

# Inventory of Litter Insects in Traditional Automatic Watering Poultry Buildings in Côte d'Ivoire

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**Abstract:** Livestock farming, which is a sub-sector of agriculture, is a rapidly growing activity, with a contribution of about 4.5% to agricultural gross domestic product (GDP) and 2% to total GDP. The objective of this work was to inventory the insects associated with the litter of poultry farm buildings with automatic watering in Côte d'Ivoire. To achieve this objective, 60 buildings were prospected in two areas. Overall, 120 buildings constituting 1080 excavation squares of 0.1 m<sup>2</sup> each were sampled in the North and South zones. The collected litter was searched using flexible forceps. The insects have been identified under binocular magnifying glass. In total, 16 species of insect belonging to five families grouped into two orders (Coleoptera and Hymenoptera) have been identified, including 11 in the North and 12 in the South. *Carcinops pumilio* (Histeridae) was the most abundant species with 64.09% of the total number. Shannon and Equitability indices were higher in the North zone ( $H' = 1.62$  and  $E = 0.67$ ) than those in the South zone ( $H' = 1.37$  and  $E = 0.30$ ).

**Keywords:** Agriculture, Poultry, Insect, Farm Buildings, Automatic Watering

## 1. Introduction

In Côte d'Ivoire, agriculture is an important economic pillar. It employs two-thirds of the working population and contributes 34% to gross domestic product (GDP) and 66% to export earnings [1]. Livestock farming, which is a sub-sector of agriculture, is a rapidly growing activity, with a contribution of about 4.5% to agricultural GDP and 2% to total GDP. This activity brings together a large number of breeders [1]. It covers the entire national territory and plays an important role in job creation [2]. Livestock contributes to ensuring food security, to diversifying the diet of populations [3]. Despite this economic importance, poultry farming is

faced with multiple constraints, among which is the poor management of litter. Poultry litter intended to keep birds comfortable until they are removed from the barn is likely to harbor a variety of insect pests and other organisms, the life cycle of which may depend on how it is managed. Numerous studies have been carried out on insects present in poultry litter in many countries around the world [4, 5]. In Côte d'Ivoire, a study was conducted by Johnson *et al* in the locality of Bingerville [5]. However, no study listing insects in the litter of livestock buildings with automatic drinkers has been carried out in the Sudanese zone and in several localities in the Guinean zone. The objective of this work was to inventory the insects associated with the litter of

livestock buildings with automatic watering of poultry in Côte d'Ivoire.

## 2. Materials and Methods

### 2.1. Study Site

This work took place in two (2) agro-ecological zones of Côte d'Ivoire, namely the Sudanese zone and the Guinean zone (Figure 1).

In the Sudanese zone, in the North of the Côte d'Ivoire, the localities of Ferkessédougou, Korhogo, Sinématiali and Koumbala were selected. This area is characterized by a Sudanese-type climate.

In the Guinean zone, in the south of the Côte d'Ivoire, the localities of Grand-Bassam, Bingerville and Azaguié have been selected. It belongs to the Guinean zone characterized by a dense humid forest with a subequatorial climate.

