lasting about three months from December to February (Suchel, 1988) [35]. In the Menoua district, the localities chosen were Fotsétsa (5°24'59.95 "N, 9°59'59.99 "E), Foto (5°27'2.92 "N, 10° 3'50.19 "E), Leppe Foto (5°27'59.88 "N, 10° 4'3.71 "E) and Campus A (5°26'00.67"N, 10°04'00.04"E) in the Dschang district. Tsingbeu (5°27'18.70 "N, 10° 7'2.25 "E), Bafou (5°32'17.07 "N, 10° 6'11.24 "E) in the Nkong-Ni district. Baloum (5°23'59.94 "N, 10°13'60.00 "E) and Balessing (5°30'18.29 "N, 10°14'15.45 "E) in the Penka-Michel district.

In the Bamboutos department, the following districts were chosen: Batcham, the localities were Bankui (5°32'42.03 "N, 10°13'31.32 "E), Bameka I (5°26'6.17 "N, 10°20'2.67 "E) and Bameka II (5°37'59.93 "N, 10°32'60.00 "E). In the Galim district, the localities of Bamenyam (5°45'25.76 "N, 10°19'18.22 "E), Mevobo (5°42'55.42 "N, 10°19'46.29 "E), Bamendjing (5°42'35. 70 "N, 10°29'34.99 "E), Kiéneghang (5°41'17.00 "N, 10°24'53.29 "E) and Yeyep (5°42'22.50 "N, 10°18'40.38 "E) were selected.

In the department of Ndé, the Bangangté arrondissement had Nenga I (5°08'00.02"N, 10°35'01.17"E), Bangoua (5°11'29.07 "N, 10°28'24.16 "E), Batela (5° 8'39. 51 "N, 10°31'26.37 "E), Bantoum I (5° 5'17.16 "N, 10°37'54.77 "E), Bantoum II (5° 5'45.55 "N, 10°39'39.21 "E) and Projet 1 route Foumbot (5°10'17.42 "N, 10°33'57.24 "E). In the arrondissement of Bazou, the locality of Balengou Kassang (5° 3'40.76 "N, 10°28'20.36 "E) was studied.

In the department of Noun, the district of Foumbot was chosen, with the following localities: Foset (5°30'44.93 "N, 10°38'24.57 "E), Matekop (5°30'48.70 "N, 10°37'46.40 "E), Mangoum (5°30'10.31 "N, 10°38'11.59 "E), Fossang (5°23'15.86 "N, 10°39'17.47 "E) and Kambo (5°31'38.84 "N, 10°39'14.46 "E).

The main crops grown in the area are coffee, vegetables, maize, beans and potatoes.

