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PREVALENCE AND ABUNDANCE OF *CHARLETONIA* SP. (ACARI: ERYTHRAEIDAE) IN *ZONOCERUS VARIEGATUS* (LINNAEUS, 1958) (ORTHOPTERA: PYRGOMORPHIDAE) POPULATION IN THE HUMID FOREST ZONE OF SOUTHERN CAMEROON

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Abstract

KEKEUNOU, S., C. PROMBO and J. L. TAMESSE, 2015. Prevalence and abundance of *Charletonia* sp. (Acari: Erythraeidae) in *Zonocerus variegatus* (Linnaeus, 1958) (Orthoptera: Pyrgomorphidae) population in the humid forest zone of Southern Cameroon. *Bulg. J. Agric. Sci.*, 21: 372–377

Zonocerus variegatus (Linnaeus, 1758) (Orthoptera: Pyrgomorphidae) is an agricultural pest in Africa. Insecticide used against this grasshopper is harmful to the environment, and the search for an acceptable control method is a necessity. Weekly captures, observation and counts carried out from January to December 2011, enabled us to study the parasitism of *Z. variegatus* by *Charletonia* sp. Prevalence of *Charletonia* sp. in *Z. variegatus* populations was 30.74 ± 0.02%. While post embryonic stages and seasons affected *Charletonia* sp. prevalence, population and sex types showed no effect. The abundance of *Charletonia* sp. was 1.63 ± 0.19 per individual of *Z. variegatus*. *Charletonia* sp. was present in all the tagma of *Z. variegatus.* The parasite was more abundant on the thorax than the head and the abdomen. *Charletonia* sp. was present in the natural area throughout the year and we observed a low correlation between *Z. variegatus* and *Charletonia* sp. and between rainfall and *Charletonia* sp. abundance. To better understand the relationship between *Z. variegatus* and *Charletonia* sp., we will combine in future investigations, field samples with laboratory observations on the development of hosts and parasites.

Key words: Parasitism, *Charletonia*, Variegated grasshopper, Yaounde

Introduction

The variegated grasshopper - *Zonocerus variegatus* (Linnaeus, 1758) (Orthoptera: Pyrgomorphidae) is a polyphagous crop pest found in the forest and savanna zones of Central and West Africa (Chiffaud and Mestre, 1990). *Z. variegatus* generally has six nymphal instars under natural conditions (Chapman et al., 1986). In Yaounde, where the present study was conducted, *Z. variegatus* is present throughout the year in two univoltine populations, which has unequal abundance and durations (Messi et al., 2006). The large population appears from early January to November or December (10.5–11 months). The small population extended from mid-October to March or April (5.5–6 months). The adults of the two annual populations of *Z. variegatus* do not overlap, but each population of adults always coexist with the young nymphal instars of the subsequent population (Messi et al., 2006).

Z. variegatus attacks in its geographical range, varieties of crop plants species such as cassava, maize and soybeans (Kekeunou et al., 2007). In Southern Nigeria, over 50% of cassava crop is estimated to be lost in years of abundance of *Z. variegatus* (Modder, 1994). In the humid forest zone of Southern Cameroon, *Z. variegatus* is ranked as the third most economically important insect pest of agriculture. The damage caused by *Z. variegatus* is higher in fields adjacent to *Chromolaena odorata* and herbaceous fallows, than in

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those adjacent to forests and shrubby fallows (Kekeunou et al., 2006a).

Up to date, insecticides remain the crop protection strategy in the tropical forest zones. Their use in large areas has been one of the most important factors which helped in the increase of crop yield (Bani, 1990). However, due to their harmful effects on the environment, their use is not recommended, and the development of new pest control has become the priority (Kekeunou et al., 2006b). Through the physical fight, grasshoppers are collected mostly for human consumption (Kekeunou et al., 2006a). But this method is not efficient because it needs a lot of efforts. Egg-exposure, to control *Z. variegatus* has been recommended but the method has not been accepted by farmers in Nigeria (Modder, 1994). GREEN MUSCLE™ (use of *Metarhizium flavoviride* spores) has been proposed as a biological method, yet the cost of the product is very high for African farmers. Fungal spore production, handling and spray application technology may pose problems to small and medium scale farmers in developing countries (Add-Mensah, 2002).

