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Research Article
Dynamics of Reduviidae Species, Predators of *Podagrica decolorata*, in West of Côte d'Ivoire

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Abstract

Background and Objective: Okra is an important vegetable crop in Côte d'Ivoire. In the okra crop, there are species of Reduviidae that are predators of insect pests. These Reduviidae occupy a very important place in biological control because of their biocontrol potential. The objective of the study was to investigate the dynamics of the Reduviidae species, predators of *Podagrica decolorata.* **Materials and Methods:** This study was conducted during the dry and rainy seasons of 2019 in the city of man located in the west of Côte d'Ivoire. Colour traps and mowing nets were used to capture the different species of Reduviidae to determine the influence of abiotic factors and the populations of the species *Podagrica decolorata* on the dynamics of Reduviidae species. **Results:** A study on the frequency of occurrence revealed two constant species which are *Rhynocoris rapax* and *Rhynocoris albopilosus* with frequencies of occurrence of 63.46 and 75%, respectively. In dry and rainy seasons, *Rhynocoris albopilosus* was higher numbers at each phenological stage. The study revealed the influence of abiotic factors (temperature, rainfall and humidity) on the population of Reduviidae species. The study also showed highly significant positive correlations between the population of Reduviidae and that of the pest, *P. decolorata* in the dry season ($r = +0.76$ and $p<0.001$) and in the rainy season ($r = +0.47$ and $p<0.001$). **Conclusion:** The study revealed a total of six Reduviidae species whose numbers varied during the two seasons as potential predators of *Podagrica decolorata*.

Key words: Okra, predators, dynamics, *Podagrica decolorata*, Reduviidae, seasons, correlations

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Okra is an important vegetable crop, which is attacked by *P. decolorata* and other insect pests. In the crop, there are Reduviidae which are insects that are present in all environments where nutritive resources are available[1,2]. They constitute the second major family of Heteroptera[3,4]. They are abundant and highly effective predators in the biological control of crop pests[5]. Several previous studies have revealed the predatory ability of a large number of Reduviidae species[6-9]. These are *Rhynocoris fuscipes*, *Rhynocoris kumari*, *Rhynocoris longifrons*, *Rhynocoris marginatus* and *Acanthaspis pedestris*, which eliminated various pest species such as *Dysdercus cingulatus*, *Helicoverpa armigera*, *Spodoptera litura and Mylabris indica* in agro-ecosystems, suggesting that they could be employed in pest management. Previous studies in Senegal revealed that *Cosmolestes pictus* was identified as a predatory species of the okra pest *P. decolorata*[10]. In Côte d'Ivoire the predatory species of Podagrica decolorata were *Rhynocoris albopilosus*, *R. rapax*, *R. bicolor*, *Cosmolestes pictus*, *Hediocoris fasciatus* and *Coranus* sp.[11,12]. The control of insect pests of okra in Côte d'Ivoire is essentially based on the use of chemical insecticides which, although effective, have adverse effects on humans and their environment. Climate change and its consequences require that the predator's Reduviidae species of *P. decolorata* be taken into account from a biological control perspective. For the implementation of this method, it is therefore essential to know the bioecology of these insect predators.

This study is envisaged to determine the relationship between certain abiotic factors (temperature, humidity and rainfall) and the dynamics of these Reduviidae species and then to determine the relationship between the population dynamics of predators and the numbers of *P. decolorata*, according to the phenological stages of okra.

MATERIALS AND METHODS

Study area: The study was carried out in the city of Man (latitude 07°20 and 07°35 North, longitude 07°25 and 07°45 West), located in the west of Côte d'Ivoire. The study was carried out in the dry season from January-March 2019 and in the rainy season from June-September, 2019.

The study area was limited to the North by the Grand-Gbapleu District, to the West by the Kogouin District and to the East by the Fraternité District. The city of Man is characterized by a mountainous climate where the temperature increases with altitude. The dry season is very short from December to March and the rainy seasons is from April to November. Rainfall varies from 1,300-2,400 mm per year and humidity ranges from 80-85%[13].

Materials

Study material consisted of technical and biological materials: The technical material was the colour trap and the swath net. The trapping device consisted of nine traps. Each trap had four racks spaced 25 cm apart and fixed on a vertical axis in different directions. On each rack was placed a yellow plastic plate of 17 cm diameter and 9 cm deep. A total of 36 yellow plates were placed on the nine traps, 4 plates per trap.

The biological materials consisted of plant material, okra of the "Hiré" variety and animal material, composed of Reduviidae species and *P. decolorata*.

