Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(4): 95-101

Received: 01-05-2021
Accepted: 03-06-2021

Dynamics of rice insects (*Oryza spp*.) according to the phenological stage in Daloa (Côte d'Ivoire)

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Abstract
In Côte d'Ivoire, rice is the most consumed cereal. Shallow cultivation of rice in the Haut Sassandra is hindered by insects pests. The objective of this study was to establish a list of rice entomofauna, with a particular interest on insects pests. "Colourful traps", "light traps" and "sweeps net" were used to collect insects every two days during the two weeks of experimentation in the course of each phenological stage of rice. The results show that species vary in abundance and diversity at different phenological stages of the plant. In total, 2743 insects were collected, which belonging to 84 genera divided to 60 families and 10 orders (Lepidoptera, Orthoptera, Coleoptera and Hymenoptera etc). Diptera are the most important with 1240 species. This represent about 45.20% of the total insects. The Isoptera are the lest important order with not more than 0.36% of the species collected.

Keywords: insect pests, rice, Haut Sassandra, Côte d'Ivoire

1. Introduction

The second most cultivated cereal in the world after wheat (Sadou *et al*., 2008) [1], rice (*Oryza* spp) occupies nearly 154 million hectares in around 100 countries. According to global statistics, rice production was estimated at 479.2 million tonnes in 2014 (Ondo *et al*., 2014) [2]. According to Sadou *et al*. (2008) [1], more than half of humanity consumes rice as a staple food. However, almost 90% of this production comes from Asia. According to Komenan *et al*. (2010) [3], rice production in Côte d'Ivoire was about 700 000 tonnes in 2008.

With the intermixing of populations following the modernization of the country, rice is now one of the mean food consumed by the populations (Pollet, 1977) [4]. It is the most consumed cereal in Côte d'Ivoire with an estimated consumption of 1.300.000 tonnes in 2008 (USDA, 2009) [5]. Local production cannot meet the needs of the population and the country has to import half of the needs for this cereal each year (Trazié *et al*., 2009) [6].

However, during its production, rice is attacked by many pests including insects (Ondo *et al*., 2014) [2]. According to Djiba (1986) [7], the pressure of these pests contributes significantly to the drop in production. Previous work of Pollet (1977) [4] revealed the constant presence of 5 boring insects, including 1 Diptera and 4 Lepidoptera, on irrigated rice in central Côte d'Ivoire. During work on the population dynamics of rice pests in Lower Casamance, Djiba (1986) [7] showed that among stem borers, species of the genus *Chilo* were the most important pests. Little work has been done on insect pests of rice in the Haut Sassandra region. To reduce the impact of insects in order to increase productivity, chemical control has been adopted. Thus, Cypermetrine 50 g / l and Carbosulfan 30 g, all synthetic insecticides are widely used against these pests. However, damage control through the use of synthetic insecticides has a negative effect on useful fauna (Rafarasoa *et al*., 2015) [8]. Thus, chemical control eliminates both pests and beneficial insects.

In depth knowledge of pests is therefore essential for the development of coherent and rational control strategies in order to increase rice production.

The aim of the study was to make an inventory of rice pests in Daloa. Specifically it was to (1) establish the distribution of insects according to the vegetative, (2) reproductive and (3) ripening stages of rice.

1.1 Study zone

The study was carried out in a rice field, in the south of Daloa (06 °52'38 "N and 06 °27'00 "W). Daloa is located at about 331 km from the economic capital Abidjan.

The region is characterized by a hot and humid climate with an average temperature of 27 °C. The average rainfall recorded over the whole year is between 1000 to 1500 mm. The climate has two rainy seasons the first runs from April to July and the second from September to November. then, two dry seasons the first runs from December to March and the second from July to September (Anonymous, 2004) [9].