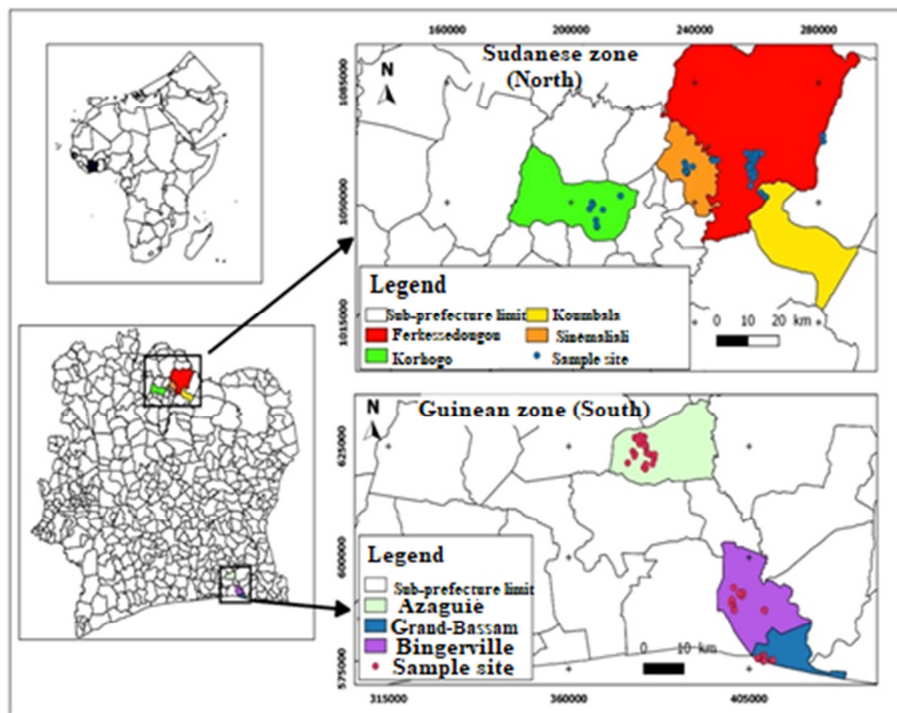


Figure 1. Geographic location of sampling areas and sites.

### 2.2. Material

#### 2.2.1. Animal Biological Material

The animal biological material is composed of all the insect species collected in the different litters of the two agro-ecological zones.

#### 2.2.2. Technical Material

Sampling equipment is made up of tape measure for marking out the sampling squares, trowels and shovels for litter sampling, gloves, sorting trays, pillboxes and entomological tongs used to handle insects and biodegradable bags used to transport the litter to the laboratory. The collected insects were stored in pillboxes containing 70° alcohol. The identification of the insects collected was carried out under a binocular magnifying glass using identification keys [6].

### 2.3. Methods

Surveys were carried out in traditional buildings with automatic watering. These are the breeding buildings whose

drinking troughs are suspended thanks to a system which allows the automatic supply of water to the poultry.

#### 2.3.1. Choice of Sampling Areas

Litter sampling was carried out in three different areas of the livestock buildings. These sampling zones are designated as follows: zone near to the wall (ZNW), contiguous to the watering zone, watering zone (WZ), side row where the drinkers are placed, manger zone (MZ), where the drinkers are placed feeders (Figure 2).

#### 2.3.2. Insect Sampling Device in Chicken Farm Buildings

The experimental device is a randomized Fisher block, with three repetitions. The surveyed buildings have a dimension greater than or equal to 100 m<sup>2</sup>. In each building visited, nine sampling squares were marked according to the three areas of the building (area close to the wall, drinking trough area and feeder area). For each areas, three sampling squares were made. The distance between the sampling areas was 2 m. The sampling squares were separated by 15 m. Each square has a dimension of 40 × 25 cm or 0.1 m<sup>2</sup> (Figure 2). After having circumscribed the excavation squares, the

litter was removed using a trowel and a manual shovel and introduced into labeled plastic bags perforated with small ventilation holes. One hundred twenty (120) buildings were sampled through the two agro-ecological zones, ie 1080 samples. In each area, 60 buildings were sampled, of which 30 buildings used wood chip litter and 30 rice husk litter. The age of the litter varied from 2 to 90 days.

