Scientific Research Publishing

American Journal of Plant Sciences, 2018, 9, 1544-1556
http://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Population Fluctuation and Vertical Distribution of the Soybean Looper (*Chrysodeixis includens*) in Soybean Culture

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How to cite this paper: Zulin, D., Ávila, C.J. and Schlick-Souza, E.C. (2018) Population Fluctuation and Vertical Distribution of the Soybean Looper (*Chrysodeixis includens*) in Soybean Culture. *American Journal of Plant Sciences*, **9**, 1544-1556.
https://doi.org/10.4236/ajps.2018.97113

Received: April 25, 2018
Accepted: June 25, 2018
Published: June 28, 2018

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Abstract

The objective of this work was to study the population fluctuation and the vertical distribution of the *Chrysodeixis includens* (Walker) (Lepidoptera: Noctuidae) in the leaf canopy of soybeans. The experiments were conducted under field conditions in the experimental area of the Embrapa Agropecuária Oeste during the 2014/2015 harvest. Adult monitoring was performed using Delta-type traps, baited with the pest sexual pheromone. The eggs were collected in the soybean plants and the caterpillars monitored through the beat cloth. The population peaks of *C. includens* occurred in the reproductive period of the soybean plants, although the adults were also found in the season soybean. Although there was no significant relationship between the trapped adults and the immature forms of *C. includens* sampled with the beat cloth, a significant linear and positive relationship was found between the egg and caterpillar densities of the pest in the culture. Adults preferentially oviposited on the lower part of the soybean plants, while the caterpillars preferred to position themselves predominantly in the lower and mid region of the plants. However, at warmer temperatures during the day, the caterpillars migrate to the upper areas of the soybean plants.

Keywords

Glycine Max, Monitoring, Sexual Pheromone, Behavior

1. Introduction

In the past, the soybean looper *Chrysodeixis includens* (Walker) (Lepidoptera:

Noctuidae) was considered as a secondary pest in soybean cultivation in Brazil [1] [2]. However, from the 2003/2004 crop, this species became a key pest in the growth due to frequent population outbreaks and damage to cultivated areas [3].

Pest monitoring is the basis of integrated pest management and it is through this that control tactics are implemented or not in crops [4]. The use of traps baited with synthetic sex pheromone is considered a practical method for pest monitoring [5]. Researches with the *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) in corn recommend that the chemical control of this caterpillar should be carried out ten days after the cumulative capture of three moths per pheromone trap [6].

The difficulties of controlling the soybean looper in the soybean crop are related to the behavior that this pest presents to remain, preferably, in the lower canopy of the soybean plants, mainly in the abaxial face of the leaves, which makes its control difficult by plant spraying with insecticides [7]. Conducting researches on the vertical distribution of pest insects may improve monitoring and assist in the development of control tactics. In addition, this information may indicate the best time or place for spraying insecticides to maximize pest control [8]. Thus, the objective of this work was to obtain information on population fluctuations, relationships between adults and immatures in the crop as well as the vertical distribution of the soybean looper on the foliar canopy of the soybean crop, aiming to provide subsidies to be used in the integrated management of this plague.

2. Materials and Methods

The experiment was carried out under field conditions in the experimental area of the Embrapa Agropecuária Oeste, in the Dourados-MS (Latitude 22˚16'30" and Longitude 54˚49'0"), during the soybean crop of 2014/2015. The cultivar Brasmax Potência RR, without seed treatment, was planted in an area of approximately one hectare on October 28, 2014, according to the technical recommendations for cultivation in the region, with humid sub-tropical climate.

2.1. Population Fluctuation and Correlation of Adults and Immatures

The adults of the soybean looper, *Chrysodeixis includens*, were monitored during the period from October 2014 to October 2015 in the soybean crop. The capture of moths was done using Delta traps (Biocontrole®) with adhesive floors, baited with the sexual pheromone *Bio pseudoplusia* (Biocontrole®). Traps were inspected weekly for captured moth counts, while the adhesive floors were also changed, and the pheromone septa were replaced every twenty-one days.

Eggs and caterpillars were visually monitored on the soybean plants shortly after their emergence. In the sampling of caterpillars, the beat cloth was used and carried out two to three times per week with five beats of cloth next to each pheromone trap. The captured caterpillars were classified as large (≥1.5 cm) or

small (<1.5 cm). At each sampling period, two plants close to each trap were also removed and taken to the entomology laboratory for inspection of the eggs on the leaves and stems. Adult trapping data on the traps and their immature forms found in soybean plants were submitted to linear regression analysis.

The weekly means of catching adults in the traps and their immature forms found in soybean plants were submitted to Pearson correlation analysis, linear regression and descriptive statistical analysis.

