Abundance and diversity (taxon families) of entomofauna within vegetable crops of urban gardens (in July and August) in Libreville and Owendo (Gabon)

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The abundance and diversity of entomofauna was evaluated in three urban gardens of Gabon, i.e. the localities of Libreville's airport (ADL), PK8 and Owendo. Insects were pan-trapped and visual observations were done on plants in July and August 2012 and 2013. Samples were collected weekly, insects were identified at the family level and classified into three categories: pests, beneficials and associated (i.e. other families). Eight orders and 84 families were recorded with 7910 and 3148 individuals of insects, were sampled in 2012 and 2013, respectively. Insect abundance on roselle (*Hibiscus sabdariffa* L. 1753; Malvaceae) was significantly higher in ADL than in PK8 and Owendo, while amaranth (*Amaranthus hybridus* L. 1753; Amaranthaceae), tomato (*Lycopersicon esculentum* Mill. 1768; Solanaceae) and cabbage (*Brassica oleracea* L. 1753; Brassicaceae) showed similar insect abundance in PK8 and Owendo. In 2012, 29.6 %, 31.4 % and 38.9 % of insects were recorded in ADL, PK8 and Owendo respectively. In 2013, only ADL and PK8 were sampled, with respective abundance of 61.7 % and 38.3 % of insects respectively. For both years, the global relative abundances were distributed between 50.6 % (4002 individuals) and 41.3 % (1300 individuals) for pests, 19.9 % (1577 individuals) and 23.4 % (737 individuals) for beneficials, and 29.5 % (2331 individuals) and 35.3 % (1111 individuals) for associated insects. The predominant insect families were, in 2012 and 2013 respectively, Aphididae (30.8 % and 21.3 %), Cecidomyiidae (4.9 % and 3.9 %) and Chrysomelidae (3.8 % and 0.3 %) for pests, Dolichopodidae (5.3 % and 16.5 %), Staphylinidae (3.0 % and 1.5 %), and Coccinellidae (2.1 % and 0.6 %) for beneficials, and Muscidae (6.5 % and 18.1 %), Psychodidae (7.7 % and 0.9 %) and Formicidae (4.9 % and 2.0 %) for associated insects. This study is one the few exploring the composition of insects within Libreville's urban gardens. The results provide knowledge to be used for developing pest management strategies and enhancing other ecosystem services in these localities of Gabon.
Keywords: Insects, amaranth, roselle, indigenous crop, Central Africa.

L'abondance et la diversité de l'entomofaune a été réalisée dans trois périmètres maraîchers du Gabon, à savoir les localités de l'aéroport de Libreville (ADL), PK8 et Owendo. Les piégeages avec des pièges jaunes des insectes et des observations visuelles sur les plants ont été réalisés de juillet à août, en 2012 et 2013. Les insectes collectées chaque semaine ont été identifiés au niveau taxonomique (famille) et classés en trois catégories: nuisibles, utiles et associés. Huit ordres et 84 familles d'insectes ont été échantillonnés avec 7910 et 3148 individus, respectivement en 2012 et 2013. L'abondance d'insectes sur l'oseille de guinée (*Hibiscus sabdariffa* L. 1753; Malvaceae) était significativement plus élevée à ADL qu'au PK8 et à Owendo, que sur l'amarante (*Amaranthus hibridus* L. 1753; Amaranthaceae), la tomate (*Lycopersicon esculentum* Mill. 1768; Solanaceae) et le chou (*Brassica oleracea* L. 1753; Brassicaceae) au PK8 et à Owendo. En 2012, 29,6 %, 31,4 % et 38,9 % des insectes ont été enregistrés respectivement à ADL, PK8

et Owendo. En 2013, seulement les sites de ADL et PK8 ont été échantillonnés, avec une abondance respective de 61,7 % et 38,3 % d'insectes respectivement. Pour les deux années, les abondances relatives totales ont été réparties entre 50,6 % (4002 individus) et 41,3 % (1300 individus) pour les ravageurs, 19,9 % (1577 individus) et 23,4 % (737 individus) pour les utiles et 29,5 % (2331 individus) et 35,3 % (1111 individus) pour les insectes associés. Les familles d'insectes prédominantes étaient, en 2012 et en 2013 respectivement, Aphididae (30,8 % et 21,3 %), Cecidomyiidae (4,9 % et 3,9 %) et Chrysomelidae (3,8 % et 0,3 %) pour les ravageurs, Dolichopodidae (5,3 % et 16,5 %), Staphylinidae (3,0 % et 1,5 %) et Coccinellidae (2,1 % et 0,6 %) pour les utiles, et Muscidae (6,5 % et 18,1 %), Psychodidae (7,7 % et 0,9 %) et Formicidae (4,9 % et 2,0 %) pour les insectes associés. Cette étude est l'une des rares à donner la diversité des insectes nuisibles et utiles dans les périmètres maraîchers de Libreville. Ces résultats permettraient de mettre en place des stratégies de contrôle durable des ravageurs rencontrés.
Mots-clés: Insectes, amarante, oseille de guinée, culture indigène, Afrique centrale.

