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Diversity of the entomofauna of maize (*Zea mays* L.) during recession in the Senegal rivé valley

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Abstract
In Senegal, maize is grown mainly for its grain in the River Valley during periods of recession when seasonal flooding allows it. This commodity in culture is often affected by the ravages of bioaggressors, the most noted of which are Lepidoptera, Coleoptera, Hemiptera and Orthoptera. Thus, this study seeks to know the diversity of the species encountered on maize.
The collection was conducted for seven days following trapping, capture and rearing methods. The insects were stored in labeled tubes containing alcohol 70. The identification was carried out in the laboratory using the IFAN collections. The Shannon and Pielou indices and the maximum diversity were determined. Also the tests of Fisher, Kruskal-wallis and Dunn were carried out.
During the period from the beginning of flowering to the beginning of maturation, the study focused on 590 individuals belonging to 58 species of insects from 24 families and 5 species of spiders belonging to eight orders. Heteroptera are the most represented in the sample with a proportion of 35.71% followed by Coleoptera with 26.43% and Orthoptera with 25%. The study environment presents an average diversity which is significant and a low regularity of the distribution of species at the beginning of maturation stage. However, this ecosystem is heavily dominated by pests including *Piezodorus* sp. So come to less *Spodoptera frugiperda*, *Helicoverpa armigera*, *Eysarcoris inconspicuus*, *Thrips* sp, *Creontiades pallidus*. These pests encountered natural enemies including *Geocoris amabilis*, *Anthicus* sp and *Nabis capsiformis*.

Keywords: Bio-aggressor, Diversity, Flood-recession corn

Introduction
For most developing countries, cereals represent the bulk of the diet of generally low-income rural populations [1]. Indeed, cereal production, in particular sorghum, millet, rice and maize, constitutes staple foods for the majority of populations [2, 3]. Among these food crops, maize (*Zea mays* L.) is a staple food for many African countries [4]. On the other hand, for developed countries, maize is mainly intended for animal feed and industry (Starch) [5]. In addition, its adaptation is observed over a wide range of climates and its distribution is very diversified compared to other cereal crops [6]. In Senegal, maize is grown mainly for its grain in four regions: Eastern Senegal, Sine-Saloum, Casamance and the Senegal River Valley [7]. In the latter, the cultivation of maize is done during periods of recession despite the drop in rainfall and flood volumes [8]. This ensures a low but secure production [9].
Despite its versatility due to the economic value that each of its parts brings [6], maize is often confronted with pedoclimatic, socio-economic and biotic constraints [10, 4, 1, 11]. Indeed, this cereal suffers damage caused by insects leading to a reduction in weight and market value [6]. These bioaggressors are of different orders, the most noted of which are Lepidoptera, Coleoptera, Hemiptera and Orthoptera [12]. It thus becomes necessary to make an inventory of the species encountered on maize in the River Valley in order to have a knowledge of the entomological richness of this crop. This study aims to better understand the diversity of maize pests and their natural enemies.

Material and Methods
Study Framework
This work was carried out in the area of Dembancane, a commune since 2008 of the department of Kanel in the region of Matam.

Its coordinates are 15° 05 North and 12° 42 West and its altitude is 23m. Located near the Senegal River and the border with Mauritania, it is crossed by the national road N2 which connects Bakel and Matam. Depending on the eco-geographical zones of Matam, it is located in the locality of Walo, also called "Dande mayo", a flood zone par excellence characterized by flood recession and irrigated cultivation (maize, sweet potato, sorghum, etc.). These crops are intended for self-consumption and local varieties are used. Maize in this zone is often rotated with cowpea or sweet potato.

Being an agro-ecological zone, the vegetation of Dembancané is dominated by *Acacia nilotica* but also presents *Balanites aegyptiaca*, *Piliostigma reticulatum*, *Momordica charantia*, *Ziziphus mauritiana*, *Gossypium* sp etc. It meets the needs of the production and supply of agricultural and fishing products [13].