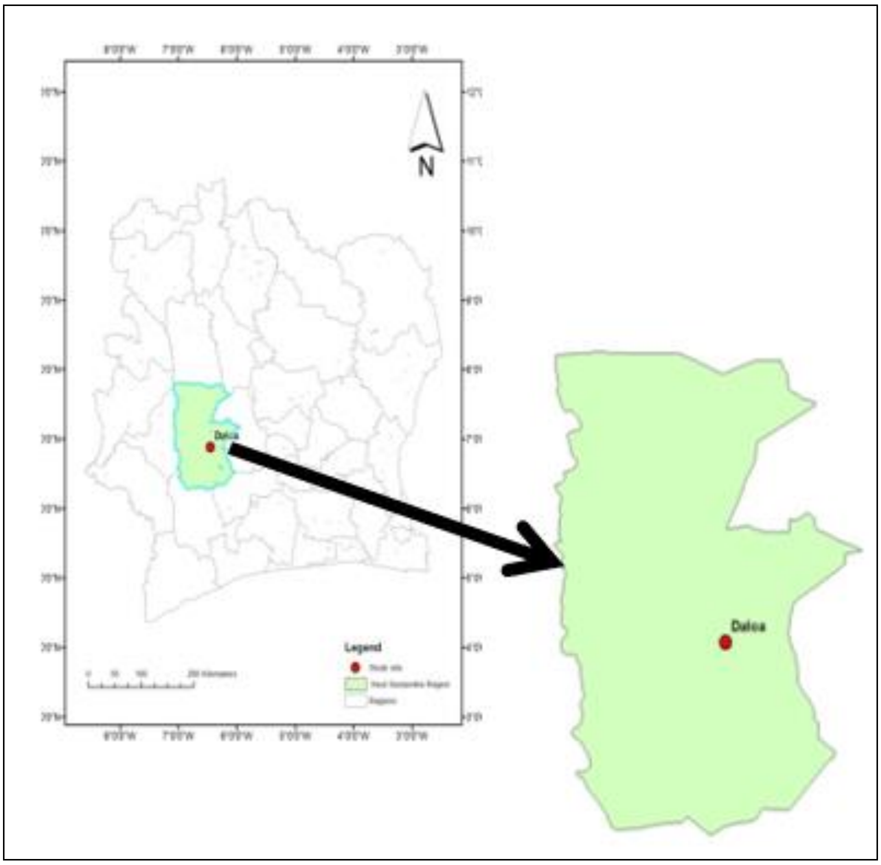

Fig 1: Localisation of the study site

2. Materials and Methods

2.1 Material

The material used is composed of biological material and technical material.

2.1.1 Biological material

- Rice plants of the Wita 9 variety;
- Insects collected on the rice plot during the different phenological phases.

2.1.2 Technical material

The technical equipment consists of equipment for the capture, conservation and identification of captured insects.

2. Methods

2.2.1 Sampling method

The sampling was made on rice plants from the first month after transplanting to maturity. The rice seeds were sprayed on a plot of 10 m long then 1 m wide. The plants stayed on this for a bout one month. Then plants from this nursery were transplanted into a field of 1 hectare. The data collections were carried out in a subplot of 400 m² (20 m x 20 m) chosen at randomny. These collections were made during a rice development cycle.

2.2.2 Sampling rhythm

During experimentation on rice variety Wita 9, observations were made according to three phenological stages identified according to Silvie *et al*. (2013) [10]. Sampling was conducted every two days, depending on the phenological stages of the plants. For each stage, the surveys were carried out during two weeks by the method of colored traps, sweet net and manual hunting.

The colored trap consists of a yellow plate filled two thirds (2/3) with soapy water. The upper part of the plate has a diameter of 16 cm. This trap was put on a iron support high to 1.5 m. later, this support has been adjusted to the height of the rice plants. Insects that fly nearly was attracted to the color and drawn in it (Franck, 2008) [11].

The light trap consists of a white sheet stretched between two (2) m high stakes lit by a flashlight suspended five centimeters behind the sheet. The 1 m wide sheet went down to the floor. A basin two-thirds (2/3) full of soapy water were put under the ground. trap was set in the subplot and lit from 6 p.m. to 6 a.m., during the two weeks of the sampling at each phenological phase. The insects were attracted by the light collide with the white sheet and fall into the basin containing the soapy water (Dabré, 2008) [12].

