ISSN: 2319-9490

Available online at http://www.ijcrls.com

International Journal of Current Research in Life Sciences
Vol. 07, No. 07, pp.2416-2422, July, 2018

RESEARCH ARTICLE

EVALUATION OF THE ENTOMOFAUNA OF MILLET (CYPERALES: POACEAE) IN THE NORTH OF COTE D'IVOIRE

[1, *]Yalamoussa Tuo, [2]Klana Kone, [1]Michel Laurince Yapo and [2]Koua Kouakou Herve

[1]Unité de Formation et de Recherche (UFR) des Sciences Biologiques, Département de Biologie Animale Université Peleforo Gon Coulibaly BP 1328 Korhogo, Côte d'Ivoire

[2]Unité de Formation et de Recherche (UFR) Biosciences Département de Zoologie, Biologie Animale et Ecologie Université Felix Houphouet-Boigny de Cocody (Abidjan Côte d'Ivoire) 22 Bp 1611 Abidjan 22

Received 22nd May, 2018; Accepted 03rd June, 2018; Published 30th July, 2018

ABSTRACT

In Côte d'Ivoire, parasite pressure is the major constraint to millet production. The entomofauna of this plant was evaluated on a plot of millet of 252 m 2 (20 m x 12.6 m). Once a week, from sowing to heading, three types of harvest were made. There are: the first from the filleting net, the second by direct observation and harvest by hand and the third with the help of colored plates. This inventory has permitted to collect 3671 individuals belonging to 9 insect orders. These 9 orders were Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Isoptera, Dictyoptera and Dermaptera. These orders were composed of 62 families. Taking into account the phases, the analyses showed that the main groups subservient to millet during the vegetative phase were Hemiptera, Hymenoptera, Diptera, Lepidoptera and Coleoptera. During the heading phase the entomofauna was marked by the presence of Hymenoptera, Lepidoptera and Hemiptera.

Key words: Millet, heading, vegetative, insects, phase.

Citation: Yalamoussa Tuo, Klana Kone, Michel Laurince Yapo and Koua Kouakou Herve, 2018. "Evaluation of the entomofauna of millet (cyperales: poaceae) in the North of Cote d'ivoire" *International Journal of Current Research in Life Sciences*, 7, (07), 2416-2422.

INTRODUCTION

Millet (*Pennisetum glaucum* (L.)), (Gnon or Sagnon in Dioula, Suguélé in Senoufo, Djoufous in Lobi) is a cereal of African origin very popular for its nutritional qualities (CNRA, 2005). Millet has a higher nutritional value than rice and wheat. A highly cultivated cereal crop in the arid and semi-arid regions of Africa and India, it is the staple food for millions of people living in these regions (Beniga et *al*, 2011). Produced on 26 million hectares for human consumption, this cereal also serves as a forage crop in Europe and the United States (Rai et *al*., 2007). Together with sorghum, it constitutes the main cereals grown in the semi-arid tropics of Africa and Asia (Djè et *al.,* 2007). In Côte d'Ivoire, it is traditionally grown in the northern region between 8 and 11 degrees north latitude (CNRA, 2005). With an annual production of 52 000 tons in 2002, this cereal ranks third in area and production after maize and rice (CNRA, 2005). But, the production does not meet the estimated domestic demand of 120,000 tons. It is very low (500 kg / ha) and has remained stationary. Indeed, in the years 1982, it was estimated at 45,000 tons (Beninga, 1993). Most of the millet in the Ivorian markets comes from neighboring countries, which represents a shortfall for the Ivorian state.

Corresponding author: **Yalamoussa Tuo,**
Unité de Formation et de Recherche (UFR) des Sciences Biologiques, Département de Biologie Animale Université Peleforo Gon Coulibaly BP 1328 Korhogo, Côte d'Ivoire

Given the best weather conditions including rainfall, if the other factors involved in the production of this cereal are met, Côte d'Ivoire could not only self-suffice but also supply Sahelian countries. The main constraints to increasing the yield of millet are: the unavailability of seeds of sufficient quality and quantity; weak adoption of technical itineraries; the prevalence of Striga species in the northern regions; the strong pressure of pests including insects, fungi and birds. To remove these constraints, a certain number of actions have already been undertaken by researchers but very little work has been done in the field of crop protection. In fact, a field survey carried out concluded that millet production was abandoned at the expense of maize because of insect pressure and the lack of an appropriate control method. This inventory of millet insects will be a starting point for the establishment of a sustainable pest management method and thus reinvigorate millet production in Côte d'Ivoire.