2.2. Vertical Distribution of Caterpillars

Eggs and caterpillars of *C. includens* were sampled in the soybean plants during flowering of the crop from six o'clock in the morning. For this, ten plants were collected and sectioned in three extracts (lower, middle and upper), which were bagged separately and taken to the laboratory for egg and caterpillar counts. The same procedure was repeated at 8 am, 10 am, noon, 2 pm, 4 pm, 6 pm and 8 pm each day. For the analysis of the movement of caterpillars between plant extracts throughout the day, the upper, middle and lower parts of the plants were considered the treatments to be evaluated, and the number of plants the 160 plants collected on the two days of sampling were evaluated, the replicates of the test conducted in the completely randomized design, after checking the normality of the means, they were compared by the Tukey test at the 5% probability level.

3. Results and Discussion

3.1. Population Fluctuation and Adult-Immature Relationships in Soybean

During the whole monitoring period, 1.199 *C. includens* moths were captured, the presence of this species being observed in all the months of the year, including the period of the planting to the soybean harvest, as well as in the off-season where second corn crop and brachiaria were grown in the studied area (**Figure 1**).

In the period of soybean cultivation (October/2014 to February/2015), the number of moths captured was significantly higher, with the highest occurrence of adults being observed in the months of January to February (**Figure 1**), when the soybean was in the reproductive stage. In April, the second peak of moths was observed, when the area was being cultivated. These adults from the second peak probably came from other nearby soybean plantations that had not yet been harvested. It is noted that the soybean crop offered the best conditions for the development of the soybean looper, which resulted in the increase of the population of moths in this crop in comparison with the other periods of sampling.

The soybean looper is considered a polyphagous pest, since it feeds on and develops in about 170 species of host plants belonging to 39 families [9]. This fact explains the survival of this pest in the period of when it would be feeding on other host plants. The species has already been observed attacking beans, tomato,

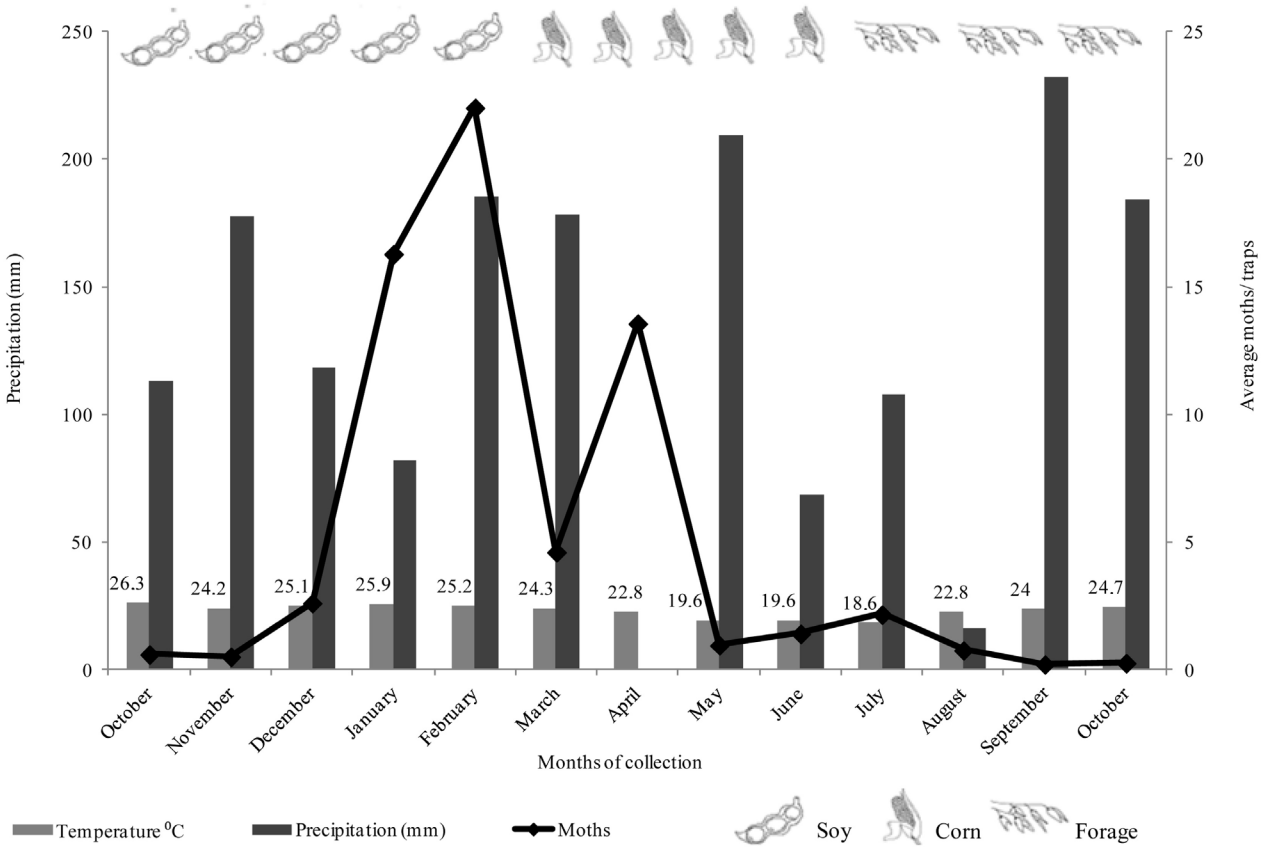

Figure 1. Population fluctuation of *Chrysodeixis includens* adults caught in sexual pheromone traps, mean temperatures and monthly precipitation observed from October 2014 to October 2015. Dourados, MS.

tobacco, sunflower, cauliflower, lettuce, as well as soybean, cotton, corn and others [10] [11]. However, researches have shown that *C. includens* has greater preference and adaptation to soybean when compared to other cultures in which it has already been verified [12].

