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Ndatabaye LF
Laboratory of Agricultural Entomology. Entomology Section. Department of Biology. Research Centre in Natural Sciences (CRSN-Lwiro), BP: D.S. / Bukavu, DR. Congo

Rubabura KJA
1 Laboratory of Agricultural Entomology. Entomology Section. Department of Biology. Research Centre in Natural Sciences (CRSN-Lwiro), BP: D.S. / Bukavu, DR. Congo
2 Agroecology and Food Systems, Doctoral School of Agroecology and Climat Sciences, UEA-UCB-UOB-UCG, South Kivu, DR. Congo

Kasole HG
Laboratory of Plant Production, Higher Institute of Agronomic et Veterinary of Mushweshwe,BP. 19/Bukavu, DR. Congo

Chihire BP
Laboratory of Agricultural Entomology. Entomology Section. Department of Biology. Research Centre in Natural Sciences (CRSN-Lwiro), BP: D.S. / Bukavu, DR. Congo

Bahwinja MI
Laboratory of Agricultural Entomology. Entomology Section. Department of Biology. Research Centre in Natural Sciences (CRSN-Lwiro), BP: D.S. / Bukavu, DR. Congo

Corresponding Author:
Ndatabaye LF
Laboratory of Agricultural Entomology. Entomology Section. Department of Biology. Research Centre in Natural Sciences (CRSN-Lwiro), BP: D.S. / Bukavu, DR. Congo

Diversity of yam insect pests at Kalonge, Kalehe territory, South Kivu, East of Democratic Republic of Congo

Ndatabaye LF, Rubabura KJA, Kasole HG, Chihire BP and Bahwinja MI

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Abstract
The present study revealed a total of 6 orders and 17 families such us Thysanoptera (Thripidae), Lepidoptera (Lymantriidae, Sphingidae, Noctuidae, Hesperiidae), Isoptera (Termitidae), Hemiptera (Cercopidae, Aphididae, Coreidae, Aleyrodidae, Pseudococcidae), Coleoptera (Cerambycidae, Chrysomelidae, Dynastidae, Scarabaeidae, Scolytidae) and Diptera (Cecidomyiidae). Again 28 species of yam pests include *Ancistrotermes* sp showed the maximum species diversity, followed by *Ferrisia virgata*, *Planococcus citri*, *Tagiades litigiosa*, *Pseudoplusia* sp, *Dialeurodes* sp, *Tagiades nestus*, *Heteroligus meles*, *Rhopasosiphum maidis*, *Aspidiotus destructor*, *Aphis gossypii*, *Aphis craccivora*, *Toxoptera* citricida, *Thrips crawfordi*, *Dasychira mendosa*, *Leptoglossus australis*, *Ptyleus grossus*, *Lasioptera* sp, *Apomecyna saltator Clytocera chinospila*, *Heteronychus* spp, *Galerucida bicolour*, *Apomecyna dioscorea*, *Heteroligus meles* and least species diversity were observed in *Crioceris livida*, *Heteroligus appius* and *Xyleborus ferrugineus*. Those yam pest cause damage on root, tuber, foliage, vine borer, galls on leaves, xylem sap feeder, phloem sap feeder, virus vector, sap sucker and sap feeder, dried roots. The study showed a rich yam pest diversity mainly attributed to the study area.

