

# Use of traps as an alternative to control *Euschistus heros* (Hemiptera: Pentatomidae) in Soybean

## Uso de armadilhas como alternativa para controle de *Euschistus heros* (Hemiptera: Pentatomidae) em soja

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### Highlights

Tested traps and attractants efficiently capture adult *Euschistus heros*.

Tested traps and attractants can control adult *Euschistus heros*.

Tested traps must be installed at the beginning of soybean reproductive stage.

### Abstract

The Neotropical brown stink bug (*Euschistus heros*) is one of the main pests affecting soybean crops, accounting for up to 60% of insecticide applications in the field. Strategies to reduce the use of chemical insecticides hold great theoretical and practical interest, especially for sustainable agriculture. Mass trapping as a pest control strategy has been studied using different traps. Thus, this study aimed to determine the attraction and capture of *E. heros* using different attractants and traps to control the Neotropical brown stink bug. The study was conducted during two soybean seasons (2021/22 and 2022/23) in Sertanópolis and Londrina, PR, Brazil, respectively. The results indicate that both the PET-type and spherical-type traps can be used for mass trapping stink bugs with equal efficiency in soybean pest control. The most effective attractant was the bovine urine-based compound. However, the commercial attractant from Agribela® can also be used despite its lower attractiveness. Although Agribela® attractant can be more expensive, it is easier to acquire and use, especially when bovine urine is unavailable. The traps should be installed before the colonizing population reaches the fields, preferably at the beginning of the soybean reproductive stage. These traps thus become an additional management alternative for stink bugs and can be easily adopted, particularly by small-scale and

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organic soybean farmers.

**Key words:** Fabaceae. *Glycine max*. Attractant. Heteroptera.

## Resumo

O percevejo-marrom é uma das principais pragas da cultura soja, responsável por até 60% dos inseticidas aplicados na lavoura. Estratégias de controle para reduzir o uso de inseticidas químicos são de grande interesse teórico e prático, principalmente para uma agricultura mais sustentável. A coleta massal como uma estratégia de controle de pragas vem sendo estudado com diferentes armadilhas. Assim, o objetivo deste trabalho foi determinar a capacidade de atração e captura de *E. heros* por diferentes compostos e armadilhas a fim de avaliar o uso desta técnica no controle do percevejo-marrom. O estudo foi conduzido em duas safras de soja (2021/22 e 2022/23) nas cidades Sertãoópolis e Londrina, PR, Brasil, respectivamente. Os resultados obtidos permitem concluir que ambas as armadilhas, tipo Pet e tipo Esférica podem ser utilizadas para coleta massal de percevejos com a mesma eficiência no controle de percevejos em soja. O melhor atrativo foi o composto a base de urina bovina. Entretanto, o atrativo sintético comercial da Agribela® também pode ser usado a um custo mais alto, mas com maior facilidade de obtenção e uso, principalmente em áreas onde a urina bovina não está disponível. A instalação das armadilhas para o controle de percevejos deve ser realizada antes da população colonizante chegar as lavouras, preferencialmente no início do período reprodutivo da soja. O uso dessas armadilhas torna-se, mais uma alternativa de manejo para percevejos, que pode ser facilmente adotada principalmente por pequenos produtores e/ou produtores de soja orgânica.

**Palavras-chave:** Fabaceae. *Glycine max*. Atrativo. Heteroptera.

## Introduction

Among the different insect pests that attack soybean, stink bugs (Hemiptera: Pentatomidae) are key pests not only in Brazil (Bueno et al., 2023) but also in Argentina (Cingolani. & Laumann, 2024) and the southeastern United States (Ademokoya et al., 2022). Their feeding directly on the pods can reduce yield and impair the physiological and sanitary quality of the seeds (Corrêa-Ferreira & Azevedo, 2002). Consequently, soybean grains become shriveled and wrinkled, affecting their production and commercial value. Thus, controlling this pest is often necessary to avoid losses (Panizzi & Slansky, 1985).