MATERIALS AND METHODS

Study site

This work was done in Nangakaha, in the sub-prefecture of Korhogo, located between $8^{o}26$ and $10^{o}27$ north latitude and $5^{o}17$ and $6^{o}19$ west longitude. This sub-prefecture is located 600 km from Abidjan in north of Côte d'Ivoire. The vegetation consists mainly of savannahs, clear forests in some places, shrub savannas and sacred forests near the villages. The most dominant forest species in size is the tree called fromager. We are also found Néré (Parkia Biglobosa) and shea (*Vitellaria paradoxa*), whose fruits are consumed and sold by the populations. Natural plant formations are being progressively replaced by orchards (mango and cashew) and by reforested forest species (mainly teak) around villages (M'Bra, 2013). The entire area is covered with tropical ferruginous soils and moderately unsaturated ferritic soils. Overall, the physical properties of these soils are good and favorable for food crops, cotton and perennial crops such as cashew and mango (M'Bra, 2013). This locality belongs to the dry tropical climatic regime of the Sudano-Sahelian type. This climate is characterized by two seasons. The rainy season which runs from May to October with a maximum of precipitation in September and the dry season from November to April, characterized by the harmattan which settles from December to February. During the year 2016, an average rainfall of 1324.7 mm was recorded and the average annual temperature varied between 24.6 ° C and 30.2 ° C (SODEXAM, 2017).

Experimental device

The experimental device consisted of a completely randomized Fisher block. The blocks, numbering 4, were spaced 1 m apart and each made up of 7 elementary plots, making a total of 28 elementary plots for the entire system. Each elementary parcel consisted of 4 lines, each with 5 poquets with gaps of 0.80 m between the lines and 0.50 m between the poquets on the line. The total area of the experimental plot was 252 m 2 (20 m x 12.6 m). Plowing followed by leveling and picking hole digging was done a few days before sowing with hoe, stakes, rope and a decameter. The seeds were previously treated with a fungicide (Oxamyl 30g / kg) before sowing. The plot was fertilized with chicken manure and NPK (15-15-15). Sowing was carried out in poquets (greater than 10 seeds) on the ridges according to the farmers' practices of the locality. Fifteen days after the lifting, a stool was removed to retain 4 plants per poquet. Weeding was done regularly throughout the cycle.

Harvest and insect identification

Once a week, three types of harvest were made. The first from the filleting net, the second by direct observation and harvest by hand and the third with the help of colored plates. The method from the filleting net consisted of lateral and transverse movements in each elementary parcel for 5 minutes. Harvested insects were kept in 70% alcohol pills and a label showing the date of harvest, parcel number, harvest method and crop phase pending identification. The one using colored plates, consisted of placing a yellow plate containing soapy water in each elementary parcel, for a total of 28 yellow plates for the whole of the experimental parcel. Each trap was sliding on a vertical metal rod to follow the growth of the plants. Harvesting was done 48 hours after the traps were set up. This operation was done once a week and the insects were kept in the same way as in the case of the filleting net. Concerning direct observation, it consisted of observing 5 randomly selected plants in each elementary plot to record the number of individuals per species. Insects that cannot be directly identified were harvested by hand and stored in the same way as in the case of colored plates. The insects collected were identified using the identification keys of Delvare and Aberlenc (1989) as well as illustrations for some species, after the observation of the morphological characters using a magnifying glass of Motic brand at 10X20 magnification.

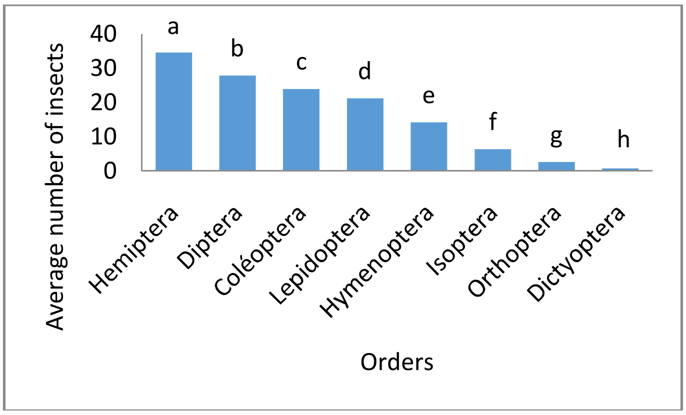
RESULTS

General observation

From this inventory, 3671 individuals belonging to 9 insect orders were captured. These 9 orders were Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Isoptera, Dictyoptera and Dermaptera. These orders consisted of 62 families. Among the latter, the order of Hemiptera included 14 families including Alydidae, Aphrophoridae, Cicadellidae, Cixiidae, Coreidae, Dictyopharidae, Lygaeidae, Membracidae, Miridae, Nabidae, Pentatomidae, Pyrrhocoridae, Reduviidae and Scutelleridae. At Hymenoptera level, 10 families have been identified. These are Andrenidae, Apidae, Chalcidoidea, Formicidae, Halictidae, Ichneumonidae, Megachilidae, Pompilidae, Sphecidae and Vespidae. The Coleoptera order consisted of 16 families including Apionidae, Cantharidae, Cerambycidae, Chrysomelidae, Coccinellidae, Curculiolidae, Elateridae, Geotrupidae, Histeridae, Lucanidae, Meloidae, Scarabaeidae, Carabidae, Silvanidae, Staphylinidae and Tenebrionidae. Concerning Diptera, the insects harvested belonged to 12 families which are that of Agromyzidae, Ampididae, Calliphoridae, Chloropidae, Lauxaniidae, Diopsidae, Drosophilidae, Fanniidae, Heleomyzidae, Rhinophoridae, Stratiomyidae and Tephritidae. With Lepidoptera, the insects collected belonged only to 4 families including those of Hesperiidae, Noctuidae, Nymphalidae and Papilionidae. The Orthoptera were represented only by the families of Acrididae, Gryllidae and Tettigoniidae. Isoptera, Dictyoptera and Dermapteres were represented by the families of Rhinotermitidae, Blattidae and Forficulidae respectively.