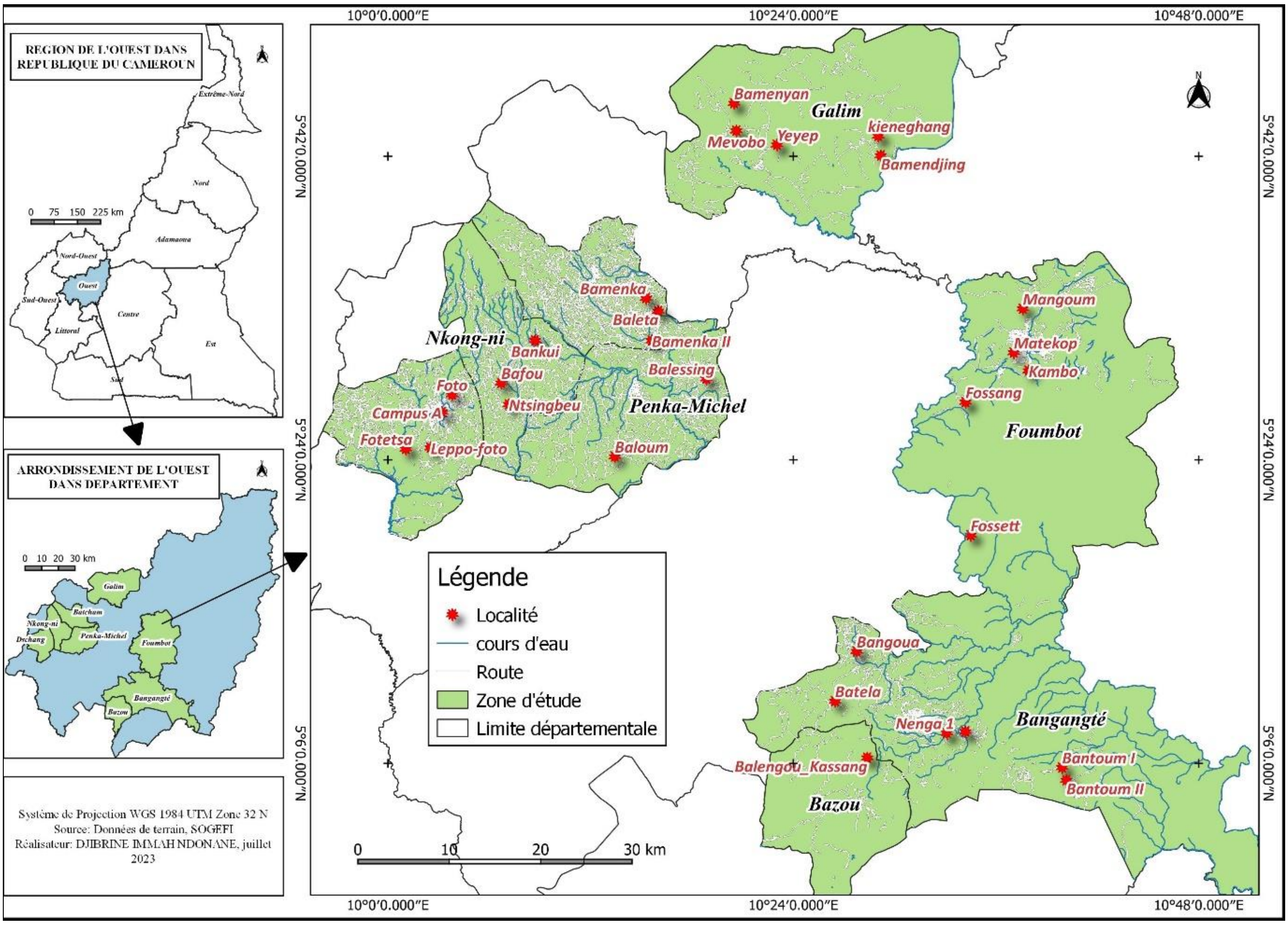

Fig 1: Geographical location of the various study sites in the four departments of the West Cameroon region.

Materials

The plant material consisted mainly of tomato varieties grown by the producers whose plots were sampled.

Methodology

The study took place in 4 departments (Noun, Ndé, Bamboutos, Ménoua) where 8 arrondissements were selected (Penka-Michel, Dschang, Nkong-ni, Bangangté, Bazou, Galim, Batcham, Foumbot) and 28 localities comprising 64 plots, i.e. 32 plots per dry and wet season) in the West Cameroon region. The study area was selected on the basis of tomato production statistics, and the localities were chosen according to the predominance of the crop and accessibility to the various plantations. The minimum surface area of the plots sampled was 200 m^2. Insects were collected from tomato plants at several phenological stages (growth, flowering, fruiting and ripening). Three yellow traps, 2/3 filled with water, were placed in 3 different locations depending on the surface area of the plot in each locality. To retain and preserve the trapped insects, the water was mixed with liquid soap and 10g of cooking salt (Collingwood *et al.* 1984) [7]; (Soro, 2007) [34]. These traps have the advantage of attracting insects circulating on the aerial parts of plants. According to Dupriez *et al.* (2001) [11], the yellow colour is known to attract most flying insects. The traps were set up one week before the insects were collected. The insects were collected using a mini colander and metal forceps. An entomological-type mowing net was used to mow the tomato plants. Collection using this net consisted of moving forward in the field while mowing any insects flying over the tomato plants (Chougourou *et al.* 2012) [6]. This method is difficult to standardise as the way of mowing varies from one individual to another. A mouth aspirator was used to capture the smallest insects. Captures were made between 8 and 11 in the morning and between 2 and 5 in the afternoon.