*Euschistus heros* (Fabricius, 1798), known as the Neotropical brown stink bug, has become the most important phytosanitary problem for soybean in Brazil, due to its wide geographical distribution, high reproductive capacity, difficulty in being controlled, and existence of populations resistant to insecticides (Sosa-Gómez et al., 2020). In addition, *E. heros* is considered the predominant species in several producing regions, accounting for more than 80% of the stink bug populations in some soybean fields (Bueno et al., 2021). Such characteristics justify the need for developing effective alternatives for its management.

The first line of defense against stink bugs is still spraying chemical insecticides (Bueno et al., 2021). However, the intensive

use of these chemicals triggers negative impacts on both human health and the environment (Jacquet et al., 2022), in addition to reducing natural enemies (Torres & Bueno, 2018) and pollinators (Kuldna et al., 2009), selecting populations resistant to insecticides (Sosa-Gómez et al., 2020), and favoring the resurgence of pests and/or secondary pest outbreaks (Bueno et al., 2021). Therefore, reducing dependence on synthetic insecticides has become a global goal (Lee et al. 2019).

An alternative strategy for pest control could be the use of traps for massive capture of insects (Sujii et al., 2002). Studies conducted with different traps, crops, and insects have shown promising results in reducing pest population (Fernandes et al., 2014; Machota, 2017). Furthermore, insect trapping might be an important alternative for pest control in organic farming where chemicals are not allowed (Costa et al., 2023).

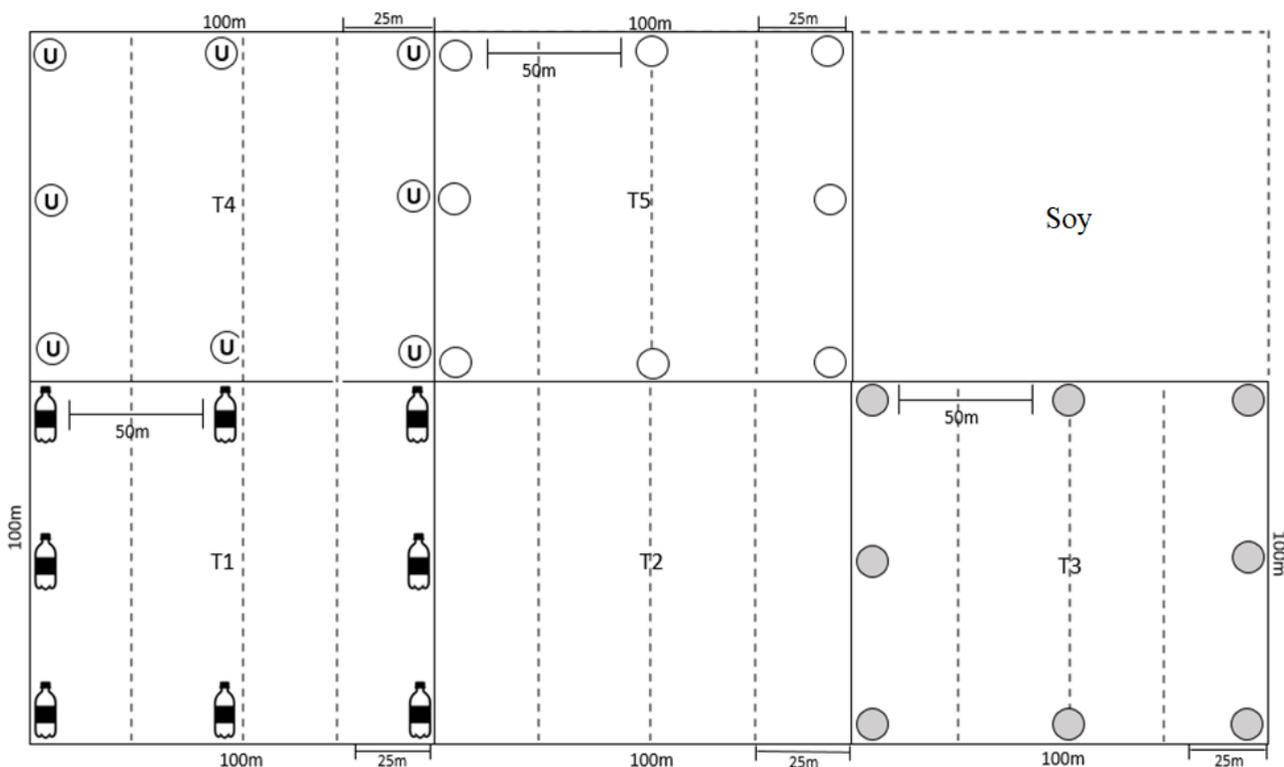
The growth of ecological awareness and the search for healthier foods have expanded the number of customers buying organic products, especially in European and North American countries, as well as in China, which has become the fourth largest organic market in the world since 2013, behind only the United States, Germany, and France (Willer et al., 2024). In Brazil, the demand for organic products began mainly in the 1980s (Reynaldo et al., 2019). Organic agriculture has grown 11.5% per year for the past two decades and is thriving as a niche market, accounting for 1.5% of global agriculture (Paull, 2023). Among the different organic products, soybeans have the largest cultivated area in Brazil, followed by corn, rice, and beans (Sousa & Goiás, 2015). The growth of organic farming worldwide further