The occurrence of this species throughout the year in the region may also be linked to climatic conditions favorable to its development. Among the main caterpillars of the subfamily Plusiinae, *C. includens* seems to be better adapted to warmer regions, compared to *Rachiplusia nu* (Guenée), which occurs more frequently in colder regions [13]. In Brazil, outbreaks of *C. includens* occur frequently in western Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, São Paulo, Paraná and Rio Grande do Sul, but lack information on the mobility of this species in tropical conditions, especially during the soybean off season [14].

The first eggs and caterpillars of *C. includens* were observed in November between the V2 and V3 phenological stages of soybean plants, while adult, egg and caterpillar peaks in soybean were observed during the month of January (**Figure 2**). These results show that the population explosion of this pest occurs when the soybean plants usually enter the reproductive stage and have a "closed" canopy. The month of January presented a lower precipitation (82 mm) when compared to the other months of soybean cultivation (**Figure 1**). It is known

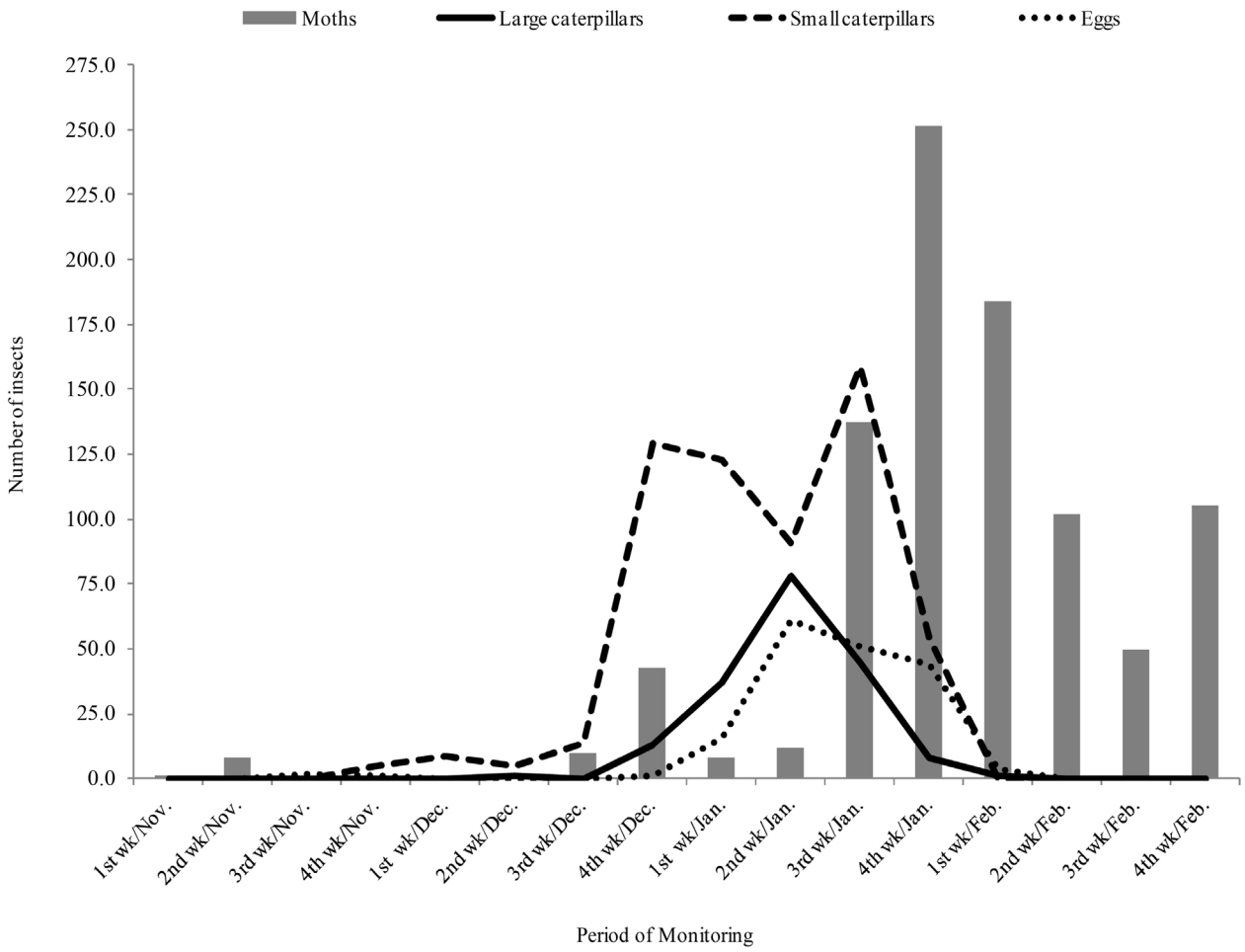

Figure 2. Population fluctuation of adults and immature forms of *Chysodeixis includens* in soybean crops during the 2014/2015 harvest. Dourados, MS.