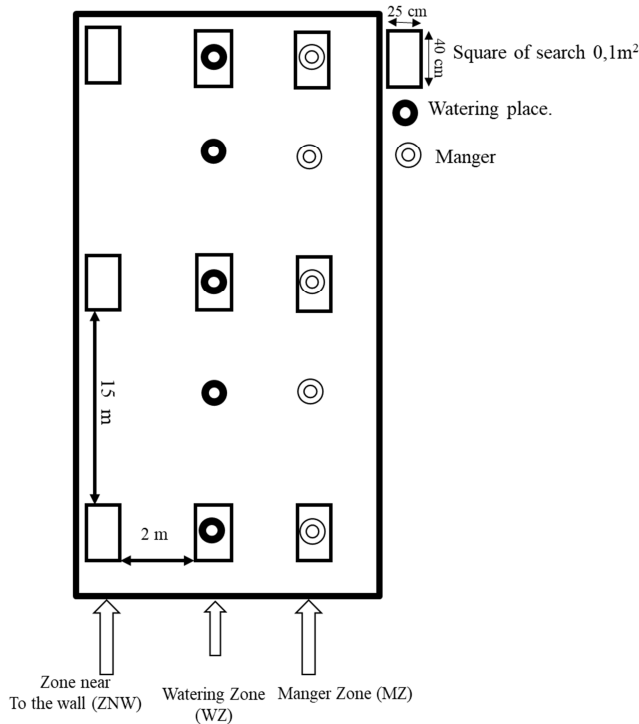


Figure 2. Sampling device in traditional houses with automatic watering.

### 2.3.3. Collection and Identification of Insects

The collected samples were been placed in plastic bags and then transported to the laboratory. The litters were been then carefully explored. The insects found there were collected and preserved in jars containing alcohol at 70°. These insects were then sorted, grouped according to their similarities, then identified under a binocular magnifying glass using reference keys [7, 8].

### 2.4. Data Processing

The data collected during this study was entered and processed with the Microsoft World spreadsheet and Excel 2016.

#### 1) Specific richness (S)

Species richness (S) corresponds to the total number of species sampled in a given environment [9].

#### 2) Relative abundance

Relative abundance (Ar) is the ratio between the number of individuals of a species (ni) taken into consideration and the total number of individuals of all species combined (N).

$$Ar(\%) = \frac{ni}{N} * 100$$

#### 3) Shannon-Weaver Diversity Index (H')

This index gives an idea of the specific diversity of an environment. That is to say the number of species in this environment (specific richness) and the distribution of individuals within these species (specific equitability).

H' is minimal (= 0) if all the individuals in the stand belong to one and the same species.

H' is also minimal if, in a stand, each species is represented by a single individual, except for a species which is represented by a large number of individuals in the stand.

The index is maximum when all the individuals are evenly distributed over all the species [10].

$$H' = \sum_{i=1}^S p_i \ln p_i$$

ni: Number of individuals of a given species i, ranging from 1 to S (total number of species), N: Total number of individuals,  $p_i = ni/N$ .

#### 4) Equitability Index

Equitability (E) measures the equitable distribution of species and makes it possible to study the regularity of the distribution of species in an ecosystem [11]. It makes it possible to compare stands comprising different numbers of taxa. Its objective is to observe the balance of the populations present.

$$E = \frac{H'}{H'_{max}}, \text{ with } H'_{max} = \ln S$$

H' = Shannon diversity index;

S = Specific richness;

E varies from 0 to 1 and tends towards 0 when a taxon largely dominates a stand and is equal to 1 when all the taxa have the same abundance. Insensitive to species richness, it is very useful for comparing potential dominance between stations or between sampling dates.

## 3. Results

### 3.1. Specific Diversity of Insects Collected in Traditional Buildings with Automatic Watering in the North and South of Côte d'Ivoire

In the litter of livestock buildings with automatic watering, 1921 adult insects, 71 larvae and 32 pupae were collected in the North and South. In the litter of livestock buildings with automatic watering, 16 species belonging to five families (Tenebrionidae, Histeridae, Erotylidae, Curculionidae and Formicidae) were identified, including 11 and 12 species respectively in the North and in the South. These species are grouped into two (2) orders: Coleoptera and Hymenoptera (Table 1). Beetles accounted for 99.89% of all species. Hymenoptera were only collected in the South in the wood chip litter with 0.27% of all species. The both areas have eight species in common. The South zone has 1 more species than the North zone. The Shannon index (H') and the Equitability index (E) were higher in the litter of the North zone (H' = 1.62 and E = 0.67) than those of the South zone (H' = 1.37 and E = 0.30). Buildings in the North zone are more diverse and have good equitability than those in the

South zone.