Mites provide an excellent example of the potential opportunity for pest managers to exploit macro-parasites in grasshopper control (Welbourn, 1983). But not withstanding, the success of this method lies on the understanding of the ecology of these parasites (Belovsky, 1998). The typical development of Parasitengona includes 6 instars. The immobile, non-feeding (calyptostatic) pre larva is succeeded by the larva which is usually mobile and displays a parasitic life-style. The protonymph is calyptostatic, the deutonymph develops within the protonymphal cuticle and displays a predatory life-style after emergence. The mobile and predatory adult emerges from the calyptostatic tritonymph (Wohltmann, 2000).

Several species of mites (red mite) are reported as ectoparsites for a variety of grasshopper, which are pests of many cash crops in the world. Erythraeidae species are reported as ectoparasite at their larval stages for a variety of grasshoppers. Erythraeidae are of considerable importance in biological control and pest suppression (Kamran, 2009). The potential of erythraeids as biological control agents was suggested by Southcott and Kawashuma (Welbourn, 1983).

The genus *Charletonia* Oudemans, is widespread in all parts of the world (Haitlinger, 2004). Several species of this genus are known as parasites of Pyrgomorphidae grasshopper: *Charletonia adellae* (Haitlinger, 2007) lives on *Zonocerus elegans* (Linnaeus, 1758) in Madagascar (Haitlinger, 2007). *C. brunni* (Oudemans, 1910) lives on undetermined Pyrgomorphidae in Benin, Ethiopia, Ghana, Nigeria and Tanzania (Haitlinger, 2006). *C. keyi* (Southcott, 1983) lives on *Greyacris profundesulcata* (Carl, 1916) (Pyrgomorphidae) in Australia (Key, 1991). Despite de work of Paraiso et al. (1991) carried out in Benin, where the euthrombidium mite have been identified on *Z. variegatus*, the relationship between *Z. variegatus* and mite is poorly known in its geographical area.

The aim of the present study is to determine (1) the prevalence and abundance of *Charletonia* sp. as an ectoparasite of *Z. variegatus*, and (2) to highlight the factors which affect the phenology of *Charletonia* sp. in the natural area.

Materials and Methods

Study site

The study was carried out in the Yaounde urban area (Cameroon) from January to December 2011. The vegetation of Yaounde is a mixed humid forest which is more degraded by human activities. In the Yaounde area, rainfall distribution is bimodal, with two unequal dry seasons and two unequal rainy seasons. The short rainy season (March–June) is followed by the short dry season (July-August), and then the long rainy season (September-November) is followed by the long dry season (November-March) (Brunneau, 1999).

Sampling procedure

Samples of *Z. variegatus* were collected by sweep netting for a period of 60 min in crop fields and natural vegetation. We carried out regular collections and observations once every 7 days from January to December 2011 in the urbanized zone of Yaounde. During the capture, the larval stage and sex of each captured individual were noted and the number of *Charletonia* sp. was counted on antenna, cephalic capsule, prothorax, mesothorax, metathorax, wing, leg and abdomen of each collected individual. After each count, the individual was kept in an aerated bag. At the end of the 60 min, they were released at the site where they were collected.

Identification of Mites

The Mite genus was identified by Ryszard Haitlinger, Acarologist at Institute of Biology, Department of Invertebrate Systematics and Ecology, Wroclaw University of Environmental and Life Scienves, Kozuchowska, Wroclaw, Poland.

