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Natural Enemies of *Calidea panaethiopica* (Heteroptera: Scutelleridae): An Insect Pest of *Jatropha curcas* L. in the South-Sudanian Zone of Burkina Faso

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Abstract

Jatropha curcas **L. is a non-edible oleaginous plant of Euphorbiacea family. Its seeds provide oil for industrial use, and when grown as a biofuel, *J. curcas* can be used to restore degraded soil by improving their fertility and by controlling water and wind erosion. The plant also reduces CO_2 emission by carbon sequestration. However, *J. curcas* is attacked by many insect pests including *C. panaethiopica*, a polyphagous heteroptera of the Scutelleridae family. Larvae and adults of the insect pest feed on *J. curcas* flowers, fruit, and seeds, thereby causing quantitative and qualitative losses. Despite the economic importance of this insect pest, there is little known about its potential natural enemies. A survey of the natural enemies of *C. panaethiopica* was carried out from 3rd June 2013 to 29th May 2014 on three *J. curcas* production sites in the South-Sudanian zone of Burkina Faso. Three Hymenopteran egg parasitoids all belonging to the Scelionidae family were found. These included *Trissolcus basalis* (Wollaston), *Psixstriaticeps* (Dodd), and *Gryon* sp. Several predator species belonging to the Araneae, Tarachodidae and Mantidae families were also found. The egg parasitism increased progressively between June and September 2013, reaching a peak (43%) in September 2013. The number of spiders and mantises was higher between July and August 2013. The highest numbers of natural enemies associated with the insect pest were recorded in *J. curcas* monoculture plantations.**

Keywords

Burkina Faso, Survey, *Jatropha curcas*, Natural Enemies, *Calidea panaethiopica*

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1. Introduction

Jatropha curcas L. is a shrub originating from South America, producing non-edible oil used as fuel in partial or total replacement of fossil fuels [1]. Its height varies between 3 and 5 m [2]. This shrub is believed to have been introduced in Africa by Portuguese sailors from Cape Verde and Guinea Bissau in the 16th century [3]. The *Jatropha* genus contains about 170 known species [4].

In Burkina Faso, 4 species of Jatropha are known: *J. curcas* L., *J. gossypiifolia* L., *J. podagrica* H. and *J. integerrima* J. [5]. But the *J. curcas* L. species is the most widely spread and the most exploited.

The toxic and anti-nutritional properties of *J. curcas* seeds are used in traditional medicine for disinfestations and as a purgative [6]. *Jatropha curcas*' seeds contain 30% to 40% oil that can be an alternative to diesel fuel [4]. Biofuels contribute to reducing dependence to energy for countries that have no access to fossil oil resources [7]. Seed yield is between 0.2 to 2 kg/tree [8]. The yield may reach 2.5 to 3 metric tons of seed per hectare by the fifth year in Southern Mali [9]. *J. curcas* L. contributes both to the diversification of agricultural production and to increasing the incomes of small scale farmers and therefore to poverty alleviation in rural areas through the promotion of its crude vegetal oil production [10]. Many other advantages are associated with *J. curcas* L besides the production of biofuels, such as the production of soap and organic fertilizer. *Jatropha curcas* L. preserves soil fertility by controlling water and wind erosion (plantations of living fences) and it mitigates the emissions of greenhouse gas through carbon sequestration [11].

However, *J. curcas* L. is exposed to the attack of many insect pests and diseases that can negatively affect production, in spite of the documented toxicity and biocidal properties of its oil [1] [12] [13].

In Africa, several insect pests feed on *J. curcas* L. These include locusts, lady beetles, plant bugs, scale insects and butterfly larvae [1] [13] [14]. In Nicaragua, major insect pests of *J. curcas* L. are Heteroptera; they feed on the flowers and fruit, inflicting premature abortion of flowers or malformation of seeds [15].

Calidea dregii, a closed cousin of *C. panaethiopica*, was reported as an insect pest of cotton in Tanzania and of sorghum and sunflower in South Africa [16]. According to the same author, it is beginning to become a new threat to the commercial crop of *J. curcas* L. in Malaysia. In Guinea-Bissau, *C. dregii* was also reported for its threat on *J. curcas* L. plantations where the larvae and adults caused tremendous damage on seed production and quality of oil [16]. This species was reported as one of the most common insect pests on *J. curcas* L. fruit in Kenya [17]. It was also reported as an insect pest of non-open cotton seeds, but its presence in cotton fields was usually short [18]. Another species, *C. panaethiopica* was observed on *J. curcas* L. in Sénégal and in Niger [19] [20].