Relative abundance of collected insects

During the vegetative phase, at the quantitative level, a significant difference at $\alpha = 0.05$, $p = 0.000005$ and ddl = 34 was observed between the averages of the different orders of insects harvested. Thus, according to the Newman keuls test, insects belonging to the Hemiptera order with an average of 34.63 ± 1.30 are the most abundant. They are followed by Diptera (27, 87 ± 2,41), Coleoptera (24 ± 1,31), Lepidoptera (21,25 ± 1,75), Hymenoptera (14,25 ± 2,55), Isoptera (6.38 ± 0.92), Orthoptera (2.62 ± 0.92) and Dictyoptera (0.75 ± 0.71) (Picture 1a). Two groups can thus characterize the vegetative phase. The most important formed by Hemiptera, Diptera, Coleoptera, Lepidoptera and Hymenoptera, opposite to that formed by Isoptera, Orthoptera and Dictyoptera, which is the weakest represented (Picture 1b). During heading, on the quantitative level, a significant difference at $\alpha = 0.05$, $p = 0.000034$ and ddl = 56 was observed between the averages of the different orders of insects harvested. According to the Newman-Keuls test, only the average insects belonging to the orders of Dermaptera (0.63 ± 0.52), Orthoptera (4.88 ± 2.17) and Dictyoptera (0.63 ± 0.74) are similar. On the other hand, those of Hemiptera (118, 50 ± 7,54), Diptera (24,38 ± 4,03), Coleoptera (13,13 ± 1,89), Lepidoptera (56,63 ± 3,29) and Hymenoptera (52 ± 4.81) are different. During this phase, Hemiptera were the most represented. It is followed by Lepidoptera, Hymenoptera, Diptera and Coleoptera (Picture 2a). Taking into account the numbers, the ascending hierarchical classification brings out three groups of insects. It consists of the group formed only of Hemiptera order, that



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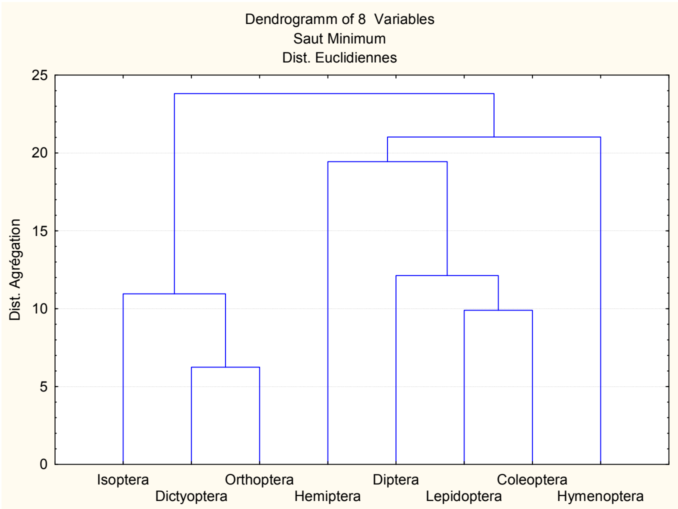
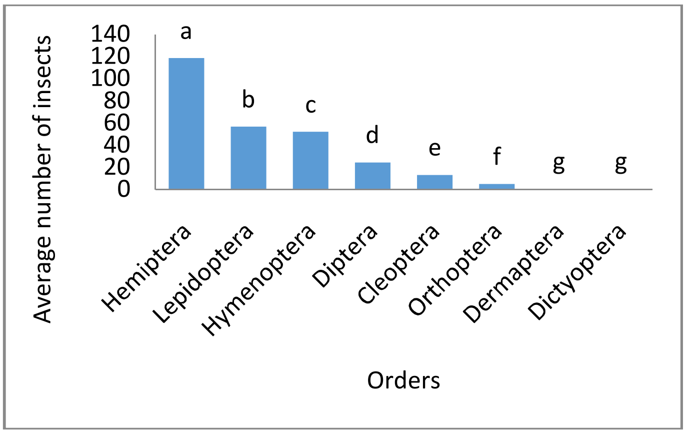


B

A: Relative abundance of insects by order

B: Ascending hierarchical classification of insects by orders

Picture 1. Quantitative evaluation of insects harvested during the vegetative phase of millet