Data analysis

The prevalence and abundance of *Charletonia* sp. in *Zonocerus variegatus* population were calculated according to the definition of Bush et al. (1997). The SAS 9.1. proc freq helped us to calculate the prevalence of *Charletonia* sp., while the abundance of the parasite was assessed with the help of proc means (SAS 9.1). The Pearson Chi-square test was used to compare the prevalence between sexes, larval

stages and seasons. Because of the count data and the lack of normal distribution, we used Kruskal–Wallis (for k-samples) and Wilcoxon two sample tests (in SAS 9.1. procedures) to compare the abundance of *Charletonia* sp. between populations types, sexes, developmental stages of *Z. variegatus* and seasons. Spearman correlation allowed us to study the linear relationship between *Zonocerus* abundance, *Charletonia* sp. abundance as well as rainfall. The differences were deemed to be significant when $p < 0.05$.

Results

Prevalence of Charletonia sp. on Zonocerus variegatus

Prevalence of *Charletonia* sp. in *Zonocerus variegatus* populations was 30.74 ± 0.02%. This prevalence increased significantly from stage 1 larva (2.53 ± 0.02%) to adult stage (79.51 ± 0.05%) (Table 1). Prevalence in adult populations was close to that of stage 6 larvae (69.05 ± 0.08%); it was almost two times higher than that of stage 5 larvae (43.22 ± 0.06%); three times higher than that of stage 3 (21.37 ± 0.04%) and 4 (24.9 ± 0.05%) larvae; four times higher than that of stage 2 larvae (12.06 ± 0.04%) and 25 times higher than that of stage 1 larvae (2.53 ± 0.02%) (Table 1). The prevalence was significantly greater during the long rainy season (49 ± 0.05%) and the short dry season (71.33 ± 0.05%); it was 2–3 times less during the long dry season (18 ± 0.029%) and during short rainy season (16.5 ± 0.028%) (Figure 1). The population and sex types did not affect the *Charletonia* sp. prevalence ($p > 0.05$).

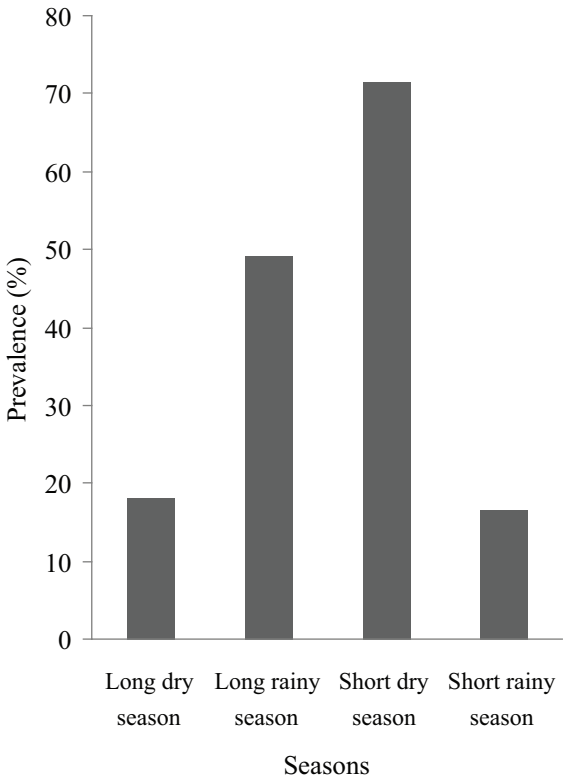

Fig. 1. Seasonal variations of the prevalence of *Charletonia* sp.on *Zonocerus variegatus* population from January to December 2011

Abundance and distribution of Charletonia sp. on Zonocerus variegatus

The abundance of *Charletonia* sp. varied from 0-47 (average 1.63 ± 0.19) per individual of *Z. variegatus*. *Charletonia* sp. abundance was higher in large population of *Z. variegatus* (1.9 ± 0.23) than in the small ones (0.6 ± 0.18) (Z = –1.99; p = 0.046). In each population of *Z. variegatus*, *Charletonia* sp. abundance increases from stage 1 larvae (0.025 ± 0.015) to adult stage (6.56 ± 0.99). Adults and stage 6 larvae were more infected than stage 5 larvae which were more infected than stage 4, 3, 2 and 1 larva (Table 2). *Z. variegatus* male and female were infected at the same level.

