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Abundance and Life Cycle of *Pyrgomorpha vignaudii* (Orthoptera: Pyrgomorphidae) in the Humid Forest Zone of Southern Cameroon

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ABSTRACT

With a view to facilitating a sustainable strategy for the control of *Pyrgomorpha vignaudii* (Orthoptera: Pyrgomorphidae), weekly captures from August 2013 to September 2014 enabled us to study the abundance and life cycle of this grasshopper in the Tongolo and Nkolbisson neighbourhoods of Yaounde in the humid forest zone of Southern Cameroon. We found that *P. vignaudii* was present throughout the year in the human-influenced zones of Yaounde. The species has a bivoltine life cycle with equal abundance and durations of the two generations. The abundance of *P. vignaudii* varied according to the post-embryonic stage, sex and season. Hatching and coupling took place during both the dry and rainy seasons. The life cycle of *P. vignaudii* in the humid forest zone of Southern Cameroon is similar to that in the Soudano-sahelian zone of Burkina-fasso.

Key words: Presence, abundance, phenology, Yaounde, *P. vignaudii*.

INTRODUCTION

Pyrgomorpha vignaudii (Guérin-Méneville, 1849) (Orthoptera: Pyrgomorphidae) (Mc Kevan and Mc Hsiung, 1985) is a crop pest widely distributed in tropical Africa. *P. vignaudii* is a mesophilous and geophilous species with a mixed diet. It is an agricultural pest associated with cowpea (*Vigna unguiculata*) (IITA, 1984), soyabean (*Glycine max*) (Adamu *et al.,* 1999; Harish 2008), rice (*Oryza sativa*) (Heinrichs and Barrion, 2004), *Ceratotheca seasamoides* (Fassakin, 1991), millet (*Sorghum arundinaceus*) and amaranth (*Amaranthus spinosus*) (Paraiso *et al*., 2012).

In the Soudano-sahelian zones of Burkina fasso, *P. vignaudii* shows continuous reproduction (Duranton *et al.,* 1987) with two generations per year, one in the rainy season (between July and November) and the other in the dry season (between December and June) (Duranton *et al*.,1987). The duration of embryonic and larval stages coupled with sexual maturation (estimated in time from final moult to first mating) were 100, 50 and 55 days for the dry season generation and 80, 30 and 20 days for the rainy season generation respectively (Duranton *et al*., 1987). In the

forest zone of Cameroon, post-embryonic development (observed in the laboratory) has seven stages. The total number of days required for larval development varied from 77 to 108. The mean duration of development of larval stages 1,2,3,4,5 and 6 were 16.48±0.43, 14.40±0.55, 13.70±0.61, 15.07±0.84, 15.21±1.31 and 16.21±1.27 days respectively. After the final molt, the females of *P. vignaudii* take an average of 12.7±1.04 days before the 1st mating (Kekeunou *et al*., 2015). The time between the first mating and first oviposition ranged from 14 to 34 days (averagely 25.2 ± 4.62 days). The females completed one to nine ovipositions during their lives. The number of eggs per egg-pod (ootheca) varies from 16 to 93 with a mean of 45.31±3.51 (Kekeunou *et al*., 2015). Nothing is known about fluctuations in abundance and the life cycle of *P. vignaudii* in the forest area of Africa.

The main objective of the present study was to assess (1) the presence and abundance of *P. vignaudii* during the year; and (2) the life cycle type of the grasshopper in the degraded zones of Yaounde. This work was done with the perspective of clarifying the phenology of *P. vignaudii* in its natural habitat.

MATERIALS AND METHODS

Study site

The study was carried out in Yaounde in the humid forest zone of southern Cameroon between August 2013 and September 2014. In Yaoundé (3°87' N, 11°52' E), the vegetation is a mixed forest and which is very degraded by human activities. The natural herbaceous grassland is dominated by annual and perennial species. Air temperature during the experimental period ranged from 22 to 29° Celsius. Rainfall distribution is bimodal, with two unequal dry seasons and two unequal rainy seasons. The short (light) rainy season (mid March-June) is followed by the short dry season (July-August), then the long (heavy) rainy season (September-mid November) is followed by the great dry season (mid November-mid March). Field sampling was done in Tongolo and Nkolbisson which are two neighbourhoods of Yaounde, separated by a distance of about 20 km. Nkolbisson and Tongolo are located in the urban zone, with scanty density of trees. The study site at Nkolbisson was dominated by turf (lawn), while the site at Tongolo had vegetation characterized by *Manihot esculenta* (Euphorbiaceae), *Zea mays* (Poaceae) during the rainy seasons and *Chromoleana odorata* (Asteraceae) and *Mimosa invisa* (Mimosaceae) during the dry seasons.