In addition to the collection using these two types of traps, some of the insects encountered on the plot were captured directly using the sweet net and by hand. This collecting technic consisted of moving forward through the plot with the sweet net and the insects encountered are captured directly by hand or with the net.

2.2.3 Identification of insect

In the laboratory, insects were observed using a LEICA EZ4 brand binocular magnifying glass. For the identification of species up to genera, the book of George (2005) [13] was used. Thus identified, the different species of each group were counted.

2.3 Statistical analysis
Excel version 2010 and Statistica version 7.1 software were respectively used for data entry and for the construction of histograms. The data are analyzed using the Shannon index of each phenological stage of the rice in the plot, with R software version 2.8.

3. Results and Discussion
3.1 Results
3.1.1 Insect sumpling
The results shows that the abundance and diversity of insects vary according to the different phenological stages of the plant. A total of 2743 insect individuals divided into 10 orders, 60 families and 84 genera, were collected (Table 1).
The Diptera order contains the largest population with 1240 species, or 45.20% of the insects collected. Heteroptera come second with 329 species or 11.99%, followed by Lepidoptera (322) or 11.74%. The orders of Coleoptera and Hymenoptera respectively recorded 279 individuals or 10.18% and 255 individuals or 9.30%. Finally, the Orthoptera group with 182 species or 6.64%, the Odonata totals 83 species or 3.03% and the Homoptera with 27 species or 0.98% are the least. The least represented orders were the Isoptera and Dermaptera with respectively 10 and 16 species.

3.1.2 Insects captured with colored traps and light traps
Diptera were the most numerous to be captured using colored traps and light traps. This group is mainly composed of the Diopsidae family which contains 192 species and Dolicopodidae with 350 species.
The Hymenoptera were collected in fairly large numbers (218 species) after the Diptera, numbering 957 by colored traps (Table 2). These trapped Hymenoptera were mainly Apidae and Tenthredinidae. Diptera belonging to the Diopsidae family were the most numerous with 192 individuals. The Lepidoptera trapped, numbering 208, were mainly Hesperidae of the genera of Pelopidae. Heteroptera, Coleoptera and some Orthoptera, Odonata and Homoptera are also found in these colored traps.
In the light trap, the Orthoptera were collected in quite large numbers (102 species) after the Diptera (105). The Orthoptera collected are Gryllidae, Gryllacrididae and Tetrigidae (Table II). The 16 Lepidoptera caught by this trap were belonging to the genera of the Noctuidae. Some Heteroptera Delphacidae (16 species), Coleoptera, Isoptera and Homoptera (7 species) were also trapped.

Table 1: insects collected on farm during the different phenological stages.