increases the demand for alternatives to traditional chemical insecticides.

In soybean, the effectiveness of the PET trap of the "R. Bianco" type, with a bovine urine-based attractant, proved to be efficient for the mass capture of different species of phytophagous stink bugs in soybean fields (Corrêa-Ferreira et al., 2014). Since then, small farmers have used this trap to reduce the population of stink bugs (Corrêa-Ferreira, 2005) but facing sometimes difficulties to find and manage the bovine urine. Therefore, this study aimed to evaluate different traps under field conditions for controlling stink bugs in soybean.

## Material and Methods

The experiment was conducted during two consecutive soybean seasons (2021/22 and 2022/23) with four treatments in the first and five in the second season, with four replicates per treatment. The treatments evaluated were: 1) PET trap with bovine urine solution; 2) Control with no trap; 3) Spherical trap with synthetic attractant; 4) Spherical trap with bovine urine solution; and 5) Spherical trap, without any attractant. The latter was conducted only in the last season (2022/23). Bovine urine solution was composed of bovine urine (3 liters), table salt (500 grams), and water in the proportions of three liters (7 liters) (Corrêa-Ferreira & Peres, 2003). The synthetic commercial attractant (acquired from Agribela®, Bandeirantes, Paraná, Brazil). Each treatment was installed in 1 ha, divided into 4 pseudo-replicates of 2500 m<sup>2</sup> (50 × 50 m). The traps were installed near the perimeter of the plots and spaced approximately 50 m apart, always at a density of 8 traps/ha (Figure 1).



**Figure 1.** Diagram of the experimental area with the distribution of treatments: 1) PET trap with bovine urine; 2) Control without trap; 3) Spherical trap with synthetic attractant; 4) Spherical trap with bovine urine; and 5) Spherical trap without any attractant.

The 2021/22 experiment was conducted from November 2021 to March 2022, in a commercial soybean field in Sertanópolis, PR, Brazil (23°10'52" S; 51°10'11" W). The altitude of the site is 630 m, and its climate is classified as Cfa on the Köppen scale. The second experiment was conducted from January 2022 to March 2022 at the experimental field station of Embrapa Soja, Londrina, PR, Brazil (23°12'23"S, 51°10'54" W). The site has an altitude of 600 m and a climate classified as Cfa on the Köppen scale (Aparecido et al., 2016).

The soybean cultivars used in the experiments were DM 66i68 IPRO and BRS 1061 IPRO, which were sown in November

2021 and October 2022, respectively. The spacing was 0.45 m between rows in both trials, with 12 seeds per linear meter in the 2021/22 and 15 seeds in the 2022/23 experiment. During sowing, 250 kg/ha<sup>-1</sup> of the formula 08-20-20 (N-P2O5-K2O) was applied in furrows.

