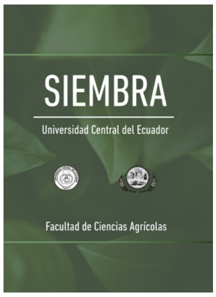
Biological cycle and reproductive performance of the rice stink bug (Oebalus insularis Stal.) in four host species



Ciclo biológico y desempeño reproductivo del chinche vaneador del arroz (Oebalus insularis Stal.) en cuatro especies hospedantes

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Abstract

The rice stink bug (*O. insularis*) is an economically important pest that affects the plant during its reproductive phase, causing direct and indirect damage. This insect can thrive in different hosts, favoring its population growth and field persistence. This research determined the biological cycle and reproductive performance of *O. insularis* in four host grasses: *Oryza sativa* L, *Echinochloa colona* L, *Echinochloa crus - galli* L and *Cynodon dactylon* L. Results showed that the biological cycle of *O. insularis* was shortest when it *C. dactylon* was the host, with a period of 25,8 days from egg stage to adult emergence. Statistical differences were presented from instar III favored by *C. dactylon* (3,30 a ± SD 0,68), instar IV represented by *O. sativa* (2,80 a ± SD 0,42), and *E. crus - galli* (3,70 ab ± SD 0,95) and instar V determined by *C. dactylon* (3,40 a ± SD 0,84) and *E. crus - galli* (3,70 a ± SD 0,68). The highest number of eggs per oviposition was obtained with *O. sativa* and *C. dactylon* (16,07 a ± SD 4,01; 14,89 ab ± SD 1,83 respectively). The alternate hosts studied are key to the insect's field persistence, and to manage its population, it is recommended to study their role in the pest's ecology in rice cultivation.

Keywords: Hemiptera, Pentatomidae, plague, alternate hosts, biology.

Resumen

El chinche vaneador del arroz (*O. insularis*) es una plaga de importancia económica que afecta a la planta durante su fase reproductiva ocasionando daños directos e indirectos. Este insecto tiene la facilidad de prosperar en distintos hospederos, favoreciendo el incremento de su población y su permanencia en el campo. En esta investigación se determinó el ciclo biológico y el desempeño reproductivo de *O. insularis* en cuatro gramíneas hospederas: *Oryza sativa* L, *Echinochloa colona* L, *Echinochloa crus-galli* L y *Cynodon dactylon* L. Los resultados mostraron que el ciclo biológico de *O. insularis* fue más corto cuando tuvo como hospedero a *C. dactylon* determinándose un período de 25,8 días desde la etapa de huevo hasta la emergencia del adulto. Se presentaron diferencias estadísticas a partir del instar III favorecido por *C. dactylon* (3,30 a ± SD 0,68), el instar IV representado por *O. sativa* (2,80 a ± SD 0,42) y *E. crus-galli* (3,70 ab ± SD 0,95) y el instar V determinado por *C. dactylon* (3,40 a

± SD 0,84) y *E. crus-galli* (3,70 a ± SD 0,68). El mayor número de huevos por ovipostura se obtuvo con *O. sativa* y *C. dactylon* (16,07 a ± SD 4,01; 14, 89 ab ± SD 1,83, respectivamente). Los hospederos alternos estudiados son la clave en la permanencia del insecto en el campo y para su manejo poblacional se recomienda estudiar su rol en la ecología de la plaga en el cultivo de arroz.

Palabras clave: Hemiptera, Pentatomidae, plaga, hospederos alternos, biología.

1. Introduction

Rice (*O. sativa*) is one of the most consumed cereals in the world after wheat, and it is cultivated in tropical and subtropical regions, in temperate and mediterranean climates. However, the majority of its production is concentrated in humid tropical climates (Buelvas Jiménez, 2021).

In 2022, the harvested area of paddy rice worldwide was 165'038.826,00 hectares, with a production of 776'461.456,00 tones (Food and Agriculture Organization of the United Nations [FAO], 2024). Just in Ecuador, the cultivated area nationwide in 2022 was 343.061,00 hectares, 337.823,00 harvested hectares, with a production of 1'561.271,00 tones. The main productive provinces were Guayas, Los Rios, Loja, Manabi and El Oro (Instituto Nacional de Estadísticas y Censos [INEC], 2024).

