*Uttar Pradesh Journal of Zoology*

***Volume 45, Issue 20, Page 497-510, 2024; Article no.UPJOZ.4288***
***ISSN: 0256-971X (P)***

# Density Relationship of the Assassin Bugs *Sycanus falleni* Stål and *Sycanus croceovittatus* Dohrn (Hemiptera: Reduviidae) and Principal Corn Pests (Noctuidae: Lepidoptera) in Hoa Binh Province, Vietnam

**Truong Xuan Lam [a,b*], Nguyen Thị Phuong Lien [a,b], Nguyen Quang Cuong [a,b] and Tran Thị Ngat [a]**

*[a] Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, No 18, Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam.*
*[b] Graduate University for Science and Technology, Vietnam Academy of Science and Technology, No 18, Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: https://doi.org/10.56557/upjoz/2024/v45i204607

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/4288

***Original Research Article***

***Received: 03/09/2024***
***Accepted: 05/11/2024***
***Published: 09/11/2024***

**Corresponding author: Email: txlam.iebr@gmail.com;*

***Cite as:*** *Lam, Truong Xuan, Nguyen Thị Phuong Lien, Nguyen Quang Cuong, and Tran Thị Ngat. 2024. "Density Relationship of the Assassin Bugs Sycanus Falleni Stål and Sycanus Croceovittatus Dohrn (Hemiptera: Reduviidae) and Principal Corn Pests (Noctuidae: Lepidoptera) in Hoa Binh Province, Vietnam". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (20):497-510. https://doi.org/10.56557/upjoz/2024/v45i204607.*

## ABSTRACT

The group of assassin bugs including the *Sycanus falleni* and *Sycanus croceovittatus* species were such potential candidates for biocontrol of key pests (fall armyworm *Spodoptera frugiperda*, black cutworm *Agrotis ypsilon*, cotton bollworm *Heliothis armigera* Hübner, maize caterpillar *Mythimna loreyi* (Lepidoptera: Noctuidae)) on Corn biomass in Hoa Binh Province. Seven species of assassin bugs belonging to the family Reduviidae as *S. falleni* Stål, *S. croceovittatus* Dohrn, *Coranus spiniscutis* Reuter*, Coranus fuscipennis* Reuter, *Polytoxus fuscovittatus* (Stål), *Endochus nigricornis* Stål, *Sphedanoletes pubinotum* Reuter were recorded on the Corn biomass, of which *S. falleni* and *S. croceovittatus* were common. The relationship between the density of the group of assassin bugs and the density species *S. falleni*, *S. croceovittatus* had a close relationship with each other (R=0.81, R=0.72 respectively).

The relationship between the density of the group of assassin bugs and the density of their prey (4 key pests) on the Corn biomass in the Winter crops and Summer-fall crops were a close relationship with each other ($R^2$= 0.5166, $R^2$= 0.7274 respectively). The relationship between the density of the species *S. falleni*, *S. croceovittatus* and the density of their prey (4 key pests) in the Winter crops, and the Summer fall crops were a close relationship with each other ($R^2$ =0.7815, $R^2$ =0.5396 respectively). However, these relationships were not closely related in the Spring-Summer crops and Winter-Spring crops.

*Keywords: Reduviidae; Sycanus falleni; Sycanus croceovittatus; Corn biomass; prey; biocontrol; relationship, correlation coefficient.*

## 1. INTRODUCTION

The species of the assassin bugs (Heteroptera: Reduviidae) have been recorded with approximately 7000 species of 29 subfamilies. Many species play an important role in the food chain of animals and plants, as well as the ecological balance. Many species are either known as predators of many dangerous pests or their indicative role for forest habitats except species blood-sucking bugs (about 139 species) are dangerous vectors of disease to humans and animals (Weirauch, 2008). In maize crops many assassin bug species of the family Reduviidae can be found, they have an important role in controlling pests, and should be conserved and enhanced for use in the biological control of the plant (Ambrose, 2002 & 2003).

The species of the genus *Sycanus* have a high ability to be used for controlling pests, and they are predacious reduviids that have a wide range of prey such as both the larvae and pupae of Lepidoptera, Coleoptera, and Diptera (Abdul et al., 2018). Several species of the genus *Sycanus* have been studied in biology as *Sycanus versicolor* Dohrn, a voracious predator upon *Heliothis armigera* Hubner and *Earias insulana* Boisdual (Kumaraswami & Ambrose, 1992), the *Sycanus sichuanensis* Hsiao were noted based on laboratory rearing and field observations (Hui Liu et al., 2012), the *Sycanus galbanus* Distant were observed to be frequently predating on *Helopeltis antonii* Signoret and reared under laboratory conditions by the larvae of greater wax moth *Galleria mellonella* Linnaeus (Nitin et al., 2017). The *Sycanus annulicornis* Dohrn reared by two prey species (*Crocidolomia pavonana* (Fabricius) and *Tenebrio molitor)* for using to attack and kill the nettle caterpillar pest *Setothosea asigna* van Eecke was performed in the laboratory (Abdul et al., 2018).

The *Sycanus collaris* (Fab.) (Hemiptera: Reduviidae) is one such potential candidate for biocontrol of *Spodoptera litura* in polyhouses and was evaluated on the KPCH 1 variety of cucumber. The plot in which *S. collaris* was released recorded a significantly lower number of *S. litura* compared to the untreated control (George et al., 1998; Singh & Jalali, 1997). The predatory functional response of 4th and 5th instar nymphs of *Sycanus croceovittatus* Dohrn with attacking efficiency of 1.159 and 2.913, handling time of 0.297 days and 0.261 days, and the maximum daily predation number of 3.906 and 3.831, respectively, and fitted well with Holling II. These results show that *S. croceovittatus* has potential for the control of *Spodoptera frugiperda* (Wang et al., 2020). Khoo (1990) studied the rearing procedure for *S. collaris* and successfully used this species in controlling the insect pest *Nezara viridula* in field maize in Malaysia. The behaviour and biocontrol efficacy of *Sycanus reclinatus* Dohrn from South India have been documented and highlighted the

distribution of reduviids at the field level and its correlation with prey in different seasons (Vennison & Ambrose, 1992). Chen Suyi et al. (2023) showed that the density of *S. falleni* was positively correlated with its prey density, and the species *S. falleni* could control *S. frugiperda*, and the predation efficiency of adults was greater than that of the larvae.