Methods

Experimental design: The experimental plot consisted of 3 blocks separated from each other by 2 m with a total area of 323 m^2. Each sub-plot measured 25 m^2 (5×5 m). The sub-plot, 1 m apart each consisted of 6 lines spaced from each other of 1 m. Each line is made up of 10 pockets, which makes 60 pockets per sub-plot. The whole experimental plot was made up of a total of 540 pockets.

Two crop cycles of okra were carried out. The first crop cycle of okra was carried out in the dry season from January-March, 2019 and the second crop cycle of okra was carried out in the rainy season from June-September, 2019.

Collection of insects: Insects were captured with yellow traps and a mowing net during each collection. A total of nine traps were placed in the sub-plots in the middle of the central line. Adults of *P. decolorata* and its predators, flying were attracted by the yellow colour and fell into the plates containing soapy water and died. Surveys were carried out twice a week between 07:00 and 10:00 am. After each collection of Reduviidae species and *P. decolorata* were counted. Abiotic factors (temperature, rainfall and humidity) were determined using meteorological data from to meteorological centre (SODEXAM) in Man.

The frequency of occurrence (C) was calculated following the formula[14]:

$$C\ (\%) = \frac{Pa}{P} \times 100$$

According to Landry *et al.*[14], the frequency of occurrence represents the ratio of the number of collections where each species of Reduviidae (Pa) is found and the total number of collections (P).

The value of C obtained was used to distinguish the insect species captured:

- Ubiquitous species (C = 100%) observed in all collections
- Constant species (50%≤C<100%) are present in more than 50% of the collections
- Frequent species (25%≤C<50%) present in 25% of collections
- Accessory species are present in less than 25% of collections

Statistical analysis: All data obtained were subjected to Analysis of Variance (1-factor ANOVA) using Statistica version 7.1 software. The multiple comparisons of means were performed by Fisher's LSD tests. The Pearson correlation test was used to show the relationship between abiotic factors (temperature, rainfall and humidity) and the dynamics of some species of Reduviidae predators of *P. decolorata* and to show the correlation between the dynamics of Reduviidae and the pest *P. decolorata*.

RESULTS

Dynamics of some species of Reduviidae, predators of *Podagrica decolorata* in okra crops:

- **Frequency of occurrence of Reduviidae species:** A total of six Reduviidae species were collected. Among these species collected, only *Rhynocoris albopilosus* and *Rhynocoris rapax* were revealed as constant species (C≥50%) with frequencies of occurrence of 75 and 63.46%, respectively. With frequencies of occurrence between 25 and 50%, *Rhynocoris bicolor* and *Cosmolestes pictus* were considered frequent species. *Hediocoris fasciatus* and *Coranus* sp., had frequencies of occurrence of less than 25%. These were accessory species (Table 1)
- **Variation in the numbers of Reduviidae species according to the phenological stages of the plant:** During the first crop cycle of okra, the average numbers of the different species of Reduviidae predators of *P. decolorata* varied slightly according to the phenology of okra

At the stage before flowering, only *R. albopilosus* and *R. rapax* were collected with average numbers of 0.06±0.01 individuals/sub-plot for *R. albopilosus* and 0.11±0.01 individuals/sub-plot for *R. rapax*.

At the flower bud stage, in addition to *R. albopilosus* and *R. rapax* collected at the stage before flowering, *R. bicolor* and *C. pictus* were collected with the same average number of 0.13±0.08 individuals/sub-plot. The mean number of *R. albopilosus* was 0.53±0.13 individuals/sub-plot and that of *R. rapax* was 0.33±0.11 sub-plot.

At the flowering-fruiting stage, all six species of Reduviidae were collected in low numbers. The only means the number of *R. albopilosus* was highest with 0.5±0.1 individuals/sub-plot. The lowest mean number of individuals was obtained by *H. fasciatus* with 0.04±0.03 individuals/sub-plot.

The other species of Reduviidae were average numbers between 0.08±0.03 and 0.33±0.05 individuals/sub-plot.

The analysis of variance revealed highly significant differences between the average numbers of individuals collected according to the phenological stages of okra for *R. albopilosus* ($F = 5.51$, ddl = 2, $p<0.01$). The analysis of variance also revealed non-significant differences between the average numbers of five species of Reduviidae and the phenological stages of okra (Fig. 1a).