Preparation and storage of collected insects

Captured insects were transferred to small plastic jars containing 70% ethanol. Those obtained from net, and butterflies in general, were placed in papillotes. The insects were kept in these media until they were identified at the Phytopathology and Agricultural Zoology Laboratory at the University of Dschang and the Applied Zoology Laboratory at the University of Yaoundé I in Cameroon.

Identification of specimens

The family identification key of (Delvare and Aberleng, 1989) [10] was used to identify the species collected.

Data analysis

The data obtained were processed in Microsoft Office Excel 2013, imported and analysed using R version 4.2.2 and R studio version 12.0 with a probability threshold of 5%.

The diversity of insect families present on tomatoes was assessed using three indices: the Shannon-Weaver index (H'), the Piélou equitability index (E) and the Simpson diversity index were calculated (Marcon, 2010) [26].

Shannon-Weaver index (H')

$H' = -\Sigma ((ni / N)*\ln (ni / N))$

Where ni: number of individuals at a given taxonomic level (here the family);
i = a family present in the environment, ranging from 1 to S (the total number of families observed), N (total number of individuals caught). It varies from 0 to 5.
When the value of H' is low, the environment is considered to be poor in families. On the other hand, if this index is high, it indicates a high diversity of families in the environment.

Piélou equitability index (E)
The distribution of species in a given environment has been evaluated. It is given by:

$E = H'/ Hmax$ where $Hmax = LogS$

Hmax being the maximum Shannon diversity and S the total number of families. Its value varies from 0 (dominance of one family) to 1 (Equidistribution of individuals within families).

Simpson index or Simpson diversity index (D)
This measures the probability that two individuals selected at random from an environment belong to the same family. It is calculated using the following formula:

$D = 1- \sum \{(ni/ni - 1) / (N/N - 1)\}$

Where ni is the number of individuals in a given family and N is the total number of individuals caught. Its value varies from 0 to 1. When this index has a value close to 0, diversity is minimal, and when it is equal to 1, diversity is maximal (Grall and Coïc, 2006) [20].

Results
A total of 24,943 individuals from 7 Orders and 66 Families were collected in the Class Insecta (Tables 1, 2), 17 individuals in the Class Arachnida-Araneidae. Arachnida-Araneae were recorded during both seasons. Of the 7 orders inventoried in yellow traps and by mowing, 54 families were recorded in the dry season and 47 families in the rainy season (Tables 1 & 2). In yellow traps, 14 209 insects were collected, i.e. 66.75% in the dry season and 33.25% in the rainy season. 78.66% of these insects were Hemiptera (Table 1). A total of 11,112 insects were collected using a swath net, 62.56% in the dry season and 38.44% in the rainy season (Table 2). 64.76% of these insects were Hemiptera. In traps and nets, 64.91% of insects were collected in the dry season and 35.09% in the rainy season. In yellow traps and swath nets, Hemiptera (72.56%), Diptera (14.61%), Lepidoptera (9.42%) and Hymenoptera (2.34%) were the most frequently collected insects in both seasons. It should be noted that the number of families and individuals in the various orders varied from one district to another.

Order Coleoptera
In yellow traps, 11 Coleoptera families were counted and 7 families with the swath net. Buprestidae, Coccinellidae, Nutidulidae, Scarabaeidae and Staphylinidae were present in the yellow traps (Table 1) and absent in the mowing traps. Also, the Alleculidae present in mowing were absent in the yellow traps. At Penka-Michel, Coleoptera were absent in yellow traps during the 2 seasons and by mowing in the rainy season. The same observation was made at Nkong-Ni in yellow traps during the rainy season. In Dschang, by mowing, they were absent during both seasons, by mowing and on yellow traps in Nkong-Ni in the rainy season and in Bazou in the dry season. Coleoptera-Chrysomelidae were most frequently collected in yellow traps and by mowing.