In Vietnam, the assassin bus species *S. falleni* and *S. croceovittatus* are the common predators on trees in agricultural ecosystems in Bac Kan, Cao Bang, Ha Tay, Ha Tinh, Hoa Binh, Ninh Binh, Son La, Vinh Phuc, Dak Lak, Kon Tum, Gia Lai, and Lam Dong Provinces (Truong et al., 2015). The reduviid *S. falleni* has the potential for biological control of pest insects in coffee, cotton and vegetable plants as this species attacks many lepidopteran larvae such as *Anomis flava* Fabricius*, H. armigera*, *S. litura, Pieris rapae* and *Plutella xylostela* (Truong, 2016; Truong & Ha, 2017). Moreover, the nymphal instars and adults of *S. falleni* can be easily reared in the laboratory by the rice meal moth *Corcyra cephalonica* (Stainton) for integrated insect pest management (*P. rapae* (Lin.), *S. litura* (Fab.) and *P. xylostella* (Lin.) on the vegetable crops in Vietnam (Truong et al., 2020). The “Corn biomass”, also known as “corn stover,” is grown as feed for a feed for livestock including dairy cows in Northwestern Vietnam, including Hoa Binh Province. The fall armyworm *S. frugiperda*, black cutworm *Agrotis ypsilon* (Hufnagel, 1766), cotton bollworm *H. armigera* Hübner, 1805, maize caterpillar *Mythimna loreyi* (Duponchel, 1827) (Lepidoptera: Noctuidae) are key pests and very dangerous to Corn biomass (Vang, 2023). These pest species are very difficult to control in the field because of genetic resistance to insecticides. Furthermore, corn biomass is feed for livestock so the use of pesticides is always limited to the lowest level (Palagacheva & Sevov, 2021; Mediouni et al., 2023). According to Vang (2023), Hoa Binh province in the Northwest of Vietnam raises about 36,156 dairy cows, with about 2,000 - 3,000 hectares of Corn biomass.

This study was conducted to understand the relationship of density between assassin bugs *S. falleni* Stal and *S. croceovittatus* and their prey (4 key pests of Noctuidae) on Corn biomass in the Hoa Binh Province, Vietnam to provide the basis to conserve and utilize the species *S. falleni* and *S. croceovittatus* as biological control agents on Corn biomass growing areas to avoid the use of pesticides in the production of animal feed to protect the health for livestock including dairy cows in Vietnam.

## 2. MATERIALS AND METHODS

### 2.1 Study Site

The survey site is at the field of Corn biomass growing in Cao Phong, Tan Lac, Lac Son, Mai Chau Districts in Hoa Binh Province in Vietnam. The Corn biomass grown here was high biomass corn varieties VN172 and DDH17-5. The investigation period is from August 2022 to July 2024 through 4 crops including Winter crops, Spring - Summer crops, Winter - Spring crops and Summer-fall crops (Table 2).

### 2.2 Sampling Techniques

The survey of the density of the assassin bug species was conducted in 5 Corn biomass fields that did not use any pesticides and were cared for equally (each Corn biomass field has an area of 10,000 $m^2$). In each Corn biomass field, 4 points were randomly selected (each point has an area of 50 $m^2$), in each point the survey was conducted using the 5 diagonal point method, and each point has an area of 1 $m^2$. The unit of measurement is individual/$m^2$. At the survey points, the number of assassin bugs (both nymphs and adults) was counted visually, adults of each species were collected from 2-3 individuals by insect net (ϕ=30cm) to determine the species name. The survey was conducted every 10 days (3 times/month). At each point, surveys were conducted from inflorescences, leaves, stems and lower parts of corn plants (Plant Protection Institute, 1997).

In parallel with the investigation of the assassin bug species, we investigated the density of their prey (the fall armyworm *S. frugiperda*, black cutworm *A. ypsilon*, cotton bollworm *H. armigera*, maize caterpillar *M. loreyi*). Their prey density was calculated as individuals/$m^2$ and was investigated using the same method as the survey of the assassin bugs at the same survey sites.

### 2.3 Taxonomy

Taxonomy of the assassin bugs species and their prey based on morphological characteristics. The analysis of morphology was conducted with an SZX7 Olympus microscope. The morphological structure was painted on SZX7 Olympus. The documents for reference and comparative morphological description are based on Cai Wanzhi (1994), Hsiao et al. (1981), Li Yongxi et al. (1988), Maldonado & Capriles

(1990), Richter et al., (1990), William et al. (1985), Palagacheva & Sevov (2021), Mediouni et al. (2023).

### 2.4 Data Analysis

The relationship between the density of reduviids and the density of their prey is expressed through the correlation coefficient R and divided into levels according to Poelou (1977):

0.5≤ |R|≤ 1: Shows a close relationship with each other

0.5< |R|: Shows no relationship with each other

The experimental data with the tracking indicators will be analysed and the probability level (P<0.05) by Primer-e. The density of the species *S. falleni* and *S. croceovittatus* were also analyzed using one-way ANOVA and independent t-tests. All statistical analyses were carried out at a 5% level of significance (P <0.05) (Poelou, 1977)

## 3. RESULTS

### 3.1 Density of the Assassin Bugs on the Corn Biomass

On Corn biomass in Hoa Binh province, we recorded 7 species of assassin bugs belonging to the family Reduviidae including *S. falleni* Stål, 1863, *S. croceovittatus* Dohrn, 1859, *Coranus spiniscutis* Reuter, 1881, *Coranus fuscipennis* Reuter, 1881, *Polytoxus fuscovittatus* Hsiao, 1965, *Endochus nigricornis* Stål, 1859, *Sphedanoletes pubinotum* Reuter, 1881 that frequently appearing, among which species *S. falleni*, *S. croceovittatus* were common with high average density (0.13-0.17 individuals/$m^2$). The remaining assassin bug species had very low average density (0.02-0.05 individuals/m2) (Table 1).

