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Cannibalism of newly hatched instar larvae and eggs in *Helicoverpa armigera* (Hubner)

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Abstract

Helicoverpa armigera is a major polyphagous global pest, causing heavy damage to agriculture, horticultural and ornamental crops Female lay eggs on the flowering and fruiting structures of crops where voracious larval feeding leads to substantial economic loss however, it performs cannibalism. Experiments carried out to quantify the cannibalism occurrence in *Helicoverpa armigera*, to confirm cannibalism interferes in the species performance and to check whether cannibalism is influenced by the population size. The parameters used in contemplation of to evaluate the performance were oviposition, fecundity, time of development, adults' weight, and survival rate. Cannibalism takes place in all larval instars. There was a propensity to increase the cannibalism practice is directly proportional to the number of co-specific increased (potential preys). Cannibalism was more intense in larvae at the end of larval development. Generally, cannibalism did not interfere in the population performance.

Keywords: *Helicoverpa armigera*, Cannibalism, Population Control.

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Introduction

Cannibalism is a natural phenomenon in several insect orders, including Hymenoptera, Neuroptera, Thysanoptera, Odonata, Orthoptera, Hemiptera, Trichoptera, Diptera, Coleoptera and Lepidoptera. The lepidoptera is most successful insects found all over the world, except Antarctica. Intraspecific predation, cannibalism is a common behavioral trait in many Lepidoptera species. It occurs among predatory species and herbivores, involving predation by the mobile adults and larvae or nymphs on each other, and on immobile eggs and pupae (Richardson *et al.* 2010).

There are many different types of cannibalism, e.g., sexual cannibalism, in which a female insect cannibalizes her male mate during copulation (Buskirk, *et al.* 1984); cannibalism as competition (Claessen *et al.* 2004); the cannibalism can increase the survival rate when food is scarce (White, 2005); intrauterine cannibalism in parasitoid insects (De Vries, *et al.* 2007), parasitizing offspring (Richardson *et al.* 2010) sibling cannibalism (Santana, *et al.* 2012) and filial cannibalism as an energetic benefit (Lawa *et al.* 2013) etc. Cannibalism is often contemplated as a populace self-regulatory measure, controlling population size, consequently suppress population outbreak. Cannibals ingest eggs, larvae and occasionally pupae (Whitman *et al*. 1994). Cannibals are benefited with the high proteinous nutritive diet by feeding on arthropod body tissue rather than fungal tissues and plant tissue in addition with abundant food supplies succeeding the elimination of competition Larvae turns into cannibals due to stress caused by the absence of food or water. Intraspecific competition is also considered to be rationale for the cannibalism. Larvae of lepidopteran *Anthocharis scolymus* and *Anthocharis cardamines* tend to be herbivorous shortage of food, high density or both these factors contributes to cannibalism (Kinoshita,1998). Cannibalism effects the population on a par with those of interspecific predation, and it has the potential to be a density-dependent regulator of population size in many species, comprises several species of Helicoverpa (Crowley *et al.*1994).In some invertebrate, the offspring reduced size is correlated with cannibalism practices (Godfray *et al.* 1991). Cannibalism in *H. armigera* is concerned with inter-larval in preference to egg cannibalism (Nyambo, 1990). Usually, cannibalism is quite high for species in the absence of close competitors (Fox, 1975) including *H. armigera*. The proteinous egg chorionis the caterpillars' first food, its vicissitudes the proteins and amino acids proportion and quality on the diet, that positively affect the performance of the species compared to non-cannibal individuals. Caterpillars that do not feed on egg chorion ingest their exoskeleton more frequently, especially in the 5th instar (Barros-Bellanda, *et al.*2001).

Cannibalism occurs during the larval stage, when there is increase on the caterpillars' hatching interval also occurs. The first caterpillar to hatch may ingest whole eggs subsequently the older or more developed caterpillars may ingest eggs or younger and more vulnerable caterpillars. The egg cannibalism in newly hatched caterpillars of *Helicoverpa armigera*, is related to the chorion ingestion behavior.

Therefore, the aim of the present study is to investigate the cannibalismrate, both of eggs and newly hatched caterpillars, its proportion related to the larval age, relation to the reproductive parameters and the cannibalism rate that is altered by the populational density in *Helicoverpa armigera.*

Materials and Methods

Eggs were collected from Tomato (*Lycopersicon esculentum*) leaves which was grown without use of any pesticides. Newly hatched caterpillars were placed in transparent plastic boxes (10x10x3.5 cm), Whatman No.1 filter paper is placed on the bottom. Larvae are checked on alternate days and any unhealthy or dead larvae are eliminated. Food was daily supplied *ad libitum* tomato leaves and food leftover are replaced regularly.

