

RESEARCH PAPER

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Diversity of insects related to maize (*Zea mays*) production in Ferkéssédougou region, Côte d'Ivoire

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ABSTRACT

Maize production is steadily increasing in Côte d'Ivoire, yet yields remain constrained by multiple biotic and abiotic factors. This study aimed to characterize the entomofaunal diversity associated with maize (*Zea mays*) cultivation. Specifically, the objectives were to inventory insect species occurring in maize fields and to assess the influence of trap position and maize growth stage on insect abundance. Insects were sampled using yellow pan traps. Results revealed a rich entomofauna within maize agroecosystems, encompassing 13 orders, 44 families, 64 genera, and 72 species. Insect abundance was strongly influenced by the composition of surrounding vegetation and cropping systems, highlighting the ecological interactions shaping maize insect communities.

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## INTRODUCTION

Maize (*Zea mays*) is the most widely cultivated cereal after wheat and rice, with global production exceeding 1.2 billion tonnes (Statista, 2022). In Sub-Saharan Africa, it is the leading staple crop, occupying nearly 200 million hectares of farmland. In Côte d'Ivoire, maize production has grown substantially over the past decade, from 641,610 tonnes in 2010 (FIRCA, 2018) to over 1.2 million tonnes in 2023 (FAOSTAT, 2023). Despite this expansion, national yields remain low, averaging 2.11 t/ha (FAOSTAT, 2020), compared to 10-11 t/ha in the United States, 6 t/ha in China, and 5 t/ha in Brazil. This yield gap is largely explained by biotic constraints, including the use of low-yielding germplasm, fungal and bacterial diseases, and insect pests. Among these, the fall armyworm (*Spodoptera frugiperda*) is particularly destructive, with infestations capable of reducing yields by 15-73% (Sharanabasappa, 2018). Historical studies by ORSTOM also reported severe infestations of the stem borer *Eldana saccharina*, with damage exceeding 60% of maize ears in northern Côte d'Ivoire. Such pest pressures highlight the urgent need to better understand the entomofaunal communities associated with maize agroecosystems.

The present study aims to evaluate insect diversity in maize fields in Côte d'Ivoire. Specifically, it seeks to (i) inventory insect species associated with maize cultivation, and (ii) assess the effects of trap position and maize growth stage on insect abundance. By characterizing the entomofauna, this research contributes to improved pest management strategies and sustainable maize production in West Africa.

## MATERIALS AND METHODS

### Study site description

The study was conducted in the Ferkéssédougou region, the administrative capital of the Tchologo Region in northern Côte d'Ivoire. Ferkéssédougou borders both Mali and Burkina Faso and is located approximately 650 km from Abidjan and 360 km from Yamoussoukro, at 9°32' N latitude and 6°29' W longitude. The vegetation is characterized by wooded savanna.

The climate is hot and dry during December and January, with the Harmattan, a strong wind originating from the Sahara, causing a significant drop in temperature. The major dry season precedes the rainy season, which is marked by two rainfall peaks, one in June and another in September. The soils are predominantly ferralitic, with a shallow arable layer (40-60 cm) limited by hardened layers (ironstone crusts or lateritic indurations) (RGPH, 2018).

### Plant

The plant material used in this study consisted of maize (*Zea mays*) varieties supplied by the National Agricultural Research Center (CNRA) at the Ferkéssédougou Research Station (Fig. 1). These varieties were selected for their adaptation to local agroecological conditions and represent improved germplasm commonly distributed to farmers in northern Côte d'Ivoire.



**Fig. 1.** Maize field in Ferkéssédougou, Côte d'Ivoire

### Animal

The animal material consisted of insects captured using traps and directly collected from maize plants.

### Technical tools

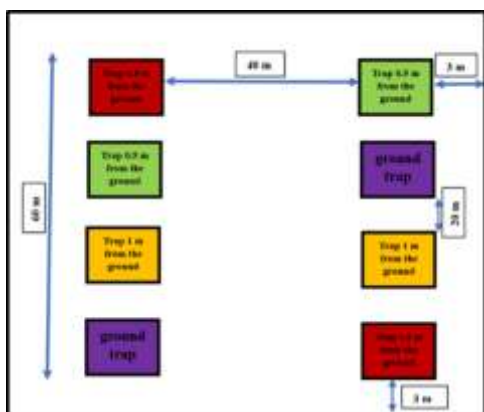
The technical equipment included tools for plot maintenance, instruments for plot delimitation, devices for field data collection (Fig. 2), and laboratory equipment for specimen processing and identification.