Research on the relationship between the density of the group of assassin bugs (the total density of 7 species recorded) (Table 1) and the density of species *S. falleni, S. croceovittatus* showed that the relationship between the density of the group of assassin bugs and species *S. falleni* (R=0.81) and *S. croceovittatus* (R=0.72) were a close relationship with each other (Fig. 1). This also shows that the increase and decrease of the density of the group of assassin bugs depend quite closely on the increase and decrease of density of species *S. falleni* and *S. croceovittatus*.

### 3.2 The Relationship between the Density of Assassin Bug and the Density of their Prey

We investigated the density prey of the group of assassin bugs are 4 key pests in Corn biomass (including species the fall armyworm *S. frugiperda*, black cutworm *A. ypsilon*, cotton bollworm *H. armigera* Hübner, maize caterpillar *M. loreyi* (Lepidoptera: Noctuidae)) (Table 2). Fig. 2 shows the relationship between the density of the group of assassin bugs and the density of their prey on the Corn biomass in four crops.

The relationship between the density of the group of assassin bugs and the density of their prey on the Corn biomass in the Winter crops ($R^2$ =0.5166) and the Summer-fall crop ($R^2$ =0.7274) were a close relationship with each other (Table 2, Fig. 2). In Winter crops and Summer-fall crop, the increase and decrease in density of 4 key pests on Corn biomass depended quite closely on the density of the assassin bugs species. This shows that the density of the assassin bug species plays a role in suppressing the density of 4 key pests on corn in the Winter crops and the Summer-fall crops. However, the predatory population was low in the Spring-Summer crop and Winter-Spring crop, and the density of the assassin bugs species does not play a role in suppressing the density of 4 key pests on the Corn biomass ($R^2$=0.0228-0.2121-no relationship with each other), so it doesn't control pest upto the mark, as like Summer-fall crop and Winter crops (Fig. 2).

The relationship between the density of the species *S. falleni* and the density of their prey on the Corn biomass in the Summer-fall crop ($R^2$ =0.7815) was a close relationship with each other (Fig.3). In the Summer-fall crop, the increase and decrease in density of 4 key pests on Corn biomass depended quite closely on the density of the *S. falleni* species. This shows that the density of the *S. falleni* species plays a role in suppressing the density of 4 key pests on corn in Summer-fall crops. However, in the Winter crops, Spring-Summer crop and Winter-Spring crop, the density of the *S. falleni* species does not play a role in suppressing the density of 4 key pests on Corn biomass ($R^2$=0.0399-0.2677-no relationship with each other) (Fig. 3).

**Table 1. Density of the assassin bugs species on the Corn biomass (corn cultivation for livestock feed) in Hoa Binh Province 2022-2024**

| Investigation month | Density (individual/m$^2$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | ***Sycanus falleni*** | ***Sycanus croceovittatus*** | ***Coranus spiniscutis*** | ***Coranus fuscipennis*** | ***Polytoxus fuscovittatus*** | ***Endochus nigricornis*** | ***Sphedanoletes pubinotum*** |
| August/2022 | 0.50 | 0.31 | 0.05 | 0.08 | 0.05 | 0.02 | 0.03 |
| September | 0.45 | 0.51 | 0.12 | 0.05 | 0.12 | 0.11 | 0.09 |
| October | 0.32 | 0.48 | 0.09 | 0.12 | 0.09 | 0.03 | 0.02 |
| November | 0.03 | 0.08 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 |
| December/2022 | 0.56 | 0.12 | 0.02 | 0.05 | 0.02 | 0.03 | 0.02 |
| January/2023 | 0.50 | 0.07 | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 |
| February | 0.06 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.01 | 0.01 |
| April | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| June | 0.20 | 0.31 | 0.03 | 0.09 | 0.00 | 0.00 | 0.00 |
| July | 0.10 | 0.04 | 0.01 | 0.02 | 0.00 | 0.01 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 | 0.01 |
| September | 0.00 | 0.02 | 0.01 | 0.03 | 0.00 | 0.02 | 0.01 |
| October | 0.17 | 0.12 | 0.04 | 0.05 | 0.03 | 0.04 | 0.03 |
| November | 0.18 | 0.05 | 0.00 | 0.09 | 0.05 | 0.03 | 0.02 |
| December/2023 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 |
| January/2024 | 0.12 | 0.03 | 0.02 | 0.04 | 0.01 | 0.01 | 0.01 |
| February | 0.08 | 0.02 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 0.05 | 0.02 | 0.02 | 0.02 |
| April | 0.00 | 0.00 | 0.03 | 0.07 | 0.02 | 0.02 | 0.01 |
| May | 0.10 | 0.05 | 0.04 | 0.09 | 0.03 | 0.03 | 0.03 |
| June | 0.25 | 0.35 | 0.05 | 0.14 | 0.03 | 0.04 | 0.02 |
| July/2024 | 0.52 | 0.43 | 0.06 | 0.08 | 0.06 | 0.04 | 0.03 |
| **Trung bình ± SD (95%)** | **0.17± 0.02** | **0.13 ± 0.02** | **0.03± 0.01** | **0.05 ± 0.01** | **0.03 ± 0.01** | **0.02 ± 0.01** | **0.02 ± 0.01** |