that *C. includens* is favored by conditions of low precipitation or periods of drought that precede the outbreaks of this pest [11] [15], as was also observed in this research.

Different authors observed greater average density of *C. includens* eggs in the stage of full bloom of the soybean (R2), similar to the one found in this study [16] [17]. Regarding the number of caterpillars, researches by [18], in several cities of Rio Grande do Sul, by [19], in IlhaSolteira in the State of São Paulo and by [20] in the state of Tocantins, also reported higher density of caterpillars in the reproductive period of the crop. However, these results differed from those observed in the State of Roraima by [21], which verified the population peaks of *C. includens* caterpillars in the vegetative phase of the crop.

The number of *C. includens* adults caught in the pheromone traps was higher than that of eggs and caterpillars sampled in the soybean from the fourth week of January to the end of the soybean growing period (**Figure 2**). This was because the adults probably migrated from other planted areas of the region, especially medium and late-season soybean cultivars, attracted by the pheromone

present in the traps. Researches conducted in the northern hemisphere have indicated that *C. includens* moths can fly long distances presenting great dispersal capacity in the regions [22] [23].

The relationships between moths caught in the pheromone-trapped traps and the immature densities sampled in the soybean crop in this study were not significant. However, a linear and significant relationship was observed between the egg and caterpillar densities of this pest (**Figure 3**). [24] found curvilinear relationships between trapped males of *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) and density of larvae and pupae in canola (*Brassica napus* L.) in Canada, while [25] found nonlinear relationships between moths caught in pheromone and immature traps of *Malacosoma dysstria* (Hübner) (Lepidoptera: Lasiocampidae), a pest that attacks the poplar (*Populus tremuloides* Michx. (Salicales: Salicaceae).

A number of factors may influence the development of a predictive strategy with pheromones, including geographic variation [26], the impact of natural enemies on the pest population [27], the climatic conditions and the quality of the pest host plant [28].

Based on the results, it can be inferred that the egg sampling in the soybean plants would be the best option to estimate the infestation of caterpillars in the crop. However, *C. includens* eggs are difficult to monitor because they are very small and measure about 0.5 mm in diameter [14], which makes this parameter inapplicable for monitoring caterpillars in soybean, and it is therefore more practical to sample the caterpillars using the beat cloth. In the conditions in which this work was carried out, the pheromone traps were effective in the detection of *C. includens* adults, important information since we know that the presence of adult in the culture predates the occurrence of eggs and caterpillars. However, there was no significant relationship between the adult population and immature densities that made it possible to estimate caterpillar or egg infestation in soybean plants by using the adult population density found in pheromone traps.

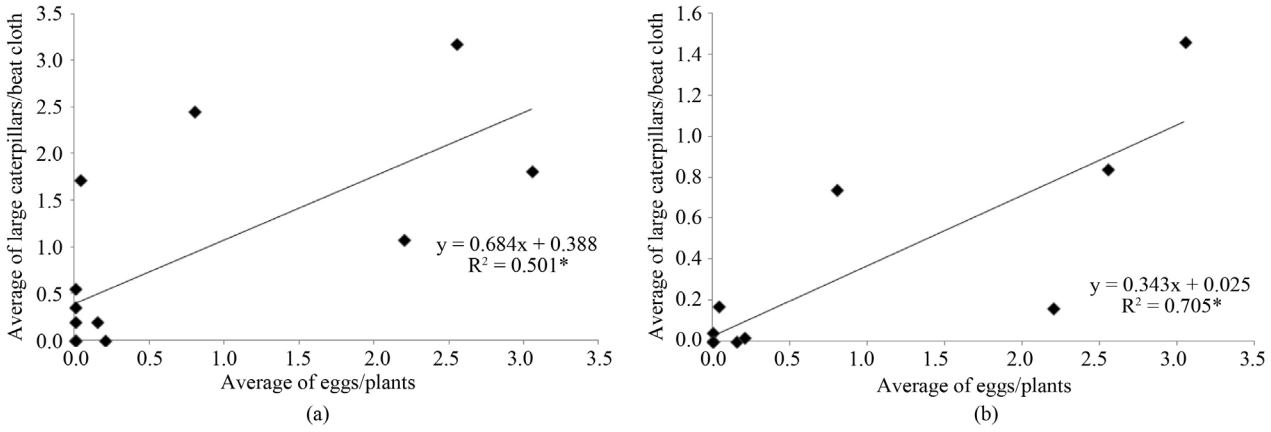

Figure 3. Linear regression between population density of eggs and caterpillars (a) of eggs and large caterpillars; (b) of *Chrysodeixis includens* sampled in the soybean crop in the 2014/2015 harvest. Dourados, MS.