When the action levels for defoliators (30% defoliation in the vegetative stage or 15% defoliation in the reproductive stage) and stink bugs (2 stink bugs  $\geq$  0.5 cm from R3 to R6 soybean stage) (Bueno et al., 2013) were reached, the insecticides were applied, including Lannate® (methomyl) at a dose of 0.5 L/ha for caterpillars and Hero® (zeta-cypermethrin + bifenthrin) at 200 mL/

ha<sup>-1</sup> for stink bugs. Fox®Xpro (bixafem + prothioconazole + trifloxystrobin) at a dose of 0.5 L/ha<sup>-1</sup> was used to control diseases caused by fungi, and Cletodim® (cletodim) at a dose of 0.45 L/ha<sup>-1</sup> was used for weed control whenever necessary, equally in all trials and their treatments.

The spherical trap and synthetic commercial attractant were provided by Agribela® and tested in the field by Embrapa Soja as part of a cooperation partnership. The trap consisted of containers to insert the attractant (which was replaced weekly) and holes to capture stink bugs. The PET traps with bovine urine were made using transparent two-liter PET bottles with five openings of approximately 3 cm in the middle third of the bottle, a model called "R. Bianco" (Bianco, 2005). In the field, these traps were fixed at the height of the soybean plant tips with wooden stakes and string. The area was monitored from the beginning of the crop. When the first adults of the Neotropical brown stink bug were verified in the field, the traps were installed. At this time, soybean was at the beginning of pod formation (phenological stage R3). The traps remained in the field until the day of the soybean harvest, totaling seven weeks of collection in 2021/22 and five weeks in 2022/23. The traps were inspected weekly, recording the number of stink bugs collected separately by sex and development stage (nymphs or adults). Concomitantly, a beat cloth (on the same day of evaluation) was employed to monitor the stink bug population present in the plots with two samples adopted for each

pseudo-replicate, totaling eight samples per treatment.

At the end of the crop cycle, when the soybean had 95% of the pods in the harvest stage, the plants were harvested manually in 2 linear meters of the two central lines of each replicate and mechanically threshed when dry. The average yield was calculated and estimated in kg/ha, after being corrected for the average moisture percentage of the samples at 13%.

### Statistical analysis

The parameters evaluated in the different treatments were compared with each other through analysis of variance (ANOVA), with means separated by the Scott-Knott test at 5% significance. The statistical software SASM-Agri (Canteri et al., 2001) and Biostat 5.0 were employed.

## Results

During the 2021/22 crop season, 2,313 stink bugs (*E. heros*) were collected by tested traps, and only 13 of them were nymphs (0.6%). In the 2022/23 crop season, 959 stink bugs were captured, of which only 9 were nymphs (0.9%). All nymphs collected in both harvests were in fourth and fifth instars. Due to the small number of nymphs collected, only adult stink bugs were considered, and the results of nymphs were disregarded in the evaluations (Table 1).

**Table 1**

**Total number of adult *Euschistus heros* (Hemiptera: Pentatomidae) bugs collected. Sertanópolis and Londrina-PR, 2021/22 and 2022/23 Crops, respectively**

Traps	Stink bug captured	
	Crop season 2021/22	Crop Season 2022/23
PET trap with bovine urine	752	414
Spherical trap with synthetic attractant	745	232
Spherical trap with bovine urine	803	272
Spherical trap without any attractant	-*	32
Total	2300	950