Order Diptera
14 families of Diptera were collected in yellow traps and 8 families by mowing. Agromyzidae, Bibionidae, Culicidae, Mycetophilidae, Sarcophagidae and Tipulidae were not collected by mowing. The Diptera-Drosophillidae were the most commonly collected by mowing and yellow traps.

Order Hemiptera
11 Hemiptera families were collected using yellow traps and mowing. Delphacidae, Membracidae and Reduviidae were only observed on yellow traps. Berylidae, Leptopodidae and Tingidae were collected by mowing. The Hemiptera-Aleyrodidae and Aphididae were the most widely collected. This Order is the most important in terms of the number of specimens collected.

Order Hymenoptera
17 families were collected in yellow traps (Table 1) and 8 by mowing (Table 2). The Hymenoptera-Bethylidae, Diapriidae, Figitidae, Ichneumonidae, Scelionidae, Sphecidae, Totymidae, Tiphiidae and Vespidae were only collected on yellow traps (Table 1). The Hymenoptera-Formicidae were the most collected by both methods.

Order Lepidoptera
Three families were collected on yellow traps (Table 1) and 4 by mowing (Table 2). Lepidoptera-Lymantriidae were not collected using yellow traps. This order is essentially represented by the Gelechiidae (Tables 1 and 2).

Order Orthoptera
In yellow traps and by mowing, 4 families were collected. At Penka-Michel, Nkong-Ni and Bazou, no Orthoptera were collected during the 2 seasons. The same was true of Dschang in the rainy season and Bangangté in the dry season. On yellow traps, Gryllidae were collected the most and Acrididae by mowing.

Order Odonata
A single specimen of Odonata-Aeshnidae was collected from yellow traps at Penka-Michel.
In the various Arrondissements, using yellow traps and mowing, the number of individuals collected in the dry season was always higher than in the rainy season, with the exception of Penka-Michel. Among animals, insects are the most adaptable to changes in environmental conditions. Some pests and their eggs are easily washed away by heavy rains, and are usually carried away from their host plants, as in the case of the Aphididae. The movements of many insects are limited by the rain, which wets their wings, reducing their speed of flight. In addition, the lack of water on host plants increases the concentration of elements in the

sap that insect pests are looking for and their appetite for consumption. Diptera-Drosophillidae, like Hemiptera-Aleyrodidae, take advantage of accidental openings or stings caused by suckers to reach the fruit and cause damage.

The most preponderant beneficials were observed in the families Hymenoptera-Bethylidae, Diapriidae, Figitidae, Formicidae, Tiphiidae, Sphecidae and Vespidae; Coleoptera-Coccinelidae and Scarabaeidae, Diptera-Syrphidae and Hemiptera-Reduviidae. The pollinating insects par excellence were the Hymenoptera-Halictidae and Apidae.

Table 1: Total number of individuals collected in yellow traps in the dry and rainy seasons