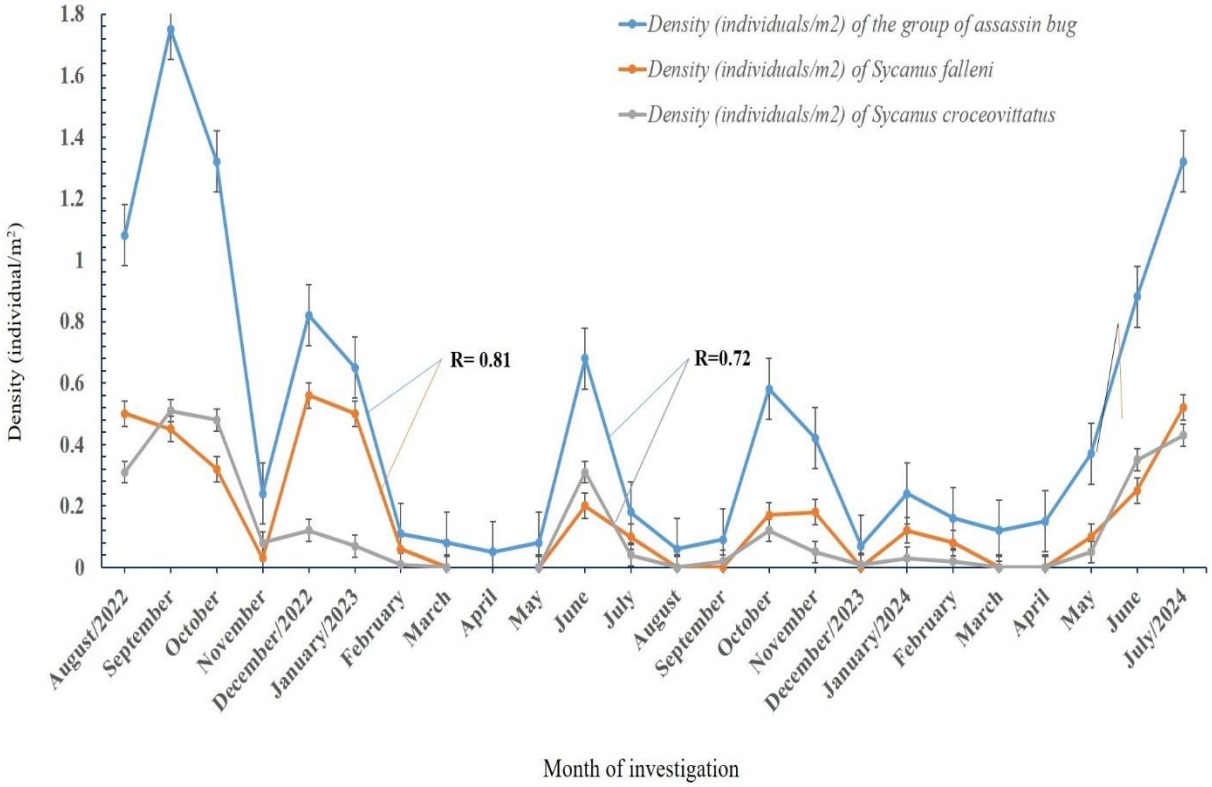


**Fig. 1. The relationship between the density of the group of assassin bugs and the density of species *Sycanus falleni* and *Sycanus croceovittatus* on the Corn biomass in Hoa Binh Province**

**Table 2. The density of the group of assassin bugs and their prey on the Corn biomass (corn cultivation for livestock feed)**

| Investigation month | Crops | Density (individual/$m^2$) | |
|---|---|---|---|
| | | Density of the group of assassin bugs (total density of 7 species) | Density of prey (total density of 4 key pests in Corn biomass) |
| August/2022 | Winter crops | 1.04 | 0.42 |
| September | | 1.45 | 0.62 |
| October | | 1.15 | 1.44 |
| November | | 0.24 | 2.4 |
| December/2022 | | 0.82 | 2.87 |
| January/2023 | Spring - Summer crops | 0.65 | 1.32 |
| February | | 0.1 | 1.02 |
| March | | 0.08 | 1.18 |
| April | | 0.04 | 2.08 |
| May | | 0.04 | 2.41 |
| June | | 0.63 | 1.55 |
| July | | 0.18 | 1.85 |
| August | | 0.04 | 1.96 |
| September | | 0.09 | 1.09 |
| October | Winter - Spring crops | 0.48 | 1.58 |
| November | | 0.42 | 1.95 |
| December/2023 | | 0.07 | 0.96 |
| January/2024 | | 0.24 | 0.65 |
| February | | 0.16 | 0.34 |
| March | Summer - fall crops | 0.11 | 1.68 |
| April | | 0.15 | 1.72 |
| May | | 0.37 | 1.15 |
| June | | 0.88 | 0.95 |
| July/2024 | | 1.22 | 0.38 |
| **Trung bình ± SD (95%)** | | **0.44 ± 0.05** | **1.39 ± 0.13** |