3.2. Vertical Distribution of Eggs and Caterpillars in Soybean

The *C. includens* moths were oviposited in all three extracts (lower, middle and upper) of the soybean plants, but the eggs were deposited in greater quantity in the lower extract, when compared to the medium and upper extracts, which presented similar oviposition rates (**Figure 4**). A total of 450 eggs were sampled in the collected plants, 61.3% of which were in the lower third, 24.8% in the medium and 13.8% in the upper one.

These results corroborate the research done by [29], who observed a higher number of *C. includens* eggs in the lower third of the soybean plants. [30] observed higher deposition of soybean loopereggs in the median region of the plants, while [17] showed higher oviposition of *C. includens* in the middle and higher parts of the soybean, similar to the results found by [31], whereas [32], did not observe a difference in egg deposition among these three extracts of the plant.

When the soybean plants are in full flowering stage, the crop is closed. In this condition, the plants grow and approach each other closing the leaf canopy, leaving the lower part of the plants more protected [29]. Moths preferentially deposited their eggs in the lower part followed by the middle part of the plants, probably due to the protection that this environment confers on its immature ones, when they are less exposed to the climatic adversities, the dehydration as

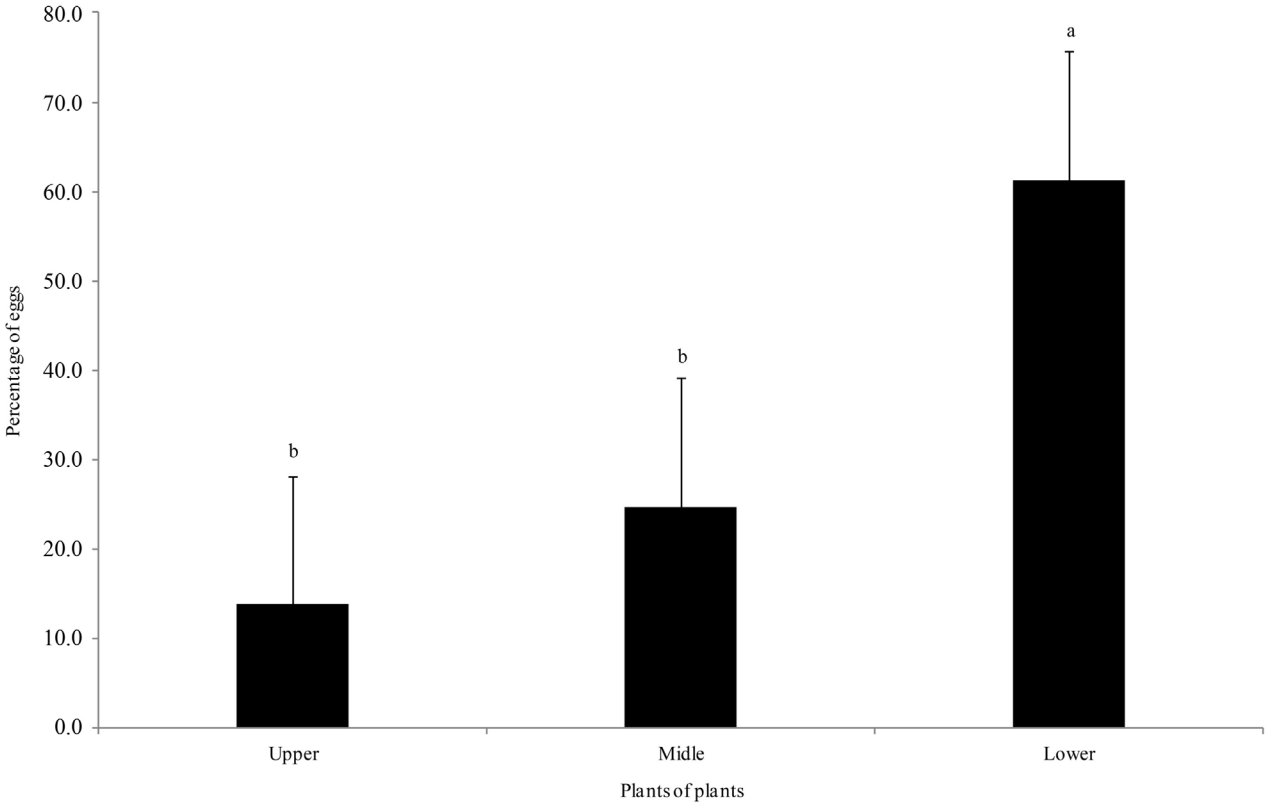

Figure 4. Vertical distribution of *Chrysodeixis includens* eggs in the profile of soybean plants in the 2014/2015 harvest. Dourados, MS. Bars followed by different letters, the values differ statistically by the Tukey's test at 5% probability.

well as the access of possible natural enemies and the chemical control.