Sampling procedure and larval identification

In each site (Tongolo and Nkolbisson), samples of *P. vignaudii* were collected by sweep-netting for a period of 30 min in natural vegetation (Duranton *et al*., 1987). We carried out regular collections and observations once every 7 days from August 2013 to September 2014. All the collections began from a fixed point and extended across the entire site. During sampling, all cases of coupling and ovipositions were recorded. The collected individuals were kept in aerated bags and were counted by stage (larval stadium and adult) and by sex in the laboratory.

Larval identification was carried out in the laboratory and/or in the natural area using the key of Kekeunou *et al*. (2015). The larvae were identified with naked eyes, portable magnifier or stereomicroscope, depending on the different larval stages. Thereafter, they were released at the site where they were collected.

Data analysis

The abundance mean of *P. vignaudii* population was analysed using SAS version 9.1. Due to the count data and the absence of normal distribution, we used Kruskal-Wallis (for k-samples) and Wilcoxon two sample tests (SAS 9.1) to compare the abundance between populations types, sexes, developmental stages of grasshoppers and seasons. The differences were deemed to be significant when $p < 0.05$.

RESULTS

Presence of *Pyrgomorpha vignaudii* in the nature

At both sites (Tongolo and Nkolbisson), *P. vignaudii* was present throughout the year. Two separate periods of coupling were observed during the year followed by two periods of presence for each nymphal instar (Figs. 1-4).

The first generation was observed from early April to mid-December (8.5 months). For this generation, stages 1, 2, 3, 4, 5, 6 larvae and adults were present respectively from early April to late June (3 months); from mid-April to mid-August (3.5 months); from late April to mid-September (4 months); from mid-May to late August (3.5 months); from late May to mid-October (4.5 months); from early July to late October (4 months) and from early August to mid-December (4.5 months). Couplings were observed from mid-August to mid-December (Figs. 1-4).

The second generation of *P. vignaudii*, was observed in late October to early June (7 months). Stage 1 larvae were present from late October to late January (3 months); stage 2 larvae were observed between early November and mid-February (3.5 months); the stage 3 larvae were present from mid-November to early March (3.5 months); those of stage 4 were observed from mid-November to late March (4.5 months); stage 5 larvae were present from mid-November to early April (4.5 months); those of stage 6 were observed from late November to mid-April (4.5 months) and adults from mid-December to late April (4.5 months). The couplings of the second generation were observed from mid-February to mid-April in the wild (Figs. 1-4).

Overlapping of the two generations of *Pyrgomorpha vignaudii*

The first annual generation of adults coexisted in each site with stages 1 to 6 larvae of the second generation between the end of October and mid-December. The adults of the second generation coexisted with stages 1 to 6 larvae of the first generation between early April and early June (Figs. 3, 4).

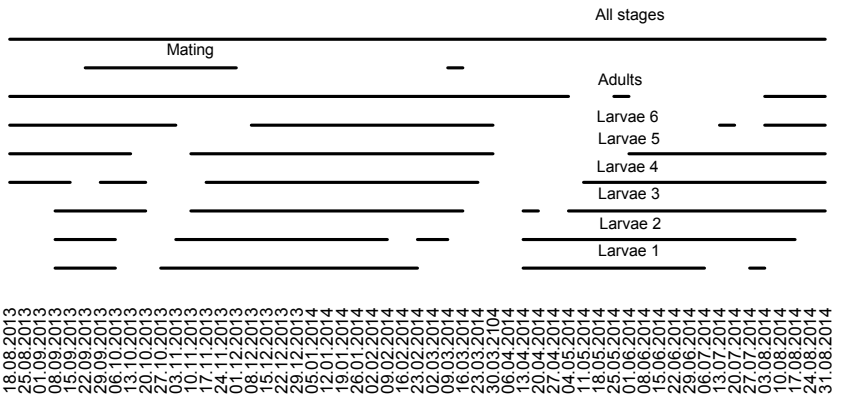

Fig. 1. Occurrence of each stage of *Pyrgomorpha vignaudii* in each generation in Nkolbisson (Yaounde-Cameroon), from August 2013 to September 2014.