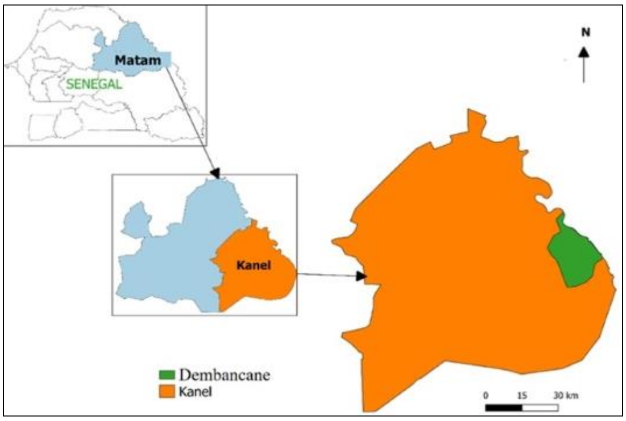

Fig 1: Geographical map of Dembancane

Sampling, Collection and Breeding of the species encountered

During this study, we had randomly visited seven fields considered as plots. The first five have à perimeter of 45m wide and 400m long, the sixth has a width of 50m by 400m long and the seventh has a width of 50m by 500m long. The study was carried out from December 25, 2020 until February 2, 2020. Of the seven partials, sampling was carried out at dusk, randomly. Our research focused on the early flowering stage and the early maturation stage found in the field. The collection was carried out for 7 days. Thus, insects were taken directly from the plant using insect forceps or captured from the surroundings by a net. Indeed, these species were trapped because they are generally found in the cones of the seedling. Besides, spiders and insects were found on the leaves, leaf creases, in the cob or on the stem.

Fig 2: Types of traps used (A) the net and (B) the stinging pliers at dusk

Then, apart from Lepidoptera, the species collected were put in labeled tubes containing 70° alcohol to prevent putrefaction. Furthermore, the caterpillars sampled (Fig 3A) were reared in Petri dishes containing maize leaves (Fig 3B) in order to continue their development cycle. Thus, these larvae had become nymphs (Fig 3C) and then adults (Fig 3D).

Fig 3: Rearing of *Spodoptera frugiperda* caterpillars

Identification of species encountered

Once in the laboratory, the species were identified thanks to the collection of IFAN Cheikh Anta Diop (French Institute of Black Africa). The morphological recognition of the species was made using a magnifying glass, allowing us to compare its characteristics with those of the species in the collection. Thus the insects collected could be distributed and classified taxonomically.

Fig 4: Material used for the morphological recognition of the species collected

Determination of the diversity of maize entomofauna

Diversity was determined by calculating diversity parameters

- The total wealth, also called **S**, corresponds to the number of species present on all the surveys [14, 15]. On the other hand, for each sample, the species wealth corresponds to the gross number of individuals per species [15].
- The Shannon index makes it possible to determine the

diversity of different communities by taking into account the number of species and the abundance of individuals within each of these species. It is calculated from the following formula:

$$H' = -\sum_{i=1}^{s} \left(\frac{ni}{N}\right).\log\left(\frac{ni}{N}\right)$$ [15].

Ni = number of individuals of species i in the sample
N = total number of individuals of all species in the sample.
Its value varies from 0 (a single species, or a dominant species very largely all the others) to log S when all the species have the same abundance with S the specific wealth [15]. From this index, the maximum diversity (Hmax) is calculated. Hmax = log2S [16, 15]. It is often accompanied.
The Pielou evenness index which is the ratio between the diversity H' (the diversity of a stand or a sample) and the maximum diversity Hmax. It expresses the distribution of individuals within species [16, 15]. Its value varies between 0 if almost all of the numbers are concentrated in a single species and 1 if the species have individuals in equal distribution [15].

Statistical analyzes

Data entry and part of the graphic visualization was carried out using the Excel table of Microsoft Office version 2016. Python software version 3.8 [17] and R version 4.0.3 [18] were used to perform the statistical tests. Quantitative data were subjected to the Shapiro wilk test. The significance threshold is set at 0.05. Fisher's test was performed to test the distribution of species according to Orders. A realization of the test of Kruskal-wallis was made in order to compare the distribution of the species in the various plots according to the two stages of development. Thus, a significant p-value found led us to the application of Dunn's test.