Economic loses represent one of the main limitations for the increase of productivity in rice cultivation. It is estimated that almost the 35% of the production is reduced at global level. From these loses, 12% are caused by insect damage, 10% by weed, 12% by pathogens and 1% is caused by vertebrates. All these issues lead to a significant increase in production costs (Laterza et al., 2023; Vivas & Astudillo, 2010; Vivas-Carmona et al., 2017).

The genus *Oebalus* (Hemiptera: Pentatomidae) includes several species of bugs commonly known as 'stink bugs' (they produce empty or low-weight grains) with a wide distribution across the American continent (Rodríguez et al., 2006; Vivas & Astudillo, 2010). These insects are considered as economically important pests in crops like rice, corn and pastures (Pal et al., 2023; VanWeelden et al., 2020; Zachrisson et al., 2014). The stinky bugs cause direct damage to the plant because they feed on flowers and developing grains, producing weak, partially filled or empty grains (Jiménez Martínez, 2021; Zachrisson, 2010). The insects also cause indirect damage when feeding because they wound the plant tissues facilitating the entry into the grain interior to pathogens with a subsequent decrease in grain quality and yield (Weber et al., 2020), reaching figures that range from 30 to 65% of the total production value (Pérez Iglesias & Rodríguez Delgado, 2019).

It exists a great diversity of alternate host plant species inside and around the rice field which influences the growth and survival of the populations of this pest, causing its migration towards the crop and vice-versa (Ponijan et al., 2023; Viera et al., 2023; Vivas & Astudillo, 2010; Vivas & Notz, 2010). Generally, the pest search for host plant species with adequate nutritional qualities but their absence or scarcity force the pest to explore alternate plants, available in time and space (Panizzi & Lucini, 2022; Queiroz et al., 2022). It is known that the genus *Oebalus* prefers the weeds from the family Poaceae (Bhavanam & Stout, 2022).

Vivas and Astudillo (2010) demonstrated that the stink bug is favored for population growth by grass (Poaceae) and legume (Fabaceae) species, such as *Echinochloa colona* L, *E. crus-galli* L, *E. polistachia* K, *Digitaria sanguinalis* L, *Paspalum dystichum* L, *Paspalum virgatum* L, *Eleusine indica* L, *Digitaria decumbens* S, *Zea mays* L, *Cyperus rotundus* L, *C. iria* L, *Fimbristylis miliacea* L, *Phaseolus vulgaris* L, *Glycine max* L, among others, showing a high preference for these species to complete its life cycle.

The present research had as an objective to study the biological cycle and the reproductive performance of *O. insularis* in four species of host plants commonly found in rice fields in Ecuador.

2. Materials and Methods

2.1. Geographical location

The study was carried out in the insectary of the Entomology Lab of the South Coast Experimental Station [EELS] of the Instituto Nacional de Investigaciones Agropecuarias [INIAP] located in the Virgen de Fatima parish, Yaguachi canton, Guayas province, Ecuador (2° 15' 15" S, 79° 30' 40" W, 17 m a.s.l).

2.2. Assay management

2.2.1. Preliminary phase: Adult collection and extraction of egg masses

Adult stinky bugs were collected with an entomological net in the rice fields of the EELS containing the genotypes INIAP IMPACTO and CRISTALINO and transported in plastic bags. Once at the lab, 20 couples were isolated and distributed equally in two plastic containers with measures of 20 x 10 cm. Consecutively, they received sufficient leaves and rice panicles in the milky stage at the base of the containers, one Petri dish (1.5 x 5.5 cm) with wet cotton was also incorporated to create an adequate microclimate and they were covered with tulle fabric for 24 hours. The food was provided on a single occasion, for this reason it was not necessary to place the panicles in jars with water inside each container. Besides, the starch reserve and other substances of the grains were sufficient to cover the nutritional need of the individuals.

At 24 hours, a lot of oviposition was observed because most of the field-collected females were in continuous production of eggs facilitating the immediate extraction to start the study. The methodology of the experiment is detailed below (with modifications from Zachrisson et al., 2014).