### 3.1.1. Distribution of Insects in Traditional Buildings with Automatic Watering in the Sudanese Zone (North)

In traditional livestock buildings with automatic watering in the North, 11 species belonging to the order Coleoptera were identified (Table 2). Among these species, six (6) were common to the two (2) types of litter, one (1) specific to wood shavings and four (4) specific to rice straw.

Shannon index ( $H'$ ) and the Equitability index ( $E$ ) were higher for the rice straw litter ( $H' = 1.69$  and  $E = 0.81$ ) than those of the wood chip. ( $H' = 1.45$  and  $E = 0.66$ ). Buildings using rice straw bedding are more diversified and show good fairness than those using wood chips. High Evenness values show a good distribution of individuals within species.

#### 1) Relative abundance of species collected in woodchip litter

In the wood chip litter of the North zone, nine (9) species belonging to the Order Coleoptera were identified. These species are grouped into four (4) families (Tenebrionidae, Histeridae, Erotylidae and Curculionidae) (Table 3). The Histeridae family represented by 4 species corresponding to 74.14% of the total abundance was the highest. In the Tenebrionidae, 3 species have been identified representing 14.88% of the total number.

#### 2) Rice straw litter

In the rice straw litter, 309 individuals were collected. These individuals are divided into 8 species belonging to five (5) families of Coleoptera Order. These are the family of: Tenebrionidae, Histeridae, Curculionidae, Nitidulidae and Erotylidae. Histeridae and Tenebrionidae families were more abundant with 56.21 and 23.73% of the total number, represented by three (3) and two (2) species respectively. The other families were represented by a single species.

### 3.1.2. Distribution of Insects in Traditional Buildings with Automatic Watering in the Guinean Zone (South)

The traditional livestock buildings with automatic watering in the South recorded 12 species, 5 of which were common to the two (2) types of litter: two (2) species specific to wood shavings and five (5) species specific to rice straw. Shannon index was relatively higher for rice straw ( $H' = 0.75$ ) than for wood chips ( $H' = 0.73$ ). Equitability Index ( $E$ ) for wood chip ( $E = 0.37$ ) was higher than that of rice straw ( $E = 0.32$ ). Rice straw litter is more diversified than wood chips. While the wood chips shows a more equitable population than the rice straw litter.

#### 1) Relative abundance of species collected in woodchip litter

In the wood chips' litter of livestock buildings with automatic watering in the South, seven (7) species belonging to four (4) families (Tenebrionidae, Histeridae, Curculionidae and Formicidae) grouped into two (2) Orders (Coleoptera and Hymenoptera) were identified. The Histeridae family had the highest richness (81.79%) with three (3) species while two (2) species were collected in the Tenebrionidae family (17.39). A single species was identified in the Curculionidae and the Formicidae representing respectively 0.54% and 0.27% of the individuals.

#### 2) Rice straw litter

In the rice straw litter, a total of 566 individuals of insects were collected. These individuals belong to 10 species grouped into four (4) families (Tenebrionidae, Histeridae, Erotylidae, Curculionidae) and all belong to the Order Coleoptera. Four (4), three (3), two (2) and one (1) species were collected respectively in the family Tenebrionidae (16.78%), Histeridae (81.63%), Erotylidae (1.06%) and Curculionidae (0.53%) (Paintings).

**Table 1.** Relative abundance (%) of insect Orders collected in the litter of livestock buildings with automatic watering.

Orders	Ar(%) insects collected in the Northern zone		Ar(%) insects collected in the Southern zone	
	Wood chips	rice straw	Wood chips	rice straw
Coleoptera	100	100	99.73	100
Hymenoptera	-	-	0.27	-
Order number by litter type	1	1	2	1
Total number of Orders by zone	1		2	

**Table 2.** Specific richness of the Orders of insects collected in the litter of livestock buildings with automatic watering.