In Burkina Faso, *C. panaethiopica* (Heteroptera: Scutelleridae) was reported as one of the most frequent (60%) insect pests observed in *J. curcas* plantations [21]. The female usually deposits its eggs on the fruit and occasionally on the inner face of *J. curcas* leaves. The larvae and adults feed on *J. curcas* flowers and fruits. The attacked flowers dry up, and the attacked fruits usually show cankered brown spots producing malformed or empty seeds. Loss in yield of *J. curcas* L. seeds due to *C. panaethiopica* was 59% [22] in South-Sudanian zone of Burkina Faso.

Despite its potential economic importance, very little is known about the natural enemies associated with *C. panaethiopica*. Therefore, the objective of this study was to investigate the complex of various natural enemies associated with this insect pest. This study was conducted from 3rd June 2013 to 29th May 2014 in the Sissili province, South-Sudanian zone of Burkina Faso in three *J. curcas* plantation types: monoculture plantations where only *J. curcas* was grown; associated plantations where *J. curcas* was grown with other food or cash crops; living fences where *J. curcas* was grown on a line to surrender and protect generally other crops or to separate different farms. Better knowledge of these natural enemies could lead to the development of a biological control method.

2. Material and Methods

2.1. Material

2.1.1. Location of Study Sites

The study was conducted from 3rd June 2013 to 29th May 2014 on three *J. curcas* L. production sites (Kayéro, Pissaï and Omliassan) in the Sissili province. These sites were chosen because they were reported to be "hotspots" for the insect. These locations were at least 30 km apart from one another and were representative of the biological diversity of the Sissili province (**Figure 1**).

The three sites ranged from 12 to 30 km away from Léo, the capital city of the Sissili province. Kayéro village is located 12 km north of Léo on the Léo-Koudougou axis; its geographical position is latitude 11˚14'12.5" North and longitude 2˚5'35.5" West, with an average altitude of 334 m. Pissaï village is located 30 km east of Léo, at latitude 11˚6'14.6" North, and longitude 1˚51'23.2" West, with an average altitude of 339 m. Omliassan village is 18 km south-west of Léo, at latitude 11˚3'12" North, and longitude 2˚11'52" West, with an average altitude of 363 m.

The Sissili province is located in the South-Sudanian zone, characterized by a dry season from November to April and a wet season from May to October. Mean annual rainfall varies between 900 and 1200 mm while the mean monthly temperature varies from 25˚C to 30˚C (**Figure 2**). The landscape ranges from tree and bush savannas to shrub savannas composed of *Detarium microcarpum*, *Isoberlinia doka*, *Burkia africana*, *Ficus plastyphylla*,