			Number of insects collected										
Orders	**Families**	**Genera and species**	**SV**			**SR**			**SM**			**Total**	**%**
			PC	**PL**	**CF**	**PC**	**PL**	**CF**	**PC**	**PL**	**CF**		
Coleoptera	Chrysomelidae	*G. trichispa*	3	0	2	0	0	3	1	0	4	13	0.47
		G. yspa	34	0	3	0	0	0	4	1	0	42	1.53
		G. oulema	3	0	4	0	0	0	0	0	0	7	0.26
		P. decolorata	1	0	0	0	0	0	0	0	0	1	0.04
		G. longitarsus	1	0	0	0	0	0	0	0	0	1	0.04
	Coccinellidae	*C. similis*	4	0	72	1	0	86	0	0	0	163	5.94
		G. cheilomnes	1	0	2	1	2	1	0	1	5	13	0.47
		G. anatis	0	0	6	0	0	2	0	0	0	8	0.29
		G. epilachna	0	0	0	0	0	0	0	0	1	1	0.04
	Curculionidae	*S. oryzae*	0	0	0	0	0	0	1	0	0	1	0.04
	Carabidae	*S. madagascaresis*	0	0	0	1	0	0	0	0	0	1	0.04
	Staphilinidae	*G. xantholinus*	0	0	0	0	3	0	0	0	0	3	0.11
	Meloidae	*G. nemognatha*	4	0	4	3	1	1	2	0	0	15	0.54
		G. hycleus	0	0	1	0	0	1	1	0	3	6	0.22
	Hydrophilidae	*G. berosus*	1	0	0	0	0	0	0	1	0	2	0.07
	Cantaridae	*G. sidius*	0	1	0	0	0	0	0	0	0	1	0.04
	Scaritidae	*G. spidoglossa*	0	0	0	0	1	0	0	0	0	1	0.04
Sub total 1			52	1	94	6	7	94	9	3	13	279	10.18
Dermaptera	Forficulidae	*Forficula senegalensis*	0	0	1	0	0	0	0	0	15	16	0.58
Subtotal 2			0	0	1	0	0	0	0	0	15	16	0.58
Diptera	Diopsidae	*Diopsis thoracica*	103	0	73	32	0	69	57	0	25	359	13.09
	Chironomidae	*G. chironomes*	0	1	0	0	0	0	0	0	0	1	0.04
	Tupilidae	*G. anyptera*	2	0	0	0	6	0	0	2	0	10	0.36
	Culicidae	*G. culex*	11	3	0	12	8	0	7	3	1	45	1.64
		Anopheles gambiae	7	0	0	6	10	0	1	6	0	30	1.09
	Sarcophagidae	*Sarcophaga carnaria*	24	0	0	44	2	0	34	0	0	104	3.79
	Muscidae	*G. musca*	25	1	0	9	1	0	28	7	0	71	2.59
	Chloripidae	*G. mepachymerus*	1	6	0	14	1	0	9	0	0	31	1.13
	Tipulidae	*G. Holorusia*	1	2	0	2	0	0	2	0	1	8	0.29
	Agromyzidae	*G. Liriomyza*	0	1	0	4	0	0	1	2	0	8	0.29
	Dolicopodidae	*Poecilobothrus nobilitatus*	95	1	2	46	16	0	92	15	0	267	9.73
		G. Scellus	48	1	0	12	0	0	23	0	0	84	3.06
	Mycetophilidae	*G. Platyura*	1	0	0	0	4	0	0	2	0	7	0.26
	Calliphoridae	*Calliphora vacina*	16	2	0	9	0	0	6	1	1	35	1.28
	Tachinidae	*G. Formosia*	0	0	0	0	0	0	59	0	0	59	2.15
	Stratiomyidae	*G. Hermetia*	3	0	0	9	0	0	19	0	0	31	1.13