Keywords: Yam pest, diversity, distribution, survey, species

Introduction

Yams (*Dioscorea* sp., family Dioscoreacea) are annual or perennial tuber-bearing and climbing plants. Of the 600 or so species of Dioscorea recognized worldwide, only 10 are grown for food in various tropical and subtropical parts of the world by Asiedu *et al.*(2001) [1]; Korada *et al*. (2010) [2], Didi Konan *et al*. (2016) [3] and Wembou *et al*. (2017) [4]. Asiedu *et al*. (2001) [1] reported a few species are grown on a small-scale for extraction of the pharmaceutical compounds dioscorin and diosgenin. Then, the tubers have organoleptic qualities that can make them the preferred carbohydrate staple and can contribute up to 350 dietary calories per person each day. Adeniji *et al*. (2012) [5] and Cornet (2015) [6] report that yam constitutes an important food crop in intertropical zones and plays a major role in the food security of millions of people. According IITA (2007) [7] and Korada *et al*. (2010) [2], yams are produced over 5 million hectares in 47 countries in tropical and subtropical regions of the world. However, more than 95% of the world's 47 million metric tonnes of yam produced annually comes from Sub Saharan Africa. Moreover, in Africa, yields varied from 8.5 t/ha to 9.5 t/ha between 1990 and 2002. This increase is almost exclusively due to the increase in cultivated areas and the increase in yields. This low yam productivity is due to several factors including pressure from insect pests and diseases. Insects act in two ways: as vectors of viral diseases (generally biting suckers) on aerial parts and as pests of both leaves and tubers (Diby, 2005 cited by Soro *et al*., 2010) [8]. According to Degras (1986) cited by Soro *et al*. (2010) [8], most of the damage observed on tubers has its origin in the fields. Foua Bi, (1982) cited by Soro *et al*. (2010) [8] reports that regarding losses due to insect pests, a reduction in the emergence rate of more than 30% due to scale insects has been reported. Manyong and Oyewole (1997) cited by Korada *et al*. (2010) [2], the productivity of yam cultivation has been severely constrained by reduction in soil fertility, increases in infestation of coleopteran pests and increases in production costs. In addition to these problems, yam is increasing pressure from a range of insect pests (e.g. leaf and tuber beetles, mealybugs, scales), fungi (anthracnose, leaf spot, leaf blight, tuber rots) and viruses, as well as nematodes; contribute to sub-optimal yields and the deterioration of tuber quality in storage. The high-risk area for nematode infestation is estimated to be 45% in yam growing regions of West Africa. Bankole and Adebanjo (2003) [9] reported dried yam chips are also containing mycotoxins. Dans la zone d'étude, une espèce d'igname principalement *Dioscorea alata* (L) en fonction de provenance paysanne a fait l'objet de l'étude repartie en dix variétés locales d'ignames suivant leurs caractéristiques morphologiques et a été classée en trois groupes et/ou catégories basées sur les facteurs productivité et rendement dont : Haut rendement(HR), moyen rendement (MR) et faible rendement (FR).Parmi elles, Katesha, Nyalushuli, Kasakura et Kabeyabeyabeya ont un rendement moyen, Nyamishi et Nyabisu (RF), Nyabongwa, Bitarama, Nyaluliga et Kazanga (HR). Certaines de ces variétés ont manifestés la sensibilité aux maladies et d'autres aux insectes. On the markets and in the industry, there is a certain varietal preference among consumers, sellers and producers. This would be explained by the level of shelf life in the field, cooking time, precocity, vigor, productivity, resistance to diseases as well as organoleptic qualities (its improved flavor/taste), thus allowing customers to be attracted. In the present study, the overall strategy consisted of updating the data on the fauna of yam insects (diversity) on local varieties in farming environments.

Materials and Methods

Study area

This study was carried out in the Kalonge group located in the territory of Kalehe, province of South Kivu, in the east of the Democratic Republic of Congo. This group constitutes the large area where yams are produced, thus partly supplying neighboring territories as well as the city of Bukavu, apart from the quantity consumed by the indigenous population. Kalonge is a group of trees with average annual temperatures of 18 °C and rainfall which can reach 2114 mm.It borders with Ninja to the south, to the north by the Kahuzi Biega National Park (PNKB), to the east by Shabunda and to the west by the other villages of the Kabare Territory.

Choice of experimental plots

Six localities form the Kalonge group. The choice of these localities was precise. However, the choice of experimental plots was based on criteria linked to fallowness and not being next to another yam field to avoid any pre-existing entomological influence in the plot and surrounding areas, thus transmitting insect pests and vectors and of course diseases.

Insect trapping

Insects were captured using sweep nets. As for the flying insects, they were also captured using sweep nets and by hand between 6 a.m. and 8 a.m. and between 4:30 p.m. and 6:30 p.m. during the 3 phases, mainly in the tuber germination phase, in the growth phase as well as in the maturation, i.e. twice a week for 60 days for each phase.

Transport of samples (captured insects)

After capturing the insects, they were directly placed in alcohol (ethanol) concentrated at 95 percent and sent directly to the packaging location while awaiting their transfer to the agricultural entomology laboratory where they were identified.

Insect Identification

The insects captured and preserved in alcohol measured at 95 percent were made using a special identification key from Kouadjo *et al*. (2018) [10] at the Agricultural Entomology laboratory of the Department of Biology, from the Natural Sciences Research Center/CRSN-Lwiro. The identification was based on the external morphological characteristics of the insects using a binocular magnifying glass capable of enlarging the image of each insect 10 to 20 times larger, while referring to the collection of other insects found at Agricultural Entomology laboratory of the same Department and the same Center.