1 INTRODUCTION

In Gabon, peoples living in urban areas represented 87 % of total population (FAO, 2017), and corresponding to food requirements that are mainly dependent on food imports (Organisation Mondiale du Commerce, 2013). Practicing urban and peri-urban agriculture was instigated by the Institut Gabonais d'Appui au Développement (IGAD) in the last twenty years. Many vegetable species (e.g. amaranth, tomato, lettuce, cabbage, roselle, okra, african nightshade) and aromatic plants (e.g. basil, persil, celery) are cultivated. However, pests and diseases cause significant damaged and losses. The control methods are based on systematic applications of chemical pesticides (Bayendi Loudit *et al.*, 2017).

Studies investigating insect pests occurring on crops are rare in Gabon, to our knowledge. Previous studies showed that many insect pests in Gabon belong to Chrysomelidae, Noctuidae, Pyralidae, Pluttelidae and Thripidae families (Bordat & Arvanitakis, 2004). On fruit trees and vegetable crops of home gardens of the Haut-Ogooué province, the major pests belong to Aphididae, Cecidomyiidae, Cicadellidae and Crambidae families (Poligui *et al.*, 2014). A similar study performed on insect diversity (i.e. pests and natural enemies) was conducted in Yaoundé, Cameroon, in the main crops from nine plant families, namely Solanaceae, Malvaceae, Tiliaceae, Amaranthaceae, Fabaceae, Apiaceae, Lamiaceae, Asteraceae and Cucurbitaceae (Djiéto-Lordon *et al.*, 2007).

In Gabonese localities of Libreville and Owendo, vegetable crops grown are mainly amaranth (*Amaranthus hybridus* L. 1753; Amaranthaceae), lettuce (*Lactuca sativa* L. 1753; Asteraceae), roselle (*Hibiscus sabdariffa* L.1753; Malvaceae), african nightshade (*Solanum nigrum* L.1753; Solanaceae) and tomato (*Lycopersicon esculentum* L. 1768; Solanaceae) (Bayendi Loudit *et al.*, 2017). The main insect pests occurring on these crops are aphids (Hemiptera: Aphididae) and chrysomelids (Coleoptera: Chrysomelidae), usually controlled by spraying conventional insecticides mainly lambda-cyhalothrine (Bayendi Loudit *et al.*, 2017). However, knowledge about the diversity of the entomofauna occurring in these areas remains limited.

This study aims to improve knowledge of entomofauna in these gabonese crops focusing on the assessment of abundance and diversity of insects from three urban gardens. This work was designed to classify the collected insects into pests, beneficials and associated. The understanding of insect pest and natural enemie occurrence and interactions would enable the setup of further integrated pest management in Libreville and Owendo.

2 MATERIAL AND METHODS

2.1 Study area and sites

The study was conducted in market gardens during two successive years in July and August 2012 and 2013. In Libreville, the first location was at proximity of Libreville's airport (ADL) (0°27'30.46" N; 9°25'6.30" E; E: 10 m above sea level) and the second was PK8 (0°24'39.89" N; 9°29'26.23" E; E: 20 m above sea level). The third location was situated at Owendo (0°18'26.86" N; 9°29'40.83" E; E: 10 m above sea level). The vegetable farmers from these sites benefit from a technical advices of IGAD.

2.2 Sampling data

Yellow pan traps (Flora®, 27 cm diameter and 10 cm depth) were placed in each vegetable species per sites according to the topography and availability of the crops grown by farmers. Each trap contains water with few drops of liquid soap (weekly changed) and fixed on a cane. Three traps were installed within each crop plot, and visited during five weeks, ensuring weekly trapping during this period. Visual observations were conducted in addition on three (3) plants per plots weekly on the same day of the week, to have a better vision of insects diversity. In 2012, four plots were investigated per site for amaranth and roselle, corresponding to 12 traps per crops. In same year, tomato plots were similarly visited at Owendo while five plots at PK8 were followed as for cabbage (five plots in PK8). In 2013, every crop was observed from three plots within all sites. The difference in number of plot replicates depended on the crop availability set by farmers.