Results

Inventory of species encountered

A total of 590 individuals were collected including 58 species of insects and 5 species of spiders in the Dembancané site. Performing the Fisher test gives a p-value = 1. Insects belong to 24 families and 7 orders (Heteroptera, Coleoptera, Orthoptera, Homoptera, Thysanoptera, Lepidoptera, Neuroptera). On the other hand, spiders belong to the order Araneae.

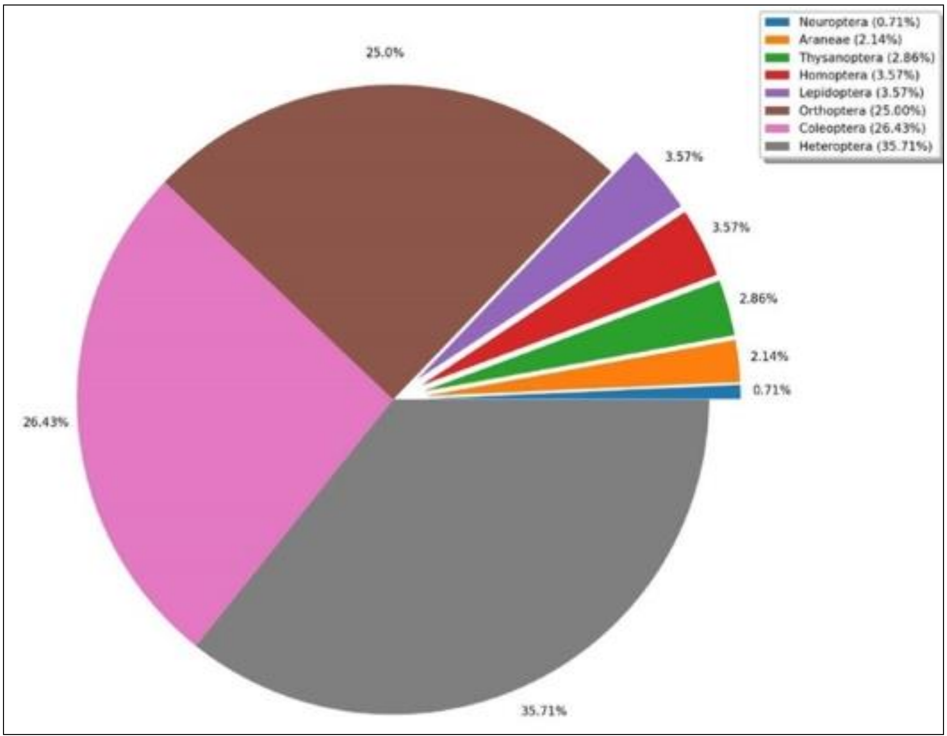

Fig 5: Percentages of the different orders of insects and the order of spiders

Assessment of the diversity and distribution of entomofauna

The calculated middle Shannon index shows a value of 2.729. On the other hand, the Pielou index obtained through the specific richness (Hmax = 5.977) is 0.457. Taking into account the two phases of plant development, a number of 100 individuals belonging to 32 species were collected during the early flowering stage against 490 for 48 species during the early maturation. The Shannon index values found 2.807 and 2.820 ares too close. While, the Pielou index sought shows values of 0.561 and 0.505 (Fig 6).