**Fig. 2.** Equipment used for insect collection in maize plots: (a) pan trap placed on the ground; (b) yellow pan trap suspended above the soil surface

### Experimental design

The traps were installed following a randomized design on two lines selected at random within each maize plot. A total of eight water pan traps were deployed, arranged along two lines separated by 40 m. Each line represented one treatment, with a distance of 20 m between treatments. Within each treatment, four traps were placed at different heights (Fig. 3).



**Fig. 3.** Experimental design used for insect sampling in maize plots

This experimental setup was replicated across two additional plots to ensure consistency and reliability of the data. In each plot, a buffer zone of three meters was maintained along the borders to minimize edge effects.

### Data collection from traps

The traps were inspected and emptied once per week in the maize fields. After each inspection, the traps were rotated to minimize positional bias. Captured insects were counted for each trap, collected using forceps, placed in vials, and transported to the laboratory for identification.

### Insect identification

Insects were identified in the laboratory using a stereomicroscope and taxonomic keys available in the reference collection hosted at the Lataha Research Station.

### Diversity analysis

Biodiversity indices were used to assess the abundance and diversity of insects, with particular focus on Tephritidae in orchard and forest plots. Alpha diversity was measured using three complementary indices: species richness (S), the Shannon-Wiener diversity index ( $H'$ ), and Pielou's evenness index (E). These metrics provided insights into both the composition and distribution of insect communities within the maize agroecosystem.

### Statistical analysis

Data were analyzed using R Studio software (version 4.1.1). A one-way analysis of variance (ANOVA) was performed to evaluate the effect of trap type and position on insect abundance. When variances were homogeneous, the Newman-Keuls post hoc test was applied to separate means and identify homogeneous groups at a 5% significance level. Graphical representations were produced using Microsoft Excel.

## RESULTS

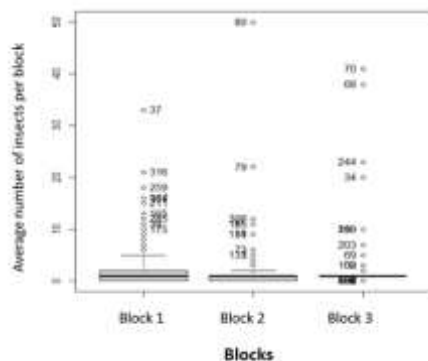
### Inventory of insects by blocks

The mean insect abundance was highest in Block 1 ( $1.73 \pm 3.55$ ), followed by Block 3 ( $1.62 \pm 4.35$ ) and Block 2 ( $1.52 \pm 3.66$ ) (Fig. 4). Although the differences among blocks were relatively small, they highlight spatial variability in insect distribution within maize plots. This variability may be influenced by trap position, microhabitat conditions, or surrounding vegetation.

### Diversity indices by blocks

Species richness was highest in Block 2, with 49 species recorded, compared to 43 species in Block 1 and 39 species in Block 3 (Table 1). The Shannon-Wiener diversity index indicated greater species abundance in Block 2 ( $H' = 3.055$ ) compared to Block 1 ( $H' = 2.89$ ) and Block 3 ( $H' = 2.51$ ). In contrast, the

Simpson index revealed a relatively homogeneous distribution of insect species across all blocks, suggesting a comparable level of community evenness (Table 1).