	Syrphidae	*G. Toxomerus*	2	0	0	17	1	3	47	0	3	73	2.66
	Drosophilidae	*G. Drosophila*	3	0	0	3	0	0	11	0	0	17	0.62
Subtotal 3			342	18	75	219	49	72	396	38	31	1240	45.2
Heteroptera	Pentatomidae	*M. ypsilon*	0	0	5	0	0	21	7	0	124	157	5.72
		O. poecilus	0	0	0	0	0	0	0	0	1	1	0.04
		G. Aspavia	0	0	0	2	0	0	4	0	0	6	0.22
	Coreidae	*G. anacanthocoris*	1	0	6	0	0	9	0	0	9	25	0.91
		M. jaculus	0	0	0	1	0	3	1	0	9	14	0.51
		L. gonagra	0	0	0	0	0	0	0	0	19	19	0.69
	Pyrrhocoridae	*G. dysdercus*	0	0	0	0	0	0	0	0	2	2	0.07
	Rediviidae	*G. rhinocoris*	0	0	0	0	0	2	0	0	4	6	0.22
	Hydrometridae	*G. hydrometra*	0	0	0	0	1	0	0	0	0	1	0.04
	Miridae	*G. lygocoris*	0	0	0	5	1	0	1	2	0	9	0.33
		G. orthotylus	2	0	0	0	0	0	0	0	0	2	0.07
		G. polymerus	3	0	0	0	0	0	0	0	0	3	0.11
	Membracidae	*G. umbonia*	1	0	0	2	0	0	6	0	0	9	0.33
	Delphacidae	*Nilaparvata lucens*	15	6	0	20	6	0	28	0	0	75	2.73
Sub total 4			22	6	11	30	8	35	47	2	168	329	11.99
Homoptera	Jassidae	*Cicadella viridis*	8	0	1	5	4	1	2	2	0	23	0.84
		G. Balclutha	2	1	0	0	0	0	1	0	0	4	0.14
Sub total 5			10	1	1	5	4	1	3	2	0	27	0.98
Hymenopteraas	Apidae	*Apis mellifera*	4	0	3	0	0	8	13	0	10	38	1.38
		G. xylocopa	0	0	0	1	0	5	8	0	5	19	0.69
	Tenthredinidae	*G. dolerus*	10	0	1	25	0	3	74	0	1	114	4.16
	Ichneumonidae	*G. barylypa*	5	0	0	4	0	0	9	0	0	18	0.66
		G. lissonota	5	0	0	1	0	0	3	0	0	9	0.33
	Evaniidae	*G. brachygaster*	4	0	0	3	0	0	0	0	0	7	0.26
	Scoliidae	*G. scolia*	5	0	0	18	0	0	10	0	0	33	1.2
	Formicidae	*G. monomorium*	1	0	0	8	0	0	1	0	0	10	0.36
	Anthophoridae	*G. amegilla*	0	0	0	0	0	0	1	0	0	1	0.04
	Braconiidae	*G. bathyaulax*	1	0	0	0	0	1	4	0	0	6	0.22
Sub total 6			35	0	4	60	0	17	123	0	16	255	9.3
Isoptera	Termitidae	*G. macrotermes*	0	0	0	0	4	0	0	6	0	10	0.36
Sous total 7			0	0	0	0	4	0	0	6	0	10	0.36
Lepidoptera	Hesperidae	*G. pelopidas*	56	0	0	107	0	1	30	0	1	195	7.11
	Pyralidae	*Maliarpha separatella*	0	0	0	1	0	1	2	0	0	4	0.14
		Nymphula depunctalis	0	0	6	4	0	81	0	0	0	91	3.32
		G. scirpophaga	3	0	0	1	0	4	0	0	0	8	0.29
		G. chilo	2	0	0	1	0	0	3	0	0	6	0.22
	Noctuidae	*G. Sesamia*	0	4	0	0	6	0	0	2	0	12	0.44
	Bombicidae	*G. edama*	0	0	0	0	0	0	0	0	1	1	0.04
	Pieridae	*E. brigitta*	0	0	1	0	0	0	0	0	0	1	0.04
	Lycaenidae	*G. everes*	0	0	0	0	0	0	2	0	2	4	0.14
Sub total 8			61	4	7	114	6	87	37	2	4	322	11.74
Odonata	Coenagrionidae	*G. coenagrion*	4	0	17	7	0	6	1	0	8	43	1.57
	Libellulidae	*G. crocothemis*	4	0	7	10	0	1	3	0	3	28	1.02
		G. libellula	1	0	3	0	0	2	0	0	3	9	0.33
	Gomphidae	*G. gomphus*	1	0	0	0	0	0	0	0	2	3	0.11
Sub total 9			10	0	27	17	0	9	4	0	16	83	3.03
Orthoptera	Gryllidae	*G. gryllus*	0	23	0	2	22	0	0	4	0	51	1.86
	Gryllacrididae	*G. gryllacris*	0	26	0	0	7	1	0	1	0	35	1.28
		G. hyalogryllacris	2	0	0	3	0	0	0	1	1	7	0.26
	Gryllotalpidae	*G. africana*	4	0	0	0	9	0	0	0	0	13	0.47
	Acrididae	*S. gregaria*	4	0	3	3	0	8	1	0	7	26	0.95
	Tetrigidae	*G. tetrix*	7	0	10	2	3	3	1	5	2	33	1.2
	Tettigoniidae	*G. conocephalus*	0	0	0	0	0	0	16	0	0	16	0.58
	Pyrgomorphidae	*G. phymateus*	0	0	0	0	0	0	0	1	0	1	0.04
Sub total 10			17	49	13	10	41	12	18	12	10	182	6.64
Total			549	79	235	459	119	329	633	65	275	2743	
	%		20.01	2.88	8.57	16.7	4.3	12	23	2.4	10		100

SV : vegetative stage ; SR : reproduction stage; SM : maturation stage ; PC : color trap ;
PL : ligth trap ; CF : sweet net trap