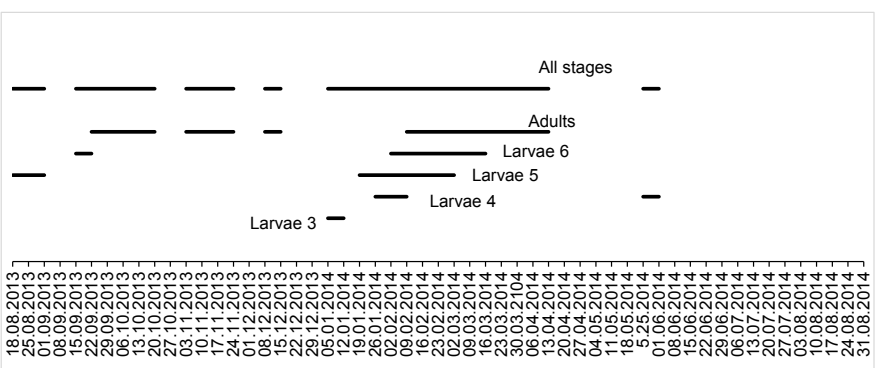

Fig. 2. Occurrence of each stage of *Pyrgomorpha vignaudii* in each generation in Tongolo (Yaounde-Cameroon), from August 2013 to September 2014.

Table 1. The abundance of post-embryonic developmental stages of *Pyrgomorpha vignaudii* in Tongolo and Nkolbisson, in the forest zone of Yaoundé, from August 2013 to August 2014.

Populations	Stage 1 larva	Stage 2 larva	Stage 3 larva	Stage 4 larva	Stage 5 larva	Stage 6 larva	Adult	Total
Nkolbisson	53,07±110,78 (0-627)	36,32±60,87 (0-240)	25,59±39,27 (0-205)	18,50±23,57 (0-81)	10,03±9,63 (0-32)	9,40±12,01 (0-52)	10,90±14,37 (0-71)	163,81±171,59 (7-860)
Tongolo	0	0,01±0,13 (0-1)	0,32±0,92(0-5)	0,34±0,86 (0-4)	0,50±1,10 (0-5)	0,57±1,26 (0-6)	1,21±2,00 (0-8)	2,97±3,79 (0-13)
Wilcoxon-value	7,37	7,79	7,69	7,3	6,82	5,87	5,35	9
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Each value in the table represents the mean (30 minutes capture per week) and standard deviation. p-value is the significant level of the Wilcoxon-value (Wilcoxon two samples test). In bracket: minimum and maximum. Number of samples = 55