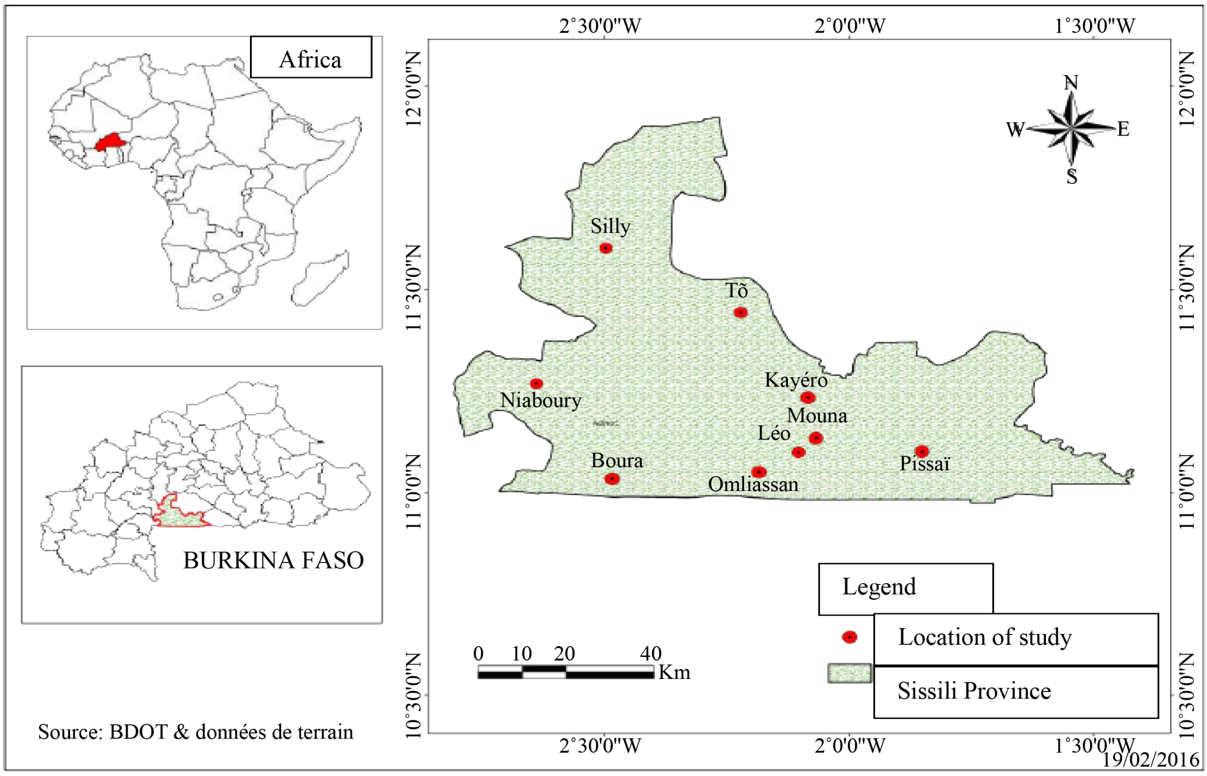

Figure 1. Map of the location of the study sites in Sissili province, Burkina Faso.

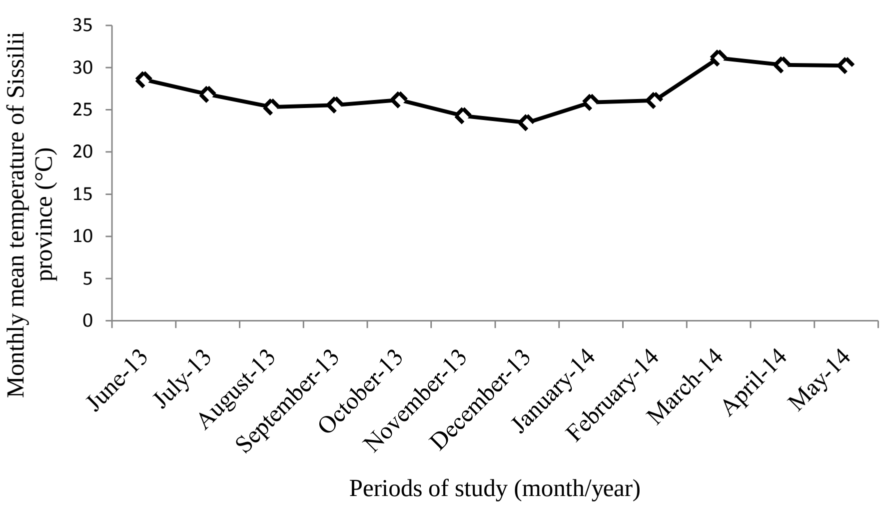

Figure 2. Variations of temperature of the Sissili province, Burkina Faso between June 2013 and May 2014.

Pilostigma toningii, and *Daniella oliveri*. The province is an agricultural and animal husbandry zone, and primarily taurine cattle are raised. Agriculture is associated with woody plants such as *Mangifera indica*, *Anacardium occidentalis, Vitellaria paradoxa*, *Parkia biglobosa*, *Jatropha curcas* and *Tamarindus indica* [23].

2.1.2. Material

In the field: plastic bottles were used for the collection of predators, larvae, *C. panaethiopica* healthy and parasitized eggs, and sent to the laboratory.

In the laboratory: plastic boxes with grid slatted shutter, and absorbent cotton were used for a contact breeding between predators and adult *C. panaethiopica* and for the incubation of parasitized eggs. A 70˚ ethanol was used for the preservation of predator and parasitoids that emerged from the parasitized eggs that were then identified. A binocular microscope and a hand magnifying glass were used for the various manipulations in the laboratory. A Canon Power shot G12 brand digital camera with high definition resolution was used for pictures both in the laboratory and the field.