Orders	Families	Districts																Total	
		Penka Michel		Dschang		Nkong-ni		Bangangté		Bazou		Galim		Batcham		Foumbot			
		ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp
Coleoptera	Anthribidae	0	/	0	/	2	/	0	/	0	/	0	/	0	/	0	/	2	/
	Buprestidae	0	0	2	2	0	0	0	1	0	0	0	0	0	0	0	0	2	3
	Carabidae	/	0	/	0	/	0	/	0	/	19	/	0	/	0	/	0	/	19
	Chrysomelidae	0	0	0	0	0	0	1	22	0	0	1	2	20	23	23	7	45	54
	Coccinelidae	/	0	/	0	/	0	/	4	/	0	/	0	/	0	/	0	/	4
	Curculionidae	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	Lyctidae	/	0	/	0	/	0	/	2	/	0	/	0	/	0	/	0	/	2
	Nitidulidae	0	0	12	4	0	0	0	0	0	1	0	0	0	0	0	0	12	5
	Pselaphidae	/	0	/	0	/	0	/	0	/	1	/	0	/	0	/	0	/	1
	Scarabaeidae	0	0	0	0	0	0	0	3	0	0	0	0	6	1	0	0	6	4
	Staphylinidae	0	0	2	2	0	0	0	0	0	1	0	0	0	0	0	0	2	3
Diptera	Agromyzidae	0	/	1	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Bibionidae	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	Calliphoridae	1	0	5	5	9	4	0	0	0	0	0	0	0	4	0	0	15	13
	Cecidomyiidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Culicidae	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1
	Dolichopodidae	0	2	3	3	0	0	0	0	2	0	0	0	0	0	0	0	5	5
	Drosophillidae	35	223	10	47	38	0	56	113	62	184	90	249	16	34	114	238	421	1088
	Muscidae	11	0	8	7	9	6	1	0	6	0	0	0	0	1	2	0	37	14
	Mycetophilidae	11	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	11	4
	Sarcophagidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Syrphidae	0	0	2	1	1	1	0	1	0	0	0	1	0	0	0	0	3	4
	Tabanidae	0	0	5	5	1	1	0	0	0	0	0	0	0	0	0	0	6	6
	Tephritidae	/	1	/	0	/	0	/	0	/	0	/	1	/	0	/	0	/	2
	Tipulidae	0	/	0	/	0	/	0	/	0	/	1	/	0	/	0	/	1	/
Hemiptera	Aleyrodidae	153	165	88	0	1652	712	3225	197	545	301	316	36	84	13	512	214	6575	1638
	Aphididae	72	47	157	107	50	65	134	662	65	53	56	17	161	43	108	42	803	1036
	Cercopidae	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/	1	/
	Cicadellidae	85	6	52	17	12	14	37	87	12	10	14	14	76	16	85	26	373	190
	Delphacidae	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	3	3
	Membracidae	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1
	Mesoveliidae	0	0	0	0	0	0	0	0	4	1	45	0	0	0	0	0	49	1
	Miridae	0	0	5	4	0	22	11	8	0	4	108	103	1	0	48	26	173	167
	Pentatomidae	1	0	0	0	0	0	3	0	0	0	2	2	1	0	7	3	14	5
	Psyllidae	0	3	43	14	0	0	17	0	6	0	15	7	15	8	10	4	106	36
	Reduviidae	0	/	0	/	1	/	0	/	0	/	0	/	0	/	0	/	1	/
Hymenoptera	Apidae	0	0	1	2	0	0	2	2	0	0	0	0	0	0	0	0	3	4
	Bethylidae	2	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	2	/
	Chalcididae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Cynipidae	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	1	2	2
	Diapriidae	3	0	0	0	0	0	0	0	0	16	1	0	0	0	0	0	4	16
	Dryinidae	0	0	1	0	1	1	0	2	0	0	0	0	0	0	0	0	2	3
	Evaniidae	2	/	1	/	0	/	0	/	0	/	0	/	0	/	0	/	3	/
	Figitidae	0	0	21	0	1	1	1	0	0	0	0	0	0	0	0	0	23	1
	Formicidae	7	0	24	11	0	0	2	127	8	12	3	6	8	17	8	10	60	183
	Halictidae	4	1	16	9	11	4	0	3	0	4	6	0	0	1	8	1	45	23
	Ichneumonidae	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0	6	4
	Mymaridae	6	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	6	17
	Scelionidae	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5	1
	Sphecidae	1	0	25	3	0	0	1	0	0	1	0	0	0	0	0	0	27	4
	Torymidae	0	/	2	/	0	/	0	/	0	/	0	/	0	/	0	/	2	/
	Tiphiidae (Thynnidae)	/	0	/	0	/	0	/	18	/	0	/	0	/	0	/	0	/	18
	Vespidae	0	/	10	/	0	/	0	/	0	/	0	/	0	/	0	/	10	/
Lepidoptera	Gelechiidae	15	14	32	3	27	18	81	2	90	43	157	5	35	0	134	29	571	114
	Noctuidae	2	0	0	0	0	0	0	0	0	0	0	0	7	4	1	0	10	4