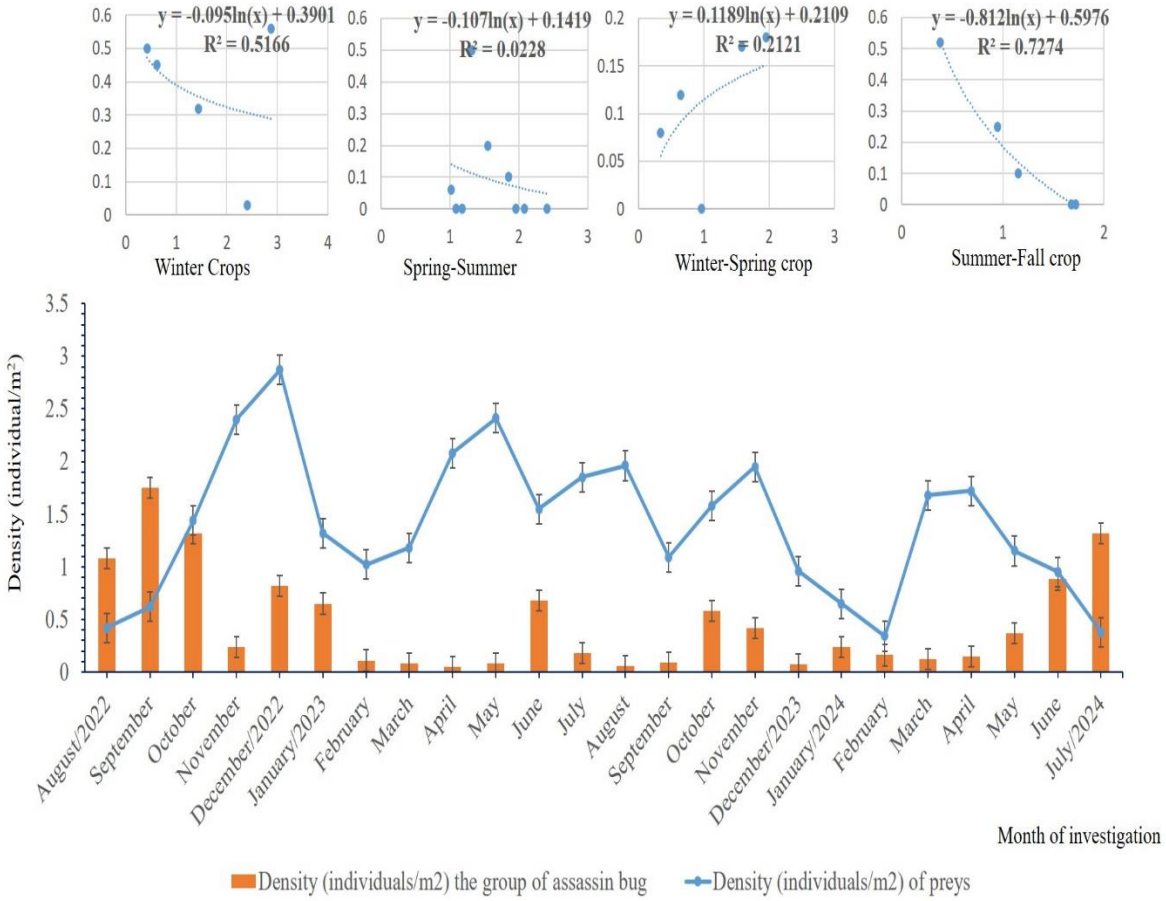


**Fig. 2. The relationship between the density of the group of assassin bugs and the density of their prey on the Corn biomass in Hoa Binh Province**

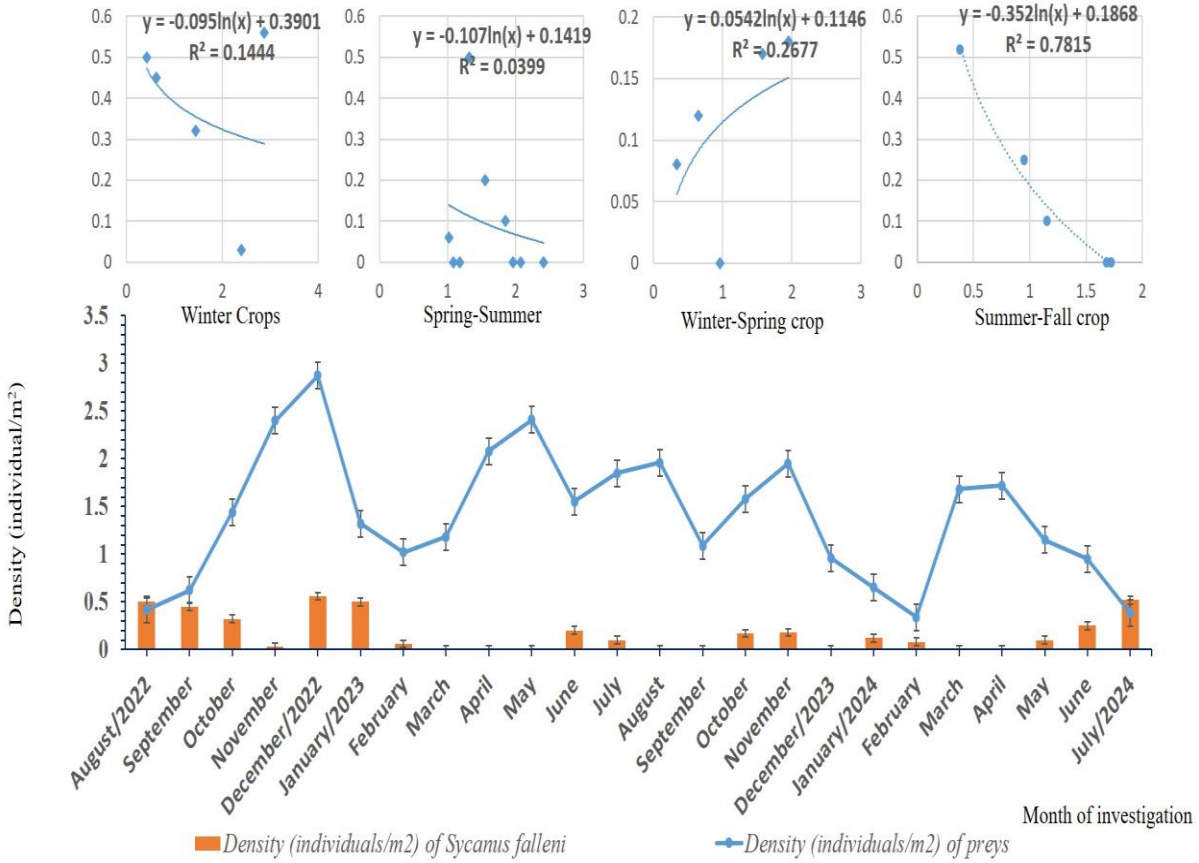


**Fig. 3. The relationship between the density of the *Sycanus falleni* species and the density of their prey on the Corn biomass in Hoa Binh Province**