During experiments caterpillars were placed in glass containers (5.5 cm diameter and 7 cm height) covered with gauze. They are kept at constant 10 hours light (provided by fluorescent lamps 400 lux) and dark schedules with controlled temperature 25 ± 2°C and moisture content was kept at 80 ± 5 % in laboratory (Barros-Bellanda *et al.* 2003).

Experiment I. The aim of the present investigation was to estimate the egg cannibalism rate in of *Helicoverpa armigera* in all the instars and its correlation with the performance of the species (fecundity, time of development and adult size).The replacement of the tomato leaves pot, the dampened cotton and the egg counting were performed daily, up to the female's death. In wild, female *Helicoverpa armigera* may lay eggs on individual hosts in which caterpillars of their own species are already present, and consequently, inevitable egg cannibalism occurs. Caterpillars were kept in glass containers covered with gauze since emergence. Five groups were placed, each one with its respective control group. During the entire larval development, they were fed with *ad libitum* tomato leaves. A stage of each larval development: 1st, 2nd, 3rd, 4th and 5th instar placed in their respective groups I, II, III, IV and V. Each larva separately received10 eggs and tomato leaves in an accessible and conspicuous visible place. The ingested eggs were counted and the removal of the remaining ones were carried out after 24hours. Ten replicates were performed per group. The results were analyzed through one-way ANOVA.

Experiment II. The larva of *Helicoverpa armigera* are gregarious therefore, experiment was conducted on cannibalism rate of isolated and group caterpillars. Seven caterpillars were selected as they are also commonly found in group of seven in nature. Commonly seven caterpillars can survive on tomato leaf without competition for whole day (Barros-Bellanda, *et al.* 2002). Tomato leaves was supplied *ad libitum* to the experimental group. In each box with seven experimental caterpillars, 70 eggs of *Helicoverpa armigera* were supplied at the 4th larval instar. The control group consisted of similar age larvae and differed from the experimental group only for the absence of eggs. Ten replicates were performed per group. The results were analyzed through the test of ANOVA One Way Analysis of variance on Ranks.

Experiment III. The aim of this trial was to observe and substantiate the cannibalism rate of newly hatched caterpillar available to the 4th instar larva. It also confirms the cannibalism rate as a consequence of the increase in the number of conspecifics future competitors. The newly hatched larvae that suffers cannibalism and the 4^{th} instar caterpillars which carry out cannibalism was selected so that the caterpillars in the experiment could easily practice cannibalism. due to the greater predation power presented by caterpillars at the end of the development period, which can be influenced by demand of food and the physical structure of the jaw. The caterpillars were reared and on the first day of the4^{th} instar larva four groups were set. The trial groups received a fixed number of newly hatched caterpillars for 24 hours, besides *ad libitum* tomato leaves; Group I (control) received only tomato leaves. Group II supplied with 7 newly hatched caterpillars and tender tomato foliage; Group III: 15 newly hatched caterpillars were provided with *ad libitum* tomato leaves and Group IV: supplied with 30 newly hatched caterpillars and ad libitum tomato leaves. After 24 hours, the counting of ingested newly hatched caterpillars and the removal of the remaining larvae were carried out. Six replicates per group were performed. Average and standard deviation were calculated for each group, with all values from each box. The results were analyzed through one-way ANOVA.

Results and Discussion

It has been observed that grown caterpillars feed on the eggs and small larvae of its own which is known as cannibalism.

Experiment I. Cannibalism is a common natural trait in *Helicoverpa armigera*. The cannibalism rate is highest in V^{th} group as compared to all the other groups that consumed more than half the eggs (Table 1.). There is no effect of cannibalism in the performance parameters of fifth larval instar. The cannibalism rate was higher in group V, the fifth larval instar which is the end of the larval development, practiced cannibalism, it provides clues about that the larval age that interferes in the cannibalism rate. Early stages of larval instar, find difficulty in breaking the chorion of eggs, hence there is rise in competition for feeding eggs with the chorion already broken. The successive consumption of eggs reveals the preference for cannibalism. The pupation period was shortin first instar larvae that had perform cannibalism, it suggests high-quality protein, containing many essential amino acids is obtain from the cannibalism that is more important in the larval development.

Table l. Egg-cannibalism rate, time of development, and fecundity of *Helicoverpa armigera (Hubner)*under the following treatments: Control group (only tomato leaves supplied), first larval instar (group I), second larval instar (group II), third larval instar (group III), fourth larval instar (group IV) and fifth larval instar (group V), each experimental group were supplied with 10 eggs.