During the second crop cycle of okra, also six species were collected with higher average numbers according to the phenological stages. The average numbers of *R. albopilosus* and *R. rapax* were high at the flowering-fruiting stage with, respectively an average of 2.67±0.28 and 1.71±0.17 individuals/sub-plot. The species *Coranus* sp., absent at the two previous phenological stages, was only caught in the colour trap at the flowering-fruiting stage with an average number of 0.29±0.07 individuals/sub-plot. The average numbers of the other species ranged from 0.02±0.01 and 0.75±0.17 individuals/sub-plot.

Table 1: Frequencies of occurrence of six species of reduviidae predators of *Podagrica decolorata*

Species of reduviidae	*R. albopilosus*	*R. bicolor*	*R. rapax*	*C. pictus*	*H. fasciatus*	*Coranus* sp.
Frequency occurrence C (%)	75	36.54	63.46	38.46	17.31	17.31
Characteristics	Constant	Frequent	Constant	Frequent	Accessory	Accessory

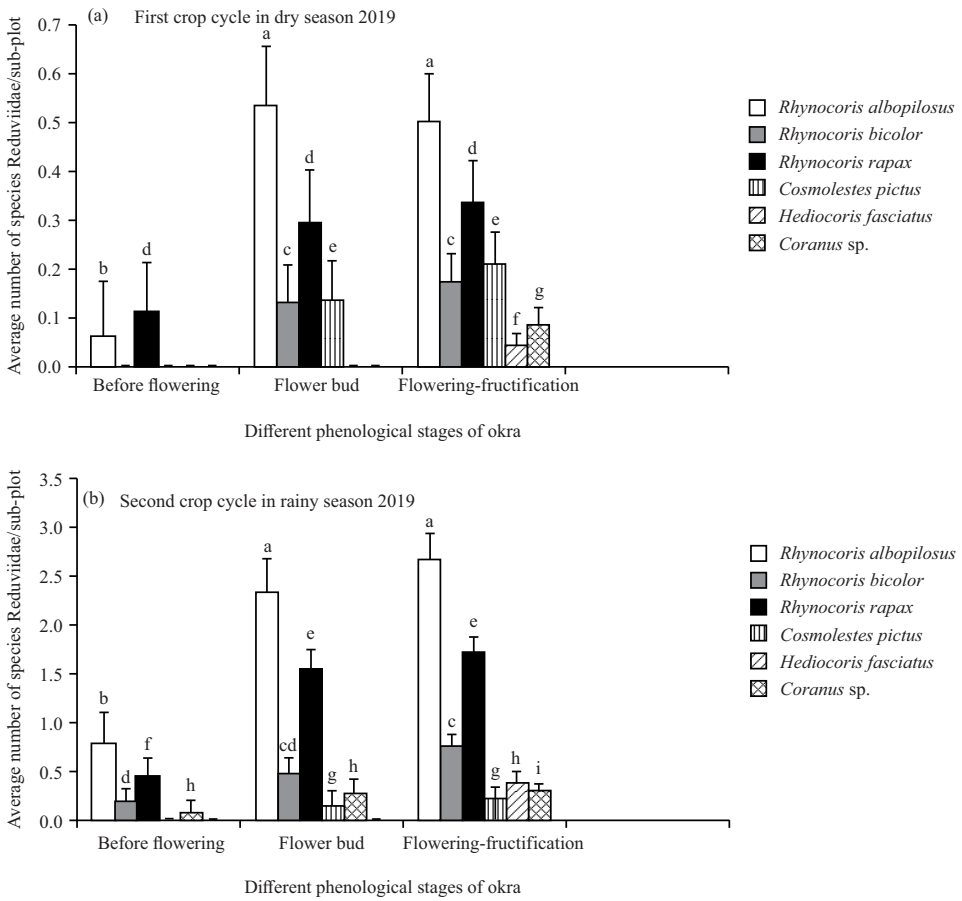

Fig. 1(a-b): Average numbers of Reduviidae species in dry and rainy seasons

*Bars with different letters are significantly different at the 5% level according to the fisher LSD

Statistical analysis revealed significant differences between the mean numbers of predatory insects according to the phenological stages of okra for the following species: *R. albopilosus*, *R. bicolor*, *R. rapax* and *Coranus* sp. Non-significant differences were revealed between the mean numbers of *C. pictus* and *H. fasciatus* and the different phenological stages (Fig. 1b).