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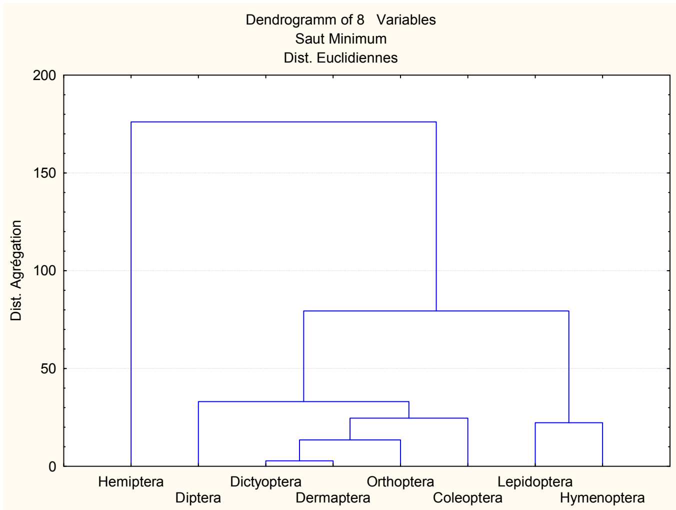


B

A: Relative abundance of insects by order

B: Ascending hierarchical classification of insects by orders

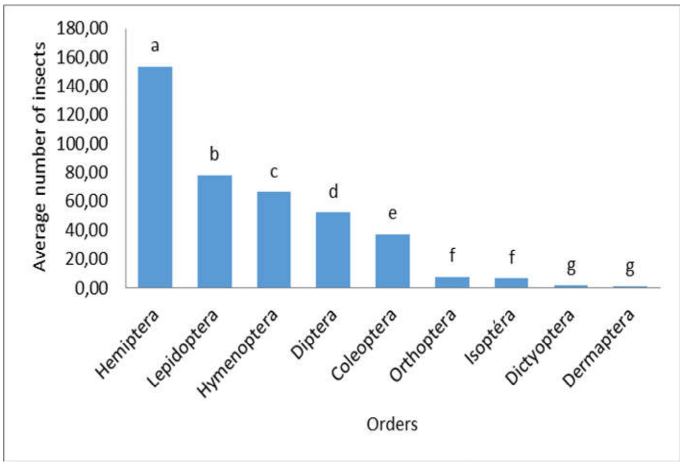
Picture 2. Quantitative evaluation of insects harvested during the heading phase of millet

consisting of Dermaptera, Orthoptera, Dictyoptera, Diptera and Coleoptera and the group formed by Lepidoptera and Hymenoptera (Picture 2b). Considering the entire cycle, the averages of the different insect orders evaluated differ significantly at α = 0.05, p = 0.000016 and ddl = 63. Comparing the averages two-by-two, the Newman-Keuls test shows a similarity between the averages of Dermaptera (0.63 ± 0.52) and Dictyopera (1.38 ± 0.74) on the one hand and between Isoptera (6.38 ± 0.92) and Orthoptera (7.5 ± 1.77) on the other hand. The most common group was Hemiptera (153,13 ± 7,20). The latter was followed by Lepidoptera (77,87 ± 4,73), Hymenoptera (66,25 ± 5,82), Diptera (52,25 ± 5,6) and Coleoptera (37,13 ± 2,85). (Picture 3A). The ascending hierarchical classification distinguishes three groups on the basis of the frequencies of each order. These are the group formed solely by Hemiptera, that consisting of the Dictyoptera, Dermapteres, Isoptera and Orthoptera and the group of Hymenoptera, Lepidoptera, Diptera and Coleoptera (Picture 3B). On the quantitative level, the number of insects collected during the heading phase (131.75 ± 4.68) is significantly greater than that collected during the vegetative phase (270.75 ± 10.26) at α = 0.5; p <0 and ddl = 14. Basing on the abundance of insects of each order, it appears that the main groups subservient to millet during the vegetative phase are Hemiptera, Hymenoptera, Diptera, Lepidoptera and Coleoptera. During the heading phase these are Hymenoptera, Lepidoptera and Hemiptera. Those present during all phases are Hemiptera, Lepidoptera and Hymenoptera.

At the family and genus level

Hymenoptera: During the vegetative phase, specimens belonging to the families Formicidae and Halictidae were the most frequently encountered. Of the insects harvested, 34 specimens (26.98%) were from the Halictidae family and 27 individuals (21.43%) from Formicidae. During the heading phase, the population was dominated by individuals belonging to the families of Halictidae (21.43%), Vespidae (18.20%), Fomicidae (17.51%), and Apidae (16, 59%). At the genre level, during the vegetative phase, Lipotrich (26.98%), Ichneumon (10.32%) and Polistes (14.29%) were the most harvested. During heading, the majority of the insects harvested also belonged to these same genders Lipotrich (20.97%), Poliste (17.51%) and Ichneumon (10.37%). In the end, it was the specimens of these genus that most frequented millet (Table 1).