Orders	Order Numbers collected in the Northern zone		Order Numbers collected in the Southern zone	
	Wood chips	rice straw	Wood chips	rice straw
Coleoptera	9	8	6	10
Hymenoptera	0	0	1	0
Number of species by type of litter	9	8	7	10
Total number of species by zone	11		12	

**Table 3.** Relative abundance (%) of insect species collected in traditional houses with automatic watering.

Orders	Families	Species	North area		South area	
			Wood chip	Rice straw	Wood chip	Rice straw
Coleoptera	Tenebrionidae	<i>Alphitobius diaperinus</i> (Panzer, 1797)	11.76	10.68	15.89	14.13
		<i>Tribolium castaneum</i> (Herbst, 1797)	2.08	6.47	0.00	1.41
		<i>Tribolium confusum</i> (Jacquelin du Val, 1861)	0.00	0.00	0.00	0.35
		<i>Latheticus oryzae</i> (Waterhouse, 1880)	0.00	0.00	1.49	0.00
		<i>Gnatocerus maxillosus</i> (Fabricius, 1801)	1.04	0.00	0.00	0.00

Orders	Families	Species	North area		South area	
			Wood chip	Rice straw	Wood chip	Rice straw
Hymenoptera	Histeridae	<i>Gnatocerus</i> sp	0.00	0.00	0.00	0.88
		<i>Acrilus minutus</i> (Herbst, 1791)	25.95	32.36	1.63	1.59
		<i>Carcinops pumilio</i> (Erichson, 1834)	47.40	29.45	79.34	79.51
		<i>Dendrophilus punctatus</i> (Herbst, 1791)	0.00	2.59	0.81	0.53
		<i>Dendrophilus</i> sp	0.35	0.00	0.00	0.00
		<i>Gnathoncus</i> sp	0.69	0.00	0.00	0.00
	Erotylidae	<i>Toramus pretty</i> (Casey, 1863)	4.15	11.33	0.00	1.06
	Curculionidae	<i>Sitophilus</i> sp	0.00	0.00	0.00	0.18
		<i>Sitophilus zeamais</i> (Motschulsky, 1855)	6.92	6.47	0.54	0.35
		<i>Carpophilus</i> sp	0.00	0.65	0.00	0.00
	Formicidae	<i>Camponotus</i> sp	0.00	0.00	0.27	0.00
	2 Orders	5 Families	100%	100%	100%	100%

### 3.2. Variation of the Ecological Indices of Insect Samples Collected in Traditional Buildings for Rearing Chickens with Automatic Watering in the Both Agro-ecological Zones

Shannon (H') and Equitability (E) indices were higher in the North zone than those in the South zone both for the wood chip litter and for the rice straw (Table 4). For the wood chip litter, Shannon (H') and Equitability indices for the North zone were 1.45 and 0.66 respectively. While those in the South were 0.73 and 0.37 respectively. In buildings using rice straw, the Shannon indices were 1.69 in the North and 1.45 in the South. Fairness was 0.66 and 0.37 in the North and South respectively. The North zone is more heterogeneous and the individuals within the species are evenly distributed compared to the South zone.

### 3.3. Specific Composition of Insects in Traditional Automatic Watering Chicken Buildings in the Both Agro-ecological Zones

The evaluation of the beta diversity (similarity) between the different zones shows that the litter insects of the two (2) agro-ecological zones studied present similarities between them in their specific compositions. In the North and South, we note the similarities of 54 and 41% respectively between the both types of litter. This similarity was 50% between the wood chip of the two zones and the woodchip in the South and the rice straw in the North. It was maximum between rice straw litter in the North and South (58%) and rice straw litter and wood chips in the North (54%) (Table 5). These results indicate that a significant number of avian insects are found between the two (2) types of litter in the same area and the same types of litter in the different areas studied.

Table 4. Ecological indices of insects collected in the litter of traditional houses with automatic watering.

Ecological indices	Northern zone		Southern zone	
	Wood chips	rice straw	Wood chips	rice straw
Total number of individuals	290	309	736	566
Species richness	9	8	7	10
Shannon index (H')	1.45	1.69	0.73	0.75
Equitability Index (E)	0.66	0.81	0.37	0.32

Table 5. Jaccard similarity index (J) between types of litter in study areas in traditional houses with automatic watering.

