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INSECT PESTS OF GRAINS STOCKS IN MARKETS OF ABIDJAN'S DISTRICT (CÔTE D'IVOIRE)

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ABSTRACT

Cereals, staple food of many peoples, are heavily attacked by insects. It is for this purpose that this study was carried out to make the inventory of insects associated with the grain stocks in Abidjan. Samples of grains (maize, rice, millet) were therefore taken during the market investigation of three municipalities in Abidjan. Thus, two samples of each cereal were taken from each market. These samples were placed in cartons to monitor insect development until adulthood to facilitate their identification. Eleven (11) species of insects belonging to nine (9) Coleopteran, one (01) Lepidopteran and one (01) Heteropteran were identified. In maize, the genus Sitophilus, primary pest, predominates with 93.26% of individuals counted. The primary pest Rhyzopertha, identified in millet, dominates with 37.31%. In rice, the genus Lophocateres predominates with 43.88% and 23.02% for the genus Tribolium; they are secondary pests. Insects are therefore a real problem for grain stocks in the markets of Abidjan's district.

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INTRODUCTION

In Côte d'Ivoire, food production represents more than 10.7 Mt per year, mainly tubers (49% yam with 5.7 Mt), roots (21% cassava with 2.4 Mt), bananas and cereals (6.4% rice and 5.9% maize, as well as millet and sorghum) (Ministry of Agriculture, Agri-Food and Forestry, French Republic, 2015). Indeed, food consumption is diversified in Côte d'Ivoire with an average contribution of 31% for cereals and 33% for roots and tubers (Resakss and Michigan State University, 2011). Rice as well as maize and millet are consumed in such a way that in Côte d 'Ivoire rice has long become the main food for almost all populations. Millet is highly prized for its nutritional qualities. It is grown and consumed in Côte d'Ivoire after maize and rice (Béninga and Akanvou, 2005). Cereals reserves constitute a vital element for the living beings survival. Thus, their storage ensures men feeding, meets the need for seed, allows trade with grain stocks building up for exchange and ensures the grain protection against insects and other pests (Ngamo and Hance, 2007). The structures used for storage may vary depending on the cereal, country and financial means. Thus, these structures can be modern such as silos and shops, traditional such as granaries in banco and straw. These storage structures, whether modern or traditional, always have specific risks (Kpatinvoh *et al*., 2017). This means that between harvest and consumption, more than 30% of production is lost (Ngamo and Hance, 2007). These losses vary between regions and even countries. They are mostly low in industrialized countries and very high in tropical developing countries (Guéye *et al*., 2011). Several pests are responsible for these losses, including rodents, fungi and insects (Ba *et al*., 2016). Insects are among the major pests that pose a threat to stocks and can completely destroy food and seed stocks in a few months if no protection is applied (Cissokho *et al*., 2015). For example, many studies refer to their attack on cereal stocks (Ashamo, 2006, Sadia-Kacou *et al*., 2015, Kpatinvoh *et al*., 2016). Insects that attack cereal stocks are generally Coleopteran and Lepidopteran (Sankara *et al*., 2017). The damage caused results in weight loss and decreased in grain

quality and loss of germination power (Dabiré *et al*., 2008). Given that grain stocks in Abidjan district are not left behind in these attacks, this study was initiated to inventory maize, rice and millet pest on some markets of this city. It is therefore to identify families, genera and species if possible within these foodstuffs.

MATERIALS AND METHODS

Study site

This study was located in the district of Abidjan in the south of Côte d'Ivoire, 5 ° 18'34 N and -4 ° 0 '45 ° W. Samples were collected in the markets of three Abidjan municipalities which are Abobo, Adjamé and Koumassi. These markets are supplied with foodstuffs from most interior cities of the country and neighboring countries. The manipulations were carried out within the Agricultural Entomology Research Unit of Nangui Abrogoua University.

Samples investigation and collection

During the sampling, questions were asked to two traders per market from whom the samples were taken to obtain information on cereal stocks available. Issues included origin, storage, price, entomological problems, and their attitudes towards insects in foodstuffs. Maize, millet and rice samples used during this work were collected in Abobo, Adjamé and Koumassi in Abidjan district. For these municipalities, five markets were selected for sampling. Two samples of each cereal were taken from each market.

Thus, 10 samples of each cereal were taken from a municipality, ie 90 samples from the three selected municipalities. The collection began on 20 June 2015 and ended on 02 September 2015.

Breeding

Insects associated with these cereals which lasted three months was raised in Agricultural Entomology Laboratory of Nangui Abrogoua University. It was intended to monitor insect's development until adulthood to facilitate identification. Glass jars containing one type of foodstuff were labeled with the following information: foodstuff name, municipality and the collection date. They were put in cartons to create storage conditions, at laboratory ambient temperature. Finally, daily observations have allowed the removal of adult insects to be stored in pill containers containing 70% ethanol.