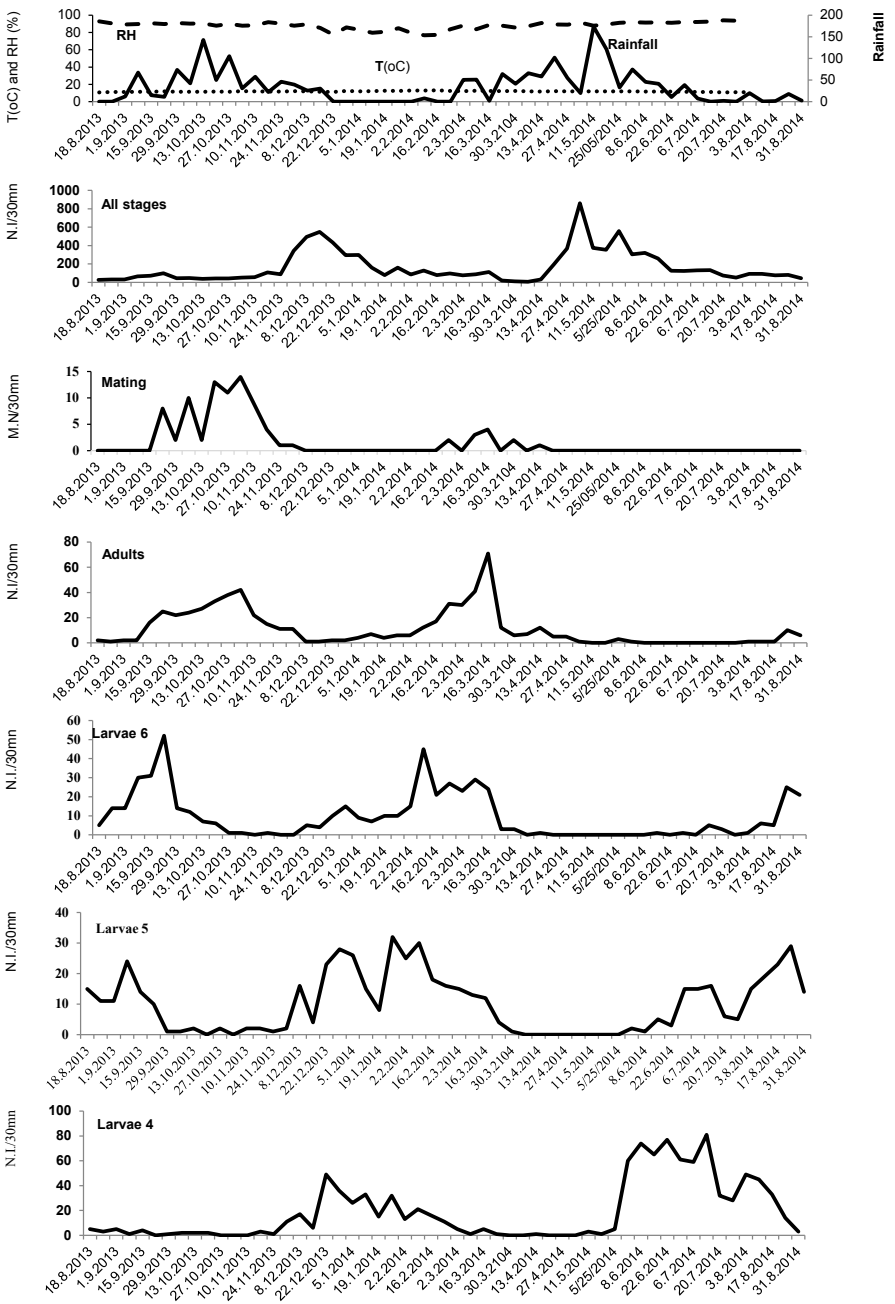

Fig. 3. Temporal fluctuations of rainfall, relative humidity (RH), temperature and *Pyrgomorpha vignaudii* abundance (30 minutes capture/week) in Nkolbisson (Yaounde-Cameroon), from August 2013 to September 2014. M.N.= Mating number, N.I.= Number of Individuals, T=temperature.

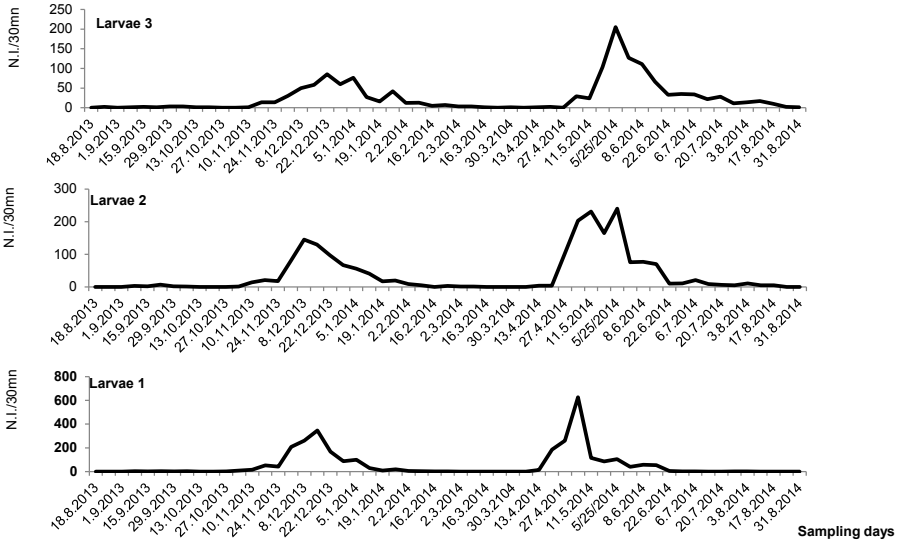

Fig. 3. Continued.