All insects were then transferred into 70 % ethanol, according to the method previously described by Duviard & Roth (1973). The insects (collected by traps) were counted and systematically classified on the basis of exterior morphology, until the family taxon (Hutcheson & Jones, 1999). Insect families were identified using keys (Delvare & Aberlenc, 1989; Chinery, 1993, 2007; Picker *et al*., 2002). At laboratory, identifications were performed by using a stereomicroscopic magnifying glass (euromex nexius zoom). Insects were tidied up by categories: crop pests, beneficials for agriculture and associated ones.

2.3 Statistical analysis

For all analyses, the total of insect (trapped and observed) per culture, per site and per year were used. Data analyses were performed with R 3.3.1 software (R Core Team, 2016). Comparisons of insect families per crop and locality were assessed using two-way analysis of variance (ANOVA, $P < 0.05$). In addition, Tukey test was conducted for comparing insect families per locality. Before this parametric test, residual deviance was checked ($P > 0.05$).

Abundance and diversity of the major pests from traps were compared following method used Shannon index (1) and its related Evenness Index (2) were calculated as (Magurran, 2004):

$H' = -\sum p_i \ln p_i$ (1) $J' = H'/Hmax = H'/\ln S$ (2) with $\boldsymbol{p_i} = n_i/N$; $\boldsymbol{n_i}$ = the abundance of the i^{th} species; $\boldsymbol{S}$ = the total number of species and $\boldsymbol{N}$ = the total abundance.

3 RESULTS

3.1 Crop species

The monitoring of the three urban gardens allowed to record 22 species of current crops (**Table 1**). The most important crops were amaranth, lettuce, roselle, cabbage and tomato.

Among these various plant species, only four were selected as main crops for monitoring insects, namely amaranth, cabbage, roselle and tomato, according to the growing duration and area importance.

3.2 Insect abundance

Global insect abundances per site and year

In 2012, insect abundances were relatively similar between ADL (2344 individuals) and PK8 (2484 individuals), while it was higher in Owendo (3082 individuals). In 2013, insect abundance was the highest in ADL (1942 individuals) compared to PK8 (1206 individuals). The results indicate that insect abundance varied according to sites and years.

Both 2012 and 2013 years provided respective global insect abundances of 7910 and 3148 individuals, with rates of 50.6 % to 41.3 %, 19.9 % to 23.4 % and 29.5 % to 35.3 % for pests, beneficials and associated entomofauna respectively (**Figure 1**).

Insect abundances according to major families

The entomofauna monitoring revealed 84 families within the three main categories, namely pests (31 families), beneficials (26 families) and associated insects (27 families) (**Table 2**).

The relative abundances were represented according to previous four main crops (amaranth, roselle, tomato and cabbage). Pest predominant families, in 2012 and 2013 respectively, were Aphididae (2436 and 707 individuals), Cecidomyiidae (391 and 123 individuals), Chrysomelidae (300 in 2012 only), Cicadellidae

Table 1: Plant diversity in garden markets of Libreville's airport, PK8 and Owendo.

	Common names	Scientific names	Families
		Major crops	
1	Amaranth	*Amaranthus hybridus* L.	Amaranthaceae
2	Lettuce	*Lactuca sativa* L.	Asteraceae
3	Cabbage	*Brassica oleracea* var. capitata L. 1753	Brassicaceae
4	Chinese cabbage	*Brassica rapa* var *pekinensis* (Lour.) Hanelt 1986	
5	Turnip	*Brassica rapa* L. 1753	
6	Radish	*Raphanus sativus* L. 1753	
7	Okra	*Abelmoschus esculentus* (L.) Moench 1794	Malvaceae
8	Roselle	*Hibiscus sabdariffa* L.	
9	African eggplant	*Solanum aethiopicum* L. 1756	Solanaceae
10	Eggplant	*Solanum melongena* L. 1753	
11	African nightshade	*Solanum nigrum* L.	
12	Hot pepper	*Capsicum frutescens* L. 1753	
13	Tomato	*Solanum lycopersicum* L. 1753	
		Minor crops	
14	Celery	*Apium graveolens* L. 1753	Apiaceae
15	Coriander	*Coriandrum sativum* L. 1753	
16	Parsley	*Petroselinum crispum* (Miller) Fuss 1886	
17	Ceylon spinach	*Basella alba* L. 1753*, Basella rubra* L. 1753	Basellaceae
18	Cucumber	*Cucumis sativus* L. 1753	Cucurbitaceae
19	Basil	*Ocimum basilicum* L. 1753	Lamiaceae
20	Green onion	*Allium cepa* L. 1753	Liliaceae
21	Leek	*Allium porrum* L. 1753	
22	Jew's mallow	*Corchorus olitorius* L. 1753	Tiliaceae

respectively, predominant families were Dolichopodidae (with 417 and 520 individuals), Staphylinidae (234 and 48 individuals), Coccinellidae (166 and 18 individuals), and Pteromalidae (160 and 29 insects). Associated five major families, in 2012 and 2013 respectively, were Muscidae (512 and 570 individuals),