In each population, *Charletonia* sp. was present in all the tagma of *Z. variegatus* and parasite was more abundant on the thorax than the head and abdomen (Table 3). The lowest abundance was noticed in the abdomen. On the thorax of the large population individuals, wings were more infested

Table 1
Prevalence(%) of *Charletonia* sp. on the post-embryonic developmental stages of the smaller and larger populations of *Zonocerus variegatus,* from January to December 2011

Population Type	Stage 1 larvae	Stage 2 larvae	Stage 3 larvae	Stage 4 larvae	Stage 5 larvae	Stage 6 larvae	Adult	p-value	X^2-value	Total
Large	1.81±0.02	6.54±0.04	16.25±0.04	18.63±0.05	39.60±0.07	69.89±0.07	79.28±0.05	<0.0001	172.17	30.85±0.02
Short	4.20±0.04	23.76±0.09	37.50±0.10	49.06±0.14	64.71±0.17	62.5±0.20	100±0	<0.0001	118.93	30.33±0.04
X^2-value	0.32	8.68	7.63	12.79	5.57	0.31	2.17			0.004
p-value	0.57	0.003	0.006	0.0003	0.018	0.58	0.14			0.95
Total	2.53±0.02	12.06±0.04	21.37±0.04	24.90±0.05	43.22±0.06	69.05±0.08	79.56±0.05			30.74±0.02

The values are percentage ± confidence limit. P-value is the significance level of Chi-square-Test

Table 2
Abundance of *Charletonia* sp. on the post-embryonic developmental stages of the smaller and larger populations of *Zonocerus variegatus*, from January to December 2011

Population Type	Stage 1 larvae	Stage 2 larvae	Stage 3 larvae	Stage 4 larvae	Stage 5 larvae	Stage 6 larvae	Adult	H-value	p-value	Means
Large	0.02±0.02	0.07±0.04	0.3±0.11	0.28±0.10	1.83±0.47	5.62±0.99	6.47±0.99	677.31	<0.0001	1.9±0.23
Short	0.04±0.04	0.42±0.19	0.72±0.34	0.70±0.24	1.24±0.41	1.17±0.57	12.67±39.48	96.34	<0.0001	0.60±0.18
Z-value	1.39	4.47	4.07	4.56	1.60	-3.10	0.91			-1.99
p-value	0.16	<0.0001	<0.0001	<0.0001	0.11	0.002	0.36			0.05
Means	0.025±0.02	0.18±0.69	0.40±0.11	0.36±0.09	1.75±0.41	5.11±0.91	6.56±0.99	755.65	<0.0001	1.63±0.19

Number of *Charletonia* sp.per *Z. variegatus* individuals capturedis given as mean values ± confidence limit. P-value is the significance level of Wilcoxon two sample (Z) and Kruskal Wallis (H) Tests.

Table 3
Abundance of *Charletonia* sp. on different tagma of the post-embryonic developmental stages of the smaller and larger populations of *Zonocerus variegatus* in the Yaounde agrosystems, from January to December 2011

Population Type	Tagma	Stage 1 larvae	Stage 2 larvae	Stage 3 larvae	Stage 4 larvae	Stage 5 larvae	Stage 6 larvae	Adult	H-value	p-value
Large	*Head*	0.007±0.009	0.009±0.01	0.01±0.01	0.03±0.03	0.07±0.05	0.05±0.04	0.005±0.009	18.33	0.005
	Thorax	0.01±0.01	0.04±0.03	0.23±0.10	0.21±0.09	1.61±0.43	5.09±0.93	6.34±0.97	699.85	<0.0001
	Abdomen	0	0.02±0.02	0.06±0.03	0.03±0.03	0.14±0.07	0.48±0.16	0.13±0.48	146.48	<0.0001
	H-value	2.81	5.32	36.62	29.99	100.59	206.4	407		621.95
	p-value	0.24	0.07	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
Short	Head	0	0.03±0.03	0.08±0.07	0.04±0.05	0.06±0.08	0	0	9.75	0.03±0.02
	Thorax	0.04±0.04	0.33±0.16	0.56±0.28	*0.53*±0.22	1.09±0.39	*0.96±0.52*	12.67±39.48	81.28	0.50±0.17
	Abdomen	0	0.06±0.07	0.08±0.07	0.13±0.09	0.09±0.13	0.20±0.18	0	24.15	0.07±0.03
	H-value	10.11	20.63	30.53	22.78	36.08	17.88	7.62		129.11
	p-value	0.006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.02		<0.0001