Larval instar in which treatment has been applied	Cannibalism rate (ingested eggs)	Pupation time (days)	Emergence time (days)	Fecundity (number of oocytes per female)
Control	————	9.51±0.41 a	15.74±0.15	543.00±95.04
I	6.01 ± 3.15 a	9.20±0.69 b	15.15±0.24	564.78± 81.67
II	6.11 ± 2.68 b	9.55±0.51 a	15.95±0.63	515.00± 76.45
III	8.01 ± 2.98 a	9.29±0.50 b	15.94±0.71	519.91± 51.87
IV	7.61 ± 3.94 a	8.96±0.10 a	16.48±0.64	516.95± 87.25
V	9.06 ± 2.63 b	9.15±0.61 a	15.88±0.50	530.74± 78.14

The results represent the average ± standard deviation (SD) of 10 replicates. Averages followed by same letter on same column are not different from each other by the test of One-Way Analysis of variance on Ranks with $P < 0.05$.

Experiment II. In this experiment, a large number of co-specifics fourth larval instar and caterpillars remained in contact with eggs for a 24 hours period were able to interact, consequently the cannibalism mean rate per larva was higher than the cannibalism average rate (Table II), showed by caterpillars at the same development phase. No influence of cannibalism occurred in the performance parameters.

Table ll. Cannibalism rates, time of development, adult size and fertility of *Helicoverpa armigera (Hubner)* submitted to the following treatments: Control group(group of 7 caterpillars, no eggs supplied) and Experimental group (group of 7 caterpillars; 70 eggs supplied at the fourth larval instar and caterpillars remained in contact with eggs for a 24 h period).

Presence of eggs for ingestion	Cannibalism rate per group	Cannibalism rate per caterpillar	Pupation (days)	Emergence time (days)	Fecundity (Number of oocytes per female)
Control	————	————	9.18 ±0.90	15.09 ±0.10	529.16±118.60
Experimental	69.15 ± 1.15	11.11±0.69	9.60 ±0.10	14.69±0.19	532.19 ± 69.51

The results represent the average ± standard deviation of 10 replicates No significant differences between Experimental and Control groups by the test of One-Way Analysis of variance on Ranks with P < 0.05.

Experiment III. Like the previous two experiments I and II, the cannibalism rate proportionately increased in consonance with the number of co-specifics *Helicoverpa armigera* (Table III). The performance parameters were not affected either by cannibalism or by its different rates. The percentage of cannibalized caterpillars and number of ingested caterpillars corresponds to the number of newly hatched larvae, that was relatively similar among all experimental groups (Table III).

Table. lll. Cannibalism rate, cannibalism percentage, pupation and emergence time, adult weight, *Helicoverpa armigera* survival rate and fecundity regarding the variation in the number of co-specifics. Group I: control group, only tomato leaves were supplied; Group II: 7 newly hatched caterpillars and tomato leaves supplied; Group III: 15 newly hatched caterpillars and tomato leaves supplied and Group IV: 30 newly hatched caterpillars and tomato leaves supplied.

Number of co-specific.	Number of ingested caterpillars	Percentage of cannibalized caterpillars	Pupation period (days)	Emergence time (days)	Adult weight (mg) Males	Adult weight (mg) Females	Oviposition	Survival rate (%)
Group I	-----------	-----------	13.48 ± 1.29	16.12±0.18	60.90 ± 2.70	69.70 ±6.9	496.10±269.00	93.03±11.01
Group II	5.19 ± 1.10a	72.06 ±15.90	13.51 ±0.33	15.95±0.39	66.00 ± 6.50	62.20±6.1	494.09±239.60	89.69± 6.09
Group III	8.53 ± 2.69a	57.46 ±20.42	13.28 ±0.36	16.24±0.31	59.70± 6.90	59.60±5.1	462.63±198.38	87.31± 9.06
Group IV	19.69±3.39b	67.45± 22.69	13.89 ±0.29	16.31±0.69	60.91± 5.40	57.60±2.8	280.15±208.19	78.74±11.18

The results represent the average ± standard deviation of 6 replicates No significant differences between Experimental and Control groups by the test of One-Way Analysis of variance on Ranks with P < 0.05.