2.2. Methods

The study of the natural enemies of *C. panaethiopica* was conducted in Kayero, Pissaï and Omliassan. On each site, six plantations of *J. curcas* L. were chosen, including two living fences, two associated plantations, and two monoculture plantations.

Each randomly chosen *J. curcas* plant was carefully examined and the number of predators, parasitoids, and parasitized *C. panaethiopica* eggs were photographed, counted, collected in plastic bottles and taken to the laboratory for breeding. Different stages of *C. panaethiopica* (adults, larvae and healthy eggs) were also collected in some plantations other than those used for the study. These were used for breeding with the predators collected from the study sites. At each site, observations were made once per week for one year. This enabled us to calculate the mean number of each predator in each type of *J. curcas* plantation with respect to time, and the ratio of parasitized eggs with respect to the observation period:

- Mean percentage of parasitized eggs of $C.\ panaethiopica = \dfrac{\text{Mean number of parasitized eggs}}{\text{Mean total number of eggs}} \times 100$

In the laboratory, each predator was placed in a well aerated plastic box, moistened with wet cotton containing *J. curcas* L. fruits and flowers, for breeding, in contact with four other adults, five larvae at different stages and a cluster of healthy eggs of *C. panaethiopica*. The attacked eggs, which were collected in the field, were incubated in the laboratory and their development monitored. Lastly, adults and larvae of *C. panaethiopica* were also placed in breeding boxes with healthy eggs, with in order to test their possible cannibalistic behavior.

Observations in the laboratory were done twice a day, at 7 a.m. and 6 p.m. At the end of the experiments, specimens of predators and parasitoids that emerged from parasitized eggs of *C. panaethiopica* were kept inside alcohol 70˚ and sent for identification.

Statistical Analysis

Data were analyzed using the GenStat (9th ed., 2007) software. The means were separated by the LSD (Least Significant Difference) test at 5% level. Figures were prepared using Excel Microsoft Office 2010.

3. Results

3.1. Identification of Natural Enemies Associated with *C. panaethiopica*

Calidea panaethiopica was described and its life cycle was abundantly documented by [22].

Natural enemies associated with *C. panaethiopica* included 3 Hymenoptera wasps all belonging to the Scelionidae family and several predators belonging to the Araneae, Tarachodidae and Mantidae families (**Table 1**). The Hymenopteran wasps included *Psixstriaticeps* (Dodd), *Triss olcus* cf *basalis* (Wollaston) and *Gryon* sp.

Both larvae and adults of *C. panaethiopica* were found to prey on the eggs of *C. panaethiopica*.

3.2. Mean Number of Healthy Eggs and Parasitized Eggs of *C. panaethiopica* with Respect to Site

The analysis of the mean number of healthy eggs of *C. panaethiopica* with respect to site revealed no significant difference between the three study sites (ddl = 2; F =2.1; $P < 0.1$). As for the mean number of parasitized eggs of *C. panaethiopica* with respect to site, a significant difference was observed (ddl = 2; F = 2.9; $P < 0.05$) between Omliassan and Pissaï (**Figure 3**).

3.3. Mean Number of Healthy Eggs and Parasitized Eggs of *C. panaethiopica* with Respect to Type of Plantation

The analysis of the mean number of healthy eggs of *C. panaethiopica* with respect to type of plantation revealed a significant difference (ddl = 2; F =3.1; $P < 0.04$) between the three types of *J. curcas* plantations. A significant difference was observed (ddl = 2; F = 2.8; $P < 0.05$) (**Figure 4**) between the mean number of parasitized eggs of *C. panaethiopica* with respect to type of plantation (monoculture, living fences and associated ones).

Table 1. Relative importance of predators of *C. panaethiopica* in South-Sudanian zone of Burkina Faso.