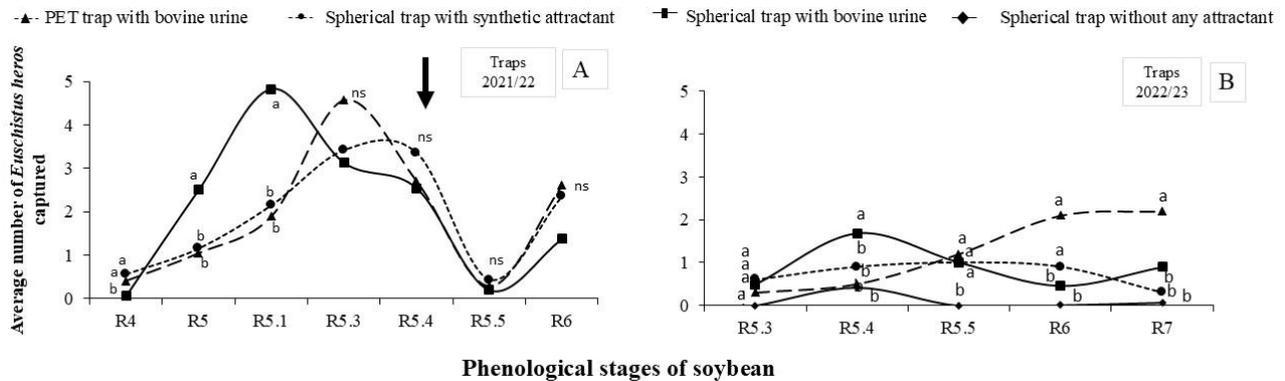
\* Treatment not performed.

In the 2021/22 season, the traps collected a similar number of adult stink bugs, with only a difference of 58 insects. The spherical trap with bovine urine captured the largest number (803), and the PET trap with bovine urine collected the smallest (752) (Table 1). In 2022/23, the largest difference between traps was 142 stink bugs. In this harvest, the greatest capture was achieved by the PET trap with bovine urine (414) and the smallest capture using the spherical trap with bovine urine (272), except the treatment with the spherical trap without any attractant, which captured no stink bugs in the first year and only 32 stink bugs in the second (Table 1).

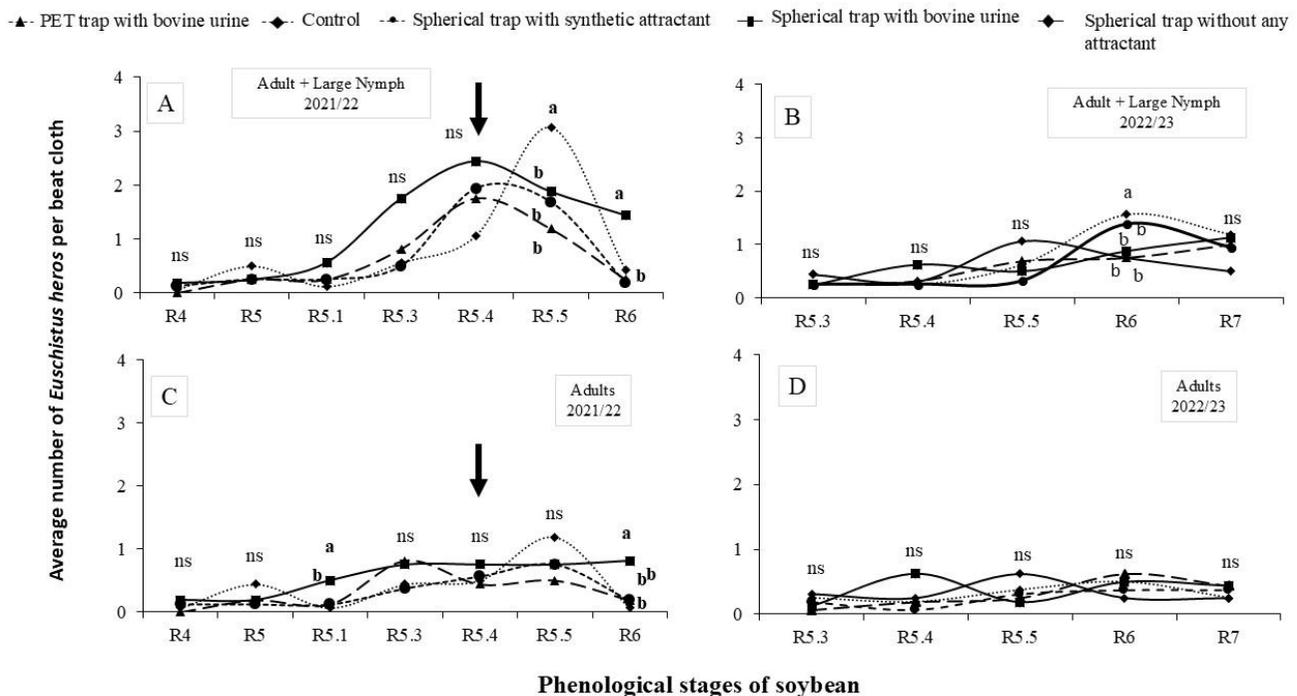
Differences were observed between treatments for three of the evaluated dates in 2021/22. (Figure 2A). When the soybean was at the R4 stage, the spherical trap with bovine urine captured fewer stink bugs, differing from the PET trap with bovine urine and the spherical trap with synthetic attractant. However, at R5 and R5.1 stages, the same spherical trap with bovine urine captured more stink bugs than the other traps, which did not significantly differ from each other.

