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Diversity and dynamics of insect pests of paddy rice stored in the city of Issia; Central-West of Côte D'Ivoire

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Abstract

Paddy rice stocks are attacked by pests that sometimes cause enormous damage. This study aims to assess the diversity and abundance of insect pests of stored paddy rice in the city of Issia. Three samples in three kilograms were taken per bag at different levels of the bag and sorted manually in three stores in the city. The collected insects were examined using a Binocular magnifying glass in the laboratory. Overall, 4867 insects were inventoried. They are all beetles belonging to three families; Bostrichydae (*Rhyzoperta dominica*); Tenebrionidae (*Tribolium chestnut*); Curculiondae (*Sitophilus oryzae* L and *Sitophilus zeamais*). Data analysis showed that Tenebrionidae slightly predominate with 36.78%; followed by Bostrichydae with 35.63% and finally Curculiondae with 27.59. The study revealed that environmental conditions and storage duration influence the multiplication and evolution of insect populations in stocks.

Keywords: Dynamics; Insects; Pests; Paddy rice stocks

1. Introduction

Rice (*Oryza sativa* L.) is the third most consumed cereal in the world after wheat and maize [1]. Demand is increasing by more than 6% per year [2]. According to World Bank forecasts, paddy rice production is estimated at 509.2 million tons in 2020 [3]. It is also the most consumed in Côte d'Ivoire, with an estimate of 1.3 million tons in 2008 [4]. Since local production is insufficient for the population, the country imports rice from Asian countries every year [5,6] However, during its production, rice cultivation faces difficulties. According to Abdou [7], various constraints are common to sub-Saharan crops: drought, recurring water deficits, diseases, weeds, poor seed quality, progressive soil depletion, lack of supervision, absence of inputs, disengagement of the State and disorganization of the sector. In Côte d'Ivoire, in addition to the problems mentioned above, rice cultivation is attacked by many pests including insects [8]. According to [9], the pressure of these pests contributes significantly to the decline in production. However, the impact of insect damage threatens seeds in stocks and thus food security. These pests are the cause of enormous losses ranging from 30 to 85% of rice stocks [10]. Insect pests of storage are classified into three groups: primary, secondary and tertiary insect pests [11]. Primary pests are insects capable of breaking the hard seed coat. Secondary pests, are those that feed on broken seeds and seeds with defective envelopes. Finally, tertiary pests feed on broken seeds, seed powder and dust left by other groups. They are more destructive in tropical countries where climatic conditions offer perfect development and intense activity [12]. Despite this threat to national production, very little data exists on the entomofauna of paddy rice in this region of the country. This study aims to assess the diversity and abundance of insect pests of stored paddy rice in Issia (Côte d'Ivoire).

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2. Material and methods

2.1. Study site

The study was conducted in Issia, a locality located in the Haut-Sassandra region. It is characterized by precipitation varying between 1,500 and 2,000 mm with an annual average of 1,800 mm. The average temperature is 27 °C [13]. Two rainy seasons (March to June and August to September) and two dry seasons (October to February and July) [14].