2.2.2. Biological cycle and reproductive performance of the rice stinky bug (O. insularis)

The initial phase of this experiment was carried out in Petri dishes (1.5 x 5.5 cm) where one egg mass with an average of 26 eggs from the insect was placed using a clamp. A wet cotton was placed to the sides, and the plate was covered with the lid. Ten repetitions were used for each treatment which were daily monitored until their emergence.

After the hatching of the first-stage nymphs, each Petri dish was opened and placed inside the clear plastic containers (1 L capacity) which contained the corresponding plant species (*O. sativa*, *E. colona*, *E. crus-galli* and *C. dactylon*) kept in glass jars with water (6 cm x 2 cm). A wet cotton was added (adequate microclimate) and the recipient was closed with tulle fabric held with rubber bands. Observations were made every 24 hours to assess the stage change based on each of the diets provided. The change of each instar was confirmed by the presence of exuviae, which were later removed with a brush. The renewal of food was done every 48 hours, and the experimental units were kept under controlled conditions (25 ºC, 70 % R.H and 12 h photophase).

Once the adults emerged, 10 couples were isolated and only one couple was placed in each recipient (1 L plastic cup), they were provided with the respective plant species for the study, as well as a wet cotton. Finally, the cup was covered with tulle fabric and rubber bands to confine them. Ten couples were used (repetitions) to ensure the corresponding follow-up.

The duration in days of the biological parameters was evaluated (eggs, stage I, stage II, stage III, stage IV, and stage V). In addition, the reproductive parameters were determined as follow:

- Pre-oviposition period.- The period in days between the adult emergence and the beginning of oviposition was considered for its fulfillment.
- Oviposition period.- The number of days with egg production was recorded.
- Post-oviposition period.- The number of days between the end of oviposition and adult death were evaluated.
- Male and female longevity.- The days elapsed from the adult's emergence to death were counted.
- Number of egg masses.- The number of eggs that a female can lay at once was recorded.
- Number of eggs per oviposition and total number of eggs.- They were respectively counted throughout the female's life cycle.
- Hatch rate.- It was calculated using the formula proposed by Vega et al. (2017) described in the equation [1].

$$\%\ \text{hatch rate} = \frac{\text{Total number of hatched nymphs}}{\text{Total number of incubated eggs}} \times 100 \qquad [1]$$

2.3. Statistical Analysis

A completely random experimental design was used with 10 repetitions per host species. The data was processed using the statistical program IBM® SPSS® version 21, where after verifying the homogeneity of variance

(Levene's Test), the difference in means was determined using the Welch statistical test, followed by Tukey's post-hoc tests at 5 % for all analyses.

3. Results and Discussions

3.1. Biological parameters of the rice stink bug (O. insularis)

3.1.1. Longevity of the stages: eggs, nymphs and adults (♀♂)

During the initial stage of the assay, the egg masses came from adults collected freely from rice fields, which fed on the rice crops and on surrounding weeds. The egg masses extracted, being a non-feeding stage, were exempt from the contribution of the host species in the study. Therefore, it was determined that the incubation period ranged from 4.20 to 4.90 days.

Other studies demonstrated that females (*O. insularis* and *O. pugnax*) are characterized by laying the eggs in a row, attached to each other by a substance released during oviposition. These eggs are initially olive-green, and they acquire a reddish tone as the days go by, as embryogenesis progresses. The hatching time of the nymphs can vary between 4-5 days at a temperature of 29 ºC (Bhavanam et al., 2021; Jiménez Martínez, 2021).

There were no statistic differences in the longevity of insects in stage I between the evaluated treatments (*E. crus-galli* 2.50 a ± SD 0.53 days, *E. colona* 2.70 a ± SD 0.82, *C. dactylon* 3,00 a ± SD 0.00 and *O. sativa* 3.10 a ± SD 0,32 days) (Figures 1 and 2B). The results obtained by Zachrisson et al. (2014) had statistical differences with respect to longevity at the first stage fed with *O. sativa* (2.90 ± 0.82) and *E. colona* (2.20 ± 0.48).