At the other evaluated phenological stages, the quantities of stink bugs captured were statistically similar in the different traps. These results indicate that the attractant composed of bovine urine exhibited a slightly higher attraction of *E. heros*, regardless of the type of trap evaluated. In the following evaluations, no significant difference was observed between the number of stink bugs captured in the traps. The evaluation during the R5.5 soybean development stage was severely impacted by the application of insecticide due to the Economic Threshold (ET) being reached, reducing the insect population throughout the experiment.

In the sampling with the beating cloth, the evaluation done at R5.5 and R6 soybean stages found a difference for all experiments compared to the control. Areas with traps had fewer stink bug adults + large nymphs (third to fifth instars). When only the adults were evaluated, a difference was observed in relation to the last evaluation when the crop was at R6. When only the *E. heros* adults were considered, the population was insufficient to reach the ET (Figure 3A).



**Figure 2.** Average daily number of *Euschistus heros* (Hemiptera: Pentatomidae) captured by the PET trap with bovine urine, spherical trap with synthetic attractant, and spherical trap with bovine urine in the 2021/22 (A). The same traps, along with a spherical trap without any attractant in the 2022/23 (B) at different reproductive stages of soybean.



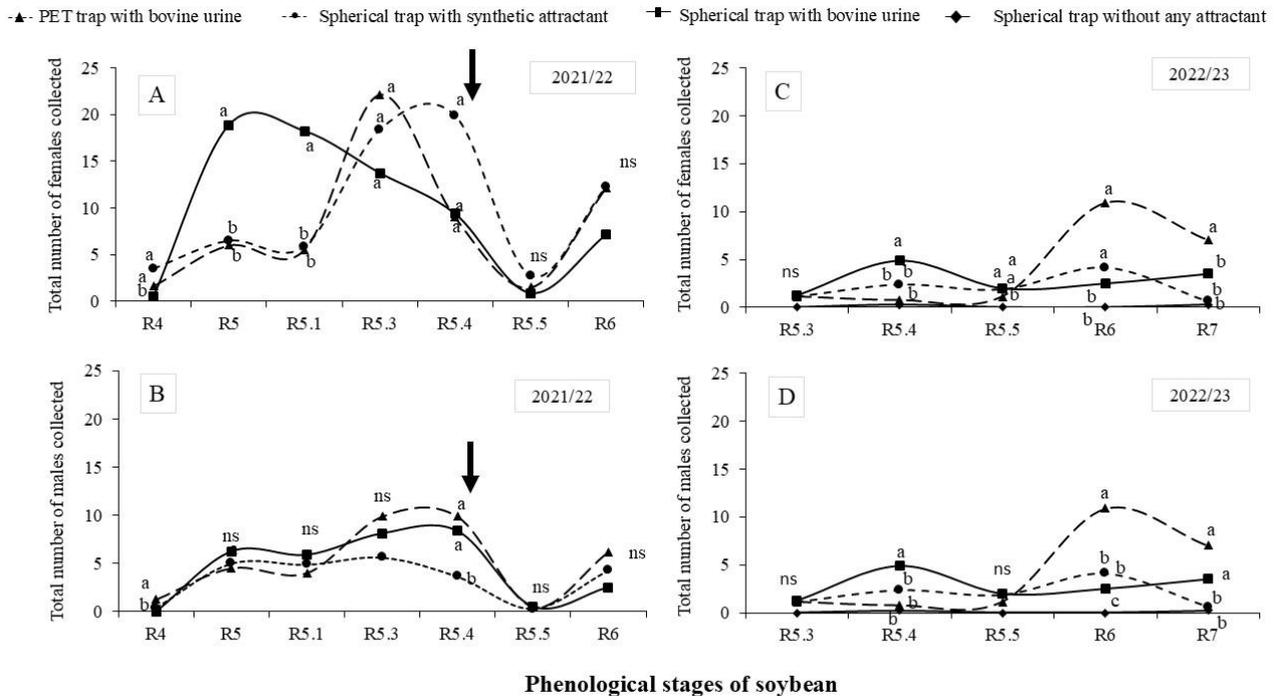
**Figure 3.** *Euschistus heros* (Hemiptera: Pentatomidae) adults + large nymphs (A and B) and only adults (C and D) captured in the 2021/22 and 2022/23 sampled by beating cloth, at different phenological stages of soybean, in the fields where the traps were installed. Sertanópolis and Londrina-PR, 2021/22 and 2022/23 crop seasons, respectively.

In the 2022/23 crop season, the overall stink bug population was smaller than in the previous crop season, never reaching the ET of two stink bugs per meter. The number of insects captured in each trap differed on four of the five evaluation dates, with no difference in the initial evaluation carried out at the R5.3 soybean development stage. In the second