Coleoptera: During the vegetative phase, the most numerous insects belonged to the families of Chrysomelidae with 42 representatives (21.88%), and Scarabaeidae with 1110



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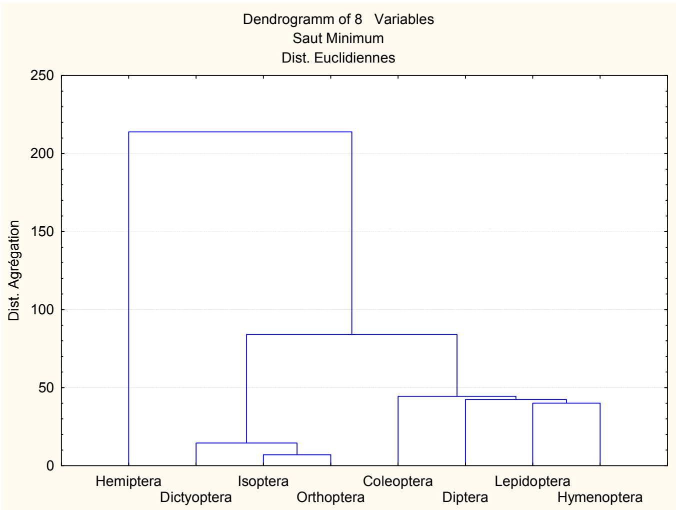

B

A: Relative abundance of insects by order
B: Ascending hierarchical classification of insects by orders

Picture 3. Quantitative evaluation of insects harvested during the whole cycle of millet

representatives (57.29%). During heading, it was the Meloidae families with 28 representatives (26.67%) and the Meloidae with 33 individuals representing a rate of 31.43%. In the end, during the whole production cycle, the specimens of the families of Scarabaeidae, Meloidae and Chrysomelidae were the most harvested on millet. At the genus level, *Aegidinus* (48.96%) and *Aulacophora* (21.88%) were the most common encounterd during the vegetative phase. During heading, it was the genus of *Pachnoda* (10.48%), *Adalia* (11.43% and *Decapotoma* (23.81%) that were harvested. Taking into account the two phases, individuals from the genus of *Aulacopora* (16.16%), *Decapotoma* (14-81%) and *Aegidinus* (34.34%) were the most common (Table 2).

Hemiptera: At the level of Hemiptera, the families most encountered were: for the vegetative phase, Cicadelidae with 141 (51.09%) and Alydidae with 82 specimens 29.71%. Concerning the heading phase, the most common insects belonged in order of importance to the families of Pyrrhocoridae with 603 specimens (44.27%), Pentatomidae with 306 individuals (22, 47%) and Alydidae represented by 218 specimens 16,01%. In sum, this order is dominated by individuals from the families of Pyrrhocoridae with 37.48%, followed by that of Pentatomidae (19.05%) and Alydidae with 18.32% of the total number of harvested insects.

Table 1. Number of insects of the order Hymenoptera collected on millet during the vegetative and heading phases

Families	Genres	Species	Vegetative	Heading
Andrenidae	*Melitturga*	*M.sp*	0	7
Apidae	*Apis*	*A.melifera*	5	39
Apidae	*Meliponula*	*M.ferruginea*	12	30
Apidae	*Thalestria*	*T.sp*	0	1
Apidae	*Trigona*	*T.sp*	1	0
Apidae	*Sphecodes*	*S.sp*	0	1
Apidae	*Xylocopa*	*X.sp*	0	1
Chalcidoidae	*Podagrion*	*P.sp*	0	1
Formicidae	*Componotus*	*C.sp*	0	9
Formicidae	*Anoplolepis*	*A.sp*	0	7
Formicidae	*Formica*	*F.sp*	10	30
Formicidae	*Dorylus*	*D.sp*	2	0
Formicidae	*Messor*	*M.sp*	15	30
Halictidae	*Lipotriche*	*L.sp*	34	91
Halictidae	*Halictus*	*H.sp*	0	1
Halictidae	*Sphecodes*	*S.sp*	0	1
Ichneumonidae	*Stenichneumon*	*S.sp*	0	1
Ichneumonidae	*Ichneumon*	*I.sp*	13	45
Ichneumonidae	*Ophion*	*O.sp*	0	1
Megachilidae	*Megachile*	*M.sp*	1	3
Pompilidae	*Nd*	*Nd*	0	10
Pompilidae	*Auplopus*	*A.sp*	2	24
Pompolidae	*Pepsis*	*P.sp*	0	1
Pompilidae	*Priocenmis*	*P.sp*	2	0
Pompilidae	*Anoplius*	*A.sp*	6	2
Sphecidae	*Ammophila*	*A.sp*	0	6
Sphecidae	*Sceliphron*	*S.sp*	5	7
Sphecidae	*Nd*	*Nd*	0	6
Vespidae	*Poliste*	*P.sp*	18	76
Vespidae	*Belonogaster*	*B.sp*	0	3