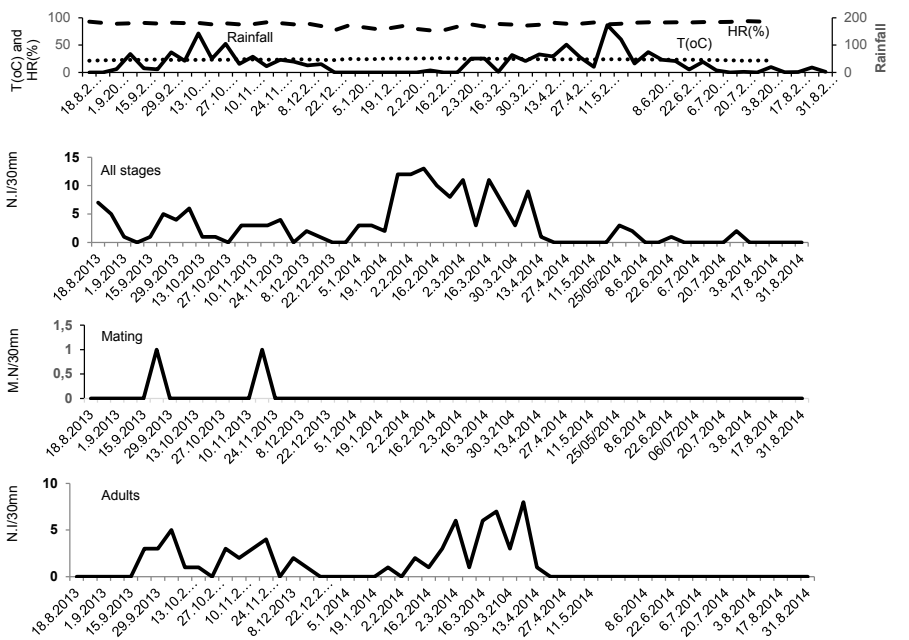

Fig. 4. Temporal fluctuations of rainfall, relative humidity (RH), temperature and *Pyrgomorpha vignaudii* abundance (30 minutes capture/week) in Tongolo (Yaounde-Cameroon), from August 2013 to September 2014. M.N.= Mating number, N.I.= Number of Individuals, T=temperature.