	Nymphalidae	3	/	0	/	0	/	0	/	0	/	0	/	1	/	0	/	4	/
Odonata	Aeshnidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
Orthoptera	Acrididae	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
	Gryllidae	0	0	6	0	0	0	0	4	0	0	1	2	6	2	7	4	20	12
	Pyrgomorphidae	/	0	/	0	/	0	/	2	/	0	/	0	/	0	/	0	/	2
	Tetrigidae	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	1	3
Total		424	462	544	253	1823	854	3572	1270	800	672	817	446	438	168	1070	603	9485	4724

Pearson's Chi-Squared Test: dry season (F-value=610.125[a], df=441, P=0.000).
Rainy season (F-value=360.915[a], df=336, P=0.168).

Table 2: Total number of individuals collected with the entomological net in the dry and rainy seasons

Orders	Families	Districts																Total	
		Penka Michel		Dschang		Nkong-ni		Bangangté		Bazou		Galim		Batcham		Foumbot			
		ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp	ss	sp
Coleoptera	Alleculidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Anthribidae	0	/	0	/	1	/	0	/	0	/	0	/	0	/	0	/	1	/
	Carabidae	/	0	/	0	/	0	/	0	/	3	/	0	/	0	/	0	/	3
	Chrysomelidae	0	0	0	0	0	0	1	1	0	2	4	1	4	0	10	9	19	13
	Curculionidae	4	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	4	/
	Lyctidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Staphylinidae	/	0	/	0	/	0	/	1	/	0	/	0	/	0	/	0	/	1
Diptera	Calliphoridae	0	0	1	0	4	2	0	0	0	0	0	0	0	0	0	0	5	2
	Cecidomyiidae	/	0	/	0	/	0	/	0	/	1	/	0	/	0	/	0	/	1
	Dilichopodidae	/	0	/	0	/	0	/	0	/	0	/	2	/	0	/	0	/	2
	Drosophillidae	1	245	107	183	0	0	44	31	4	208	320	320	33	262	85	168	594	1417
	Muscidae	0	0	0	0	6	8	0	0	0	0	0	0	0	0	0	0	6	8
	Syrphidae	2	0	0	0	1	2	0	0	0	0	0	1	0	0	0	0	3	3
	Tabanidae	0	/	0	/	1	/	0	/	0	/	0	/	0	/	0	/	1	/
	Tephritidae	0	1	0	0	0	0	1	0	0	0	6	4	0	0	0	0	7	5
Hemiptera	Aleyrodidae	49	6	160	0	1594	1160	171	321	193	62	70	40	375	87	375	163	2987	1839
	Aphididae	16	3	242	52	57	41	109	73	128	6	52	8	573	13	117	19	1294	215
	Cercopidae	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	4	1
	Cicadellidae	285	0	46	34	16	13	7	4	6	1	7	9	21	2	53	23	441	86
	Berytidae	/	0	/	0	/	0	/	0	/	0	/	0	/	2	/	0	/	2
	Leptopodidae	5	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	5	/
	Mesoveliidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Miridae	2	0	78	2	0	18	39	6	8	5	74	0	1	0	29	11	231	42
	Pentatomidae	1	0	0	2	0	0	5	0	0	0	0	0	0	0	4	4	10	6
	Psyllidae	0	0	1	0	0	0	6	0	0	0	0	2	12	0	4	7	23	9
	Tingidae	0	/	0	/	0	/	0	/	0	/	1	/	0	/	0	/	1	/
Hymenoptera	Apidae	0	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	8	1
	Chalcididae	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	3
	Cynipidae	2	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	2	/
	Dryinidae	0	0	0	0	2	8	0	0	0	0	1	0	0	0	0	0	3	8
	Evaniidae	0	/	0	/	0	/	0	/	0	/	2	/	0	/	0	/	2	/
	Formicidae	5	0	10	6	0	0	4	6	3	6	3	4	0	4	11	9	36	34
	Halictidae	1	0	0	0	4	6	0	0	0	1	2	0	3	0	0	0	10	7
	Mymaridae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
Lepidoptera	Gelechiidae	9	41	62	14	31	16	198	95	74	126	414	37	92	20	352	98	1232	447
	Lymantriidae	0	/	1	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
	Noctuidae	0	/	0	/	0	/	0	/	0	/	0	/	0	/	2	/	2	/
	Nymphalidae	1	/	0	/	0	/	0	/	0	/	0	/	0	/	0	/	1	/
Orthoptera	Acrididae	3	0	0	0	0	0	0	2	6	2	0	0	1	0	0	0	10	4
	Gryllidae	0	/	0	/	0	/	1	/	0	/	0	/	0	/	0	/	1	/
	Pyrgomorphidae	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
	Tettigonidae	2	/	1	/	0	/	0	/	0	/	0	/	0	/	0	/	3	/
Total	42	394	296	709	295	1717	1274	594	547	426	420	950	432	1116	390	1042	513	6952	4160