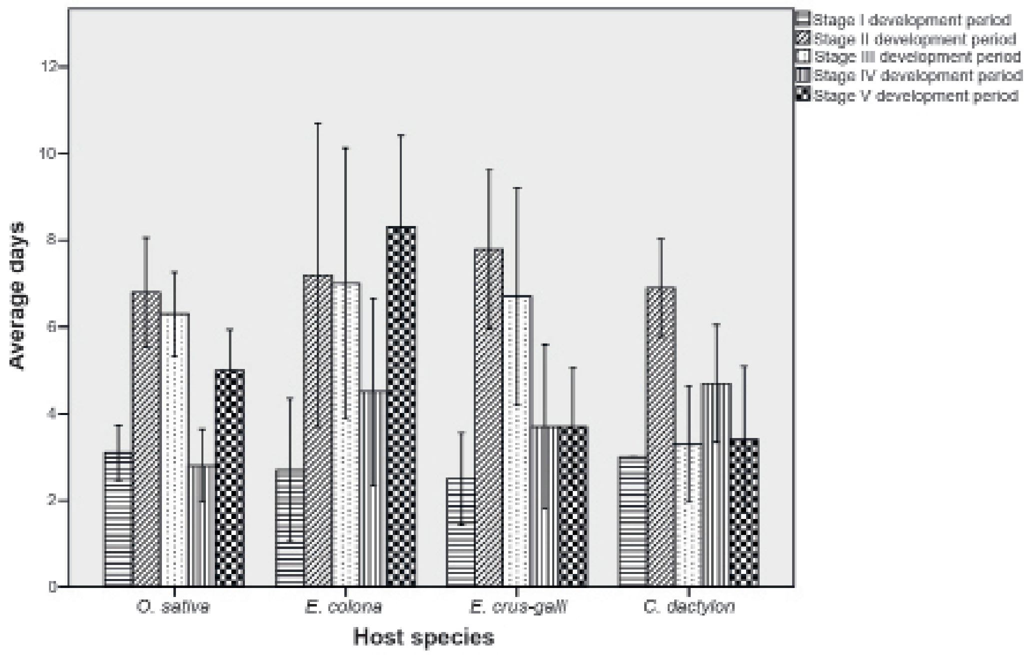

Figure 1. Longevity of the biological parameters of *O. insularis* based on four host species.*

* Vertical lines in the bars represent the standard deviation.

The result of this study is explained because stage I has a period of development of two days when the insect does not feed on its host but survives instead from the symbionts vertically transmitted from the mother, identifying several bacterial taxa associated with heteropterans such as Actinobacteria, Alphaproteobacteria, Bacteroidetes, Betaproteobacteria, Firmicutes and Gammaproteobacteria (Awuni et al., 2014; Bhavanam et al., 2021; Pal et al., 2023).

Stage II has a gregarious behaviour and at this stage the insect does feed on its host (Bhavanam et al., 2021). The results obtained in the present study did not show statistical differences among the host plants with respect to the time of development of this stage (*O. sativa* had 6.80 a ± SD 0.63 days; in *C. dactylon* 6.90 a ± SD 0.57, in *E. colona* 7.20 a ± SD 1.75 and in *E. crus-galli* 7.80 a ± SD 0.92 days) (Figures 1 and 3A).