**Fig. 4.** Mean number of insects recorded per

**Table 1.** Insect diversity indices across blocks

| Diversity indices | Bloc1  | Bloc2  | Bloc3  |
|-------------------|--------|--------|--------|
| Taxa_S            | 43     | 49     | 39     |
| Simpson_1-D       | 0.9097 | 0.9247 | 0.8639 |
| Shannon_H         | 2.899  | 3.055  | 2.516  |
| Equitability_J    | 0.7709 | 0.7851 | 0.6868 |

### Diversity indices by species

#### Species richness

Species richness was highest for *A. binotatus*, *A. cerana*, *A. mellifera*, *A. armigera*, *C. sulphurea*, *C. albiceps*, *D. sukuzii*, *Eumenes* sp., *G. campestris*, *H. illucens*, *L. villosa*, *L. cibosa*, *M. domestica*, *Nomada* sp., *N. halterata*, *O. gazella*, *P. anxia*, *P. vignaudii*, *S. frugiperda*, *S. ribesi*, *Syrphus* sp., and *Z. variegatus*, compared to other species.

#### Alpha diversity index

The Shannon-Wiener diversity index indicated higher abundance for *A. cerana*, *A. armigera*, *C. sulphurea*, *Eumenes* sp., *L. cibosa*, *Nomada* sp., *N. halterata*, *P. anxia*, *Syrphus* sp., and *Z. variegatus* relative to other species. The evenness index (Pielou's E) revealed a high degree of homogeneity among species, suggesting that insect communities were relatively balanced without dominance by a single taxon.

#### Taxonomic composition of collected insects

Across all blocks, a total of 1,244 individuals were collected, distributed among 13 orders, 44 families, 64

genera, and 72 species. Diptera was the most abundant order, with 482 individuals, followed by Coleoptera (214 individuals) and Hymenoptera (195 individuals). Other orders were represented by fewer individuals (Table 2).

Within Diptera, *Chrysomya albiceps* was the most abundant species, with a relative frequency of 14.46%. It was followed by *Drosophila sukuzii* (7.79%), *Musca domestica* (6.91%), and *Hermetia illucens* (6.59%). Other dipteran species were less represented.

In Coleoptera, *Onthophagus gazella* was the most abundant species (6.18%), followed by *Cheilomenes sulphurea* (4.34%). Other coleopteran species were minor contributors.

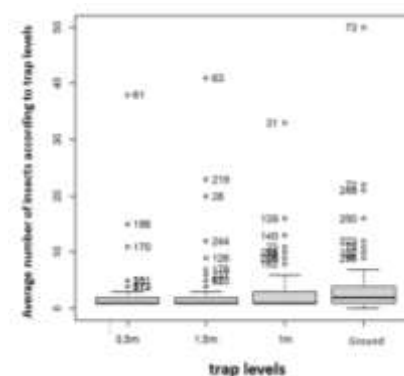
In Hymenoptera, *Lipotriches cibrosa* was the most abundant species (7.87%), followed by *Apis mellifera* (2.00%) and *Eumenes* sp. (1.12%). Other hymenopteran species were weakly represented.

#### Effect of trap position on insect abundance

Fig. 4 illustrates the mean number of insects captured at different trap heights. Insects were most abundant in ground traps ( $4.57 \pm 7.79$ ), followed by traps placed at 0.5 m above the ground ( $2.45 \pm 4.74$ ), traps at 1.5 m ( $2.77 \pm 5.33$ ), and traps at 1 m ( $2.82 \pm 4.16$ ).

#### Diversity indices by trap height

Species richness varied with trap height. At 1 m above the ground, 32 species were recorded (29.63%), followed by 31 species at 0.5 m (28.70%), 30 species at 1.5 m (27.77%), and 15 species at ground level (13.63%) (Fig. 5).