Nd : not determined

Table 2. Number of insects of the Coleoptera order harvested on millet during the vegetative and heading phases

Families	Genres	Species	Vegetative	Heading
Apionidae	*Apion*	*A.sp*	0	1
Cantharidae	*Cantharis*	*C.sp*	0	2
Cerambycidae	*Aphrodisium*	*A.sp*	0	1
Cerambycidae	*Aphrodisium*	*A.sp*	0	4
Chrysomelidae	*Aulacophora*	*A.sp*	42	6
Coccinellidae	*Adalia*	*A.sp*	13	12
Curculiolidae	*Sitophilus*	*S.sp*	0	3
Elateridae	*Sericus*	*S.sp*	0	4
Geotrupidae	*Geotrupe*	*G.sp*	0	1
Histeridae	*Hister*	*H.sp*	6	1
Lucanidae	*Platycerus*	*P.sp*	0	2
Meloidae	*Decapotoma*	*D.sp*	19	12
Meloidae	*Cerocoma*	*C.sp*	0	3
Meloidae	*Decapotoma*	*D.sp*	0	13
Scarabaeidae	*Oxycetonia*	*O.sp*	0	1
Scarabaeidae	*Schizonicha*	*S.sp*	0	3
Scarabaeidae	*Protaetia*	*P.sp*	0	2
Scarabaeidae	*Pachnoda*	*P.sp*	1	4
Scarabaeidae	*Scarabaieus*	*S.sp*	7	0
Scarabaeidae	*Nd*	*Nd*	4	1
Scarabaeidae	*Aegidinus*	*A.sp*	94	8
Scarabaeidae	*Pachnoda*	*P.sp*	0	11
Scarabaeidae	*Polybaphes*	*P.sp*	0	1
Scarabaeidae	*Protaetia*	*P.sp*	0	1
Scarabaeidae	*Phyllophaga*	*P.sp*	4	1
Carabidae	*Carabus*	*C.sp*	1	0
Silvanidae	*Nd*	*Nd*	0	1
Staphylinidae	*Xylodromus*	*X.sp*	0	3
Staphylinidae	*Ocepus*	*O.sp*	1	0
Tenebrionidae	*Dendariis*	*D.sp*	0	1
Tenebrionidae	*Dendariis*	*D.sp*	0	2

At the genus level, *Riptortus* (24,28), Cicadella (25%) and Lyrist (20,65%) were the most commonly seen during the vegetative phase., they are the genus of *Riptortus* (10.06%), *Agonoscelis* (15.57%), and *Dysdercus* (44.27%). In summary, the most common genre were *Riptortus* (12.45%), *Agonoscelis* (13%) and *Dysdercus* (37.48%) (Table 3).

Table 3. Number of insects of the Hemiptera order harvested on millet during the vegetative and heading phases

Families	Genres	Species	Vegetative	Heading
Alydidae	*Riptortus*	*R.sp*	67	137
Alydidae	*Merperus*	*M. sp*	1	0
Alydidae	*Camptopus*	*C.sp*	0	47
Alydidae	*Leptocorisa*	*L.sp*	14	34
Aphrophoridae	*Philaenus*	*P.sp*	14	22
Cicadellidae	*Cicadella*	*C.viridis*	0	4
Cicadellidae	*Agallia*	*A.sp*	0	9
Cicadellidae	*Euscelis*	*E.sp*	0	1
Cicadellidae	*Cicadella*	*C.sp*	69	1
Cicadellidae	*Euscelis*	*E.sp*	0	18
Cicadellidae	*Lyristes*	*L.sp*	57	7
Cicadellidae	*Neolymnus*	*N. sp*	15	0
Cixiidae	*Bothriocera*	*B.sp*	0	14
Coreidae	*Clavigralla*	*C.sp*	12	97
Coreidae	*Anoplocnemis*	*A.curvipes*	3	3
Coreidae	*Anoplocnemis*	*A.curvipes*	0	1
Dictyopharidae	*Dictyophara*	*D.sp*	0	2
Lygaeidae	*Rhyparochromus*	*R.sp*	0	7
Lygaeidae	*Spilostethus*	*S.sp*	0	9
Membracidae	*Centrotus*	*C.sp*	4	1
Miridae	*Neolygus*	*N.sp*	0	11
Nabidae	*Nabis*	*N.sp*	0	2
Pentatomidae	*Aspavia*	*A.armigera*	3	9
Pentatomidae	*Oebalus*	*O.sp*	0	1
Pentatomidae	*Picromerus*	*P.sp*	0	1
Pentatomidae	*Aspavia*	*A.albidomaculata*	1	8
Pentatomidae	*Nd*	*Nd*	0	2
Pentatomidae	*Piezodorus*	*P.sp*	1	0
Pentatomidae	*Acrosternum*	*A.sp*	0	8
Pentatomidae	*Nezara*	*N.viridula*	0	29
Pentatomidae	*Peribalus*	*P.sp*	0	11
Pentatomidae	*Agonoscelis*	*A.sp*	1	212
Pentatomidae	*Nezara*	*N.sp*	0	23
Pentatomidae	*Thyanta*	*T.sp*	0	2
Pyrrhocoridae	*Dysdercus*	*D.sp*	11	603
Reduviidae	*Rhinocoris*	*R.sp*	2	13
Scutelleridae	*Phimodera*	*P.sp*	0	1
Scutelleridae	*Sphaerocoris*	*S.sp*	1	2
Scutelleridae	*Eurygaster*	*E.sp*	0	1
Scutelleridae	*Eurygaster*	*E.sp*	0	9