In the researches of vertical distribution of *C. includens* caterpillars, 282 insects were sampled, being 186 small caterpillars and 96 large caterpillars. Regardless of the size of the caterpillars, they were distributed in the plant profile, preferably in the lower third, followed by the middle third, similar to that observed for the oviposition behavior (**Figure 5**). The caterpillars have a preference for the lower part of the plants, probably because in this environment they are more protected from natural enemies and from climatic adversities. [32] observed that regardless of the size of the caterpillars, they found no difference in the distribution of *C. includens* in the extracts of the soybean plants. However, [33] found that soybean looper usually feed on the lower third of soybean plants, as was also observed in this work. [34], in researches with *A. gemmatalis*, reported the displacement of caterpillars, as they develop, to the higher regions of plants. It should be noted that this behavior of caterpillars makes it difficult to control them by applying insecticides because these caterpillars are less exposed to contact with insecticides when applied to soybean, especially when the crop is in the reproductive stage where the top of the plants is closed (**Figure 1**), which can be used as a barrier for the penetration of spray droplets, known as "the

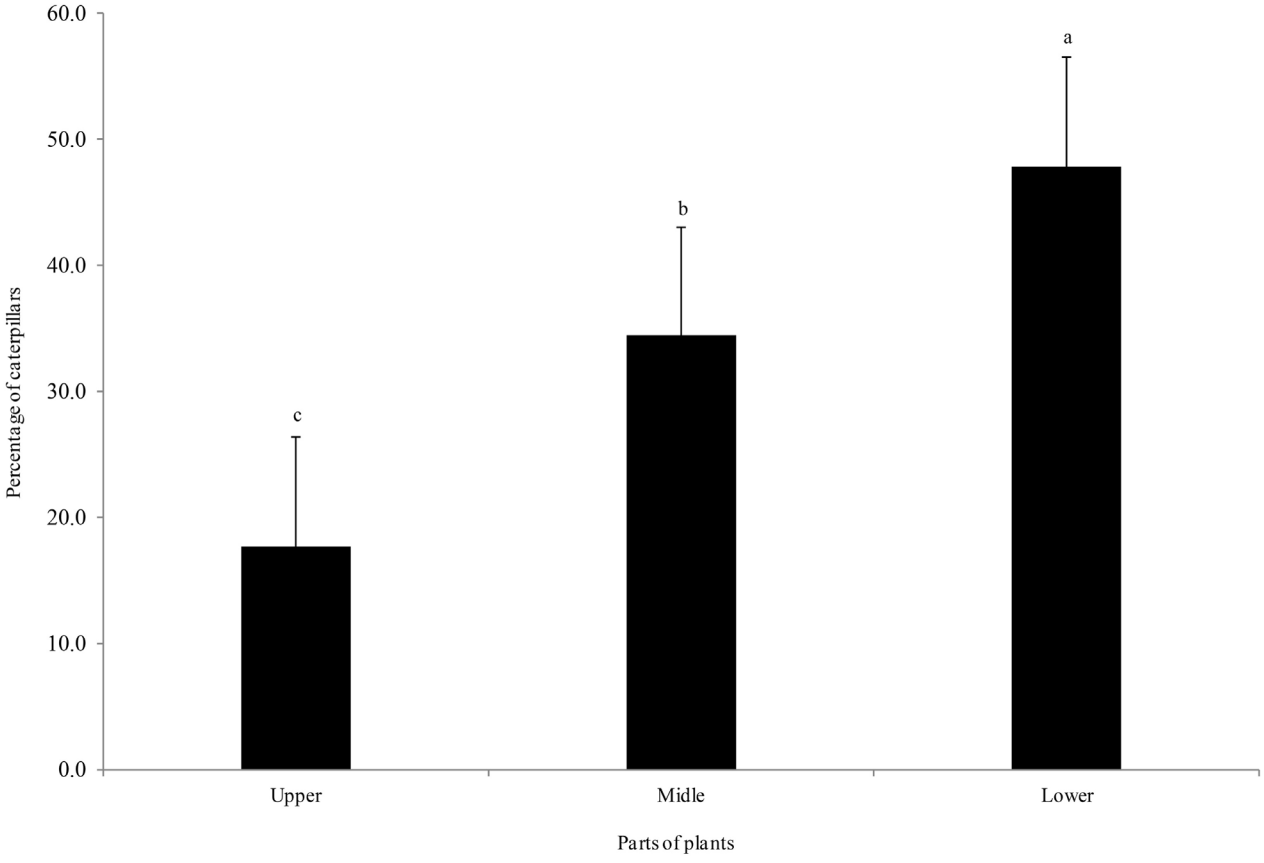

Figure 5. Vertical distribution of total (large + small) *Chrysodeixis includens* caterpillars in the profile of soybean plants in the 2014/2015 crop. Dourados, MS. Bars followed by different letters, the values differ statistically by the Tukey's test at 5% probability.

umbrella effect" [33] [35]. Regarding *S. frugiperda*, [36] observed that, even under favorable environmental conditions, the control performed at 12 h was unsatisfactory. The results were attributed to the behavior of the caterpillar that remains during the day protected inside the cartridge of the corn plants, making it difficult to control due to its lower exposure to insecticides compared to the night.