Insects Identification

We use the identification keys and pictures from Delobel and Tran (1993), Delvare and Aberlenc (1989). The identified insects are stored in pill containers with 70% ethanol.

Data analysis

A comparative study to detect differences between insects by commodity was performed using the Kruskal-Wallis non-parametric test (p= 0.05) (Statistica 7.1).

Table 1. Insects identified in rice, maize and millet stock from different markets

Orders	Families	Genus/species	Maize	Rice	Millet
Coleopteran	Bostrichidae	*Rhyzopertha dominica*	5	12	103
		Prostephanus truncatus	3	0	0
	Tenebrionidae	*Tribolium castaneum*	34	32	20
	Cucujidae	*Cryptolestes ferrugineus*	100	13	23
	Lophocateridae	*Lophocateres pusillus*	31	61	0
	Silvanidae	*Oryzaephilus surinamensis*	1	4	0
	Curculionidae	*Sitophilus zeamais*	3806	7	99
		Sitophilus oryzae	91	14	0
		Sitophilus granarius	8	0	18
Lepidopteran	Pyralidae	N.I	2	0	6
Heteropteran	Anthocoridae	N.I	0	0	7

N.I : Unidentified Species

Table 2. Cereal stock insects distribution according to municipalities markets visited

Municipalities	foodstuffs	Families number	Species number	Individuals number
Abobo	Rice	4	4	40
	Maize	5	6	1349
	Millet	6	4	83
Adjamé	Rice	6	7	46
	Maize	5	7	1423
	Millet	6	5	85
Koumassi	Rice	4	5	53
	Maize	5	8	1309
	Millet	5	5	108
Total				4496

RESULTS

Survey data

During the investigation, 30 traders were interviewed including 8 retailers and 2 wholesalers in each municipality. Maize samples obtained at forum market of Adjamé were from Korhogo and Odienné localities. In Abobo and Koumassi markets, the maize collected are from Burkina Faso and for the other foodstuffs no precision was given because the traders affirmed taking their stock in big markets. The price per kilogram of maize and millet was 400 CFA francs, but the price of rice varies according to the variety. Concerning the sale, rice flows faster followed by maize and millet. In big markets, the traders had stores. On the other hand, retailers in the neighborhoods did not have shops but shelves or trays in which all cereals were superimposed. Inside the stores, no storage rules are observed, ie no hygiene, stores are unventilated, bags are unclassified and disposed on the floor, with the presence of several foodstuffs at the same place.According to traders, insects constitute a serious problem followed by rodents. To reduce the enormous losses, they use mechanical methods such as winnowing and manual sorting. Most of wholesalers say using chemicals for their food treatment. However, no product names were mentioned.

Insect's abundance and diversity from Abidjan markets

Insects collected in various samples of maize, rice and millet are Coleopteran, Heteropteran and Lepidopteran. A total of 11 species with 9 species of Coleopteran have been identified. Coleopteran species are: *Rhyzopertha dominica*, *Oryzaephilus surinamensis*, *Tribolium castaneum*, *Sitophilus oryzae*, *Sitophilus zeamais*, *Sitophilus granarius*, *Lophocaterae pusillus*, *Cryptolestes ferrugineus* and *Prostephanus truncatus*. In this order, Curculionidae family presents three species followed by Bostrichidae family with two species. As for Lepidopteran and Heteropteran, only one family was identified for each order (Table 1).

Insects collected in maize stocks

The majority of insects identified in maize samples are Coleopteran. In total, two orders, 07 families and 9 species were counted. Sitophilus is the most important genus collected with 3905 individuals followed by the genus *Cryptolestes* with 100 individuals. A Lepidopteran family (Pyralidae) was identified (Table 1). The dominant species is *Sitophilus zeamais* with 3806 individuals identified, accounting for 93.26% of all insects total. Of the 4081 insects identified from maize stock samples, 1423, 1309 and 1349 insects are respectively from Adjamé, Koumassi and Abobo municipalities. Eight species with five families were identified in samples from Koumassi stocks, 7 species with 5 families from Adjamé, 6 species with also 5 families from Abobo. Lepidopteran species have not been determined (Table 2).

Insects collected in rice stocks

Insects identified in rice samples are Coleopteran. *Lophocateres pusillus* is the most widely represented species, with 61 out of 139 individuals (43.88% of the total), followed by *Tribolium castaneum* with 32 individuals (23.02% of the total) (Table 1). Out of a total of 139 insects collected from rice stocks, 40, 46 and 53 insects were from Abobo, Adjamé and Koumassi municipalities respectively. In samples from Adjame stocks, 7 species and 6 families were identified. In Koumassi, 5 species and 4 families were identified while in Abobo 4 species and 4 families were identified (Table 2).