Table 4. Number of insects of the Diptera order harvested on millet during the vegetative and heading phases

Families	Genres	Species	Vegetative	Heading
Agromyzidae	*Agromyza*	*A.sp*	0	42
Ampididae	*Nd*	*Nd*	0	1
Calliphoridae	*Lucilia*	*L.sp*	48	35
Calliphoridae	*Calliphora*	*C.sp*	64	76
Chloropidae	*Dicraeus*	*D.sp*	21	9
Lauxaniidae	*Nd*	*Nd*	8	0
Diopsidae	*Diopsis*	*D.sp*	0	1
Drosophilidae	*Drosophila*	*D.sp*	0	1
Fanniidae	*Fannia*	*F.sp*	0	5
Heleomyzidae	*Tephrochlamys*	*T.sp*	0	5
Rhinophoridae	*Nd*	*Nd*	0	1
Stratiomyidae	*Hermetia*	*H.illucens*	10	10
Tephritidae	*Nd*	*Nd*	72	5

Table 5. Number of insects of the Orthoptera order harvested on millet during the vegetative and heading phases

Families	Genres	Species	Vegetative	Heading
Acrididae	*Anacredium*	*A.sp*	0	1
Acrididae	*Oedaleus*	*O.sp*	14	2
Acrididae	*Nd*	*Nd*	1	3
Gryllidae	*Acheta*	*A.sp*	0	1
Gryllidae	*Gryllus*	*G.sp*	4	1
Tettigoniidae	*Tettigonia*	*T.sp*	0	28
Tettigoniidae	*Nd*	*Nd*	1	3

Diptera: During the vegetative phase, Diptera are dominated by the family of Calliphoridae with 112 representatives (50.22%) and Tephritidae with 72 specimens (32.29%). During heading, Agromyzidae (21.99%) and Calliphoridae (58.12%) dominate.

Table 6: Number of insects of the Lepidoptera order harvested from millet during the vegetative and heading phases

Families	Genres	Species	Vegetative	Heading
Hesperiidae	*Pelopidas*	*P.sp*	19	34
Noctuidae	*Heliocheilus*	*H.sp*	100	310
Noctuidae	*Nd*	*Nd*	0	2
Noctuidae	*Conieta*	*C.sp*	0	1
Nymphalidae	*Acrea*	*A.sp*	0	28
Nymphalidae	*Acrea*	*A.serena*	51	77
Papilionidae	*Graphium*	*G.sp*	0	1

In fact, throughout the millet cycle, the most representative families of the Diptera order are Calliphoridae and Tphritidae. At the genus level, the entomofauna was marked by the *Lucilia* genus (21.52%) and *Calliphora* (28.70%) during vegetation. During heading, the *Agromyza* genus (21.99%), *Lucilia* 18.32%) and *Calliphora* (39.79%) were the most prevalent (Table 4).

Orthoptera: The most represented families of this order were: Acrididae (75%) and Gryllidae (20%) for the vegetative period. During the heading phase, the most heavily harvested specimens were Tettigoniidae with 31 specimens representing 79.49% of the total population. In sum, the most common orthopterans were families of Acrididae and Tettigoniidae. At the genus level, the most common individuals belonged to the genus of *Oedaleus* (70%) for the vegetative phase and *Tettigonia* (71.79%) during heading (Table 5).

Lepidoptera: Concerning this order, the majority of insects harvested were families of Noctuidae and Nymphalidae. During the vegetative phase, Noctuidae were represented by 100 individuals (58.82%), and during heading by 313 specimens (69.09%). With Nymphalidae, 51 individuals (30%) were harvested during the vegetative period against 105 specimens (23.18%) during heading. At the specific level, *Acrea serena* and *Heliochelus sp* are the most present. During vegetation, 100 specimens of *Heliocheilus* (58.82%) against 51 individuals of *Acrea serena* (30%) were collected. During heading, 310 specimens of *Heliocheilus* (68.43%) and 77 specimens (17%) were harvested (Table 6).

Isoptera, dictyoptera and dermaptera: At the level of Isoptera, the harvested specimens belonged to a single family and a single genus (*Coptotermes*) and this during the vegetative phase only. Concerning the order of the Dictyoptera, the insects harvested were all of the family of Blattidae. For Dermaptera, the insects harvested were of the family of Forficulidae, the genre of *Forficula* and the species of *Forficula senegalensis*.