In these studies, on the vertical distribution of *C. includens* caterpillars in the soybean profile during the day, it was verified that the caterpillars migrate to different plant extracts according to the time of day (**Figure 6** and **Figure 7**). During the hottest periods of the day, between 10 am and 4 pm, most caterpillars migrate from the upper and middle extracts to the lower plant extract. However, at warmer temperatures (6 h, 8 h, 18 h, and 20 h), the caterpillars return to the medium and even the upper reaches of the soybean plants. At these times, the upper extract proportionally presents a higher percentage of caterpillars than in other periods.

In the evaluation of the behavior of small caterpillars, the displacement of caterpillars from the upper and middle parts of the plants to the lower part of the soybean as of 10 h in the morning was observed (**Figure 6**). And the reverse happened when dusk began, in which a good part of these caterpillars moved from the lower part of the plants and returned to the middle and upper parts, although most of them remained in the middle part of the plants. For large

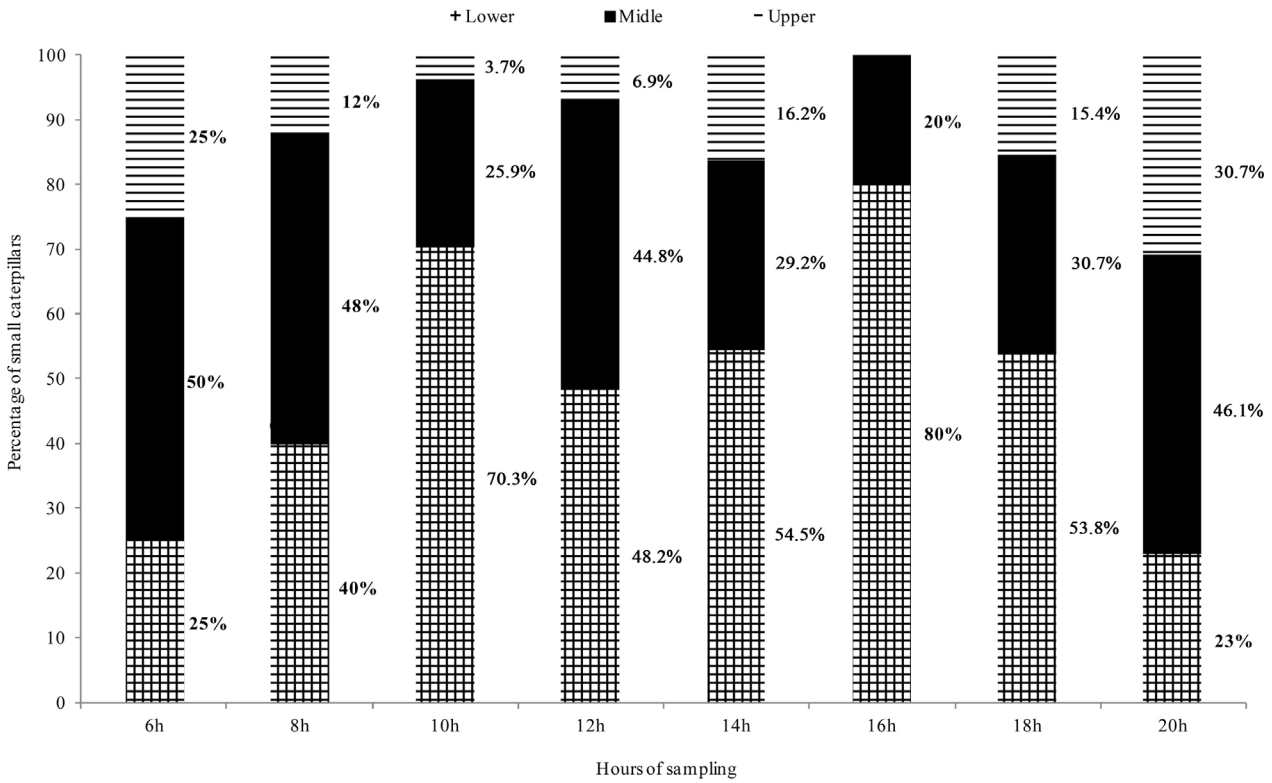

Figure 6. Vertical distribution of small *Chrysodeixis includens* caterpillars throughout the day in the profile of soybean plants in the 2014/2015 harvest. Dourados, MS.