Correlation between Reduviidae species average numbers and abiotic factors

Case of first crop cycle of okra in the dry season:

- **Average temperature:** Non-significant positive correlations between the average numbers of five Reduviidae species and average temperature were obtained. A positive, significant correlation between the average number of *Coranus* sp. and temperature was revealed (Table 2)
- **Average rainfall:** Non-significant positive correlations were also found between the average numbers of five species of Reduviidae and average rainfall. A non-significant negative correlation was found between the average number of *R. bicolor* and the average rainfall (Table 2)
- **Relative humidity:** Positive correlations were observed between the average numbers of six species of Reduviidae and humidity. The correlations were highly significant between humidity and the average numbers of *R. rapax* and those of *C. pictus*. It was significant for *R. albopilosus*. The other species of Reduviidae were not significantly correlated (Table 2)

Case of second crop cycle of okra in the rainy season:

- **Average temperature:** The average numbers of all predatory species were non-significant negative correlations with average temperature except for *R. albopilosus* (Table 3)
- **Average rainfall:** The average numbers of five species of Reduviidae were correlated positively. Highly significant

positive correlations were revealed between average rainfall and *R. bicolor* and *R. rapax*. Significant positive correlations were obtained between rainfall and *C. pictus* and *Coranus* sp. The average number of *R. albopilosus* was correlated positively and non-significantly with average rainfall. A negative and non-significant correlation was revealed between average numbers of *H. fasciatus* and rainfall (Table 3)

- **Relative humidity:** The average numbers of *R. rapax*, *C. pictus* and *Coranus* sp., showed non-significant positive correlations with relative humidity. The correlation between an average number of *R. bicolor* and relative humidity was negative and not significant. The correlations between relative humidity and average numbers of *R. albopilosus* and *H. fasciatus* were positive and highly significant (Table 3)

Correlation between average numbers of Reduviidae species and *P. decolorata*: The study of the relationship between average numbers of *P. decolorata* adults and the population of all Reduviidae species predators showed highly significant positive correlations during the first crop cycle of okra in the dry season ($r = +0.76$ and $p<0.001$) and the second crop cycle of okra in the rainy season ($r = +0.47$ and $p<0.001$) (Fig. 2a-b).

Table 2: Correlation between average numbers of species of Reduviidae predators and some climatic factors during the first crop cycle of okra in the dry season

	Dry season 2019		
	Correlation coefficient of climatic factors		
Species of Reduviidae	Humidity relative (%)	Average temperature (°C)	Average rainfall (mm)
Rhynocoris albopilosus	r = +0.46	r = +0.36	r = +0.10
	p = 0.02 (S)	p = 0.07 (NS)	p = 0.62 (NS)
Rhynocoris bicolor	r = +0.00	r = +0.29	r = –0.03
	p = 0.42 (NS)	p = 0.15 (NS)	p = 0.89 (NS)
Rhynocoris rapax	r = +0.58	r = +0.25	r = +0.19
	p<0.01 (HS)	p = 0.21 (NS)	p = 0.35 (NS)
Cosmolestes pictus	r = +0.50	r = +0.28	r = +0.01
	p<0.01 (HS)	p = 0.17 (NS)	p = 0.98 (NS)
Hediocoris fasciatus	r = +0.14	r = +0.22	r = +0.11
	p = 0.50 (NS)	p = 0.29 (NS)	p = 0.61 (NS)
Coranus sp.	r = +0.27	r = +0.40	r = +0.06
	p = 0.19 (NS)	p = 0.04 (S)	p = 0.76 (NS)

HS: Highly significant at the threshold of 5%, NS: Non-significant and S: Significant

Table 3: Correlation between average numbers of species of Reduviidae predators and some climatic factors during the second crop cycle of okra in the rainy season

	Rainy season 2019		
	Correlation coefficient of climatic factors		
Species of Reduviidae	Humidity relative (%)	Average temperature (°C)	Average rainfall (mm)
Rhynocoris albopilosus	r = +0.51	r = -0.51	r = +0.28
	p<0.01 (HS)	p<0.01 (HS)	p = 0.16 (NS)
Rhynocoris bicolor	r = -0.06	r = -0.15	r = +0.70
	p = 0.76 (NS)	p = 0.45 (NS)	p<0.001 (HS)
Rhynocoris rapax	r = +0.23	r = -0.30	r = +0.61
	p = 0.26 (NS)	p = 0.13 (NS)	p<0.001 (HS)
Cosmolestes pictus	r = +0.27	r = -0.23	r = +0.39
	p = 0.18 (NS)	p = 0.26 (NS)	p = 0.04 (S)
Hediocoris fasciatus	r = +0.54	r = -0.32	r = -0.08
	p<0.01 (HS)	p = 0.11 (NS)	p = 0.69 (NS)
Coranus sp.	r = +0.01	r = -0.14	r = +0.52
	p = 0.95 (NS)	p = 0.48 (NS)	p<0.01 (HS)