Table 2: Efficacity of differents traps methods

Order	ligth trap	color trap
Diptera	105	957
Heteroptera	16	93
Coleoptera	11	67
Homoptera	7	18
Hymenoptera	0	218
Isoptera	10	0
Lepidoptera	16	208
Odonata	0	31
Orthoptera	102	45
Total	267	1637

3.1.3 Diversity of insects according to the stages of rice development

The lowest biological diversity index (H '= 1.37) was recorded during the vegetative stage. The reproductive and maturation stages were the most diversified with the indices of biological diversity respectively H '= 1.45 and H' = 1.43. But, these values are not statistically different (Kruskal-Wallis. p = 0.5349) (Figure 2).

3.1.4 Relative abundance of insect orders by phenological stage

The most abundant Order in the three stages of rice development was the order of Diptera (Figure 3). The relative abundance of this order was expressed at 50.52% at the vegetative stage. 37.49% at the reproductive stage and 47.60% at the maturation stage. The Isoptera Orders and Dermaptera one have not been observed in the vegetative and reproductive stages. At the vegetative stage, the Order of Coleoptera had a relative abundance of 17.03% followed by the Orders of Orthoptera and Lepidoptera with respectively a relative abundance 9.18% and 8.36%. At the reproductive stage, the Order of Lepidoptera recorded a relative abundance of 22.82% of the Orders collected, Coleoptera, Heteroptera, Hymenoptera and Orthoptera were also collected there with a relative abundances of 11.80%, 8.05%, 8.49% and 6.94%. At the maturation stage, the Order of Heteroptera (22.26%) followed by that of Hymenoptera (14.26%) were the most abundant after Diptera. The least abundant Orders at this stage of development were Dermaptera, Homoptera and Isoptera with relative abundance of 1.54%. and 0.61% respectively.