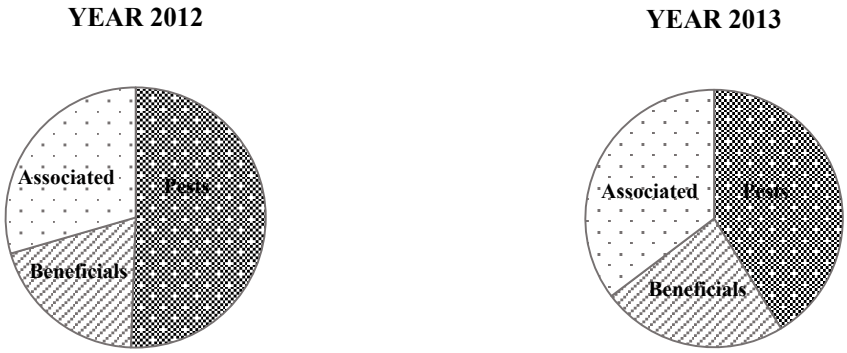

Figure 1: Total insect prevalence according to their categories in 2012 and 2013.

Psychodidae (612 and 28 insects), Formicidae winged insect only (384 and 64 insects), Calliphoridae (60 and 254 insects) and Anthomyiidae (314 and 36 insects). In addition to these major families, there were 54 other and minor families, respectively 21 for pests, 17 for beneficials and 16 for associated.

Table 2: Main insect families and their relate abundance per location and selected crop species.

	Insect families	ADL					Pk8						Owendo			Total	
		Amaranth		Tomato	Roselle		Amaranth		Tomato		Cabbage		Amaranth	Tomato	Roselle		
		2012	2013	2012	2012	2013	2012	2013	2012	2013	2012	2013	2012	2012	2012	2012	2013
Pests	Aphididae	69	63	34	1373	243	223	229	70	67	298	69	129	100	140	**2436**	**671**
	Cecidomyiidae	33	10	6	31	56	52	25	37	14	52	18	48	37	95	**391**	**123**
	Chrysomelidae	5	1	4	4		19	2	21	-	12	5	20	48	167	**300**	**8**
	Cicadellidae	2	1	6	3	61	27	9	11	6	9	3	45	24	11	**138**	**80**
	Delphacidae	3	2	-	5	4	16	27	6	21	23	2	28	32	26	**139**	**56**
	Plutellidae	-	-	-	-	1	-	4	-	10	-	176	-	-	-	-	**191**
	Thripidae	9	1	2	-	9	39	2	12	-	12	6	18	51	17	**160**	**18**
	Agromyzidae	-	9	-	10	15	-	20	7	-	13	-	-	-	6	**36**	**44**
	Miridae	3	3	2	4	4	4	4	2	9	4	6	9	7	15	**50**	**26**
	Lygaeidae	2	3	-	-	4	-	5	1	-	2	-	26	7	13	**51**	**12**
	Minor families (21)	12	6	3	15	43	39	10	40	8	28	4	43	68	53	**301**	**71**
Beneficials	Dolichopodidae	29	221	44	97	283	61	3	17	9	19	4	58	49	43	**417**	**520**
	Staphylinidae	1	2	-	6	1	42	16	10	6	62	23	74	25	14	**234**	**48**
	Coccinellidae	15	3	1	1	3	35	9	10	1	27	2	20	17	40	**166**	**18**
	Pteromalidae	14	2	4	10	3	10	6	9	10	49	8	26	20	18	**160**	**29**
	Halictidae	-	3	-	4	3	1	2	4	7	3	-	13	17	27	**69**	**15**
	Cynipidae	-	-	-	-	-	36	0	11	7	24	2	-	-	-	**71**	**9**
	Braconidae	4	-	-	-	2	5	4	6	6	11	16	3	5	3	**37**	**28**
	Syrphidae	2	-	4	1	4	2	1	3	8	5	-	8	11	11	**47**	**13**
	Andrenidae	18	2	3	13	1	8	-	-	-	1	-	7	1	3	**54**	**3**
	Ichneumonidae	3	-	4	4	-	5	4	1	2	4	4	3	16	1	**41**	**10**
	Minors families (16)	18	6	9	21	20	44	6	29	10	29	2	38	57	36	**281**	**44**
Associated	Muscidae	55	98	4	74	391	58	35	49	37	82	9	60	55	75	**512**	**570**
	Psychodidae	5	1	-	1	4	34	9	18	7	45	7	179	176	154	**612**	**28**
	Formicidae	10	4	7	9	7	172	36	55	9	65	8	25	27	14	**384**	**64**
	Calliphoridae	21	22	2	11	215	9	7	-	8	2	2	13	2	-	**60**	**254**
	Anthomyiidae	27	6	2	51	13	21	-	21	4	22	13	75	41	54	**314**	**36**
	Phoridae	2	14	3	3	35	28	20	10	14	27	5	22	7	13	**115**	**88**
	Scarabaeidae	50	3	5	21	7	-	-	1	-	-	-	4	5	4	**90**	**10**
	Tipulidae	-	1	-	-	-	14	4	7	-	3	-	9	24	18	**75**	**5**
	Tridactylidae	-	-	-	2	3	-	5	-	5	22	14	-	-	-	**24**	**27**
	Nitidulidae	-	-	-	-	-	7	-	2	-	2	-	13	8	8	**40**	**-**
	Minor families (17)	3	5	-	6	15	19	3	10	6	17	-	13	20	17	**105**	**29**
	Total families (84)	**415**	**490**	**149**	**1780**	**1450**	**1030**	**507**	**480**	**293**	**974**	**408**	**1029**	**957**	**1096**	**7910**	**3148**