HS: Highly significant at the threshold of 5%, NS: Non-significant and S: Significant

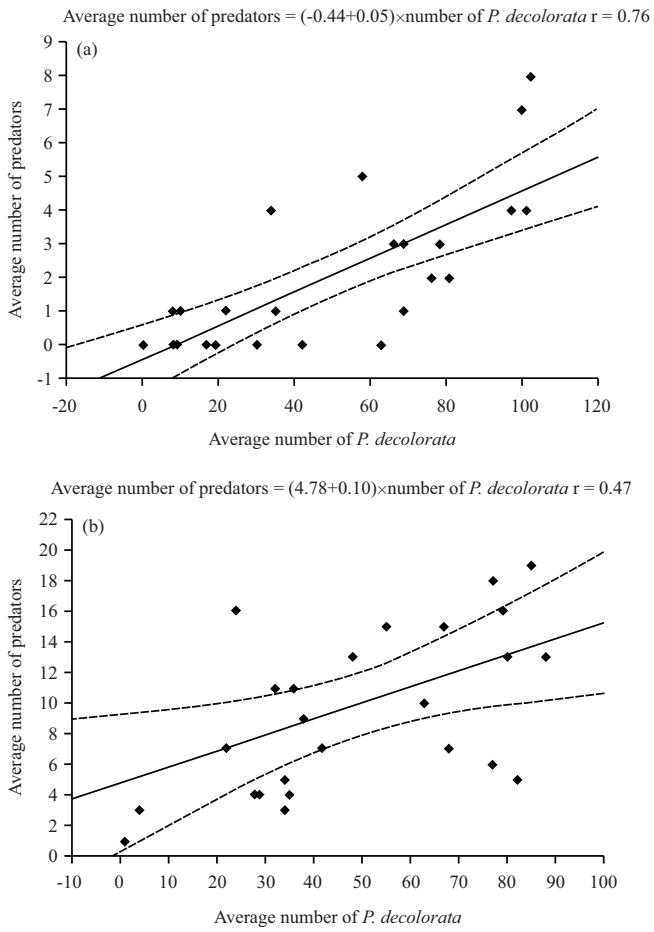

Fig. 2(a-b): Correlation between average numbers of predators and *P. decolorata* during the two crop cycles of okra, (a) First cycle in the dry season and (b) Second cycle in rainy season

DISCUSSION

During two crop cycles carried out in dry and rainy seasons, the study identified two species of Reduviidae, *R. albopilosus* and *R. rapax*, that were constant. The species *R. bicolor* and *C. pictus*, were considered frequent species. *H. fasciatus* and *Coranus* sp., were considered accessory species. The results obtained were close to those of N'guessan *et al.*[12], who reported that *R. albopilosus* was a constant species while *R. rapax* was frequent species. They also showed that *H. fasciatus* and *Coranus* sp., are accessory species. However, these authors indicated that *R. rapax* was an accessory species and *R. bicolor* a constant species.

The average numbers of the six species of Reduviidae varied in each season according to the phenological stage of the plant. In dry and rainy seasons, the flowering-fruiting stage attracts a large number of predators. This could be explained by a large number of flea beetles present in the plot at this stage of plant development. The results are similar to those of Shimoda and Takabayashi[15] and Shimoda *et al.*[16]. Indeed, these authors revealed that the emission of volatile substances by the host plant would attract insect predators of the host plant's pests. The study revealed that abiotic factors influence the population of predatory. Indeed, average rainfall, temperature and relative humidity would influence the abundance of Reduviidae. The results obtained were similar to those of Vennison and Ambrose[17] who reported that the population dynamics of seven species of Reduviidae were regulated by abiotic factors. The average number of predators and pests, *P. decolorata* increased synchronously during two cultivation cycles carried out in dry and rainy seasons. These results would be due to the high number of *P. decolorata* that would attract a high number of predatory Reduviidae species.

CONCLUSION

The study showed that abiotic factors and variations in the numbers of the pests *P. decolorata* influence fluctuations

in the populations of Reduviidae predators. The frequency of occurrence of the predatory species revealed *R. albopilosus* and *R. rapax* as constant species.

SIGNIFICANCE STATEMENT

The study revealed six species of Reduviidae, predators of *P. decolorata*. These predatory species can be used in an integrated pest management programme to control the major okra pest *P. decolorata*.

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