evaluation (R5.4), the spherical trap with bovine urine captured more stink bugs than the other traps evaluated. However, this higher capture by the spherical trap with bovine urine was not repeated on the other dates. In the evaluation at R5.5, all the traps that contained attractants had similar numbers and more insects than the spherical trap without any attractant. Unlike these first evaluations, on the dates later in the cycle (R6 and R7), the PET trap with bovine urine positively stood out, capturing more stink bugs than the other evaluated traps (Figure 2B).

In 2022/23, the number of stink bugs (nymphs from third to fifth instar + adults)/meter found on the beat cloths was different in the evaluation carried out at soybean

development stage R6 than in the other evaluations. Despite the greater capture of stink bugs in the PET trap with bovine urine, this treatment also presented the highest insect infestation (Figure 3C). However, when comparing only the number of adults per cloth, there was no difference between the treatments (Figure 3D).

All studied traps captured more female than male stink bugs (Figure 4). In the first evaluation (R4) of 2021/22, the spherical trap with bovine urine presented the lowest number of captured females. However, in the two following evaluations (R5 and R5.1), the spherical trap with bovine urine captured approximately twice as many females as the other tested traps (Figure 4A). All the traps captured a similar number of females during R5.3, R5.4, R5.5, and R6. In the first evaluation of 2021/22, the PET trap with bovine urine presented the greatest capture of males of all treatments. At R5.4, both PET and spherical traps with bovine urine captured most male stink bugs. On the other dates, the collection of males did not differ among treatments (Figure 4B).



**Figure 4.** Total number of males and females of *Euschistus heros* (Hemiptera: Pentatomidae) captured by PET trap with bovine urine, spherical trap with synthetic attractant, and spherical trap with bovine urine in 2021/22 crop season (A and B); and the same traps as well as the spherical trap without any attractant in the 2022/23 crop (C and D), during different reproductive stages of soybean.