**Fig. 5.** Species richness according to trap height

**Table 2.** Taxonomic composition and relative abundance of insect species collected in maize plots

| Order              | Family           | Genus                 | Species               | Number of individuals | Relative frequency (%) |
|--------------------|------------------|-----------------------|-----------------------|-----------------------|------------------------|
| Coleoptera         | Carabidae        | <i>Anisodactylus</i>  | <i>binotatus</i>      | 22                    | 1.768488746            |
|                    | Chrysomelidae    | <i>Chaetocnema</i>    | <i>pulicaria</i>      | 2                     | 0.160771704            |
|                    |                  | <i>Diabrotica</i>     | <i>balteata</i>       | 4                     | 0.321543408            |
|                    | Coccinellidae    | <i>Cheilomenes</i>    | <i>sulphurea</i>      | 54                    | 4.340836013            |
|                    |                  | <i>Harmonia</i>       | <i>axyridis</i>       | 4                     | 0.321543408            |
|                    | Elateridea       | <i>Agriotus</i>       | <i>lineatus</i>       | 7                     | 0.562700965            |
|                    | Meloidae         | <i>Mylabris</i>       | <i>affinis</i>        | 2                     | 0.160771704            |
|                    | Nitidulidae      | <i>Glischrochilus</i> | <i>quadrisignatus</i> | 1                     | 0.080385852            |
|                    | Oedemeridae      | <i>Asclera</i>        | <i>ruficollis</i>     | 19                    | 1.52733119             |
|                    | Scarabaeidae     | <i>Onthophagus</i>    | <i>gazella</i>        | 77                    | 6.189710611            |
|                    |                  | <i>Pachnoda</i>       | sp                    | 2                     | 0.160771704            |
| <i>Phyllophaga</i> |                  | <i>anxia</i>          | 13                    | 1.045016077           |                        |
| Tenebrionidae      | <i>Lagria</i>    | <i>villosa</i>        | 7                     | 0.562700965           |                        |
| Subtotal           |                  |                       | 214                   | 17.20257235           |                        |
| Dermaptères        | Forficulidae     | <i>Forficula</i>      | <i>auricularia</i>    | 2                     | 0.160771704            |
| Dictyoptères       | Blattidae        | <i>Blatta</i>         | <i>orientalis</i>     | 2                     | 0.160771704            |
| Diptera            | Calliphoridae    | <i>Chrysomya</i>      | <i>albiceps</i>       | 180                   | 14.46945338            |
|                    | Drosophilidae    | <i>Drosophila</i>     | <i>suzukii</i>        | 97                    | 7.797427653            |
|                    | Muscidae         | <i>Musca</i>          | <i>domestica</i>      | 86                    | 6.91318328             |
|                    | Sarcophagidae    | <i>Metopia</i>        | <i>campestris</i>     | 5                     | 0.40192926             |
|                    |                  | <i>Nyctia</i>         | <i>halterata</i>      | 10                    | 0.803858521            |
|                    | Stratiomyidea    | <i>Hermetia</i>       | <i>illucens</i>       | 82                    | 6.591639871            |
|                    | Syrphidae        | <i>Syrphus</i>        | sp                    | 9                     | 0.723472669            |
|                    |                  | <i>Syrphus</i>        | <i>ribesii</i>        | 12                    | 0.964630225            |
|                    | Tephritidae      | <i>Bactrocera</i>     | <i>dorsalis</i>       | 1                     | 0.080385852            |
| Subtotal           |                  |                       | 482                   | 38.74598071           |                        |
| Hemiptera          | Pentatomidae     | <i>Aspavia</i>        | <i>armigera</i>       | 16                    | 1.286173633            |
|                    | Reduviidae       | <i>Rhynocoris</i>     | <i>segmentarium</i>   | 1                     | 0.080385852            |
|                    |                  | <i>Rhynocoris</i>     | sp                    | 1                     | 0.080385852            |
|                    | Vespidae         | <i>Geocoris</i>       | sp                    | 11                    | 0.884244373            |
|                    |                  | <i>Eumenes</i>        | sp                    | 14                    | 1.125401929            |
|                    | Cercopidae       | <i>Cercopis</i>       | <i>vulnerata</i>      | 5                     | 0.40192926             |
|                    | <i>Poophilis</i> | <i>costalis</i>       | 1                     | 0.080385852           |                        |
| Subtotal           |                  |                       | 49                    | 3.938906752           |                        |
| Heteroptera        | Anthocoridae     | <i>Orius</i>          | sp                    | 1                     | 0.080385852            |
|                    | Pyrgomorphidae   | <i>Dysdercus</i>      | <i>völkeri</i>        | 1                     | 0.080385852            |
| Subtotal           |                  |                       | 2                     | 0.160771704           |                        |
| Hymenoptera        | Apidae           | <i>Amegilla</i>       | sp                    | 12                    | 0.964630225            |
|                    |                  | <i>Apis</i>           | <i>cerana</i>         | 8                     | 0.643086817            |
|                    |                  | <i>Apis</i>           | <i>mellifera</i>      | 25                    | 2.009646302            |
|                    |                  | <i>Ceratina</i>       | <i>calcarata</i>      | 2                     | 0.160771704            |
|                    |                  | <i>Nomada</i>         | sp                    | 8                     | 0.643086817            |
|                    |                  | <i>Xylocopa</i>       | <i>virginica</i>      | 4                     | 0.321543408            |
|                    | Eulophidae       | <i>Sympiesis</i>      | <i>viridula</i>       | 1                     | 0.080385852            |
|                    |                  | <i>Sympiesis</i>      | sp                    | 8                     | 0.643086817            |
|                    | Eumenidae        | <i>Belonogaster</i>   | <i>juncea</i>         | 1                     | 0.080385852            |
|                    | Formicidae       | <i>Camponotus</i>     | sp                    | 7                     | 0.562700965            |
|                    |                  | <i>Crematogaster</i>  | <i>scutellaris</i>    | 1                     | 0.080385852            |
|                    | Halictidae       | <i>Lipotriches</i>    | <i>cibrosa</i>        | 98                    | 7.877813505            |
|                    | Tachinidae       | <i>Lydella</i>        | <i>thompsoni</i>      | 6                     | 0.482315113            |
|                    | Vespidae         | <i>Eumenes</i>        | sp                    | 14                    | 1.125401929            |
|                    | Subtotal         |                       |                       | 195                   | 15.67524116            |
|                    | Lepidoptera      | Crambidea             | <i>Ostrinia</i>       | <i>nubilalis</i>      | 3                      |
| Drepanidae         |                  | <i>Raghuva</i>        | <i>albipuncta</i>     | 1                     | 0.080385852            |
| Hesperiidae        |                  | <i>Calpodes</i>       | <i>ethlius</i>        | 1                     | 0.080385852            |
| Noctuidae          |                  | <i>Agrotis</i>        | <i>ipsilon</i>        | 1                     | 0.080385852            |
|                    |                  | <i>Helicoverpa</i>    | <i>zea</i>            | 1                     | 0.080385852            |
|                    |                  | <i>Heliocheilus</i>   | <i>albipunctella</i>  | 1                     | 0.080385852            |
|                    |                  | <i>Hydraecia</i>      | <i>micacea</i>        | 1                     | 0.080385852            |

