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Preliminary Study of Predation Effectiveness of the Assassin Bug *Rhynocoris rapax* Stal (Heteroptra: Reduviidae) on Fall Armyworm *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae), a Major Pest of Maize Crops

Assiénin Hauverset N'Guessan[1*], Brice Sidoine Essis[2], Achi Laurent N'cho[3], Hugues Annicet N'da[4], Kouamé Jean-Noël Konan[5], N'Guessan Alphonse Kouassi[6]

[1]National Centre for Agronomy Research, Research Station of La Mé, Laboratory of Entomology, Abidjan, Côte d'Ivoire
[2]National Centre for Agronomy Research, Food Crops Research Station, Laboratory of Phytopathology, Bouaké, Côte d'Ivoire
[3]National Centre for Agronomy Research, Research Station of Maize, Millet and Sorghum, Laboratory of Phytopathology, Ferkessédougou, Côte d'Ivoire
[4]National Centre for Agronomy Research, Research Station of Maize, Millet and Sorghum, Plant Breeding Laboratory, Ferkessédougou, Côte d'Ivoire
[5]National Centre for Agronomy Research, Research Station of La Mé, Plant Breeding Laboratory, Abidjan, Côte d'Ivoire
[6]National Centre for Agronomy Research, Research Station of La Mé, Soil Science Laboratory, Abidjan, Côte d'Ivoire
Email: *assienin.nguessanh@gmail.com

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Abstract

Maize is a staple food in many sub-Saharan African countries, grown on large surfaces and with high production. However, maize's cultivation is often confronted with attacks by the fall armyworm, which considerably reduces production. Thus, the use of biological agents in the control of the fall armyworm would contribute effectively to the sustainability of agriculture. It is in this context that this study, conducted at the La Mé station of the National Centre for Agronomy Research, aims to test the effectiveness of *Rhynocoris rapax,* a powerful predator of various insect families, on the fall armyworm *Spodoptera frugiperda*, for biological control of this maize pest in Côte d'Ivoire. Therefore, 3 batches of 1 adult individuals of *Rhynocoris rapax* were captured in trial plots set up at the La Mé station. These individuals were then put in contact with 3 batches of 5, 20 and 40 larvae of the pest in rearing boxes at an average temperature of 26.4˚C and an average relative humidity of 60%, in order to evaluate the efficiency of the predation. The results showed that *Rhynocoris rapax* kills more larvae when these are in large numbers. The mortality of the high number of larvae was observed during the first three

days, probably due to the voracity and aggressiveness of *Rhynocoris rapax* that period. So *R. rapax* is a potential predator of fall armyworm and should be protected.

Keywords

Effectiveness, Predation, *Rhynocoris rapax*, *Spodoptera frugiperda*, Maize

1. Introduction

With an average annual production of about 817 million tons in 2009, maize is the most widely grown cereal before wheat (681 million tons) and rice (678 million) [1]. In Africa, maize is a major staple food consumed by populations with diverse preferences and socio-economic backgrounds in sub-Saharan Africa. For that, it is grown in diverse agro-ecological zones and farming systems on an area of 34,075,972 ha with an average production of 70,076,591 tons [2]. In Côte d'Ivoire, maize is the second most cultivated cereal after rice. Its annual national production is about 654,738 tones, for a total harvest area of 327,800 ha [3]. Despite the many advantages of maize, its cultivation is confronted with several attacks by insect pests that have a negative impact not only on nutritional quality, but also on yield. These include the corn borer *Ostrinia nubilalis* Hübner (Lepidoptera: Crambidæ), the rootworms *Diabrotica virgifera* LeConte and *Diabrotica barberi* Smith & Lawrence (Coleoptera: Chrysomelidae), the stem and cob borer caterpillars *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) [4] [5] [6] and the fall armyworm *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) which was first reported from the African continent in January 2016 [7]. This caterpillar causes enormous damage to crops on the African continent. In Côte d'Ivoire, it has been seen on crops such as cotton, rice, maize, etc. [8] [9]. Chemical control has been used for a long time against this insect but it has not proved to be very effective due to acquired resistance. In the context of plant and environmental protection and sustainable agriculture, biological control consisting of the use of a biological agent against the pest was the subject of this study. The aim was to evaluate the predation efficiency of the assassin bug *Rhynocoris rapax* against *Spodoptera frugiperda*, a major pest of maize cultivation.

2. Materials and Methods

2.1. Study Site

The work was carried out at the La Mé research station of the National Centre for Agronomy Research. This station is located in the south-east of Côte d'Ivoire in the district of Abidjan on the road leading to Alépé, with the geographical coordinates of 5˚26' North Latitude and 3˚50' West Longitude. It is bordered to the east by the Mé River and to the south by the Aghien Lagoon. The predatory

insects and the fall armyworm *S. frugiperda* were captured in maize fields on the station. The test was carried out in the Entomology Laboratory of the research station.