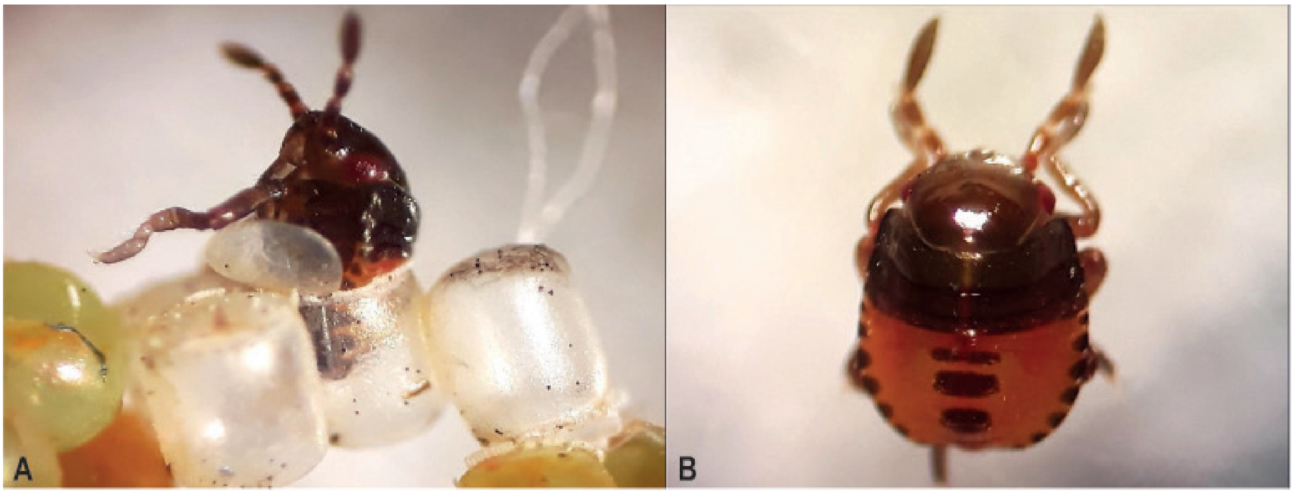

Figure 2. A) Nymph emergence. B) Dorsal view of nymph I.

Figure 3. Dorsal view. A) Nymph II. B) Nymph III. C) Nymph IV.

On the other hand, stage III presented significant differences in function of the host *C. dactylon* (3.30 a ± SD 0.68), which favours the growth and development of the pest in less time, while the rest of hosts were equal to each other (*O. sativa* 6.30 b ± SD 0.48; *E. crus-galli* 6.70 b ± SD 1.25 and *E. colona* 7.00 b ± SD 1.56) (Figures 1 and 3B). This condition can be attributed to the presence of some nutritional elements in *C. dactylon* (protein 11.6 g, fat 2.1 g, total carbohydrates 75.9 g, fiber 25.9 g, Ca 530 mg, P 220 mg, Fe 112 mg, K 1630 mg, and others) which has a pivotal role over the behaviour of the insect (Khatun & Kumar Das, 2020). The nutritional information of the host species in this study is detailed in Table 1.

Table 1. Nutritional information of the host species studied.

Species	Protein (g)	Fat (g)	Total carbohydrates (g)	Fiber (g)	Calcium (mg)	Phosphorous (mg)	Iron (mg)	Potassium (mg)
E. colona	5.45	2.80	65.98	22.80	4.84	220	2.10	7.05
E. crus-galli	7.40	2.90	81.10	31.30	0	0	0	0
C. dactylon	11.60	2.10	75.90	25.90	530	220	112	1630
O. sativa	7.13	0.66	79.95	1.30	28.00	115.00	0.80	115.00

* Estimate values in 100 g.

Source: Heuzé and Tran (2015); Khatun and Kumar Das (2020); Herrera Fontana et al. (2021) ; Elqarnwdy et al. (2021); Beauv (2024).

During stage IV the hosts *O. sativa* (2.80 a ± SD 0.42) and *E. crus - galli* (3.70 ab ± SD 0.95) were statistically similar, reaching a shorter time of pest development, but they were also different to the species *E. colona* and *C. dactylon* (4.50 bc ± SD 1.08; 4.70 c ± SD 0.68), delaying the development of the insect (Figures 1 and 3C).

Regarding stage V, the hosts *C. dactylon* (3.40 a ± SD 0.84) and *E. crus-galli* (3.70 a ± SD 0.68) were statistically similar, favouring the insect biology in a shorter period of time, leading to adulthood. However, these hosts were different to *O. sativa* and *E. colona* (5.00 b ± SD 0.47 and 8.30 c ± SD 1.06) (Figures 1 and 4). In a study related to the biological cycle of *O. insularis*, some similarities among stages III, IV and V were determined when the insects were fed on *O. sativa* and *E. colona* (Zachrisson et al., 2014).

Figure 4. V instar nymph dorsal view.

In summary, the shorter the nymphal development period, the better the host plant. On the contrary, the longer the adult longevity, the better the host.

3.1.2. Longevity of the egg-emergence phase of adults

The results from this variable contemplated the time from the egg phase to the emergence of the adult but not until the dead of the insect which is why the earliest host is considered the most important. In this sense, when comparing the group means (Tukey with $p < 0.05$), it was observed that with the host *C. dactylon* (25.80 a ± SD 1.75 days), the metabolic processes of the pest were accelerated which was favorable to fulfill the reproductive parameters. On the other hand, the species *E. colona* (34.60 c ± SD 0.69 days) resulted in the extension of this stage. While the hosts *O. sativa* (28.20 b ± SD 0.42) and *E. crus-galli* (28.90 b ± SD 1.45) were statistically similar (Figures 5 and 6A, B, C).