Number of *Charletonia* sp.per *Z. variegatus* individuals captured is given as mean values ± confidence limit. P-value is the significance level of Kruskal Wallis (H) tests

than legs and the body of the thorax while legs were more infected in the smaller population than wings and the body of the thorax. Regarding the head, in the both populations, no difference of abundance were noticed between antenna, mouth part and head capsule.

Parasites were most abundant in August during the short dry season. The abundance was low during the long dry season and the long and short rainy season (Figure 2). When considering each developmental stage, we found out that the stage 1 larvae were more abundant during the short rainy season, while stage 2 larvae were more abundant during the long rainy season. Stage 3 larvae were most abundant during the long dry and rainy seasons. Stage 4, 5 and 6 larvae were more abundant during the short dry season. Adults were more abundant during the dry season and most abundant during the short rainy season.

Relationship between Z. variegatus and Charletonia sp. abundance and rainfall

Charletonia sp. and *Z. variegatus* were both permanently present in the natural area throughout the year. The correlation between *Z. variegatus* and *Charletonia* sp. abundance was non significant. *Z. variegatus* abundance increased significantly with rainfall ($r = 0.38$; $p = 0.005$), while the correlation between rainfall and *Charletonia* sp. abundance was non significant ($r = 0.09$; $p = 0.49$).

Discussion

The mite species which parasites *Z. variegatus* in Yaounde are different from that which parasites the same host in Benin (Paraiso et al., 1991). Then, *Z. variegatus* is parasited by several mite species in his geographical range. The fact that *Charletonia* sp. was present throughout the year in all of the post-embryonic developmental stage of *Z. variegatus* (larvae and adults) suggests that *Z. variegatus* is a well suited host for *Charletonia* sp. under natural conditions. However, Key (1991) considers *Charletonia* larvae as an occasional parasite of Pyrgomorphidae. The permanent presence of *Charletonia* sp. in the natural area could be linked to the synchronization of the *Charletonia* phenology with that

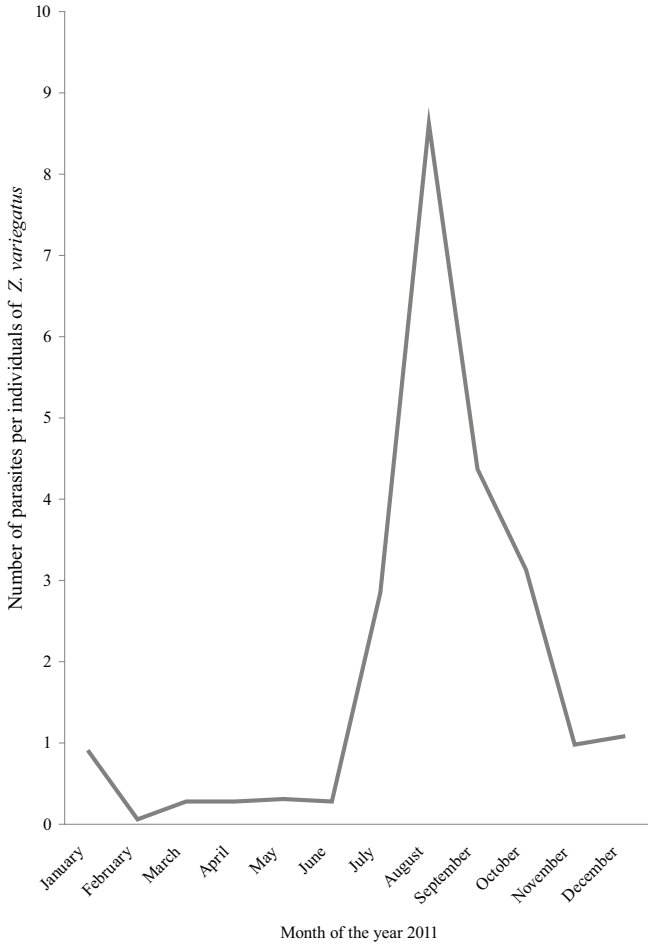

Fig. 2. Monthly variations of the abundance of *Charletonia* sp. per individual of *Zonocerus variegatus* from January to December 2011