The ingestion of co – specifics in *Helicoverpa armigera* arise whenever there is opportunity that influences the rate of cannibalism. The confinement and quality of food provided to the larvae in laboratory effects the cannibalism that is also very similar and common in nature. The developmental stage (i.e., instar) of the larvae and the number of potential co-specific prey effect the cannibalism rate. The strong mandible of 4th and 5th instar are able to break chorion of eggs to ingest them quickly in proportion to previous instar stages, and hence rate of cannibalism rises with the developmental stage of instar larvae.4th and 5th instar larvae are ravenous, agile and itinerant predators particularly significant for cannibalism on newly hatched caterpillar. These predators' larvae require a high proteinous nutritive diet in large amount for their development. High cannibalism rate and high ingestion rate of tomato leaves decrease feeding competition in order to assure its own food upto pupation stage. There was propensity towards group size reduction in replicates with high number of potential co-specific preys, this indicates cannibalism controls the population growth. Cannibalism rate is proportional to the number of co-specifics.

Commencement of cannibalism in the beginning of the development enhance the performance, existence and endurance of individuals which survived cannibalism. Cannibalism increases the survival probability of individual larvae by providing reduction on the risk of predation and/or parasitism.

According to Dennehy *et al.* (2001), the cannibalism rate decreases in low densities of the preys because the cannibal fails to interact with co-specifics newly hatched caterpillar at low densities. The intra-specific competition is natural during the larval instar phase in *Helicoverpa armigera* species. Cannibalism control population size in *Tenebrio* beetles (Peters & Barbosa 1977). According to Chapman *et al.* (2000), cannibalism causes substantial reduction in the local population density that, successively reduce parasitism and/or predation. 4th and 5th instar of *Helicoverpa armigera* finds places with a high density of co-specifics caterpillar preys tend to remain longer at the site. Volatile compounds originate from injured hosts or from high density prey itself, are known for indicating the prey's location to attract a higher number of co-specific predators (Drukker *et al.* 1995).
In *Helicoverpa armigera*, one to two days after copulation oviposition starts. The females, lay small egg masses. The copula can last up until 15 days, after which females die, due to fatigue. Approximately 10 to 20 eggs were deposited during the first days that gradually increases towards the end of the oviposition period. (Queiroz-Santos *et al.* 2018). Laying eggs in batches is advantageous for *Helicoverpa armigera*, it generates intra-specific competition and incite migration. Though, such intra-specific competition may be weakened by cannibalism, keeping the survival rates high. The chorion ingestion in the beginning reduces the time period (Table I) of development in *Helicoverpa armigera* (Barros-Bellanda & Zucoloto 2001), possibly cannibalism provides an important supply of protein for this phase of the development.

The reduction in developmental period increases the probability of individual to survive and reproduce due to decrease in the exposure time to mortality factors such as parasite, predators and environmental factors. Cannibalism minimizes the risk of predators; it indicates that the reduction in predation compensates for the costs associated with cannibalism(Chapman *et al.* 2000). In *Spodoptera frugiperda*, cannibal individuals have lower survival rate because they may acquire fatal infection by feeding on infected co-specifics. In *A. monuste*. without competition the cannibalism usually doesn't change the nutritional performance, due to lack of protease enzyme and consequently there is increase in the excretion of excess nitrogenous products. Lemos *et al.* (1992) studied that larva of *Ceratitis capitata*, that are naturally herbivorous, when fed on a diet based on meat flour (animal protein) release a lower quantity of aminopeptidase into the gastrointestinal tract in comparison to the larvae that feed on a diet based on yeast. The release of a small quantity of peptidase might be an adaptation, to avoid a high growth of amino acids in the digestive tract, (Dadd 1985) when cannibalism occurs in *Helicoverpa armigera*.

This study quantifies the cannibalism occurrence in *Helicoverpa armigera*, to confirm whether cannibalism interferes in the species performance and to check whether cannibalism is influenced by the population size. The parameters used in order to evaluate the performance were time of development, adults' and weight, fecundity, oviposition and survival rate. Cannibalism occurred in all larval instars. There was a tendency to increase the cannibalism practice as the number of co-specific increased (potential preys). Cannibalism was more intense in larvae at the end of larval development. Generally, cannibalism did not interfere in the population performance. The most probable hypothesis for the occurrence of cannibalism in the conditions here studied would be the hypothesis of cannibalism as having the function of population control.