Data Analysis

In this study, for biodiversity analysis the data from collected insect samples were grouped according to source. The averages were calculated and there are several ways to test the species diversity. The biodiversity count was made using the Shannon diversity index (Shannon, 1948) [11] to estimate species richness uniformity and species diversity.

Species Diversity

The species diversity index was calculated by using the Shannon-Wieners Diversity index formula. H= - $\sum_{i=1}^{s} p_i \ln p_i$

Where p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and is the number of species.

Diversity index of different pests from Kalonge

The total of 6 orders and 17 families such us Thysanoptera (Thripidae), Lepidoptera (Lymantriidae, Sphingidae, Noctuidae, Hesperiidae), Isoptera (Termitidae), Hemiptera (Cercopidae, Aphididae, Coreidae, Aleyrodidae, Pseudococcidae), Coleoptera (Cerambycidae, Chrysomelidae, Dynastidae, Scarabaeidae, Scolytidae) and Diptera (Cecidomyiidae). The damage of *Dasychira mendosa* (Lymantriidae), *Hippotion celerio* (Sphingidae), *Pseudoplusia* sp. (Noctuidae), *Tagiades litigiosa* and *Tagiades nestus* (Hesperiidae), *Leptoglossus australis* (Coreidae), *Xyleborus ferrugineus* (Scolytidae), *Crioceris livida* and *Galerucida bicolour* (Chrysomelidae), *Ferrisia virgata* and *Planococcus citri* (Pseudococcidae) and *Thrips crawfordi* (Thripidae) were on the foliage. *Ancistrotermes* sp., *Macrotermes* spp., and *Microtermes* spp. (Termitidae), attack dried roots and tuber. *Heteroligus appius*, *Heteroligus meles*, *Heteronychus* spp. attack the tuber as *Apomecyna dioscorea* and *Planococcus citri*. The latter is a virus vector as those Aphididae such as *Toxoptera citricida*, *Rhopasosiphum maidis*, *Aphis gossypii*, Aphis *craccivora* and *Dialeurodes* sp. (Aleyrodidae) attacks sap feeder. *Toxoptera citricida* and *Rhopasosiphum maidis* attack sap sucker and *Aphis gossypii* and *Aphis craccivora* attack phloem sap feeder. *Lasioptera* sp. (Cecidomyiidae) causes galls on leaves and *Ptyleus grossus* (Cercopida) attacks xylem sap feeder. The two Cerambycidae, *Apomecyna saltator* and *Clytocera chinospila* are the vine borer and *Apomecyna dioscorea* attacks root (Table 1).

Table 1: List of insects of yam: field/pre-harvest

Order	Family	Species	Damage
Coleoptera	Cerambycidae	*Apomecyna dioscorea* Pierce	Root, tuber
		Apomecyna saltator Fab.	Vine borer
		Clytocera chinospila Gahan	Vine borer
	Chrysomelidae	*Crioceris livida* Dalman	Foliage
		Galerucida bicolour Hope	Foliage
	Dynastidae	*Heteroligus appius* (Burmeister)	Tuber
		Heteroligus meles	Tuber
	Scarabaeidae	*Heteronychus* spp.	Tuber
	Scolytidae	*Xyleborus ferrugineus* (Fab.)	Foliage
Diptera	Cecidomyiidae	*Lasioptera* sp.	Galls on leaves
Hemiptera	Cercopidae	*Ptyleus grossus* Fab.	Xylem sap feeder
	Aphididae	*Aphis craccivora* Koch	Phloem sap feeder & virus vector
		Aphis gossypii Glover	Phloem sap feeder & virus vector
		Aspidiotus destructor Signoret	Foliage
		Rhopasosiphum maidis (Fitch)	Sap sucker & virus vector
		Toxoptera citricida (Kirkaldy)	Sap sucker & virus vector
	Coreidae	*Leptoglossus australis* Fab.	Foliage
	Aleyrodidae	*Dialeurodes* sp.	Sap feeder
	Pseudococcidae	*Ferrisia virgata* Cockerell	Foliage
		Planococcus citri (Risso)	Foliage, virus vector, tuber
Isoptera	Termitidae	*Ancistrotermes* sp.	Dried roots and tuber
		Macrotermes spp.	Dried roots and tuber
		Microtermes spp.	Dried roots and tuber
Lepidoptera	Lymantriidae	*Dasychira mendosa* Hubner	Foliage
	Sphingidae	*Hippotion celerio* L.	Foliage
	Noctuidae	*Pseudoplusia* sp.	Foliage
	Hesperiidae	*Tagiades litigiosa* Moschler	Foliage
		Tagiades nestus (C. Felder)	Foliage
Thysanoptera	Thripidae	*Thrips crawfordi* Nakahara	Foliage

Table 2: Species Diversity Index.