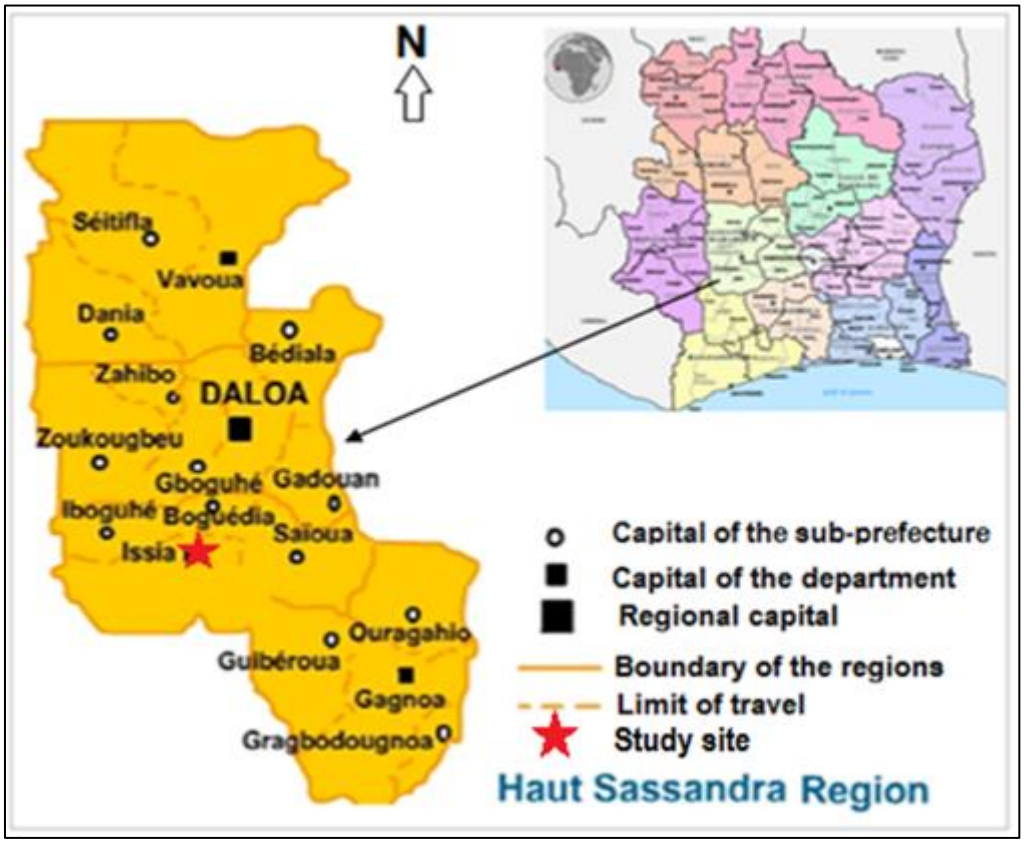

Figure 1 Location of the study area (source: [14])

2.2. Collecting insects

The study was carried out in the city of Issia during the months of September to October 2023. Three (3) paddy rice storage warehouses were chosen. The choice of these warehouses is based on the different durations of paddy rice stocks. Two months for store 1, five for store 2 and twelve months for store 3. The collection was carried out by manual sorting in three kilograms of paddy rice. Three (3) samples are taken per bag: 1 above 1 in the middle and 1 at the base of the bag. The captured insects are kept in numbered bottles. A total of four visits were made to each store, two in September and two in October.

2.3. Species identification

Identification was made in the laboratory using the identification keys of [15, 16, 17]. The number of insects of each species identified is then determined by counting under the binocular microscope.

2.4. Data Analysis

2.4.1. Diversity

The diversity of species present on paddy rice was evaluated based on the calculation of Shannon diversity index, Simpson diversity index (SI) and evenness index.

2.4.2. The Shannon Index (H'),

It is determined by the expression: H'= -Σ ((Ni / N) * log2 (Ni / N)) with Ni: number of individuals of a given species, i ranging from 1 to S (total number of species), N: total number of individuals. that the environment is highly populated with species or favorable to the development of species. This index was determined using Excel 2010 and R 2.8.0 software

2.4.3. Chi-square test

This test was used to compare insect frequencies as a function of storage duration. In all these analyses, the significance level was set at $p < 0.05$. This test was performed using Excel 2010 and Statistica 7.1.

3. Results

3.1. Entomofauna of paddy rice stocks

Four (4) species, all Coleoptera and belonging to three families were collected: *R. dominica* (Bostrichydae), *T. castaneum Herbs* (Tenebrionidae), *S. oryzae L* (Curculionidae) and *S. zeamais* (Curculiondae) (Table 1). These species are classified into two categories according to the feeding mode: primary pests (*S. oryzae L ; R. dominica ....*) and secondary pests (*T. castaneum* Herbs).

3.2. Overall abundance of each insect pest

The study conducted in the three stores revealed a different distribution of pests. The proportion differs according to the species (Figure 2). Of the four beetles encountered, *T. castaneum* records the highest percentage with 38.05% followed by *R. dominica* and *S. oryzea* with respectively 34.91% and 25.69% and finally *S. zeamais* with 1.35%.

3.3. Relative abundance of insect pests as a function of storage duration

Out of 4,867 individuals collected in the different stores, the 12-month stocks with 53.73% harbor the greatest number of pests. They are followed by the 5-month stocks with 41.05% and finally those of 2 months with 5.22% (Table 1 and Figure 3). The determination of the p-value for a confidence interval of 5% showed a significant difference between the different environments ($p < 0.0001$).