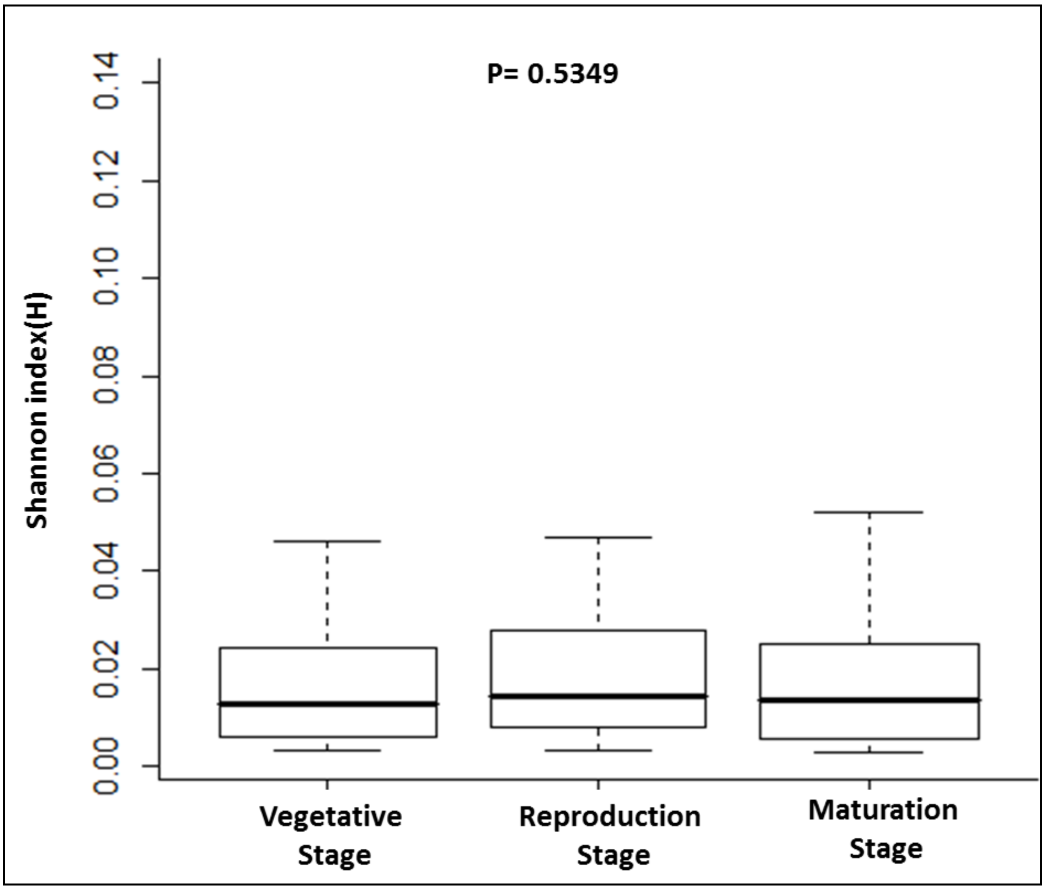

Fig 2: Diversity of insects according to the rice stage

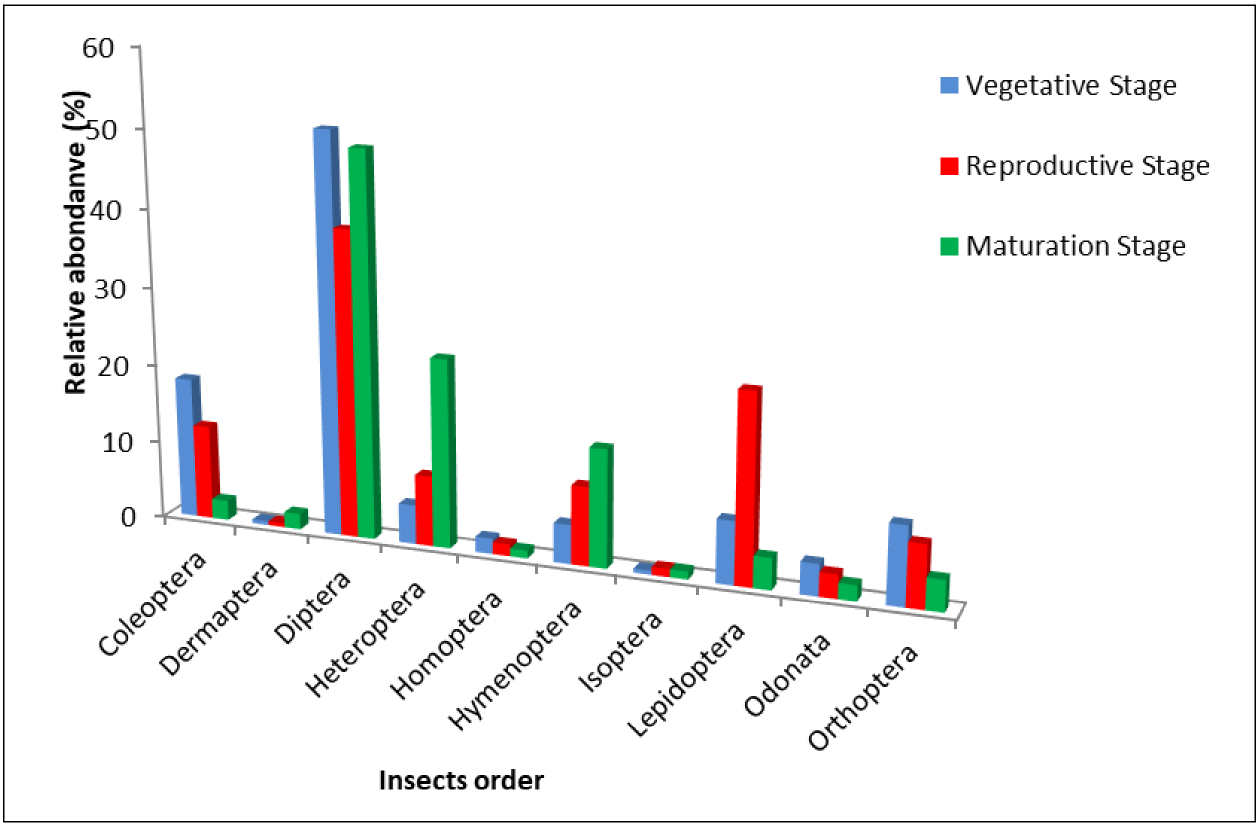

Fig 3: Abondance relative of insects according to rice phenological stage

4. Discussion

The relative abundance of insect orders collected is closely related to the different stages of rice development (Sadou *et al*., 2008) [1]. However. this parameter is higher at the vegetative stage for the Orders of Diptera, Coleoptera and Orthoptera. These results are similar to those obtained by Pollet (1977) [4]. Indeed of the 5 genera of stem borers and the 2 genera of phytophagous Lepidoptera inventoried by this author during the complete cycle of rice in Kotiessou. All the others were observed at the vegetative stage during the work. In addition, at the vegetative stage a large population of Chrysomelidae and Coleoptera were observed (Ondo *et al*., 2014; Rafarasoa *et al*., 2015) [2, 8].

During collections, the most observed Diptera belong to two families: Diopsidae and Dolichopodidae. Dolichopodidae and Culicidae have been captured in collections probably because of the lowland environment suitable for the development of larvae of species from these two families. These results corroborate those of Gourmel (2014) [14] and Rafarasoa *et al.* (2015) [8] who showed that most larvae of Dolichopodidae and Culicidae live in moist or swampy soils.

In view of the results obtained on Diopsidae it appears that the largest populations of Diopsis were observed at the vegetative stage. This could be explained by the good nutritional and environmental condition offered by this stage of development. These results are close to those reported by Brenière (1969) [15] ; Appert and Deuse (1988) [16] ; Polaszeck and Delvare (2000) [17], who report the presence of Diopsidae from the growth phase of rice. Also, Pollet (1977) [4], after a study on this genus, showed that the tillering stage is favorable to the multiplication of Diopsis but some individuals can also be observed at the beginning of the bolting stage.

Regarding Heteroptera, their presence on rice begins at the tillering stage and continues until the ripening stage with a peak at this stage. This proves that Heteroptera appreciate flowers and grains more. They are mainly Pentatomidae, Coreidae and Pyrrhocoridae grouped under the name Bug (Gourmel, 2014) [14]. They prick the seeds of the plants and suck the sap. Pollet (1977) [4], Ondo *et al*. (2014) [2] ; Rafarasoa *et al*. (2015) [8] reported that the bugs intervene on the panicles and bite the grains in formation or ripening. In addition, these results are similar to those obtained by Gourmel (2014) [14] who in his work on the main insect pests and crop auxiliaries in Guyana showed that the species Mormidea ypsilon and Oebalus poecilus of the Pentatomidae family are in Guyana. The main rice pests attacking grains at the milky stage. The species Mormidea ypsilon has, however, been observed in collections in the vegetative and reproductive stages. This is explained respectively by the proximity of other neighboring production subplots at more mature ages (subplots at the maturation stage) and by the appearance of the first panicles during the last two sampling runs. Orthoptera have been observed in the vegetative stage and in the ripening stage of rice. However. they are less abundant at the ripening stage. This low representativeness at the maturation stage can be explained by the fact that certain insects such as Gryllidae which are widely collected in light traps which feed on young stems are no longer present on adult plants. These results agree with those of Chhann (1975) [18], who showed that the economic incidence of phytophagi tends to decrease very rapidly with the growth of rice.

5. Conclusion

The study on the distribution of insects in relation to the phenology of rice (*Oryza spp*.). Showed that fluctuations in the number and genera of insects are a function of the phenological stages of the plant. It identified 2743 individuals during a production cycle. They are divided into 60 families belonging to 10 orders of insects. The main ones being the orders of Diptera with 1240 individuals, Heteroptera (329 individuals), Lepidoptera (322 individuals), Coleoptera (279 individuals), Hymenoptera (255 individuals) and Orthoptera (182). The abundance of insects at one stage compared to another is explained by food preferences but also by the environmental conditions offered by this environment. The insects collected are divided into pests predators and pollinators.

6. Aknowledgement

At the end of the study, we would like to thank ANADER zone of Daloa as well as all the rice farmers in the city for their collaboration. Indeed, this work is the result of your frank collaboration.

7. References

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