	Cop ZN	Cop ZS	Pail ZN	Pail ZS
Cop ZN	1	0.50	0.54	0.45
Cop ZS		1	0.50	0.41
Pail ZN			1	0.58
Pail ZS				1

Cop: Wood chip; pail: Rice straw; ZN: Northern Zone; ZS: Southern Zone.

## 4. Discussion

The study of the entomofauna of the litter of traditional livestock buildings with automatic watering in the Sudanese (North) and Guinean (South) zone of Côte d'Ivoire made it possible to collect two (2) orders (Coleoptera and Hymenoptera) of insects. Many authors have reported that insect species associated with poultry litter belong to several orders [5, 12]. The two orders cited in our work were mentioned by Retamales *et al.* as well as the order Diptera

and Lepidoptera in a study in China, on the litter of poultry farmed chickens [12]. Regarding the work of Johnson *et al.*, apart from these two orders, the order Blattoptera and Dermaptera have been reported [5]. As for Rueda et Axtel, they noted the presence of seven orders in their work [13].

The Coleoptera order was the most abundant with 99.89% of the total number of identified insects. Our results corroborate those of [5, 14] who reported that the order Coleoptera was the most abundant in their respective studies with 99.82% and 74% of the abundance of harvested individuals. This same observation was made by Johnson *et al* [5]. The abundance of

this order in the breeding litter could be explained by their diets. Indeed, these insects are mostly omnivores, granivores, carnivores, predators and cannibals [14].

The study of the diversity of insects allowed us to collect 16 species belonging to 5 families. These results are close to those of Johnson *et al* [5]. Indeed, these authors identified, during a study on poultry litter in Bingerville, 10 species belonging to 4 orders, namely Coleoptera, Hymenoptera, Dictyoptera and Dermaptera. Hulley and Pfeleiderer identified 23 species belonging to 12 families [15]. This difference could be explained by several factors. These factors are related to the environmental conditions in the operating buildings. Also by the type of building (method of watering). The continuous use of a litter over a more or less long period could promote the diversity of these insects.

Of all the species collected, 11 belong to the Coleoptera order. The Tenebrionidae and Histeridae families were the best represented. Retamale *et al.* also made similar observations [12]. Polat and Yildirim in a study on the contribution to the knowledge of Histeridae mentioned 17 species of Histeridae [16]. Five species belonging to three (3) families of Coleoptera have been reported by Sanver and Tezcan [4] in the province of Izmir in Turkey.

Our results revealed that *Carcinops pumilio* (Erichson) (Coleoptera: Histeridae) was the most abundant species with 64.09% of the total number. This observation could be explained by the absence of drinker support, which, when present, favors the pullulation of *A. diaperinus*. The small size of this insect could allow it to hide more easily in the litter. This result is in agreement with that of Pfeiffer et Axtell [17]. On the other hand, this observation differs from that of several authors who have shown that several species of Coleoptera are associated with poultry farms and *Alphitobius diaperinus* is the species mostly encountered in this environment [4]. Thus, in Brazil, Fernandes has shown in his various works that *A. diaperinus* is the most abundant beetle in the litter of the explored farms with 96.63% captured beetles [18]. The study of the biological indices showed that the North zone was more diversified than the South zone. The insect species collected were distributed more or less equitably in the North zone than those in the South zone. The similarity index was higher between the rice straw litters of the both zones. This could be explained by the fact that the specific composition of each type of litter varies little from one area to another.

## 5. Conclusion

The inventory of the entomofauna associated with the litter of traditional livestock buildings with automatic watering of poultry in Côte d'Ivoire made it possible to identify 16 species belonging to five (5) families and grouped into two (2) Orders (Coleoptera and Hymenoptera). Eleven and 12 species have been recorded in the North and South respectively. *Carcinops pumilio* was the species most encountered with 64.09% of the total number. The Shannon index and the Equitability index were higher in the North

( $H' = 1.62$  and  $E = 0.67$ ) and lower in the South ( $H' = 1.37$  and  $E = 0.30$ ). The greatest similarity (58%) was observed between the rice straw litter from the Northern and Southern zone.

## Conflict of Interest Statement

The authors declare that they have no conflict of interest regarding this article.

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