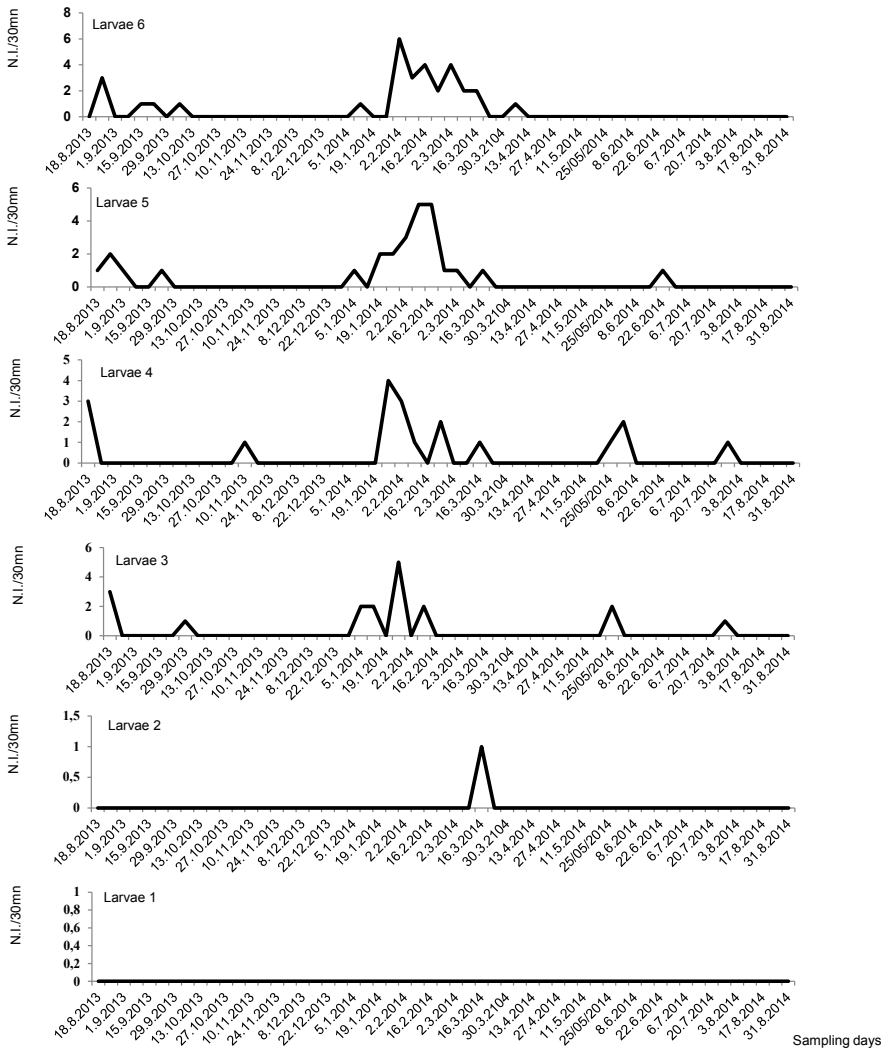

Fig. 4. Continued.

Variation in abundance of *Pyrgomorpha vignaudii*

In all post-embryonic developmental stages, *P. vignaudii* was more abundant in Nkolbisson than in Tongolo; the population level was very low in Tongolo (Table 1). The two generations showed the same level of abundance (Table 2). The first generation of *P. vignaudii* was present during all the four seasons, but with highest abundance during the short dry and rainy seasons (Fig. 5). The second generation was present mainly during the short dry season. This generation was absent during the short dry season but present in the rainy seasons with a very low abundance (Fig. 5).

The number of couplings observed varied from 1 to 14, with an average of 7.00 ± 4.94 in the first generation and 1 to 4 (1.50 ± 1.51 on average) in the second generations (Figs. 3, 4).

Table 2. The abundance of post-embryonic developmental stages of the first and second generations of *Pyrgomorpha vignaudii* in the forest zone of Yaoundé, from August 2013 to August 2014.

Generation	Stage 1 larva	Stage 2 larva	Stage 3 larva	Stage 4 larva	Stage 5 larva	Stage 6 larva	Adult	Average
First	43,06±115,62 (0-627) n=36	33,05±67,001 (0-240) n=38	20,9±42,47 (0-205) n=42	16,25±25,98 (0-81) n=44	5,1±7,62 (0-29) n=52	4,85±10,01 (0-52) n=54	7,73±11,34 (0-42) n=44	16,99±51,03 (0-627) n=310
Second	27,38±70,77 (0-347) n=50	13,74±32,17 (0-145) n=54	8,5±18,84 (0-85) n=64	5,94±10,93 (0-49) n=54	7,47±9,84 (0-32) n=42	7,15±10,29 (0-45) n=40	6,52±12,53 (0-71) n=50	11,02±32,05 (0-347) n=354
Wilcoxon-value	0,1	1,18	0,86	1,29	1,57	2,01	0,33	0,31
p-value	0,91	0,23	0,4	0,19	0,11	0,04	0,73	0,76

Each value in the table represents the mean (30 minutes capture per week) and standard deviation. p-value is the significant level of the Wilcoxon-value (Wilcoxon two samples test). In bracket: minimum and maximum. n=number of samples.

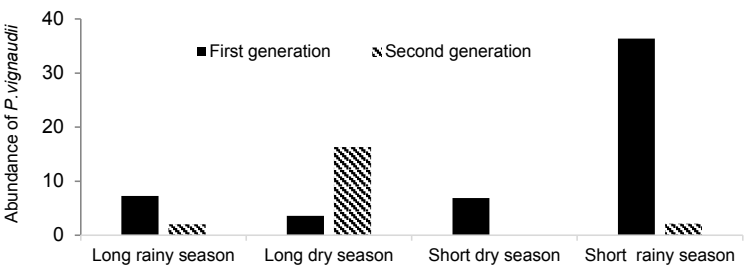

Fig. 5. The abundance of the first and second generations of *Pyrgomorpha vignaudii* in the rainy and dry seasons of the forest zone of Yaoundé, from August 2013 to August 2014.