It is possible that the composition, nutritional concentration, and the particular metabolism of the host plants could influence and cause the acceleration of the metabolic processes of the pest (Molina-Rugama et al., 1997; Newkirk, 2020). It is known that proteins, carbohydrates, lipids and nitrogen play a vital role in the nutrition of the pentatomids (Wilson & Stout, 2020; Possebom et al., 2020; Queiroz et al., 2022).

This study differs with the results obtained by Zachrisson et al. (2014), who demonstrated statistical similarities with the hosts *E. colona* (21.20 ± 2.40) and *O. sativa* (20.90 ± 1.20) on the longevity of *O. insularis.*

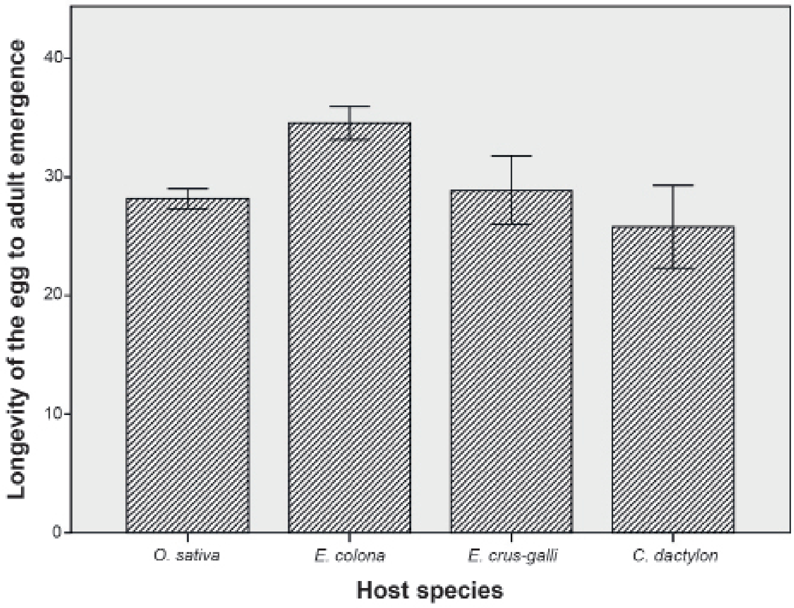

Figure 5. Longevity of the egg to adult emergence phase of *O. insularis* based on four host species.

* Vertical lines in the bars represent the standard deviation.