Main families related to abundances

The most abundant pest families in 2012 and 2013 were Aphididae (30.8 % and 21.3 %), Cecidomyiidae (4.9 % and 3.9 %), Chrysomelidae (3.8 % and 0.3 %), Cicadellidae (1.7 % and 2.5 %) and Delphacidae (1.8 %). The most abundant beneficial families in both years were Dolichopodidae (5.3 % and 16.5 %), Staphylinidae (3.0 % and 1.5 %), Coccinellidae (2.1 % and 0.6 %) and Pteromalidae (2.0 % and 0.9 %). The predominant associated families in both years were Muscidae (6.5 % and 18.1 %), Psychodidae (7.7 % and 0.9 %), Formicidae (4.9 % and 2.0 %), Calliphoridae (0.8 % and 8.1 %) and Anthomyiidae (4.0 % and 1.1 %).

Insect abundance per crops and alimentary categories

Insect abundance on roselle (*H. sabdariffa*) was significantly higher in ADL site than in PK8 and Owendo sites, while amaranth, tomato (*L. esculentum*) and cabbage (*B. oleracea*) showed close ($p > 0.05$) insect abundance in PK8 and Owendo (**Figure 2**). Excepted for ADL where pests were only dominant on roselle, in PK8 and Owendo, pests were dominant on all crops, followed by associated insects.