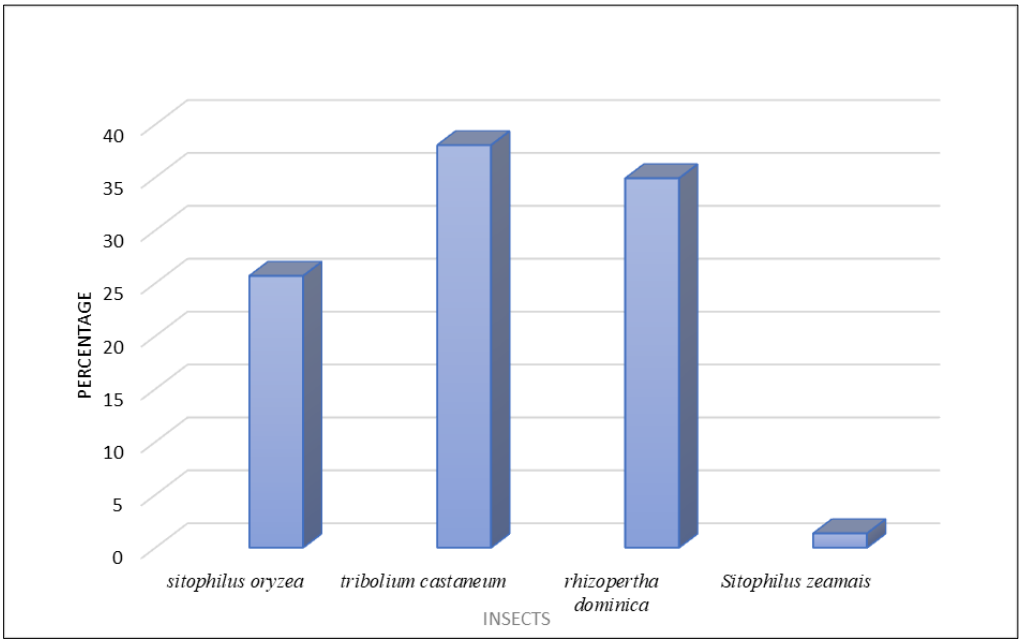

Figure 2 Abundance of paddy rice insect pests

Table 1 Insect abundance as a function of storage duration

Species	2 months	5 months	12 months	Total workforce / species	% by species
S. oryzea	169	531	576	1276	26.22
Tribolium castaneum	11	646	1133	1790	36.78
R. dominica	74	754	906	1734	35.62
S. zeamais	0	67	0	67	1.38
Total workforce / period	254	1998	2615	4867	-
% by stock	5.22	41.05	53.73	-	100