Genus	Species	No. of individuals	Proportion (pi)	(Σ (sum) of pi^2 $(n/N)^2$	ln pi	Σ (sum) of pi ln pi
Ancistrotermes	*Ancistrotermes* sp	400	0.1368	0.0187	-1.9892	-0.2721
Macrotermes	*Macrotermes* spp	390	0.1334	0.0178	-2.0146	-0.2687
Ferrisia	*F virgata*	190	0.0649	0.0042	-2.7337	-0.1776
Planococcus	*P citri*	168	0.0574	0.0033	-2.8567	-0.1641
Tagiades	*T litigiosa*	165	0.0564	0.0032	-2.8748	-0.1622
Pseudoplusia	*Pseudoplusia* sp	148	0.0506	0.0026	-2.9835	-0.1510
Dialeurodes	*Dialeurodes* sp	145	0.0496	0.0025	-3,0039	-0,1489
Tagiades	*T nestus*	143	0.0489	0.0024	-3.0179	-0.1476
Hippotion	*H celerio*	139	0.0475	0.0023	-3.0462	-0.1448
Rhopasosiphum	*R maidis*	135	0.0462	0.0021	-3.0754	-0.1419
Aspidiotus	*A destructor*	132	0.0451	0.0020	-3.0979	-0.1398
Aphis	*A gossypii*	130	0.0445	0.0019	-3.1132	-0.1384
Aphis	*A craccivora*	129	0.0441	0.0019	-3.1209	-0.1377
Toxoptera	*T citricida*	126	0.0431	0.0018	-3.1444	-0.1355
Thrips	*T crawfordi*	120	0.0410	0.0017	-3.1932	-0.1310
Dasychira	*D mendosa*	100	0.0342	0.0012	-3.3755	-0.1154
Leptoglossus	*L australis*	27	0.0092	8.5265E-05	-4.6848	-0.0433
Ptyleus	*P grossus*	25	0.0085	7.3101E-05	-4.7618	-0.0407
Lasioptera	*Lasioptera* sp	18	0.0061	3.7896E-05	-5.0903	-0.0313
Apomecyna	*A saltator*	17	0.0058	3.3802E-05	-5.1475	-0.0299
Clytocera	*C chinospila*	13	0.0044	1.9767E-05	-5.4157	-0.0241
Heteronychus	*Heteronychus* spp	12	0.0041	1.6843E-05	-5.4958	-0.0225
Galerucida	*G bicolour*	11	0,0038	1,4152E-05	-5.5828	-0,0210
Apomecyna	*A dioscorea*	10	0.0034	1.1696E-05	-5.6781	-0.0194
Heteroligus	*H meles*	10	0.0034	1.1696E-05	-5.6781	-0.0194
Crioceris	*C livida*	8	0.0027	7.4856E-06	-5.9013	-0.0161
Heteroligus	*H appius*	7	0.0024	5.7311E-06	-6.0348	-0.0144
Xyleborus	*X ferrugineus*	6	0.0020	4.2106E-06	-6.1889	-0,0127
Total no. of species collected	28					
Total no. individuals		2924	1			
Shannon diversity index (H)		2.8721				

The species diversity index was calculated by the Shannon-Weiner index formula,and the letter was 2.8721. *Ancistrotermes* sp showed the maximum species diversity, followed by *Ferrisia virgata*, *Planococcus citri*, *Tagiades litigiosa*, *Pseudoplusia* sp, *Dialeurodes* sp, *Tagiades nestus*, *Heteroligus meles*, *Rhopasosiphum maidis*, *Aspidiotus destructor*, *Aphis gossypii*, *Aphis craccivora*, *Toxoptera* citricida, *Thrips crawfordi*, *Dasychira mendosa*, *Leptoglossus australis*, *Ptyleus grossus*, *Lasioptera* sp, *Apomecyna saltator Clytocera chinospila*, *Heteronychus* spp, *Galerucida bicolour*, *Apomecyna dioscorea*, *Heteroligus meles* and least species diversity were observed in *Crioceris livida*, *Heteroligus appius* and *Xyleborus ferrugineus* (Table 2).