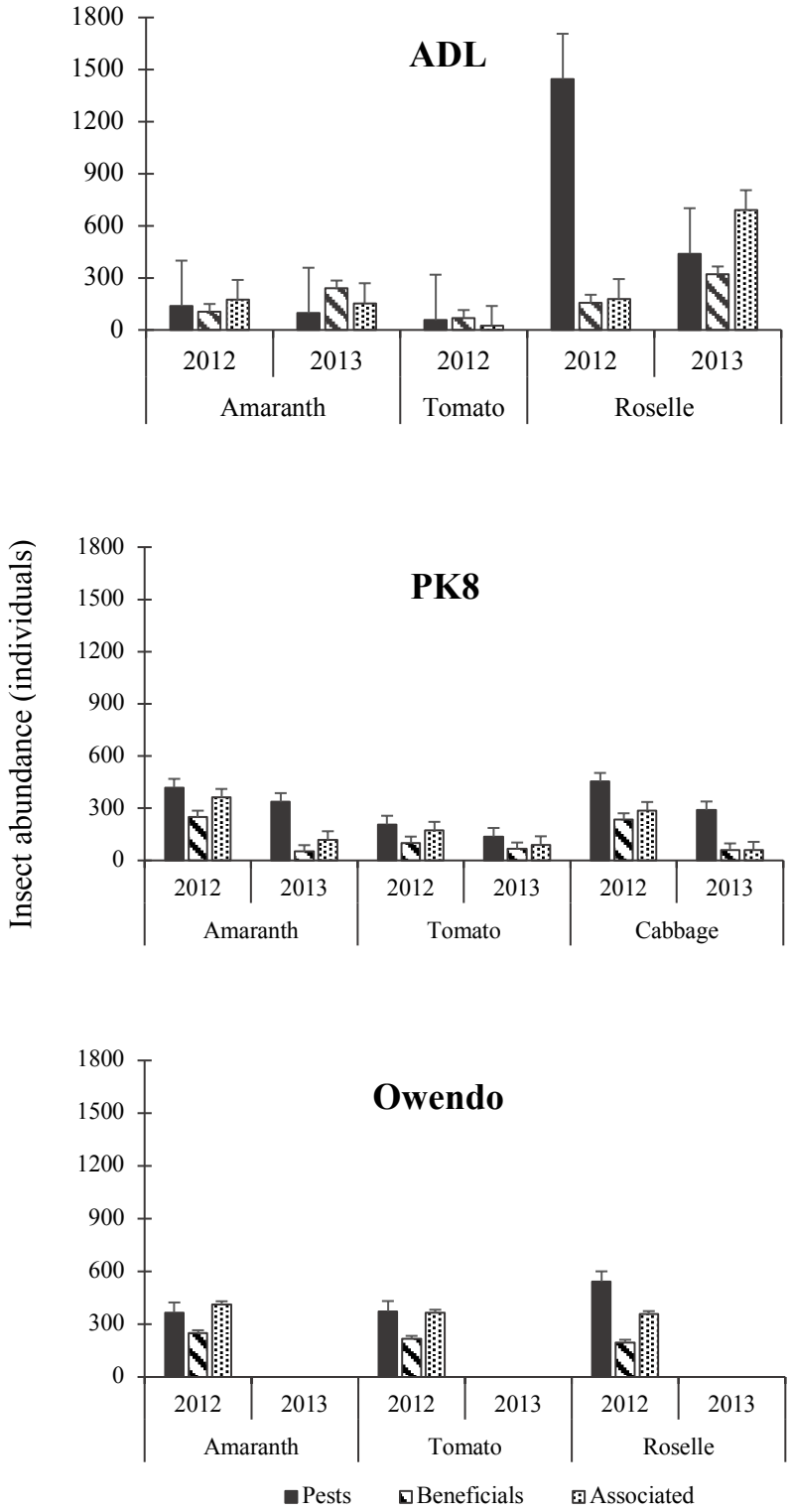

Figure 2: Insect categories abundance per crops (means ±SE) and year according to sites.

Table 3: Distribution of insect diversity (expressed in family number) according to crops and localities.

		Pests		Beneficial		Associated		Total families	
Crops	Localities	2012	2013	2012	2013	2012	2013	2012	2013
Amaranth	ADL	16	16	-	8	10	11	43	32
	PK8	16	14	18	12	15	9	49	35
	Owendo	18	-	19	-	15	-	52	-
Roselle	ADL	14	18	14	14	11	13	39	45
	Owendo	19	-	19	-	15	-	53	-
Tomato	ADL	9	-	10	-	6	-	25	-
	PK8	18	10	16	14	14	11	48	35
	Owendo	17	-	19	-	16	-	52	-
Cabbage	PK8	24	13	19	10	16	8	59	31
Total families (84)		**29**	**25**	**24**	**18**	**23**	**17**	**77**	**60**

3.3 Entomofauna diversity

Insect diversity (taxon family) according to crops and sites

Insect family abundances differed significantly between localities ($\chi^2 = 18.1961$, $P < 0.05$). There was a highly significant difference between the insect families in Owendo and ADL ($P < 0.001$) and a significant difference between PK8 and ADL ($P < 0.05$). There was no significant difference of insect families within crops ($P > 0.05$) during both years. Nevertheless, comparing sampling years, 2012 allowed to record a higher number of families (77) than 2013 (60) (**Table 3**).

Insect family occurrence per crop during both years

Only ADL and PK8 sites were sampled for both years 2012 and 2013. Monitoring in Owendo was performed in 2012, Common families were more numerous on amaranth (26) and roselle (30) in ADL site (**Figure 3**). In PK8, tomato and amaranth provided a lower number of common families (23). Comparing both years, there was a higher number of insect families in 2012 than in 2013, respectively on amaranth in ADL (17 in 2012 against 6 in 2013) and PK8 (26 in 2012 against 10 in 2013) (**Figure 3**). On roselle, the insect family number appears to be lower in 2012 (9 against 15 for 2013). On tomato, there was the same number of families (24) for common as for insect families caught in 2012, while only 11 exclusive families were caught in 2013 (**Figure 3**).