Pearson's Chi-Squared Test: dry season (F-value=4715a, df=71, P=0.01).
Rainy season (F-value=177.97a, df=71, P=0.57).

Entomological diversity of insect families on tomatoes

In the dry season, the Shannon diversity index is lowest in the Nkong-ni district (0.44), where one species of the Hemiptera-Aleyrodidae family is highly dominant. Nkong-Ni is probably poor in families, with 16 out of 54. It is higher in the arrondissements of Bazou (1.25) and Foumbot (1.21), and would indicate a wide diversity of families. In the wet season, it is lowest in the same arrondissement of Nkong-ni (0.71) and highest in the arrondissements of Dschang (1.43), Bazou and Batcham (1.31), indicating poverty and a rich diversity of families respectively. In all arrondissements, during both seasons, the equitability index was 0.2 in Nkong-Ni and 0.64 in Bazou. In Bazou, one family is dominant. Simpson's index is lower in Nkong-Ni

(0.18) and higher in Bazou (0.64), showing respectively a minimum and maximum diversity of individuals in the various families of insects captured.

On yellow traps, Pearson's Chi-Squared Test shows a significant difference between the different families in dry season (F-value=610.125[a], df=441, P=0.000). The difference is not significant in the rainy season (F-value=360.915[a], df=336, P=0.168). The families were larger and the number of individuals greater in the dry season.

By mowing, the same test shows a significant difference between the different families in the dry season (F-value=4715[a], df=71, P=0.01) and a non-significant difference in the rainy season (F-value=177.97[a], df=71, P=0.57). The number of families and individuals is greater in the dry season.