Results and Discussion

Diversity index of different

The total of six orders such us Thysanoptera (Thripidae), Lepidoptera (Lymantriidae, Sphingidae, Noctuidae, Hesperiidae), Isoptera (Termitidae), Hemiptera (Cercopidae, Aphididae, Coreidae, Aleyrodidae, Pseudococcidae), Coleoptera (Cerambycidae, Chrysomelidae, Dynastidae, Scarabaeidae, Scolytidae) and Diptera (Cecidomyiidae). The damage of *Dasychira mendosa* (Lymantriidae), *Hippotion celerio* (Sphingidae), *Pseudoplusia* sp. (Noctuidae), *Tagiades litigiosa* and *Tagiades nestus* (Hesperiidae), *Leptoglossus australis* (Coreidae), *Xyleborus ferrugineus* (Scolytidae), *Crioceris livida* and *Galerucida bicolour* (Chrysomelidae), *Ferrisia virgata* and *Planococcus citri* (Pseudococcidae) and *Thrips crawfordi* (Thripidae) were on the foliage. *Ancistrotermes* sp., *Macrotermes* spp., and *Microtermes* spp. (Termitidae), attack dried roots and tuber. *Heteroligus appius*, *Heteroligus meles*, *Heteronychus* spp. attack the tuber as *Apomecyna dioscorea* and *Planococcus citri*. The latter is a virus vector as those Aphididae such as *Toxoptera citricida*, *Rhopasosiphum maidis*, *Aphis gossypii*, Aphis *craccivora* and *Dialeurodes* sp. (Aleyrodidae) attacks sap feeder. *Toxoptera citricida* and *Rhopasosiphum maidis* attack sap sucker and *Aphis gossypii* and *Aphis craccivora* attack phloem sap feeder. *Lasioptera* sp. (Cecidomyiidae) causes galls on leaves and *Ptyleus grossus* (Cercopida) attacks xylem sap feeder. The two Cerambycidae, *Apomecyna saltator* and *Clytocera chinospila* are the vine borer and *Apomecyna dioscorea* attacks root (Table 1). My research is also consistent with Maliki *et al*. (2012) [12], Andres *et al*. (2017) [13], Kouadjo *et al*. (2018) [10]. Yam is attacked and damaged by field and storage pests wherever it is grown elsewhere, resulting in yield and storage losses (Taylor, 1964; PANS, 1978; Akinlosotu, 1985 and Emehute *et al*., 1998 cited by Asante *et al*. (2007) [14] and Korada *et al*. (2010) [2]. Some of the most common pests include yam beetle, mealy bugs, termites, and nematodes. Pests may damage the yam tubers by decreasing their dry matter content, thus reducing germination capacity. Furthermore, the damage they cause to the epidermis may trigger secondary infections by rot fungi (i.e., molds), which can lead to high storage losses. Yam farmers hardly use synthetic pesticides. Effective control of pests is necessary to optimize yam yields (Andres *et al*., 2017) [13].

The species diversity index was calculated by Shannon-Weiner index formula comprising(2.8721), *Ancistrotermes* sp showed the maximum species diversity, followed by *Ferrisia virgata*, *Planococcus citri*, *Tagiades litigiosa*, *Pseudoplusia* sp, *Dialeurodes* sp, *Tagiades nestus*, *Heteroligus meles*, *Rhopasosiphum maidis*, *Aspidiotus destructor*, *Aphis gossypii*, *Aphis craccivora*, *Toxoptera* citricida, *Thrips crawfordi*, *Dasychira mendosa*, *Leptoglossus australis*, *Ptyleus grossus*, *Lasioptera* sp, *Apomecyna saltator Clytocera chinospila*, *Heteronychus* spp, *Galerucida bicolour*, *Apomecyna dioscorea*, *Heteroligus meles* and least species diversity were observed in *Crioceris livida*, *Heteroligus appius* and *Xyleborus ferrugineus* (Table 2). Goergen *et al.* (2010) [15] reported not similar results during the study.

Conclusion

The study area supports a rich diversity of insect pests with wide varieties of yam which provide an ideal breeding environment for yam insect pest. It is estimated that there are more than 28 yam insect pests' species on the Kalonge, Kalehe Territory, South Kivu, East of Democratic Republic of Congo as they are specific to different seasons and this survey was conducted for only six months. Therefore, it is difficult to collect, preserve, photograph and identify all species within the study area. The study is an attempt to provide a checklist for yam insect pests in the study area and will be continually updated for future reference. It was observed that *Ancistrotermes* sp was the most abundant species and had the highest number of individual species observed during the study, and *Xyleborus ferrugineus* had the least number of species observed respectively from the survey. Yam insect pests' diversity depends upon the cultural strategies or among other factors as climatic and soil. Therefore, it is possible that yam can be protected against those insect pests by improving the yam yield the study area.

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