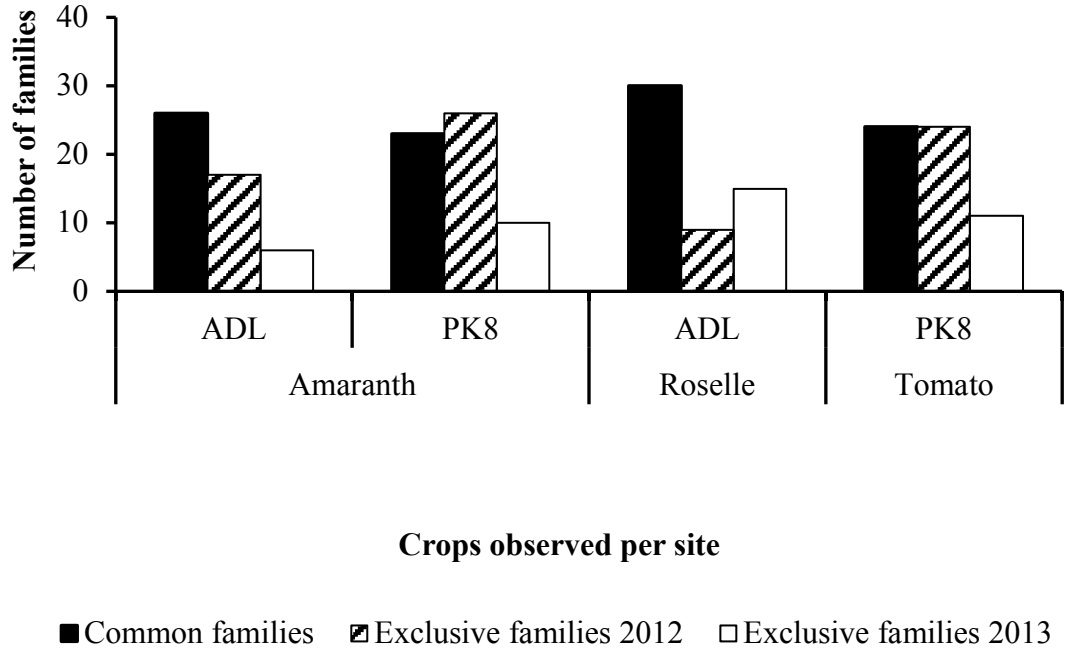

Figure 3: Insect diversity occurrence within sampled sites and crops.

Insect diversity index within sites and years

The Shannon index calculation showed that the diversity level depended on the insect categories, on their sites and the trapping year (**Figure 4**). Pests, beneficials and associated insects recorded lower rates of diversity in 2012 in ADL site. However, diversity rate was relatively similar between insect pests from ADL (in 2013) and PK8 (in 2012 and 2013). Owendo recorded the highest level of insect pest diversity (2012). Shannon evenness of pests was weak in ADL and PK8, but high in Owendo. Then, there was a balance of insect pest family distribution within both sites and years. In Owendo, the evenness is high because there was predominance occurrence of three families, namely Aphididae, Cecidomyiidae and Chrysomelidae. The Evenness was high for both beneficial and associated insects during both years, indicating a balance between the few families occurring in these sites.

Insect diversity within crops

Regarding crops, similar diversity level was found on amaranth between sites, with the highest levels in 2012. On cabbage, a similar diversity level was also observed between PK8 and Owendo. On roselle, higher diversity was obtained from Owendo while it was the low at ADL.

Globally, in both 2012 and 2013, the Evenness corresponding to the highest diversity rate varied from 0.65 and 0.83, indicating that there was a group of dominant insect families occurring in these sites.

4 DISCUSSION

Our study gave preliminary results of insect diversity in vegetables produced in peri-urban area in Libreville and Owendo. In the two towns, about 22 plant families are cultivated within the peri-urban area. Most of crop families cultivated like Malvaceae, Amaranthaceae, Basellaceae and Tiliaceae are described as African indigenous vegetables (Shackleton *et al.*, 2009). In our knowledge no previous inventories about insect pests were known for each of these crops in Gabon. This research was done with the farmer conditions, meaning that we did not manage the plant sowing but only used existing plots for visual observations and insect trapping in the fields. Then, our results depends on the crop accessibility/availability in the investigated areas. During the two years, the most important crops were amaranth, tomato, cabbage and roselle.

In 2013, the insects collected were 2.5 times more abundant than the ones counted in 2012. The difference between insect abundance in the two years was due to the closure of the Owendo site and the number of traps. That site was closed for political reasons in relation to terrestrial management. In addition, some farmers thought that our presence on the sites was due to a governmental control and used pesticides to protect crops.

Whatever the considered site or crop, the pests were more important than associated and beneficial insects. The result of the present study showed that the most important pest were aphids that are polyphagous and caused many damages on plants. Most of this pest are vectors of phytoviruses (Blackman & the late Eastop, 2017). This results confirmed Djiéto-Lordon *et al*., (2007) study where aphids were also the most abundant pests on Solanaceae, Malvaceae, Amaranthaceae, Fabaceae, Lamiaceae and Curcurbitaceae cultures. Although Chrysomelidae insects were not very abundant, several damages (holes on the leaves) were observed essentially on roselle crop.