In 2022/23, a difference was observed between the traps in the second (R5.4), third (R5.5), fourth (R6), and fifth (R7) evaluations for both females (Figure 4C) and males (Figure 4D). In the second evaluation, the spherical trap with bovine urine captured more females than the other studied traps (Figure 4C). In the third evaluation, all traps with attractants captured the same number of females, higher than the spherical trap without any attractant, which did not collect any insects. In the fourth evaluation, the spherical trap with bovine urine achieved the highest capture of females in the second evaluation, but at R6 captured the fewest females, equal to the spherical trap without any attractant (Figure 4C).

In 2022/23, the spherical trap with bovine urine captured more male insects than the other tested traps, while in the third evaluation (R5.5), no difference was observed. Later in the cycle, during soybean phenological development stages R6 and R7, the PET with bovine urine trap had the highest capture, which was equal to the spherical trap with bovine urine at R7 (Figure 4D).

Despite the variations in the collection of stink bugs by the different traps, all treatments produced similar soybean yields, including the control treatment without any trap, in both crop seasons, regardless of whether or not the ET of two stink bugs/meter was reached (Table 1).

## Discussion

The greater attractiveness of the evaluated traps for adults compared to nymphs of *E. heros* can be explained by the lower dispersal capacity of nymphs, who do not have wings (Souza et al., 2018; Nanzer, 2022), which negatively impacts the capture of nymphs and consequently the use of such traps against this immature development stage. Similarly, other studies evaluating other types of traps and attractants have demonstrated a negligible capture of *E. heros* nymphs (Corrêa-Ferreira, 2005; Nonino et al., 2006). Corrêa-Ferreira (2005) found insignificant capture of nymphs in traps baited with sex pheromone, which was expected since nymphs do not reproduce. Large nymphs ( $\geq 0.5$  cm), which include nymphs of third, fourth, and fifth instars, are capable of causing similar damage as adults, consequently, reducing soybean yield and quality if not managed. Therefore, the ability of traps to control only adults can limit their use in the field (Maciel et al., 2018).

Traps should be installed at the end of the vegetative period when the first stink bugs arrive in the field, preferably along the edge of the field and close to forest areas, to ensure efficient reduction of subsequent generations.

The colonizing stink bug populations are those older insects that survived from the previous crop season and entered quiescence to pass through the soybean off-season period. This population is mostly formed by adults (Corrêa-Ferreira & Hoffmann-Campo, 2009). More efficient capture of stink bugs with traps early at the reproductive stage was also previously reported by Corrêa-Ferreira et al. (2014), evaluating other types of traps and attractants.

The date of evaluation was a significant variable in the capture rate. When deciding which trap and attractant to use, the practicality of maintaining the traps and the supply of the attractant is important, which might vary depending on the region where the field is located (Batista, 2021). The use of bovine urine as an attractant, which is based on nitrogen compounds, might have a lower environmental and social impact, in addition to using a substance that would otherwise be discarded (Goulart et al., 2015). However, there is no standardization of the urine collected, since several variations, such as the amount of water consumed by the animal, can change the concentration of urea and other compounds, directly impacting its attractiveness for stink bugs. Therefore, a synthetic commercial attractant could be a viable alternative. Its practicality and standardization of attractiveness may be easier to employ, even though it captured slightly fewer stink bugs than the bovine urine in our experiments.

The greater capture of females in the traps, probably due to a greater proportion of females in the natural population, was also observed by Corrêa-Ferreira (2005) and may be favorable for reducing the population in the field, since each female has an average fecundity of 120 to 170 eggs throughout her life cycle (Corrêa-Ferreira, 2005).

Overall, we concluded that both types of stink bug traps evaluated in this study (PET or spherical) can be used for mass capture of stink bugs as a pest control strategy for small farms or organic growers who cultivate soybeans. The most efficient attractant was based on bovine urine; however, the synthetic attractant can also be used at higher costs as it is easier to obtain, especially in areas

where bovine urine is unavailable. The traps for mass collection of stink bugs should be installed before the colonizing population reaches the crops, preferably at the end of the vegetative stage and beginning of the reproductive stage, because mostly adults were captured by the traps.

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