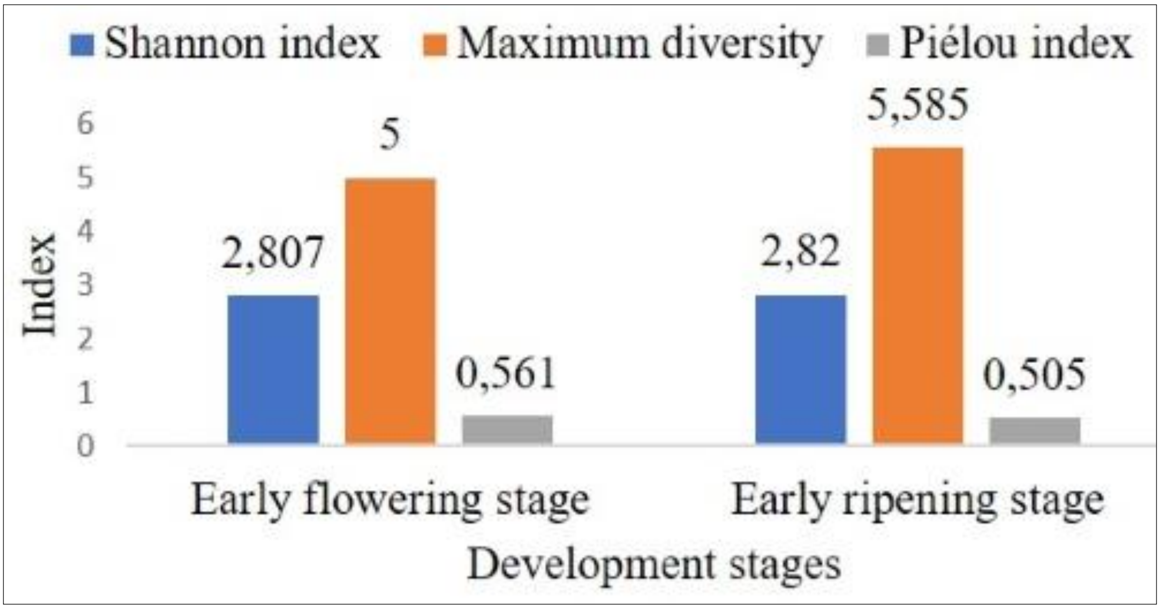

Fig 6: Diversity indices of the species encountered according to the early flowering and maturation stages

The analysis of his Mustache Boxes (Fig 7) shows a distribution of species according to the plots at the beginning of flowering and beginning of maturation stages. Indeed, this dispersion of species within the plots differs following the Kruskall wallis test which shows a p-value of 4.710-5. This difference in species distribution is insignificant (0.13) at the beginning of flowering stage and significant (0.01) at the beginning of maturation stage. According to the statistics, the boxes assigned to the same letters or having at least one common letter do not have significant differences.

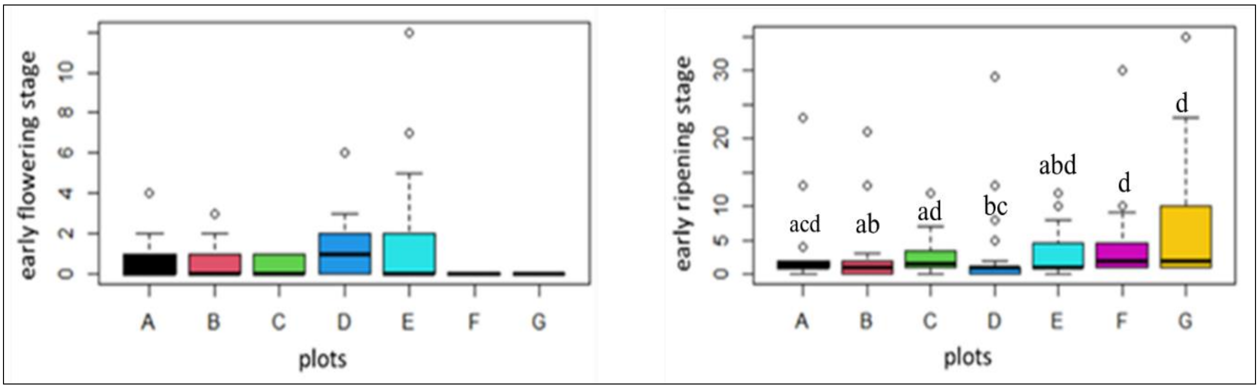

Fig 7: Species dispersal boxes in different plots during the two stages of development

The significance of the deviations is shown by Dunn's test which reveals that the diversity of parcel D is significantly different from that of C. In addition, plots F and G visited only at the early stage of maturation have different diversities to those of plots B and D.