Insects collected in millet stocks

Insects found in millet samples are mainly Coleopteran, Lepidopteran and Heteropteran. In sum, 3 orders, 6 families and 7 species were determined (Table 1). Koumassi samples show 5 species belonging to 5 families, Adjamé markets group 5 species and 6 families, and Abobo have 4 species and 6 families recorded (Table 2). Whatever the municipality, insect families' number observed on municipalities is relatively similar. However, species and individuals highest number was recorded on maize (Table 2). Individual's largest number was identified in Adjamé municipality, 1554 individuals followed by Abobo municipalitywith 1472 individuals. The statistical tests (Kruskal Wallis ANOVA) showed no significant difference between the different family'smeans, species and individuals ($p > 0.05$) concerning insects identified distribution according to municipality markets (Table 3).

DISCUSSION

Foodstuffs conservation is a real problem that the traders interviewed Abidjan markets, despite initiatives taken on both sides for their protection. Similar observations have been reported by Waongo *et al*. (2013). According to investigation, insects are the main predators of cereal stocks followed by rodents and micro-organisms. In addition, traders use chemical products of which they are unaware. Thus, Dabiré (2001) points out that production increasing coupled with insect attacks severity requires synthetic insecticides use for stocks protection. These insecticides have many disadvantages, including resistant strains appearance (Benhalima *et al*., 2004; Kpatinvoh *et al*., 2016), and food poisoning (Regnault-Roger, 2002). Therefore, essential oils and other insecticides from plant extracts use is important because they leave less or no residues in cereals (Adjalian *et al*., 2014, Kayombo *et al*. 2015).

Coleopteran and Lepidopteran families identified in this work are recognized to be insects that attack food (Waongo *et al*., 2013, Huchet, 2014, Cissokho *et al*., 2015), with the exception of Anthocoridae which are Heteropteran predatory. Similar results were obtained in studies conducted by Sadia-Kacou *et al*. (2015) in Abidjan port which also found this insect predominance. At the Lepidopteran level, there were fewer individuals collected than the Coleopteran. This could be related to cereals nature and also breeding time. Therefore, individual's largest number was found in Adjamé municipality. Indeed, it is through this municipality the majority of the products transit and then to be sold in the other municipalities of Abidjan and other cities. This would explain pest large number. In maize stocks, the study revealed a high level of pest diversity. The choise of maize by pests could be explained either by grain size or by the storage form or corn intrinsic properties favorable to pest's development (Waongo *et al*., 2013). On maize, a remarkable predominance of *S. zeamais* is observed, contrary toWaongo results (2009) which counted four predominant species. *S. zeamais* predominance was also observed by Ouedraogo *et al*. (2016) in Burkina Faso. Other predominant species absence could be explained by the too short breeding time for the majority maize pest's

emergence. In addition, studies made by Ngamo and Hance (2007) have shown that corn losses due to weevils (Coleopteran: Curculionidae) can exceed 25% at harvest or even reach 40% in six months of storage. Thus, for this foodstuff protection, the same authors think that phytopesticides using, local biodiversity productsis today a promising alternative. In millet stocks, a Coleopterans pecies, *Rhyzopertha dominica* was singularly important because representing 37.31% of the individuals observed. This result is comparable to studies conducted by Waongo *et al*. (2013) who also found a significant number of *R. dominica* on sorghum. The important presence of this species is related to sorghum small size, and millet and sorghum have similar sizes. This could also explain this species large number on millet. Other previous studies on millet pest have also revealed pest presence on this foodstuff. In rice, the results indicated only Coleopteran presence with *L. pusillus* dominance, followed by *T. castaneum*, accounting for 43.88% and 23.02%, respectively. Thus,*L. pusillus* larvae are essentially psychophagous (consumers of crumbs including consumers of primary pest excretions) and necrophagus (cadaver's consumers and other animal substances). It is, however, capable to attack intact grains of rice varieties whose glumes are not sufficiently hermetic. *T. castaneum* infests rice, millet and maize. This species is frequently encountered on rice as shown in Camara (2009) works. Psychophagus, mycophagus (mold-borne consumers) and necrophagus, it does not attack the intact grain, only the germ is consumed most of the time. Only one predator family was identified in millet stocks. The presence of this predator (Anthocoridae) could be justified by many pests presence which would serve as prey. This predator therefore contributes to pest population's regulation in food stocks (Sing and Arbogast, 2008).

Conclusion

In the end, the study carried out on cereal stocks (maize, millet and rice) permitted to understand that insects are the main cause of enormous damage observed in the samples collected in Abidjan municipalities. Insects sampled and identified in this study belong to Coleopteran, Lepidopteran and Heteropteran orders, with a dominance of Coleoptera. Insects variety based on foodstuff was observed. There were more insects collected on maize than millet and rice. On maize, *S. zeamais* dominated while on millet and rice are respectively *R. dominica* Fabricius and *L. pusillus* Klug. Cereal stocks on Abidjan district markets are heavily attacked by insect pests. Traders must therefore take hygiene measures to reduce these attacks and guarantee cereals quality.

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