Order	Family	Genus	Species	Number	Percentage
Dictyoptera	Mantidae	*Epitenodera*	*Epitenodera sp.*	140	30.0
Dictyoptera	Mantidae	*Polyspilota*	*Polyspilota aeruginosa* (Goeze)	98	21.0
Dictyoptera	Tarachodidae	*Tarachodes*	*Tarachodes similis* Gillon & Roy	71	15.2
Dictyoptera	Mantidae	Indeterminant	indet. sp.	157	33.7
Total				466	100

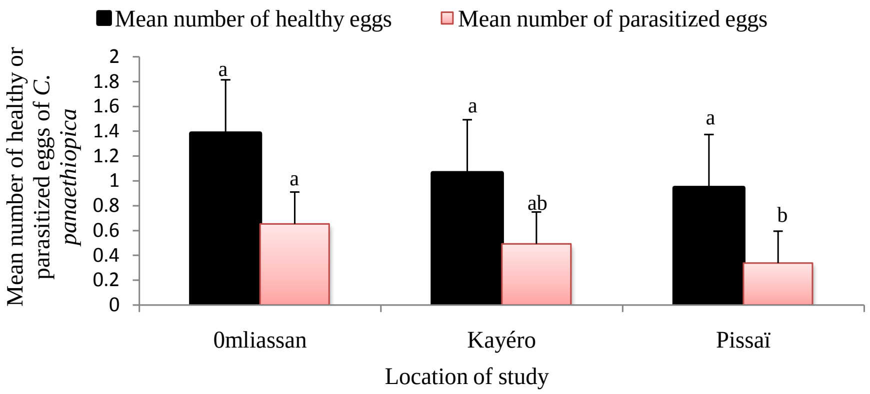

Figure 3. Mean number of healthy and parasitized eggs of *C. panaethiopica* with respect to site. The vertical lines indicate the LSD (the Least Significant Difference). Same letters above lines indicate homogenous groups at 5% level.

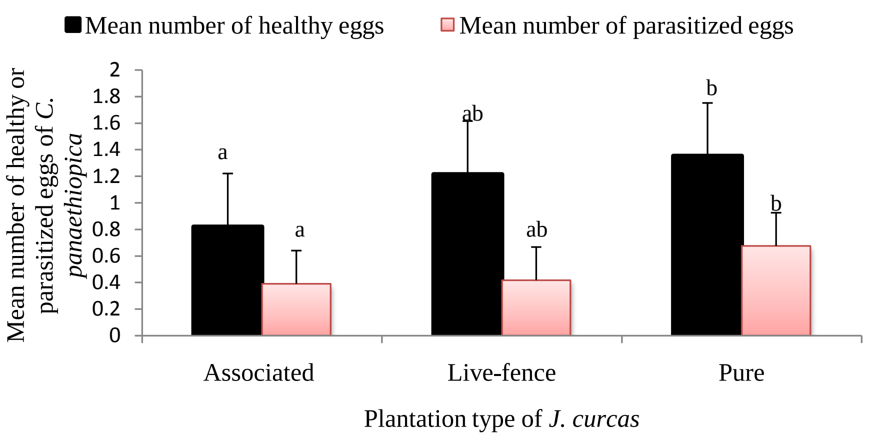

Figure 4. Mean number of healthy and parasitized eggs of *C. panaethiopica* with respect to type of plantations. The vertical lines indicate the LSD (the Least Significant Difference). Same letters above lines indicate homogenous groups at 5% level.

3.4. Mean Number of Healthy Eggs and Parasitized Eggs of *C. panaethiopica* with Respect to Time

The ANOVA of the mean number of healthy eggs (ddl = 11; F = 8.7; P < 0.001) and parasitized eggs (ddl = 11; F = 8.5; P < 0.001) of *C. panaethiopica* with respect to time revealed a highly significant difference between the various observation dates. Healthy eggs of *C. panaethiopica* were observed in the *J. curcas* plantations throughout the study period between June 2013 and May 2014, except for February 2014, however the mean number of these eggs varied in an irregular pattern, with respect to time. Starting June 2013, the mean number of healthy eggs of *C. panaethiopica*, progressively increased and reached a peak in August (**Figure 5**). Then, from September, we noticed a progressive decrease of the mean number of healthy eggs of *C. panaethiopica*, until their total absence in February 2014, followed by a new, slight, but progressive increase starting in March 2014.

Parasitized eggs of *C. panaethiopica* were observed between June 2013 and November 2013. However, the mean number of parasitized eggs varied in a regular monthly pattern. Starting in June 2013, we observed a continuous increase of the mean number of parasitized eggs reaching their maximum value in September 2013. Then, from October to November 2013, we noticed a drop in the mean numbers of parasitized eggs, and from December 2013 to April 2014, no parasitized eggs of *C. panaethiopica* were recorded. Starting in May 2014, we observed again some parasitized eggs in the same progression pattern as the mean number of healthy eggs.