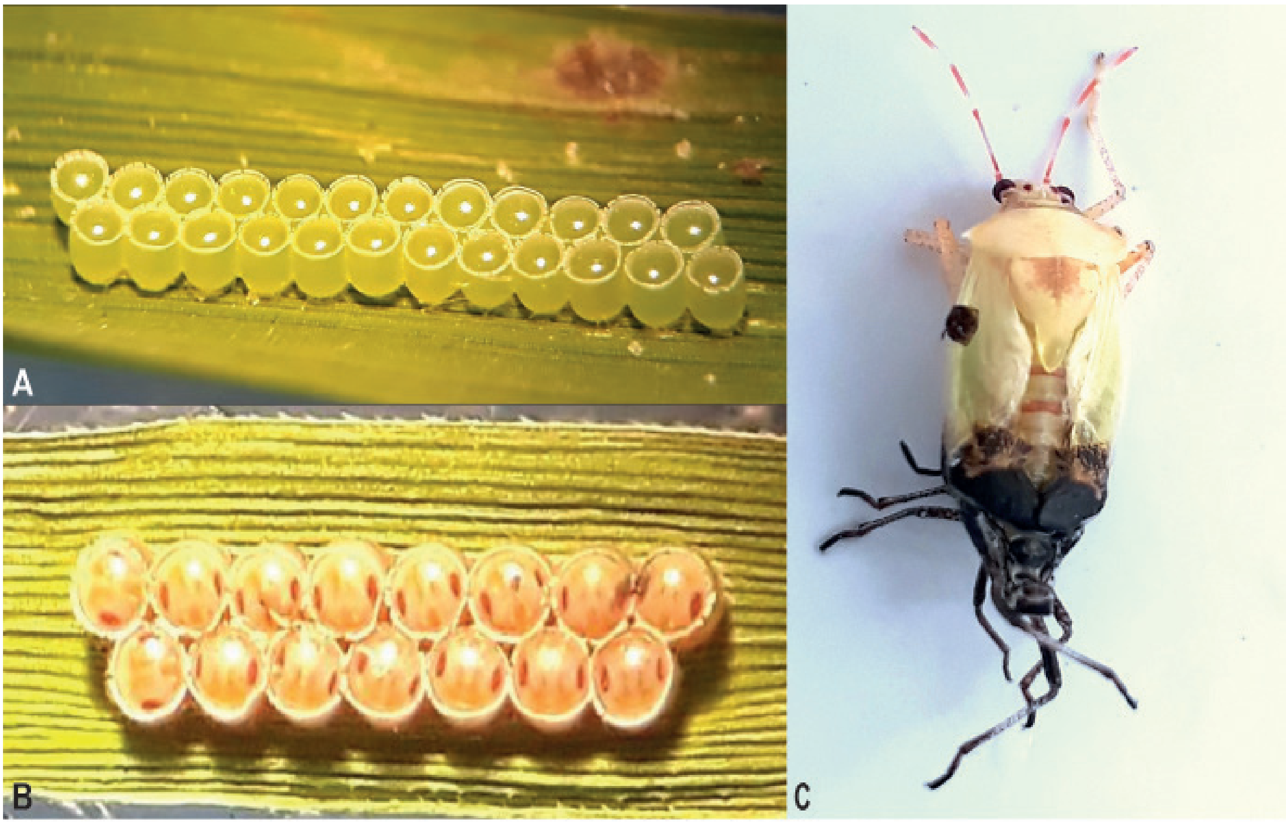

Figure 6. *O. insularis*. A) Fresh oviposition. B) Oviposition during incubation. C). Shedding of the exuviae to become an adult.

The concentration of nutrients in each host did influence the longevity of the studied species. According to another study that evaluated the behaviour of the stink bug *O. pugnax* (nymph I - adult) under controlled conditions found a shorter longevity in the host *O. sativa* with 18.1 days in comparison to *Leptochloa panicoides* with 22 days (Bhavanam et al., 2021).

3.1.3. Longevity of the female and male

There were no statistical differences for the longevity variable of the female fed on *E. colona* 39.50 a ± SD

7.10; *E. crus-galli* 40.80 a ± SD 6.44; *C. dactylon* 42.30 a ± SD 8.86; and *O. sativa* 43.10 a ± SD 6.57 (Figures 7 and 8A,B,C).

On the ther hand, the longevity period of the male was longer on the hosts *E. crus-galli* (56.70 a ± SD 12.04) and *E. colona* (50.20 ab ± SD 15.88). However, when comparing these species to the rest of hosts, it was observed some statistical differences that determined a shorter lifetime (*O. sativa* 31.50 c ± SD 6.88 and *C. dactylon* 37.80 bc ± SD 19.69) (Figures 7, and 9A,B,C).