of *Z. variegatus*. In fact, (1) *Z. variegatus* is present throughout the year in the humid forest zone of Southern Cameroon (Messi et al., 2006); (2) the high degree of synchronization of populations found in most species of parasitengona results in the synchronous appearance of larvae with their hosts (Wohltmann, 2000).

In the urban zone of Yaounde, *Charletonia* sp. prevalence is low (30.74%). This is similar to that of Eutrombidid which parasites *Z. variegatus* in Lama (Benin) (30%) by December (Paraiso et al., 1991). This prevalence rate is higher than that of *Eutrombidium* on *Hieroglyphus oryzivorus* (18.25%), *Hieroglyphus nigrorepletus* (12.86) and *Hieroglyphus perpolita* (12.31%) in Pakistan (Sultana et al., 2012). However, in some trombidioid species infestation rate is usually much less than 50%, but may be higher and reach up to 100% in particular species at particular places (Wohltmann, 2000).

The seasonal variation in the prevalence observed here was also reported by Chiffaud and Mestre (1990) in *Blaesoxipha filipjevi* populations, which showed a prevalence of nearly 80% during the rainy season. However, during our study, in addition to the long rainy season (49.30%), the short dry season (69.96%) also corresponds to a period of high prevalence. The variation in prevalence observed between the different stages of development and different seasons could be linked to the variation in the incidence of the parasite, and the persistence of the parasite in the environment (Hostetter et al., 1991).

The abundance of *Charletonia* sp. on *Zonocerus variegatus* ranged from 0-47 individuals (an average of 1.59 ± 0.19). These values are close to those obtained in Trombidiidea by Hostetter (1998) who noted an abundance of 1-41 parasites per individuals. In the Lama forest in March, up to 45 mites were counted on one individual of *Z. variegatus* (Paraiso et al., 1991). *Charletonia* sp. lives preferably under the wings of *Z. variegatus*. This site preference has been noted for some Microtrombidiidae parasitizing *Brachycera*. In this case, the field data indicates site specificity to the dorsal parts of the thorax and the first abdominal segments (Wohltmann, 2000). The high abundance of mite on the wings of grasshopper has also been noticed by Hostetter (1998). This high abundance of *Charletonia* sp. on the wings of *Z. variegatus* might be linked to the soft nature of the membrane attachment of the wing on the body. However, in "short-horned" grasshoppers in Australia, sites of attachment on the host vary with the species of mite (Key, 1991). Many Erythraeidae (e.g. *Charletonia cardinalis*, *Erythraeus* spp., *Leptus* spp.) display no clear site specificity but attach to various parts of the host (Wohltmann, 2000).

Conclusion

In the natural vegetation of the Yaounde urban area, *Charletonia* sp. is an ectoparasite of *Z. variegatus*. *Charletonia* sp. is present throughout the year and parasites all the post embryonic developmental stages and all tagma of *Z. variegatus*. The prevalence of *Charletonia* sp. is 30.74 ± 0.02% while the abundance is 1.63 ± 0.18 parasites per host individual. Parasites are most abundant on the thorax. The correlation between rainfall and *Charletonia* sp. abundance is low. The knowledge obtained in this work is useful in the search for possibilities of using *Charletonia* sp. in the fight against *Z. variegatus*. To better understand the relationship between *Z. variegatus* and *Charletonia* sp., we will combine in future investigations field samples with laboratory observations, on the development of hosts and parasites.

Acknowledgments

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