DISCUSSION

The inventory of entomological fauna subservient to millet throughout its cycle in northern Côte d'Ivoire is a prerequisite for the revitalization of the production of this cereal in this locality. From this inventory, an abundant and diverse insect was harvested. This abundance and diversity shows that millet during its cycle offers favorable conditions for the proliferation of several types of insects. Indeed according to Tapsoba (1991), all parts of the millet plant from germination to harvest and even during storage are attacked by insects. Thus, pests of seedlings, leaves, stems, ears and millet are noted during storage. These results are close to those obtained by Seybou (2013). According to this author, the entomological fauna of millet is quite rich and is mainly composed of Lepidoptera, Coleoptera, Heteroptera and Orthoptera. Our results are also in line with those obtained by Mbaye in 1993. This author has pointed out that the most dangerous species for millet belong to the orders of Lepidoptera, Diptera and sometimes Coleoptera. According to Pantenius and Krall (1993), the main pests of millet in West Africa are Lepidoptera, Coleoptera, Diptera, Orthoptera, Heteroptera and Dermaptera. Dabre (2008) also obtained similar results. According to the latter, the entomofauna of the millet consisted of individuals belonging to the orders Coleoptera, Lepidoptera, Hemiptera and Orthoptera. In Côte d'Ivoire, according to the work carried out by Béninga in 2015, the pests of millet are mainly Lepidoptera, Coleoptera, Hemiptera and Orthoptera which attack especially stems and seeds. Insect diversity on crops was also observed by Chougourou and *al*. in 2012 on tomato. These authors reported that the entomofauna subservient to tomato consisted of Hemiptera, Coleoptera, Lepidoptera, Hymenoptera, Diptera, Orthoptera, Thysanoptera and Odonata. During their work on yellow rice variegation in 2008 in North Cameroon, Sadou and allies reported that the rice entomofauna is composed of 46 species belonging to seven orders and 26 families. The orders of Lepidoptera and Hemiptera were the most dominant. Diptera, Coleoptera and Hymenoptera are moderate. However, from the relative analysis of the entomofauna, it is clear that the harvested species vary in abundance and quality according to the phrenological stages of the plant. Thus, insects are more abundant as a whole during heading than during the vegetative phase. These results are close to those obtained by Mbaye et *al.* (1993). Indeed, these authors observed an abundance of insects of millet during the heading phase. The presence of insects on a plant is never fortuitous. Either they come to feed directly on a part of the plant during a given period, or indirectly by attacking other insects that come to feed. According to Sadou and *al.* (2008), insect species harvested from rice vary in abundance and quality at different phrenological stages of the plant. Soro et *al*. (2010) reported that insects are subservient to yam depending on the phrenological stage and the species of the plant. The strong dominance of individuals belonging to the order of Hemiptera could be explained by the fact that millet would offer ecological conditions favorable to the proliferation of species of this order. In addition, the farmers surveyed argue that the upsurge of insects on millet will be linked to the production of cotton. According to these producers, before the advent of cotton, very few insects were encountered on millet. Given the presence of insects of the Hemiptera order on cotton, including pods, this hypothesis from the producers deserves special attention. Such results have already been reported by Dabré and *al.* in 2008 during their inventories of millet insects. At the fonio level, Ouedraogo and *al*. (2015) observed the preponderance of Homoptera belonging to the large group of Hemiptera. According to Hala and *al.* (2012), the relative abundance of oil palm inflorescences is due to their bioecological characteristics.

Conclusion

This inventory of millet insects carried out in the sub-prefecture of Korhogo has allowed us to pinpoint the problem of the farmers of this area with regard to the production of this cereal. Indeed, it appears from this inventory that the insects subservient to millet during its cycle are very numerous. They are even more during the heading phase, which comes at a time when there is no more crops in production in the savannah. The ears are black with insects dominated by those belonging to the order of Hemiptera. Owing to the abundance of insects on millet and their damage, the production of this grain cannot be done without the implementation of a pest management strategy. Moreover, the current varieties being plants whose size is greater than 2 m, the selection of reduced-sized varieties would facilitate the possible insecticide treatments. In addition, the selection of biological insecticides could be the solution. Therefore, the probable implication of cotton growing in the upsurge of pests affecting millet deserves to be enlightened.

Acknowledgements

This work has been done with the help of a certain number of people whom we wish to thank here. This is Dr. Tuo Yalamoussa's research team including Yao Félix Getheme, Traoré Drissa, Soro Fokin, Coulibaly Karna David, Yeo Kafana Bakary, Kone Boubakary. We would also like to thank the Chief of Nangakaha Village, the landowner of the experimental plot, the millet producers in the study area and Mr. Tuo Siongagniqui, Soro Tiognetia and Soro Awa for the plowing and cleaning of the study plot.

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