DISCUSSIONS

The present study showed that *Pyrgomorpha vignaudii* is present throughout the year with a bivoltine life cycle carrying an equal abundance and duration of the two generations. The fact that the embryonic developmental period of *P. vignaudii* is almost 49.72±9.35 (29-74) days in Yaoundé (Kekeunou, unpublished data), strongly suggests that, the adult of each period is the parent of the first nymphal instars with which these adults coexist. In terms of number of generation, this type of life cycle is similar to that reported in the Soudanian-Sahelian zones (Burkina Fasso) (Duranton *et al*., 1987). Also, the life cycle of *P. vignaudii* is stable; it is not a flexible type as that of *Z. variegatus* (De Gregorio, 1982; Chapman *et al*., 1986; Duranton *et al*., 1987).

In the humid forest area, however, *P. vignaudii* appears earlier than in the Sahel. The first generation in forest areas appeared in April, while that of the Sahel appears 3-months later, around the month of July. The second generation starts in the forest

zone in October and in the Sahelian zone around December (about 1-month later). This delay would be related to the ecological differences which occurred between forest and Sudanian zones. In fact, the distribution of rainfall in the forest (Yaounde) zone is bimodal, with high rainfall (about 1600mm), whereas in the Sahelian and Sudanian (Burkina Fasso) zones, the vegetation type is savanna and the rainy season is short, unimodal and very low (400 mm of rain per year) and does not exceed 3 months in length.

A trivoltine population was found in *P. cognata* in the Sahel by Duranton *et al.* (1987). This shows that, the life cycle type varies in the genus *Pyrgomorpha.* This variation of voltinism between the species of this genus would be due to the differences in the number and duration of post-embryonic stages of development. Indeed *P. vignaudii* shows 6 larval stages (Kekeunou *et al.,* 2015) or 6-7 stages (Popov, 1989) and *P. cognata* shows 5 stages (Launois-Luong and Lecoq, 1989). Overlapping generations noted in this study is not a new phenomenon in the genus *Pyrgomorpha*; it has also been observed in *P. cognata* (Duranton *et al*., 1987). This phenomenon is explained by the type of development, which is a continuous type for these species (Duranton *et al*., 1987).

The high abundance of *Pyrgomorpha vignaudii* noted in Nkolbisson related to Tongolo can be explained by the differences in the structure and composition of vegetation present in the two sites. The Nkolbisson neighbourhood would offer more favorable conditions for the survival of *P. vignaudii.* Indeed, the site of Nkolbisson is dominated by turf (lawn) unlike the site of Tongolo showing a studded vegetation characterized by *Manihot esculenta* (Euphorbiaceae), *Zea mays* (Poaceae) during the rainy seasons and *Chromoleana odorata* (Asteraceae) and *Mimosa invisa* (Mimosaceae) during the dry seasons. Lawns seem to be the preferred habitat for the *Pyrgomorpha* species; this type of habitat has also been observed in *P. conica* in the Sahel (Burkina Faso) (Launois-Luong and Lecoq, 1989). This can also be explained by the fact that the capture site at Nkolbisson was very close to the experimental rice field of IRAD. Indeed, in Cameroon, Heinrich and Barrion (2004) had noted that *P. vignaudii* is a pest of rice plants.

The abundance of *P. vignaudii* varies between post-embryonic developmental stages. At Nkolbisson, it decreases from stage 1 larvae to adult stage; an opposite trend to that of Nkolbisson is noted in Tongolo (Table 1). These differences between the two sites might be explained by the differences noted in the vegetation structure of the two sites. The turf (lawn) which dominated the Nkolbisson site is a herbaceous vegetation of very small height (<30 cm) which facilitates the capture of larvae and adults while in Tongolo, the vegetation is constituted of Manihot esculenta (Euphorbiaceae), *Zea mays* (Poaceae), *Chromoleana odorata* (Asteraceae) and *Mimosa invasa* (Mimosaceae) which sometimes form dense clumps in which the larvae can hide. In fact, the young larvae of *P. vignaudii* live near the ground and the length of *P. vignaudii* developmental stages increases after each molt. It is obvious that the abundance of larvae increases in Tongolo from stage 1 larvae to adult stage.

The fact that the level of abundance of both generations is the same suggests that the fertility rate of two generations is on equal basis, unlike the case of *Zonocerus*

variegatus where both populations are characterized by different genetic features and reproduction.

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