|            |                  |                      |                    |      |             |
|------------|------------------|----------------------|--------------------|------|-------------|
|            |                  | <i>Spodoptera</i>    | sp                 | 3    | 0.241157556 |
|            |                  | <i>Spodoptera</i>    | <i>frugiperda</i>  | 133  | 10.69131833 |
|            |                  | <i>Pseudaletia</i>   | <i>unipuncta</i>   | 4    | 0.321543408 |
|            | Nymphalidae      | <i>Acraea</i>        | <i>terpsichore</i> | 3    | 0.241157556 |
|            |                  | <i>Agraulis</i>      | <i>vanillae</i>    | 1    | 0.080385852 |
|            | Subtotal         |                      |                    | 153  | 12.29903537 |
| Malvales   | Dipterocarpoidea | <i>Anisoptera</i>    | sp                 | 2    | 0.160771704 |
| Mantoptera | Mantidae         | <i>Mantis</i>        | <i>religiosa</i>   | 2    | 0.160771704 |
| Neuroptera | Hemerobiidae     | <i>Micromus</i>      | <i>angulatus</i>   | 3    | 0.241157556 |
| Odonota    | Siebloiidae      | <i>Odonata</i>       | sp                 | 4    | 0.321543408 |
| Orthoptera | Acrididae        | <i>Locusta</i>       | <i>migratoria</i>  | 1    | 0.080385852 |
|            | Gryllidae        | <i>Gryllus</i>       | <i>campestris</i>  | 80   | 6.430868167 |
|            | Pyrgomorphidae   | <i>Atractomorpha</i> | <i>cremulate</i>   | 4    | 0.321543408 |
|            |                  | <i>Pyrgomorpha</i>   | <i>vignaudii</i>   | 10   | 0.803858521 |
|            |                  | <i>Pyrgomorpha</i>   | <i>cognata</i>     | 2    | 0.160771704 |
|            |                  | <i>Pyrgomorpha</i>   | sp                 | 1    | 0.080385852 |
|            |                  | <i>Zonocerus</i>     | <i>varigatus</i>   | 34   | 2.733118971 |
|            | Tettigoniidae    | <i>Tettigonia</i>    | <i>viridissima</i> | 2    | 0.160771704 |
|            | Subtotal         |                      |                    | 134  | 10.77170418 |
|            | Total            |                      |                    | 1244 | 100         |