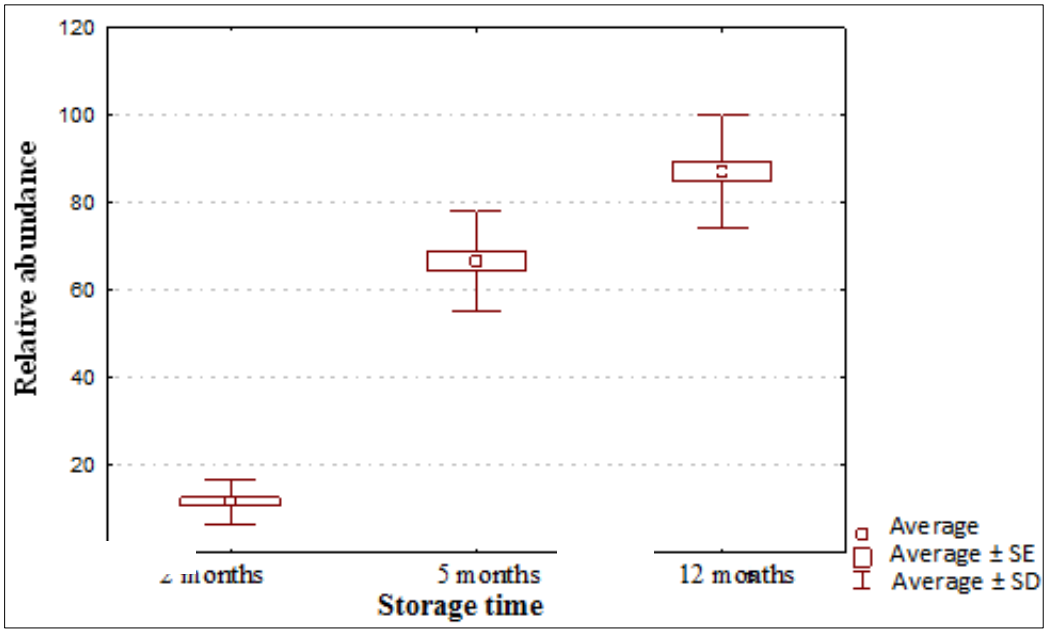

Figure 3 Relative abundances of insects according to storage duration

3.4. Relative abundance of insect pests in each paddy stock

In the two-month stocks, the high abundance observed is that of *Sitophilus oryzea* followed by *Tribolium castaneum* and *R. dominica* which has the low abundance. There is no *S. zeamais*. 5-month stocks have a high abundance of *R. dominica* followed by *T. castaneum*, *S. oryzea* and *S. zeamais.* In the 12-month stocks, *T. castaneum* was the most abundant followed by *R. dominica* and *S. oryzea.* The absence of *S. zeamais* is noted in these stocks.

3.5. Diversity of insects according to stores

The determination of the Shannon Weaver index (H') made it possible to detect the biological diversity of the different stocks. The 5-month stocks are more diversified with H' = 1.2 followed respectively by the 2-month stocks with H' = 1.06 and finally the 12-month stocks with (H' = 1.04) which have H' very close

Table 2 Diversity indices of different environments

Periods	Shannon (H')	Simpson (IS)	Fairness (E)
2 Months	1.043841	0.6318561	0.9501446
5 Months	1.198853	0.6816336	0.8647898
12 Months	1.062874	0.6439694	0.9674693

4. Discussion

During the inventory of insects in paddy stocks in Issia, 4867 insects all of the order Coleoptera were collected belonging to three families. The Curculionidae family was the most represented with 2 species followed by Tenebrionidae and Bostrichydae with 1 species each. Insects of the Tenebrionidae family are the most numerous with a proportion of 36.78% followed very closely by those of Bostrichydae with 35.63%. Finally, that of Curculionidae with 27.59%. The exclusive presence of Coleoptera in paddy had already been reported by [18] who present Coleoptera as being the most devastating group of stored grains. The high proportions of certain insect families could be explained by the climatic conditions of the region. Indeed, the temperature of the region varies from 18° to 36°C and the relative humidity oscillates from 20 to 90%. While the development and multiplication of these families of insects of the stocks is maximum in these conditions of temperature and relative humidity of the air [19]. The pests encountered can be divided into three categories. The primary pests: *S. oryzea, R. dominica and S. zeamais* appear occasionally in the stocks of paddy. The secondary pest *T. castaneum* was also collected. The simultaneous presence of these different categories of insects could be explained by the lack of treatment of bags and warehouses. Indeed, warehouses and conservation bags that are generally already used for external stocks could contain grains in which larvae are found of a pest. In 2004, Groot in his work had made the same observation [11]. For this author the presence of larvae is synonymous with the presence of adults. The presence of broken grains could explain the presence of secondary and tertiary pests. According to Foua - Bi [20], the concomitance of several products (cereals) in the same store could lead to the simultaneous presence of primary, secondary and tertiary pests. The high rate of *T. castaneum* could be explained by the climatic conditions of the study area favorable to the multiplication and longevity of the species. According to Badr [21] a population of *T. castaneum* can be multiplied by 70 in less than a month under optimal conditions and with a longevity of up to 2 years. *R. dominica* and *S. oryzea,* two major primary pests best known on paddy rice, have a lower proportion than *T. castaneum.* This could be explained by the mode of development of these species in the stocks. Indeed, [22, 23] reported that these insects are light-shy and that they develop in grains. This mode of development does not allow their numbers to be determined accurately, which is not the case for *T. castaneum* which lives freely in stocks. The low rate of *S. zeamais* could be due to their preferential attack on corn. It is therefore present in paddy stocks only when they are stored in the same store with corn stocks. In addition, a short longevity as reported by Badr [21], which is 3 to 5 months. The results show that 12-month stocks harbor a high relative abundance followed by 5-month and 2-month stocks. Indeed, according to him, the population of insect pests increases with storage duration.

5. Conclusion

This study made it possible to carry out the diversity and dynamic of the paddy rice stocks entomofauna in Issia. Overall, 4,867 insects were recorded. These insects are of the order Coleoptera and include three families that are enemies of paddy stocks. The evolution of the population is due on the one hand to the climatic conditions of the study areas which are favorable to the multiplication and development of insects and on the other hand to the storage duration. The population of insect pests increases with the storage duration.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest with respect to this article.

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