3.5. Mean Total Number of *C. panaethiopica*'s Eggs with Respect to Time

The ANOVA of the mean total number of *C. panaethiopica* eggs with respect to time revealed a significant difference between the different observation dates (ddl = 11; F = 12; P < 0.001). The mean total number of *C. panaethiopica* per tree, progressively increased between June and August 2013. However, the mean number of parasitized eggs of *C. panaethiopica* progressively increased for a longer period of time, also starting in June, but continuing through September 2013. In fact, the highest mean percentage (43%) of the parasitism of *C. panaethiopica*'s eggs was recorded in September 2013 (**Figure 6**).

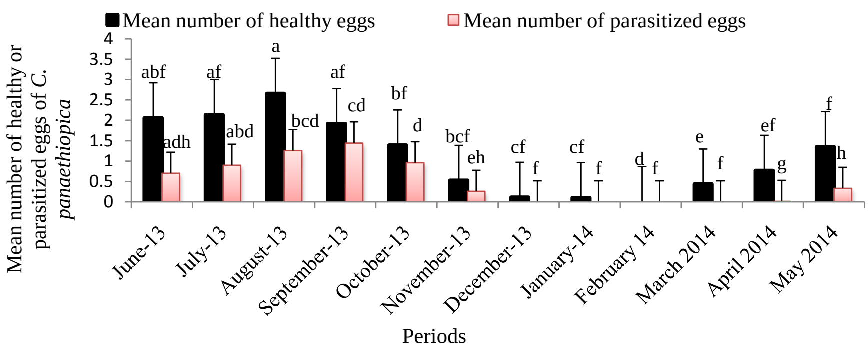

Figure 5. Mean number of parasitized or healthy eggs of *C. panaethiopica* with respect to time. The vertical lines indicate the LSD (the Least Significant Difference). Same letters above lines indicate homogenous groups at 5% level.

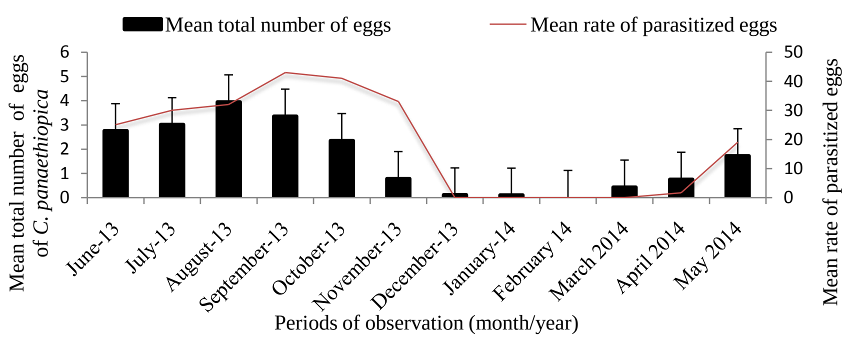

Figure 6. Mean total number of *C.panaethiopica* eggs and the mean rate of parasitized eggs of *C. panaethiopica* between June 2013 and May 2014. The vertical lines indicate the LSD at 5% level.

3.6. Mean Number of *C. panaethiopica*'s Predators (Spiders and Mantises) per Tree with Respect to Location

The ANOVA of the mean number of spider predators of *C. panaethiopica* per tree and with respect to site revealed a significant difference (ddl = 2; F = 3; P < 0.05) between sites. A significant difference (ddl = 2; F = 16.6; P < 0.001) between sites was observed between the mean number of mantis predators of *C. panaethiopica* per tree (**Figure 7**).

3.7. Mean Number of *C. panaethiopica*'s Predators (Spiders and Mantises) per Tree with Respect to Plantation Type

The ANOVA of the mean number of spider predators of *C. panaethiopica* per tree with respect to plantation type revealed a significant difference (ddl = 2; F = 6; P < 0.002) between associated plantations and living fences and between the monoculture plantations and the associated ones. Actually, more spiders per tree were recorded in the monoculture plantations than the two other plantation types.

A significant difference (ddl = 2; F = 4.5; P < 0.01) was observed in the mean number of mantis predators per tree between associated plantations and living fences, and between the associated and the monoculture plantations. More mantises per tree were found in the monoculture plantations than the living fence or the associated ones (**Figure 8**).