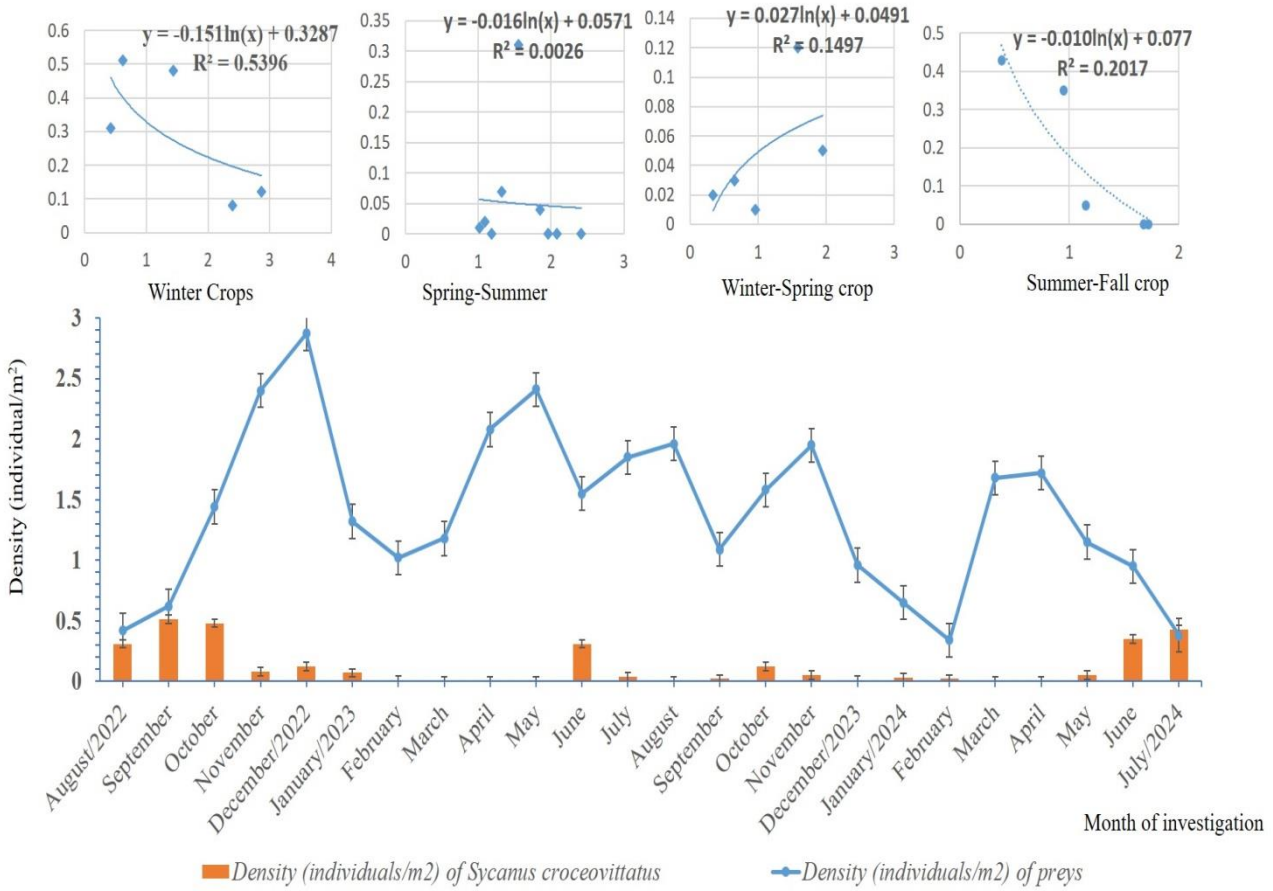


**Fig. 4. The relationship between the density of the *Sycanus croceovittatus* species and the density of their prey on the Corn biomass in Hoa Binh Province**

The relationship between the density of the *S. croceovittatus* species and the density of their prey on the Corn biomass in Winter crops ($R^2$ =0.5396) was a close relationship with each other (Fig. 4). In Winter crops, the increase and decrease in density of 4 key pests on Corn biomass depended quite closely on the density of the *S. croceovittatus* species. This shows that the density of the *S. croceovittatus* species plays a role in suppressing the density of 4 key pests on corn in Winter crops. However, in the Spring-Summer crop, Winter-Spring crop, Summer-fall crop the density of the *S. croceovittatus* species does not play a role in suppressing the density of 4 key pests on Corn biomass ($R^2$=0.0026-0.2017- no relationship with each other) (Fig. 4).

## 4. DISCUSSION

In this study, the prey of predator species *S. falleni* and *S. croceovittatus* were the fall armyworm *S. frugiperda*, black cutworm *A. ypsilon*, cotton bollworm *H. armigera*, maize caterpillar *M. loreyi* on Corn similar from the study of Abdul et al. (2018) to comment that the species of genus *Sycanus* have a high ability to be used for controlling pests, and they are predacious reduviids that have a wide range of prey such as both the larvae and pupae of Lepidoptera, Coleoptera, and Diptera. Similar to the study of Kumaraswami & Ambrose (1992) the species of genus *Sycanus* have a high ability to be used for controlling pests, and they are predacious reduviids that have a wide range of prey such as both the larvae and pupae of Lepidoptera, Coleoptera, and Diptera, of Zheng-rong et al. (2020) when it was said the prey of *S. falleni* is species *S. frugiperda,* and the predation efficiency of the adult was greater than that of the larvae, of Truong Xuan Lam (2021) when it was said the prey of *S. falleni* and *S. croceovittatus* were species *A. flava*, *H. armigera* , *S. litura,* and of Chen Suyi et al. (2023) when it was assumed that the species *S. croceovittatus* is a widely distributed predatory natural enemy in the southern provinces of China, and is a potential biological control agent for Lepidoptera, Coleoptera and Hemiptera pests**.**