2.2. Capture of *Rhynocoris rapax*

The capture of *Rhynocoris rapax* predators (Figure 1) was carried out between 8 am and 11 am in maize plots set up at the La Mé station and infested with fall armyworm. During these cooler hours of the day, the predator is more active. It is most often found in maize plots. The capture was done with a mowing net. Once captured, the insect was put in a rearing box and sent to the Entomology laboratory for the predation test. For this test, solely the adults of *R. rapax* were used.

2.3. Collection of *Spodoptera frugiperda* Larvae

Daily visits to plots were made to observe the damages caused by the fall armyworm on maize crops (Figure 2). When fresh fall armyworm waste was observed on an infested plant, the youngest leaves at the whorl were opened (Figure 3). The larvae inside were pulled out with soft entomological forceps to avoid

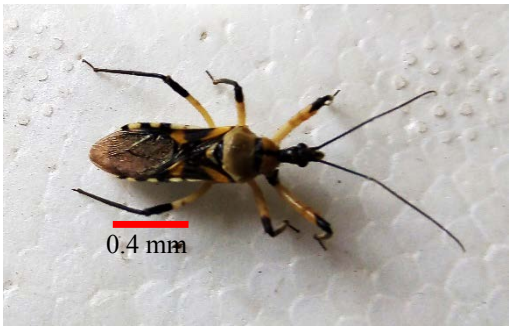

Figure 1. *Rhynocoris rapax* (Heteroptera: Reduviidae).

Figure 2. Maize trial plot infested by the fall armyworm.

Figure 3. Fall armyworm in the whorl of a maize plant.

crushing them. They were then put in boxes to be sent to the laboratory for testing. Also larvae of the pest were used because only the larvae are dangerous for the cultures. However, the larval stages 4, 5 and 6 were combined for the study.

2.4. Study of Predation Effectiveness of *Rhynocoris rapax* on Fall Armyworm

The predation test of *Rhynocoris rapax* on *Spodoptera frugiperda* was carried out in the laboratory at an average temperature of 26.4˚C and a relative humidity of 60%. Five (5) individuals of *R. rapax* (Heteroptera: Reduviidae) were placed in 5 boxes each containing 5 larvae of *Spodoptera frugiperda*. Contact of the predator with *Spodoptera frugiperda* larvae in rearing boxes allowed us to observe the action of *R. rapax* on *S. frugiperda* (**Figure 4**). Thus, the study of predation by the predator on the fall armyworm consisted of three categories of three boxes, each containing pieces of fresh maize leaves as food for the fall armyworm:

- the first three boxes with sizes of 25 × 19 × 8 cm contained 5 larvae of *S. frugiperda* and 1 individual of *R. rapax*;
- the next three boxes each containing 20 larvae of *S. frugiperda* and 1 individual of *R. rapax* and;
- the last three boxes with 40 larvae of *S. frugiperda* and 1 *R. rapax* individual.

Daily monitoring was used to count the number of *S. frugiperda* larvae killed by the predator *R. rapax* and the time taken by the predator to kill all the larvae.

2.5. Data Analysis

The data obtained in this study were subjected to statistical analysis using the Statistical Analysis System software (SAS 9.4). The separation of means was performed by the LSD (Least Significant Difference) test at the threshold $\alpha = 0.05$.

3. Results

3.1. Predation of *Rhynocoris rapax* Depending on Number of *Spodoptera frugiperda* Larvae

The study of the predation of *Rhynocoris rapax* on *Spodoptera frugiperda* larvae

Figure 4. Fall armyworm caught by *Rhynocoris rapax* in rearing boxe.

revealed the number of *S. frugiperda* larvae killed as a function of the population density of the pest. Thus, the results showed that for 40 *S. frugiperda* larvae and 1 *R. rapax* adult, the number of larvae killed was higher with an average of 6.66 ± 0.77 larvae per predation. This number was average with 20 *S. frugiperda* larvae where 1 *R. rapax* adult devoured 3.00 ± 0.79 larvae. Predation was lower with 5 larvae of *S. frugiperda* for 1 individual of *R. rapax*. A low number of 5 *S. frugiperda* larvae were observed, with 1.15 ± 0.19 larvae. The analysis of variance showed significant differences between the number of *S. frugiperda* killed and their population level ($p = 0.0001$) (**Table 1**).

3.2. Prey Mortality Rate Depending on the Time

Evaluation of the mortality rate of *S. frugiperda* larvae showed that the predator *R. rapax* kills fall armyworms as a function of population level and time. A decrease in the trend curve was observed as a function of time regardless of the number of larvae. Thus, for 5 *S. frugiperda* larvae, the highest number of larvae killed was observed during the first three days. Between 20% and 33.33% of the larvae were killed by the predator (**Figure 5**). For 20 *S. frugiperda* larvae, 15% to 43.33% of these caterpillars were killed. For the 40 *S. frugiperda* larvae, 16.67% to 27% of the larvae were killed by *R. rapax* during these first three days (**Figure 6** and **Figure 7**). At the latest, 7 days later all larvae were killed by the predator (**Figures 5-7**). In general, the highest mortality of larvae was observed during the first three days.