For beneficial insects Dolichopodidae was the most important for both years. For these insects, adult and larval stages are predatory. Nevertheless, the preys used by both stages are notably different : the adults are predatory on small, soft-bodied insects and mites, and the larvae are probably all carnivorous (Hagen *et al*., 1999). Also, Coccinellidae and Ichneumonidae were found both in Gamba (Gabon) forest and gardens (Basset *et al*., 2008).

This work constituted a first inventory of crop and insect family diversities in the garden market in Libreville and Owendo. Further study should be performed to determine more accurately the different insect species and their importance in agriculture.

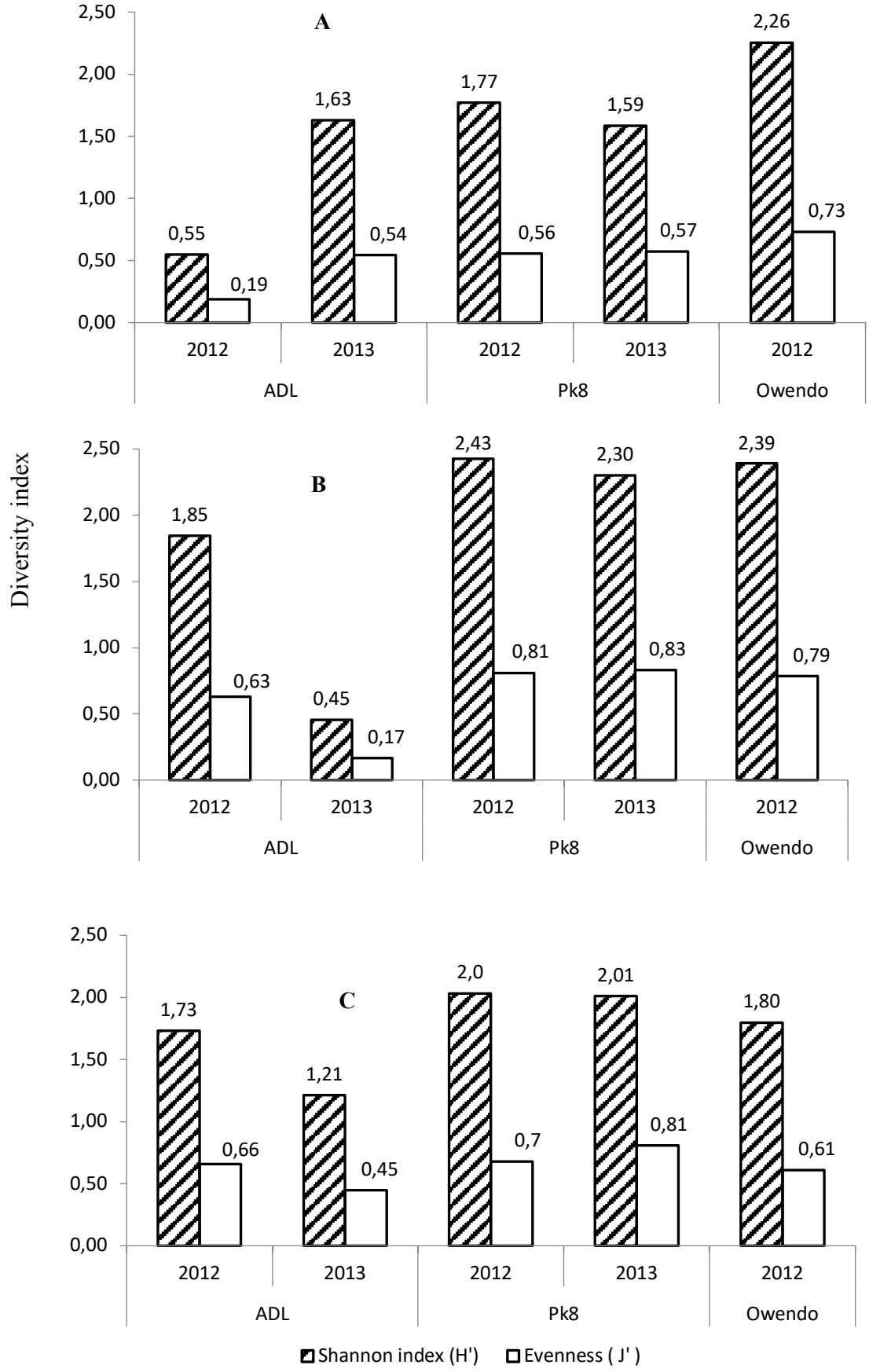

Figure 4: Comparison of Shannon Index diversity and Eveness within sampled sites and crops.

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