Discussion

The number of insects caught in yellow traps (14209 individuals, 56.11%) was greater than by mowing (11112 individuals, 43.88%) during both seasons. During the rainy season, 37.44% of insects were collected by mowing. The traps were fixed and permanent, allowing continuous capture day and night. During mowing, some specimens flee and escape from our mowing net. So there is no handling bias with traps. In Ménoua during the rainy season, Dzokou *et al.* (2021a) [13] collected 4333 Insecta and Arachnida on sweet pepper. This number is higher than the 4160 Insecta collected in this work, but represents only 37.44% of the individuals collected by mowing. This work was carried out in several localities in the West Cameroon region, whereas in 2021, the collection only concerned the Ménoua division. Of the 8 districts surveyed, Foumbot ranked 3rd after Bangangté and Nkong-Ni respectively. In these three districts, tomatoes and other solanaceous plants such as peppers, chillies and potatoes are grown extensively over large areas, even as monocultures. This could contribute to the permanent presence of pests in these three districts. At Foumbot, Dzokou *et al.* (2020) [12] collected 6485 insects of 3 Orders (Diptera, Hemiptera, Lepidoptera) by mowing on tomatoes, with the Hemiptera-Aleyrodidae accounting for the greatest number of individuals (62.94%). In the present mowing survey, the Hemiptera-Aleyrodidae were the most numerous in both seasons. Orthoptera were also collected in small numbers during both seasons. In Penja-Cameroon, Dzokou *et al.* (2021b) [14] collected more Orthoptera on *Piper nigrum* and justified their results by the fact that *Spondias mombin*, the support tree, also hosts Orthoptera. The dry season is also marked by high temperatures and little rainfall, which favours the rapid multiplication of insects, whereas in the wet season, the rains wash away the eggs, larvae and even adults of certain insects, gradually reducing their numbers. According to Kisserli *et al.* (2012) [24], the higher the temperature, the greater the number of generations. The work of Dzokou *et al.* (2021a) [13] in the Menoua reports 9 orders of insects (Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Thysanoptera, Odonata, Mantoptera) from 85 families. Thysanoptera and Mantoptera were not reported in this work. The results of this work are also in agreement with the work of Djieto-Lordon *et al.* (2014) [9] on the assessment of insect pests of *Capsicum annuum* in Yaoundé where 7 orders of insects were identified. The work of Tendeng *et al.* (2017) [37] on the pests and auxiliaries of vegetable crops in Basse Casamance in Senegal reports a total of 7 insect orders belonging to 27 families. The Mantoptera, Thysanoptera and Acari present in their work are absent from this study. The work of James *et al.* (2010) [21] showed that tomato crops are subject to a range of insect pests that seriously compromise their yield.

This study also revealed the presence of natural enemies. Similar work by Chougourou *et al.* (2012) [6] in Benin revealed 9 orders, including Thysanoptera, which we did not capture. Similarly, Araneae beneficials were not reported in their work in Benin. Similar work was also carried out by Patouma *et al.* (2020) [31] in Meskine, Extreme North Cameroon, where they identified 8 orders including the Nervroptera. However, these authors did not mention the Odonata and Araneae in their work. Useful insects such as pollinators and predators live alongside pests. This observation is supported by the work of Tchuenguem Fohouo *et al.* (2007) [36] in Cameroon, Toni *et al.* (2018) [38] in Benin and Atibita *et al.* (2015) [3] in Yaoundé; Farda *et al.* (2018) [18] in Ngaoundéré-Cameroon. These authors have shown that, bees improve the fruit yield of flowering plants, including tomatoes, by pollinating flowers during their foraging activities. As for predators, the natural enemies of certain pests, their presence helps to reduce the numbers of small insects such as aphids and thrips (Gigon, 2016) [19].

This work also showed a fairly abundant diversity of insect families (66 families). Some districts are richer in insect families than others and the number of individuals is more related to monoculture over large areas (Bangangté, Nkong-Ni, Foumbot). Dibong and Ndjouondo (2014) [8] have shown that the more degraded the environment, the less diverse it is. For them, sociability associated with habitat preference influences the diversification of the environment.

Conclusion

The tomato entomofauna provided information on the biodiversity of insects associated with West Cameroon. 25321 individuals of 7 orders and 66 insect families and 17 individuals of Arachnida-Araneida were collected in 8 districts of the 4 production basins. The vast majority of this fauna consists of pests causing yield losses. The number of individuals collected was greater in the dry season than in the rainy season. Bangangté, Nkong-ni and Foumbot recorded more individuals than the other districts. The species collected belong to the orders Hemiptera, Diptera, Hymenoptera, Lepidoptera, Orthoptera, Coleoptera, Odonata and Araneida. However, the presence of a number of predatory and parasitoid beneficials suggests that, biological or integrated pest management is still possible. This study is the first step in setting up a database that will provide useful information before choosing a control strategy for tomato pests.

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