4. Discussion

Predation by *Rhynocoris rapax* showed that the average number of *Sopdoptera frugiperda* larvae killed was higher when the population level of the pest was high. The increase in mortality of fall armyworm as a function of population level is thought to be due to the fact that *Rhynocoris rapax* is a highly voracious generalist predator. [10] stated that prey consumption in these insect groups varies according to the energy requirements of the species. As an example, these

Table 1. Average number of *S. frugiperda* larvae killed as a function of the density.

Number of *R. rapax*	Number of *S. frugiperda* larvae	Average number of killed larvae
1	40	6.66 ± 0.77[a]
1	20	3.00 ± 0.79[ab]
1	5	1.15 ± 0.19[b]

Means with the same letter in the same column are not significantly different (LSD test, $p \leq 0.05$).

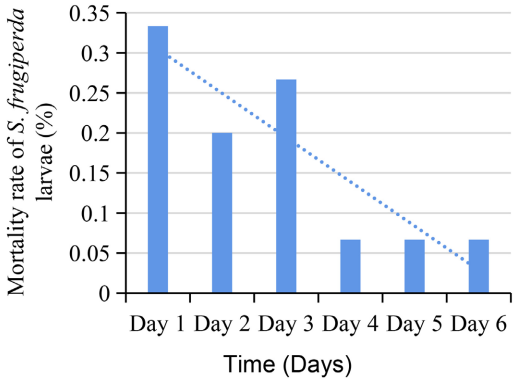

Figure 5. Mortality rate of *S. frugiperda* larvae (1 *R. rapax*/5 larvae).

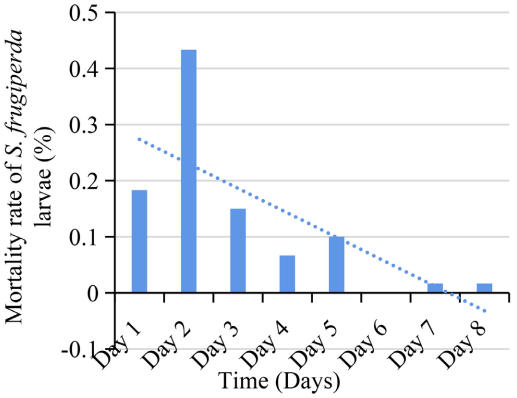

Figure 6. Mortality rate of *S. frugiperda* larvae (1 *R. rapax*/20 larvae).

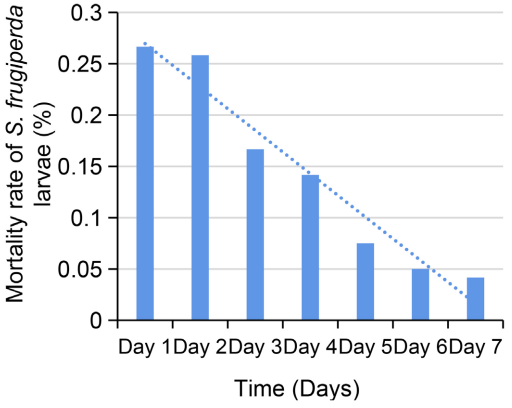

Figure 7. Mortality rate of *S. frugiperda* larvae (1 *R. rapax*/40 larvae).

authors indicated that the ladybird (*Coccinella septempunctata* L.) can consume 100 aphids per day. The same is true for the soldier bug *Podilus maculiventris* Say which can consume up to 10 CPB (Colorado potato beetle) eggs per day, thus explaining the high mortality of *S. frugiperda* when its population increases. According to [11], the effect of predators on prey depends on the dominant functional types, which in turn are determined by the structure of the landscape. The results also showed that the mortality rate of *S. frugiperda* caterpillars varied with larvae population level and time. The high mortality observed during the first three days could be explained by the aggressiveness of *Rhynocoris rapax* towards *S. frugiperda* larvae. [12] indicated that prey consumption is increasing with the development of the predator and also with the number of prey. To this effect, [13] reported that the nutritional requirements of *Rhynocoris marginatus* F. (Heteroptera: Reduviidae) increase from the first to the fifth day instar when fed with *Spodoptera litura* F. In addition, [14] also noted that daily prey consumption tends to be higher in the later development stages of predators. This is in agreement with our results as in that study it was *R. rapax* adults which were put in contact with fall armyworm larvae.

5. Conclusion

The study of the predation effectiveness of the fall armyworm *Spodoptera frugiperda* by *Rhynocoris rapax* showed that this predatory heteropteran killed significantly *more S. frugiperda* larvae when their population level was high. This predator caused high mortality during the first three years probably due to its high aggressiveness and voracity towards its prey during the first days. This entomophagous insect is therefore a potential enemy of the fall armyworm. However, further studies will have to be carried out to verify the effectiveness of this predator in the field. It will be necessary to breed for mass production and carry out inundative releases.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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