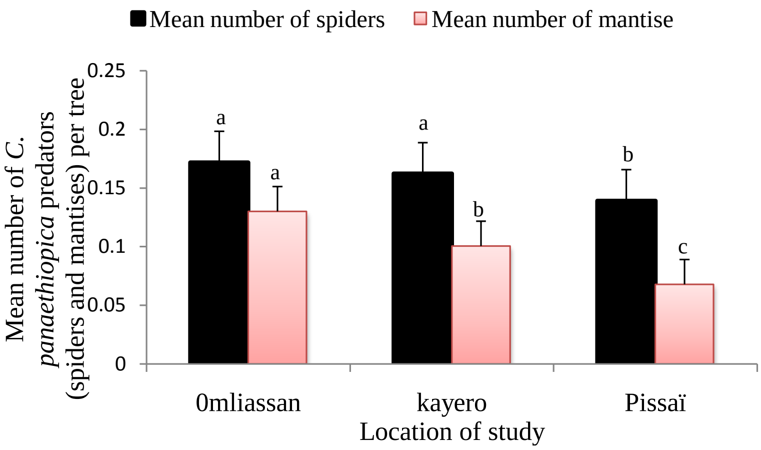

Figure 7. Mean number of *C. panaethiopica* predators (spiders and mantises) per tree with respect to location. The vertical lines indicate the LSD. Same letters above lines indicate homogenous groups at 5% level.

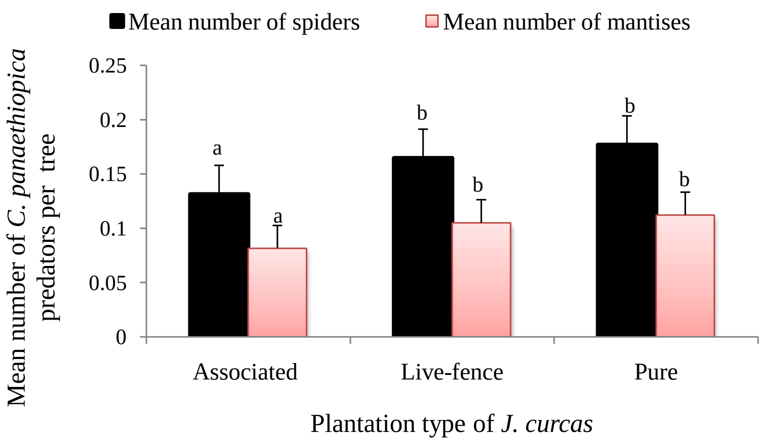

Figure 8. Mean number of *C. panaethiopica* predators (spiders and mantises) per tree with respect to plantation type. The vertical lines indicate the LSD. Same letters above lines indicate homogenous groups at 5% level.

3.8. Mean Number of *C. panaethiopica*'s Predators (Spiders and Mantises) per Tree with Respect to Time

The ANOVA performed on the mean number of spider predators of *C. panaethiopica* per tree with respect to time showed a significant difference (ddl = 11; F = 5.1; P < 0.001) between the different dates of observation. The variation of mean number of spider predators of *C. paneathiopica* per tree, constantly varied with time. Overall, however, during the rainy season (June and October 2013) the mean number of spiders per tree was higher than during the dry season. Its maximal value was seen in August 2013, and the lowest number of spiders was observed in January 2014.

The ANOVA of the mean number of the mantises per tree with respect to time revealed a significant difference (ddl = 11; F = 5.1; P < 0.001) between the dates. The mean number of mantises varied with respect to time. Between June and October 2013, a large number of mantises were recorded; the peak value was observed in July 2013 (**Figure 9**). Afterwards, the low number of mantises per tree was recorded between November 2013 and April 2014. Starting in May 2014, an increase of the mean number of mantises per tree was observed.

4. Discussion

This study on the natural enemies of *C. panaethiopica* revealed the existence of three egg parasitoid species and four predator species in the Mandidae, Tarachodidae and Araneae families. The largest number of parasitized eggs, mantises, and spiders was found on the Omliassan plantations. These plantations were located next to two humid shallow lands, which were conducive to the development of arthropods, including the observed pest species. However, [24] reported that the climate influenced dynamic manner of the interactions among the plants, insect pests and natural enemies.