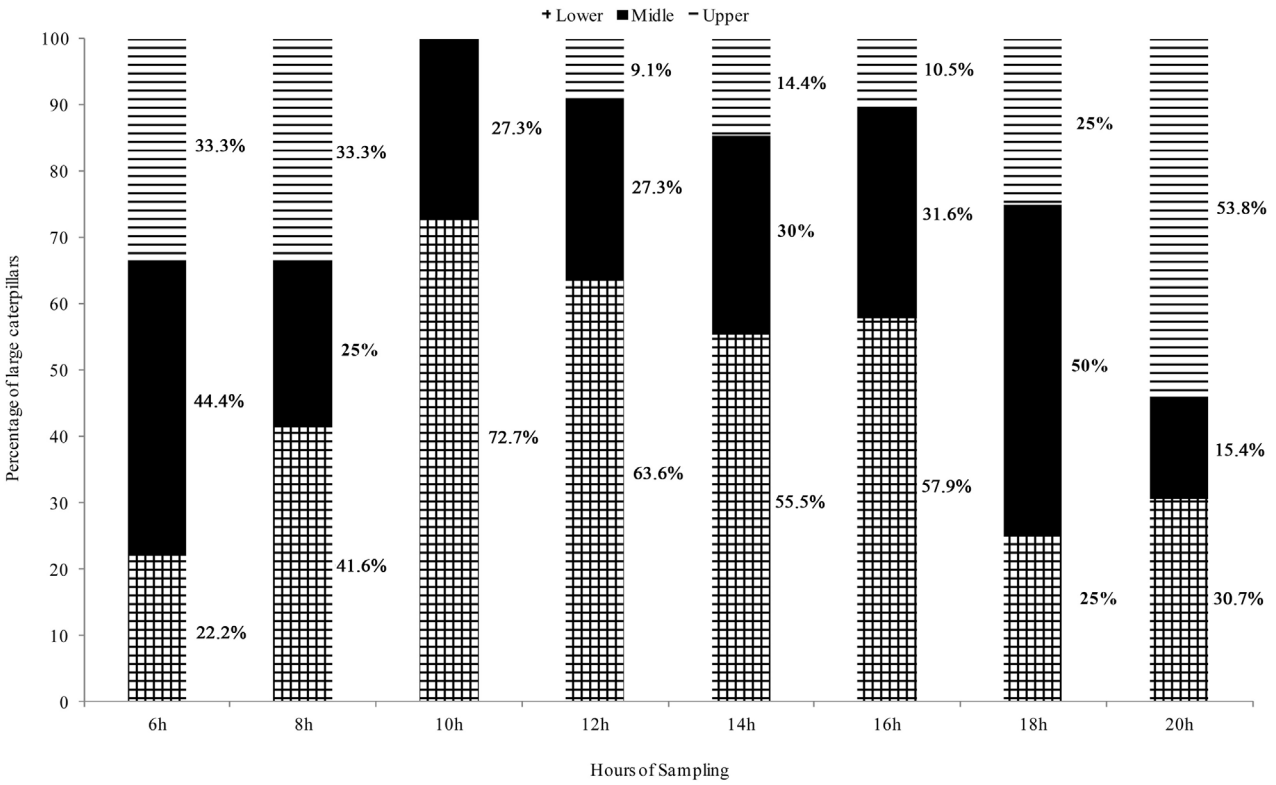

Figure 7. Vertical distribution of large *Chrysodeixis includens* caterpillars throughout the day in the profile of soybean plants in the 2014/2015 crop. Dourados, MS.

caterpillars the behavior is similar, since at 20 h more than 50% of the caterpillars were concentrated in the upper plant extract (**Figure 7**). This information is extremely important especially for the management of large *C. includens* caterpillars in the soybean crop since these caterpillars are more difficult to control than small ones.

Researches on the behavior of soybean looper throughout the day are scarce. However, [37] reported on the dietary behavior of *C. includens* caterpillars that the activity of searching for food extended throughout the 24 hours of the day, intensifying at the end of the evening period.

According to the results obtained in this work, it can be inferred that the chemical control of large and small soybean looper should be carried out preferentially in the first hours of the day or at dusk, since in these periods, the caterpillars are more exposed to contact with the products sprayed in the culture. The most successful cases of chemical control of the soybean looper in drought periods are more common with nocturnal sprays and good plant cover [38].

4. Conclusion

Chrysodeixis includens adults can be found practically all year round in the region of Dourados, MS, but the peak of their occurrence and immature forms is observed in the months of January and February. There is a significant and positive linear relationship between the density of *C. includens* eggs and the densities

of small caterpillars and large caterpillars in soybean plants. *C. includens* females have preference in ovipositing in the inferior part of the soybean plants. Small and large *C. includens* caterpillars usually remain in a larger proportion in the lower part of the soybean plants, in relation to the median and upper parts. However, during the day, these caterpillars move in the profile of the soybean plants, being more exposed in the medium and upper extracts at times of milder temperatures, especially for large caterpillars.

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