The predation density of *S. croceovittatus* was positively correlated with its prey density, and the species *S. croceovittatus* could control *Spodoptera exigua*, and the predation efficiency of adults of *S. croceovittatus* was greater than that of the larvae. Moreover, the author also showed the density of *S. croceovittatus* was positively correlated with its prey density, and the species *S. croceovittatus* could control *S. exigua*, and the predation efficiency of adults was greater than that of the larvae (Sahayaraj, 2014; Sahayaraj & Balasubramanian, 2016; Siti & Norman, 2016; Srikumar et al., 2014), and these studies are also completely consistent with the results in this study as the *S. croceovittatus* species are such potential candidates for biocontrol of 4 key pests in Corn biomass and the relationship between the density of the species *S. croceovittatus* in the Winter crops and the density of their prey (fall armyworm *S. frugiperda*) on the Corn biomass were a close relationship, and the relationship between the density of the species *S. croceovittatus* and the density of their prey in the Spring-Summer crops and Winter-Spring crops weren't relationships with each other.

The behaviour and biocontrol efficacy of *S. reclinatus* Dohrn from South India has been documented and highlighted that the distribution of reduviids at field level and its correlation with prey in different seasons (Vennison & Ambrose, 1992) was similar to that of *S. croceovittatus* and the density of their prey in the Winter crops and Summer-fall crops were a close relationship ($R^2$ =0.54), and in the Spring-Summer crops, Winter-Spring crops weren't relationships with each other in this study.

## 5. CONCLUSION

In Corn biomass in Hoa Binh province were recorded 7 species of assassin bugs among which species *S. falleni* and *S. croceovittatus* were common with high average density. The group of assassin bugs on Corn biomass including the *S. falleni* and *S. croceovittatus* species were such potential candidates for biocontrol of 4 key pests. The density of predatory populations *S. falleni* and *S. croceovittatus* were high in the Corn biomass, so it can control pests up to the mark in the Winter crops and Summer-fall crops but it doesn't control pests in Winter-Spring crops, Spring-Summer crops.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

## 6. ACKNOWLEDGEMENTS

This research was funded by the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 106.06-2021.38 to Truong Xuan Lam.

## COMPETING INTERESTS

The authors have declared that no competing interests exist.

## REFERENCES

Abdul, S., Wahyu, D. N., Hersanti, F., & Sudarjat, N. (2018). Laboratory rearing of *Sycanus annulicornis* (Hemiptera: Reduviidae) on two species of prey: Differences in its biology and efficiency as a predator of the nettle caterpillar pest *Setothosea asigna* (Lepidoptera: Limacodidae). *European Journal of Entomology*, *115*, 208–216.

Ambrose, D. P. (2002). Assassin bugs (Heteroptera: Reduviidae) in integrated pest management programmes: Success and strategies. In *S. Ignacimuthu & A. Sen (Eds.), Strategies in Integrated Pest Management: Current Trends and Future Prospects* (pp. 73-85). Phoenix Publishing House Pvt. Ltd.

Ambrose, D. P. (2003). Biocontrol potential of assassin bugs (Hemiptera: Reduviidae). *Journal of Experimental Zoology, India*, *6*(1), 1-44.

Cai, W., Zhou, Y., & Lu, J. (1994). The morphology, postembryonic development, and evolution of stridulitra in Reduviidae (Heteroptera: Reduvioidea), with special reference to their taxonomic importance. *Entomologia Sinica*, *1*(1), 1-16.

Chen, S., Zhao, P., Shi, A., Shi, A., Wang, C., Cai, W., & Li, H. (2023). Predation effect of *Sycanus croceovittatus* on the 3rd-instar larvae of *Spodoptera exigua*. *Chinese Journal of Biological Control*, *39*(2), 289-296.

George, P. J. E., Sreenivasagan, R., & Karuppasamy, G. (1998). Life table and intrinsic rate of increase of *Sycanus collaris* Fabricius (Heteroptera: Reduviidae), a predator of *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae). *Journal of Biological Control*, *12*(2), 107-111.

Hsiao, T. Y., & Ren, S. Z. (1981). A handbook for the determination of the Chinese Hemiptera-Heteroptera (II). 390-538.

Hui, L., Hu, L., Chengcheng, Y., Osamu, T., & Wanzhi, C. (2012). Taxonomic and bionomic notes on *Sycanus sichuanensis* Hsiao (Hemiptera: Reduviidae: Harpactorinae). *Journal of the Faculty of Agriculture, Kyushu University*, *57*(1), 73–77.

Jyoti, R. B., Jaya, L. G., Hadi, H. K., & Ramkinkar, S. (2017). Bionomics of the rice meal moth, *Corcyra cephalonica* (Stainton) reared under laboratory conditions on different diets. *Journal of Entomology and Zoology Studies*, *5*(5), 722-727.

Khoo, S. G. (1990). Use of natural enemies to control agricultural pests in Malaysia. *Extension Bulletin (ASPAC/FFTC)*, No. 304, 12-22.

Kumaraswami, N. S., & Ambrose, D. P. (1992). Biology and prey preference of *Sycanus versicolor* Dohrn (Hemiptera: Reduviidae). *Biological Control*, *6*(2), 67-71.

Kumaraswami, N. S., & Ambrose, D. P. (1992). Biology and prey preference of *Sycanus versicolor* Dohrn (Hemiptera: Reduviidae). *Biological Control*, *6*(2), 67-71.