Discussion

The purpose of this study is to know the diversity of the entomofauna of flood recession maize in the Senegal River Valley. The inventory of the entomofauna of flood maize in the commune of Dembancané gave 590 individuals including 58 species of insects and 5 species of spiders. They are divided into 8 orders including Heteroptera, Coleoptera, Orthoptera, Homoptera, Thysanoptera, Lepidoptera, Neuroptera and Araneae. However, according to the work of Ndiaye *et al*. [19] done in the Niayes, the insects dependent on sweet corn in Senegal are of ten orders (Coleoptera, Lepidoptera, Heteroptera, Homoptera, Orthoptera, Diptera, Geophilomorpha, Hemiptera, Hymenoptera and Dermoptera). Indeed, this dissimilarity would be due to the climate characterized by rainy season and dry season.

The value of the Shannon index (H' = 2.729) shows an average diversity of the environment and that a small part of the species largely colonize the environment. The insects associated with flood recession maize are diverse and this is related to the different phases of development of the maize plant. In the early flowering stage and the early ripening stage, this index takes values close to 2.807 and 2.820. If we refer to the work of Ndiaye *et al*. [19] and Ouali-n'goran *et al*. [20], we can say that this parameter is more important with these two stages of development. Also, during these two stages, the plant presents the maximum nutrients for insects. This could be the cause of the maize attack at these stages.

The regularity of species distribution is an important element of diversity. A species in abundance or represented by a single individual does not make the same contribution to the ecosystem [21]. However, this Pielou index takes a low value at the early ripening stage compared to the early flowering stage. Indeed, a community of a given richness in which all the individuals (with the exception of a negligible number) are concentrated in a single species reaches the minimum level of equitability [21]. In addition, this ecosystem is strongly dominated at the early maturation stage by the species *Piezodorus* sp. Thus come at least the species *Geocoris amabilis*, *Eysarcoris inconspicuus* and *Rhaphidopalpa* sp. This ecosystem is strongly dominated by the species *Piezodorus* sp. Thus come at least the species *Geocoris amabilis*, *Eysarcoris inconspicuus* and *Rhaphidopalpa* sp. These results disagree with those of Aderolu *et al*. [6] where there is codominance between species due to equal distribution and great diversity.

There is no significance on diversity at the start of flowering stage. On the other hand, at the beginning of maturation stage a significant p-value is observed. Contrary to Jean and Boisclair [22] who find that the diversity is significantly different at the flowering stage compared to the vegetative stage. This discrepancy could be explained by the fact that we did not sample at the first phase of plant development. In addition to the species found on maize at the beginning of flowering stage, other groups come to make its discovery at the beginning of maturation stage, including the families of Coreidae, Nabidae and Scutelleridae. Male and female inflorescences are specifically attacked by certain Hemiptera, Coleoptera and Lepidoptera larvae [20]. However, pests from the Pentatomidae, Pyrgomorphidae and Noctuidae families increased in the early maturation phase as did their predators including Lygaeidae. These results agree with those of Ndiaye *et al*. [19] who showed that these pests attack maize during these two stages of development. In addition, the abundance of the pest is at the origin of the increase in the number of natural enemies by a phenomenon of dependent population [23]. Indeed, at this stage, the already fertilized ovules evolve by swelling to become the corn grain by accumulating nutritional substances [24].

Conclusion

In brief, This study was conducted to assess the diversity of flood-recession maize pests in the Senegal River valley. Thus, 590 individuals including 585 insects and 5 spiders were identified and distributed into eight orders (Heteroptera, Coleoptera, Orthoptera, Homoptera, Thysanoptera, Lepidoptera, Neuroptera and Araneae). In addition, an average diversity of the environment was found and that à small part of the species largely colonize the environment. The Shannon index parameter is found important at both stages of development and takes values close to 2.807 and 2.820. Despite this, the regularity of species distribution remains low at the early stage of maturation. In addition, this ecosystem is strongly dominated by pests including *Piezodorus* sp. So come to less *Spodoptera frugiperda*, *Helicoverpa armigera*, *Eysarcoris inconspicuus*, *Thrips* sp, *Creontiades pallidus*. In addition, the latter encountered natural enemies including *Geocoris amabilis*, *Anthicus* sp and *Nabis capsiformis*. Furthermore, there is no significance on diversity at the start of flowering stage. On the other hand, at the beginning of maturation stage a significant p-value is observed. A contribution to the improvement of this work remains interesting in the continuation at different phases of development of flood-recession corn, on other study stations and on other crops, namely millet, rice and sorghum.

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