References

1. Barros-Bellanda, H. C. H. &Zucoloto F. S. (2001). Influence of chorion ingestion on the performance of *Ascia monuste* and its association with cannibalism. Ecological Entomology 26: 557-561.
2. Barros-Bellanda, H. C. H. &Zucoloto. F. S. (2002). Effects of intraspecific competition and food deprivation on the immature phase of *Asciamonuste orseis* (Lepidoptera, Pieridae). Iheringia, Série Zoologia, 92(1): 93-98.
3. Barros-Bellanda, H. C. H. &Zucoloto. F. S. (2003). Importance of larval migration (dispersal) for the survival of *Ascia monuste* (Godart) (Lepidoptera: Pieridae). Neotropical Entomology 30(1): 11-17.
4. Buskirk, R.E.; Frohlich, C.; Ross, K.G. (1984), The natural selection of sexual cannibalism. Am. Nat. 123, 612-625.
5. Chapman, J. W.,Williams T, Martínez A. M.,Cisneros J., Caballero P., CaveR.D. &Goulson D.(2000). Does cannibalism in *Spodoptera frugiperda* (Lepidoptera, Noctuidae) reduce the risk of predation? Behavior, Ecology and Sociobiology 48: 321-327.
6. Claessen, D.; de Roos, A.M.; Persson, L. (2004), Population dynamic theory of size–dependent cannibalism. Proc. R.Soc. Lond. B271, 333–340.
7. Crowley, P.H. and K.R. Hopper, 1994. How to behave around cannibals: A density-dependent dynamic game. American Naturalist 143: 117–154.
8. Dadd, R. H. (1985). Nutrition: organisms, p. 313-390. *In*: G. A. Kerkurt& L. I. Gilbert (Edit.). Comprehensive Insect Physiology, Biochemistry and Pharmacology. v. 4. Oxford, Pergamon Press.
9. Dennehy, J. J., Robakiewiez P. & Lividahl.T (2001). Larval rearing conditions affect kin-mediated cannibalism in a tree hole mosquito. Oikos 95:335-339.
10. De Vries, T.; Lakes-Harlan, R. Prenatal cannibalism in an insect. Naturwissenschaften 2007, 94, 477–482.
11. Drukker, B.; P. Scutareanu& M. W. Sabelis. (1995). Do anthocorid predators respond to synomones from *Psylla*-infested pear trees under field conditions? Entomologia Experimentalis et Applicata 77: 193-203.
12. Fox, L.R., (1975.) Cannibalism in natural populations. Annual Review of Ecology and Systematics 6: 87–106.
13. Godfray, H. C. J.; L. Partridge& P. H. Harvey. (1991) Clutch size. Annual Review of Ecology 22: 409-429.
14. Kinoshita, M. (1998). Effects of time-dependent intraspecific competition on offspring survival in the butterfly, *Anthocharis scolymus* (L.) (Lepidoptera, Pieridae). Oecologia 114: 31-36.
15. Lawa, Y.H.; Rosenheim, J.A. (2013) Presence of conspecific females motivates egg cannibalism owing to lower risk of filial cannibalism. Anim. Behav., 85, 403–409.
16. Lemos, F. J. A., F. S. Zucoloto & W. R. Terra. (1992). Enzimological and Excretory Adaptations of *Ceratitis capitata* (Diptera: Tephritidae)Larvae to High Protein and High Salt Diets. Comparative Biochemistry Physiology 102 A(4): 775-779.
17. Nyambo, B.T., (1990) Effect of natural enemies on the cotton bollworm, *Heliothis armigera* (Lepidoptera: Noctuidae) in Western. Tropical Pest Management 36, 50-58.
18. Peters, T. M. &Barbosa P.(1977). Influence of populational density inthe size, fecundity and development rate in insect culture. Annual Review of Entomology 22: 431-450.
19. Queiroz-Santos, MM Casagrande, A Specht (2018) Morphological Characterization of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae: Heliothinae). Neotrop Entomol https://doi.org/10.1007/s 13744-017-0581-4
20. Richardson, M.L.; Mitchell, R.F.; Reagel, P.F.; Hanks, L.M. (2010) Causes and consequences of cannibalism in non carnivorous insects. Annu. Rev. Entomol., 55, 39–53.
21. Santana, A.F.; Roselino, A.C.;Cappelari, F.A.; Zucoloto, F.S. (2012) Cannibalism in insects. In Insect Bioecology and Nutrition for Integrated Pest Management; Panizzi, A.R., Parra, J.R.P., Eds.; CRC Press: Boca Raton, FL, USA, pp. 177–194.

22. Whitman, D. W, Blum M.S & Slansky F., JR. (1994). Carnivory in phytophagous insects, p. 161-205. *In*: T. N. Ananthakrisnan (Edit.). Functional dynamics of phytophagous insects. New Delhi, Oxford & IBH Publishing Co. Pvt. Ltd.

23. White, T.C.R. (2005) Why Does the World Stay Green? Nutrition and Survival of Plant-Eaters; CSIRO Pub.: Sydney, Australia.

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