Li, Y., Zhou, Z., Wang, Z., & Pu, T. (1988). *Economic insect iconography of Guangxi*. Guangxi Press of Science and Technology.

Maldonado-Capriles, J. (1990). *Systematic catalogue of the Reduviidae of the world* (Insecta: Heteroptera). *Caribbean Journal of Science* (Special Edition), 1-694.

Mediouni Ben Jemâa, J., Soltani, A., Djebbi, T., Mejri, I., Kanyesigye, D., & Otim, M. H. (2023). The maize caterpillar *Mythimna* (= *Leucania*) loreyi (Duponchel, 1827) (Lepidoptera: Noctuidae): Identification, distribution, population density and damage in Tunisia. *Insects*, *14*, 786.

Nitin, K. S., Bhat, P. S., Raviprasad, T. N., & Vanitha, K. (2017). Biology, behaviour and predatory efficiency of *Sycanus galbanus* Distant (Hemiptera: Reduviidae: Harpactorinae) recorded in cashew plantations. *Journal of Entomology and Zoology*, *5*(2), 524-530.

Palagacheva, N., & Sevov, A. (2021). Cotton bollworm (*Helicoverpa armigera* Hübner) – a key pest on sweet corn. *Bulgarian Journal of Agricultural Science*, *27*(1), 156–160.

Plant Protection Institute. (1997). *Plant protection research methods, Volume I, Basic investigation methods of agricultural pests and their natural enemies*. Hanoi Agricultural Publishing House.

Poelou, E. C. (1977). *Mathematical Ecology*. Wiley-Interscience.

Rajan, S. J., Suneetha, N., & Sathish, R. (2017). Biology and predatory behavior of an assassin bug, *Sycanus collaris* (Fabricius) on rice meal moth, *Corcyra cephalonica* (Stainton) and leaf armyworm, *Spodoptera litura* (Fabricius). *Agricultural Update*, *12* (Techsear-5), 1181-1186.

Sahayaraj, K. (2014). Reduviidae and their advantages in biological control. In *Basic and Applied Aspects of Biopesticides* (pp. 195–214). Springer.

Sahayaraj, K., & Balasubramanian, R. (2016). Reduviid: An important biological control agent. In *Artificial Rearing of Reduviid Predators for Pest Management* (pp. 1–28). Springer.

Singh, S. P., & Jalali, S. K. (1997). Management of *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae). *Shashpa*, *2*, 203-206.

Siti, N.A., & Norman, K. (2016). Growth and longevity of the insect predator, *Sycanus dichotomus* Stål, fed on live insect larvae. *Journal of Oil Palm Research, 28*(4), 471–478.

Srikumar, K.K., Bhat, P.S., Raviprasad, T.N., Vanitha, K., Saroj, P.L., & Ambrose, D.P. (2014). Biology and behaviour of six species of Reduviids (*Hemiptera*: *Reduviidae*: *Harpactorinae*) in a cashew ecosystem. *Journal of Agricultural and Urban Entomology, 30*, 65–80.

Truong, X.L. (2016). The species diversity of assassin bugs (*Heteroptera*: *Reduviidae*) and their preys in Central Highlands of Vietnam. *Biological Forum – An International Journal, 8*(2), 247– 252.

Truong, X.L. (2021). The species of assassin bugs (*Heteroptera*: *Reduviidae*) and their preys in the mountainous region of Northern Vietnam. *Biological Forum – An International Journal, 13*(3a), 700– 708.

Truong, X.L., & Ha, N.L. (2017). Composition and diversity of assassin bugs of the subfamily *Harpactorinae* (*Heteroptera*: *Reduviidae*) in some habitats in Kon Chu Rang natural reserve, Gia Lai province. In *Proceedings of the 7th National Scientific Conference on Ecology and Biological Resources* (pp. 763– 767). Publisher of Natural Science and Technology. ISBN: 978-604-913-615-3.

Truong, X.L., Wanzhi, C., Masaaki, T., & Tadashi, I. (2015). The assassin bug subfamily *Harpactorinae* (*Hemiptera*: *Reduviidae*) from Vietnam: An annotated checklist of species. *Zootaxa, 3931*(1), 101–116.

Vang, N.D. (2023). Review of the livestock production in Vietnam. In *Proceedings of the National Conference on Animal and Veterinary Sciences* (AVS'15) (pp. 3–19). Can Tho University, Vietnam.

Vennison, S.J., & Ambrose, D.P. (1992). Biology, behavior and biocontrol efficiency of a reduviid predator, *Sycanus reclinatus* Dohrn (*Heteroptera*: *Reduviidae*) from Southern India. *Miu. Zool. Mus. Berl, 68*(1), 143–156.

Wang, Y., Zhao, S., He, Y., Wu, K., Li, G., & Feng, H. (2020). Predation of the larvae of *Spodoptera frugiperda* (J. E. Smith) by *Sycanus croceovittatus* Dohrn. *Chinese Journal of Biological Control, 36*(4), 525–529.

Weirauch, C. (2008). Cladistic analysis of *Reduviidae* (*Heteroptera*: *Cimicomorpha*) based on morphological characters. *Systematic Entomology, 33*, 229– 274.

Xuan Lam Truong, Huy Phong Pham, & Thi Ngoc Lam Thai. (2020). Biology and predatory ability of the reduviid *Sycanus falleni* Stål (*Heteroptera*: *Reduviidae*: *Harpactorinae*) fed on four different preys in laboratory conditions. *Journal of Asia-Pacific Entomology, 23*, 1188–1193.

Zheng-rong Hou, Bei-bei Sun, Xian-jian Liu, Zhe Yin, Jin-ping Li, & Xihong Guo. (2020). Predatory functional response of assassin bug *Sycanus falleni* to the larvae of fall armyworm *Spodoptera frugiperda*. *Journal of Plant Protection, 47*(4), 852–858.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/4288*