The Shannon–Wiener diversity index indicated higher species diversity in traps placed at 1.5 m, 1 m, and 0.5 m above the ground compared to ground traps. In contrast, the Simpson index revealed relatively low similarity among trap heights, suggesting that insect communities were distributed in a fairly homogeneous manner across vertical strata (Table 3).

**Table 3.** Diversity indices according to trap height

|                | Sol    | 0.5 m  | 1 m    | 1.5m   |
|----------------|--------|--------|--------|--------|
| Taxa_S         | 15     | 31     | 32     | 30     |
| Simpson 1-D    | 0.7857 | 0.8892 | 0.8621 | 0.8849 |
| Shannon_H      | 1.835  | 2.667  | 2.523  | 2.551  |
| Equitability_J | 0.6775 | 0.7765 | 0.7279 | 0.75   |

## DISCUSSION

The traps installed in maize fields captured several insect species, among which Diptera were the most abundant. The high capture rate may be attributed to the yellow color of the traps, which is known to attract many insect taxa. In addition, the presence of dead flies inside the traps likely enhanced attraction, as reported by Sy (2004), who observed that drosophilids were drawn to traps containing dead flies. Later, Munyempundu (2022) also noted that trap humidity combined with yellow coloration increased insect captures. The predominance of Diptera in the traps may also be explained by the affinity of the fall armyworm (*Spodoptera frugiperda*) for maize, as this species is closely associated with the crop. According to RAP (2018), the fall armyworm is a polyphagous pest that attacks several host plants, with maize being its

preferred host. The higher mean number of insects in Block 1 compared to other blocks can be explained by the presence of additional cereal crops surrounding Block 1, which likely increased insect abundance. These findings corroborate those of Baghem (2018), who demonstrated that the presence of multiple cereal crops enhances insect attraction.

Infestations of fall armyworm were abundant in maize plots because the maize growing season coincided with the rainy season, a period of high pest proliferation during the vegetative stage of maize. These results are consistent with Ahissou (2022), who reported that fall armyworm lays eggs on maize seedlings under favorable conditions (low temperature and moderate rainfall). The eggs hatch, and severe damage occurs at the second instar stage when larvae are older. The high abundance of stem borers in maize fields was associated with the maturation stage of maize plants. At this stage, plants begin to dry, and carbohydrate reserves increase, making them more susceptible to attack. This increased presence of stem borers was also observed at the end of the rainy season, likely due to food scarcity, forcing larvae to bore into maize stems to survive throughout the dry season. Our findings corroborate those of Samuel (1994) and Mballo (2017), who reported that at the end of the cropping season, larvae enter diapause and remain inside maize stems during the dry season. The greater abundance of stem borers in Block 3 compared to other blocks may be explained by the presence of host plants surrounding the

experimental sites, which provided additional resources for insect populations.

## CONCLUSION

The study of maize entomofauna revealed a considerable diversity of insect species associated with maize cultivation. In total, 1,244 individuals were collected, distributed across 13 orders, 44 families, 64 genera, and 72 species. Diptera was the most abundant order, with 482 individuals, followed by Coleoptera and Hymenoptera. The insect community was characterized by a high abundance of species belonging to these three major orders. Furthermore, insect abundance within maize plots was closely linked to the surrounding cropping systems. The presence of additional cereal crops and other host plants in the vicinity contributed to variations in insect diversity and abundance, highlighting the importance of landscape context in shaping insect communities in maize agroecosystems.

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