We observed that more eggs of *C. panaethiopica* and more predators were found on monoculture plantations than those on the two other plantation types. The total number of *C. panaethiopica* eggs per tree progressively increased between June and August 2013 and reached its maximum in August 2013. The number of parasitized eggs followed the same progression, but its peak was observed later, in September 2013, with a mean parasitism level of 43%. In contrast, no parasitized eggs of *C. panaethiopica* were recorded in *J. curcas* plantations between December 2013 and April 2014, which was a dry period of the year.

The number of spider and mantis predators of *C. panaethiopica* was higher between July and August 2013, and their lowest number was recorded between November 2013 and April 2014. This is consistent with the population dynamics of *C. panaethiopica* whose highest populations were recorded in June through August (Djimmy and Nacro, paper submitted to *Intern. Journal of Trop. Insect Science*). These conditions favored the population growth of natural enemies; mostly during the period when *C. panaethiopica*s populations were more abundant.

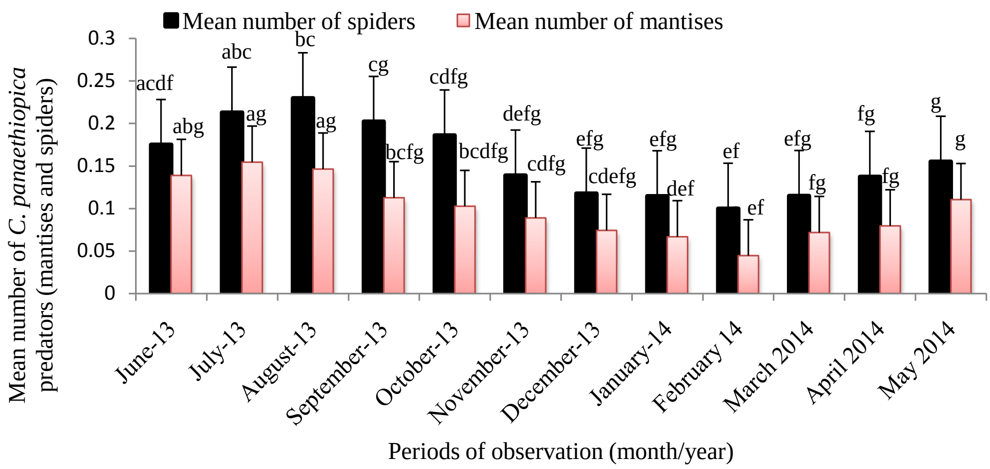

Figure 9. Mean number of *C. panaethiopica* predators (mantises and spiders) per tree, with respect to time. The vertical lines indicate the LSD. Same letters above lines indicate homogenous groups at 5% level.

Our results are comparable to those by [25] who reported that the natural vegetation, namely the self-sowing plants, played an important role in maintaining diversity and abundance, of both insect pests and of their natural enemies in the environment. Author [26] reported *Trissolcus* sp. (Hymenoptera: Scelionidae) as an egg parasitoid of *Leptoglossus zonatus* (Hemiptera: Coreidae), a polyphagous insect pest of maize in Itumbiara, Goiás State of Brazil. According to [27], *Trissolcus* spp. (Hymenoptera: Scelionidae) was the most efficient parasitoid of *Eurygaster integriceps* Put. (Hemiptera: Scutelleridae), an insect pest of wheat in Western Iran. For [28], the egg parasitoid of *Nezara viridula*, *Trissolcus basalis* (Hymenoptera: Scelionidae) was more important in low-lying vegetation habitats than in the maintained orchards. Authors [29] reported that *Trissolcus semistriatus* (Hymenoptera: Scelionidae) could parasite up to 100% of *Eurygaster integriceps* (Heteroptera: Scutelleridae) eggs, a species that was quite close to *C. paneathiopica* and that was reported as an insect pest of wheat in Turkey. Authors [30] reported *Trissolcus japonicus* (Ashmead) as an egg parasitoid of the brown bug, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae), a polyphagous insect pest in the USA. Authors [31] reported that in Australia, *Trissolcus basalis* was less common in summer. According to [32], parasitoid hymenoptera were often present in low density populations in the environment and they affected the populations of their hosts proportionally on their density. Mortality inflicted by parasitoids is higher in nature than mortality associated with predators and microorganisms combined.

The study of the bioecology of the three Scelionidae egg parasitoids of *C. panathiopica* is necessary to assess the potential of using these wasps as a biological control. The biology and the ecology of the predators will need to be better determined as well.

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