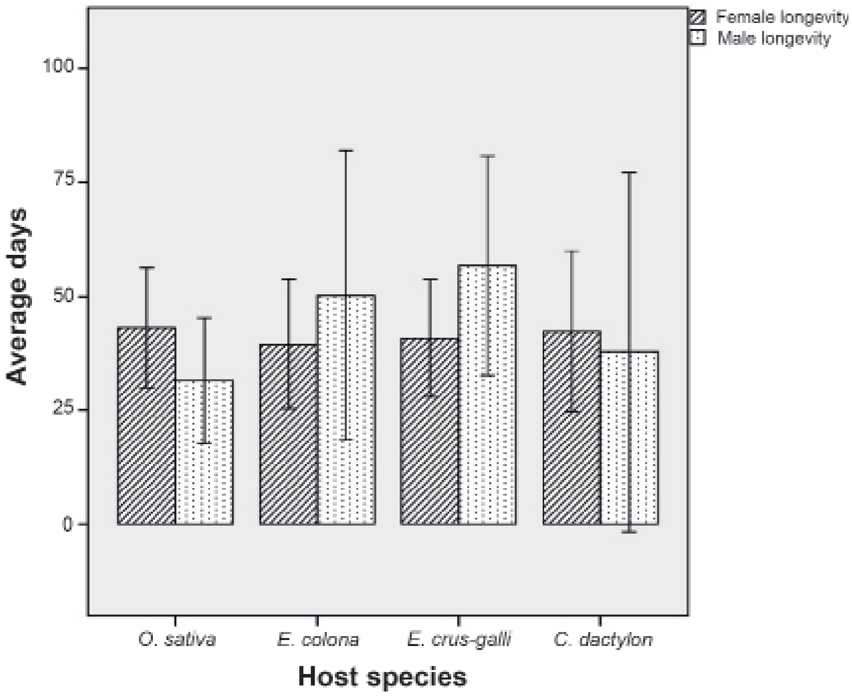

Figure 7. Longevity of *O. insularis* adults. based on four host species.

* Vertical lines in the bars represent the standard deviation.

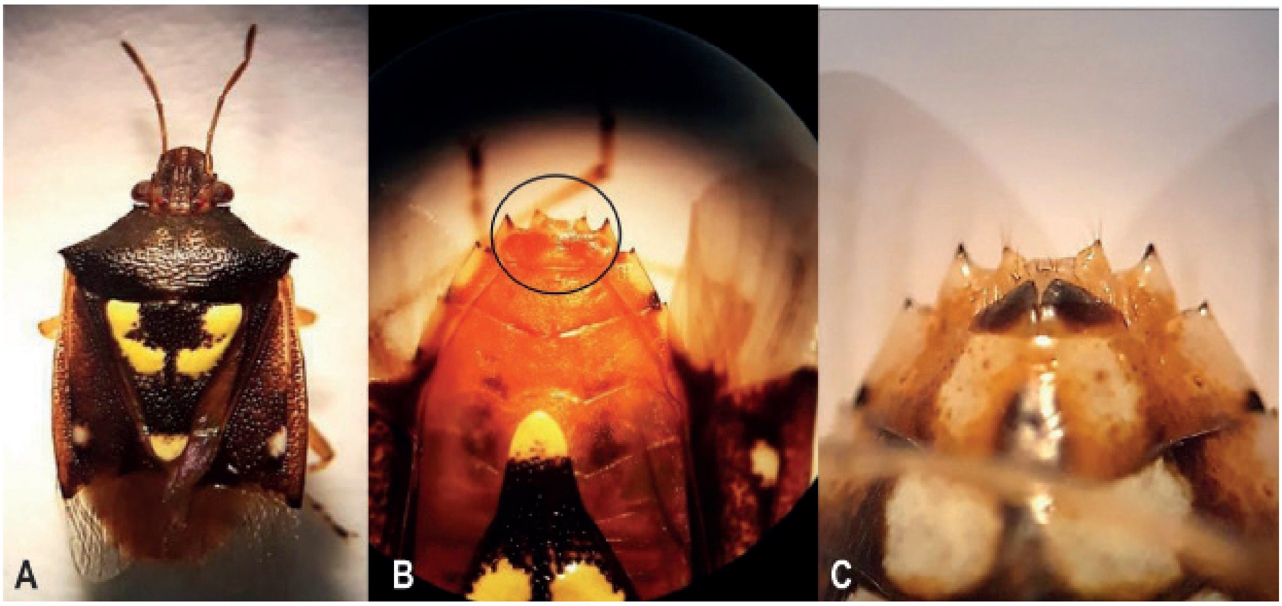

Figure 8. A) Dorsal view of the female. B) Female genitalia - dorsal view. C) Female genitalia - ventral view.

Zachrisson et al. (2014) determined no statistical differences in the lifetime of *O. insularis* when interacting with the plant species *O. sativa* and *E. colona* because this condition depended on various parameters such as the kind of food, environment and the answer to the pest in function of the species to which it feeds on. For example, Bhavanam et al. (2021) determined that the mean longevity of *O. pugnax* fed on *O. sativa* was higher in the females (50 days) in comparison to the males' (39 days).

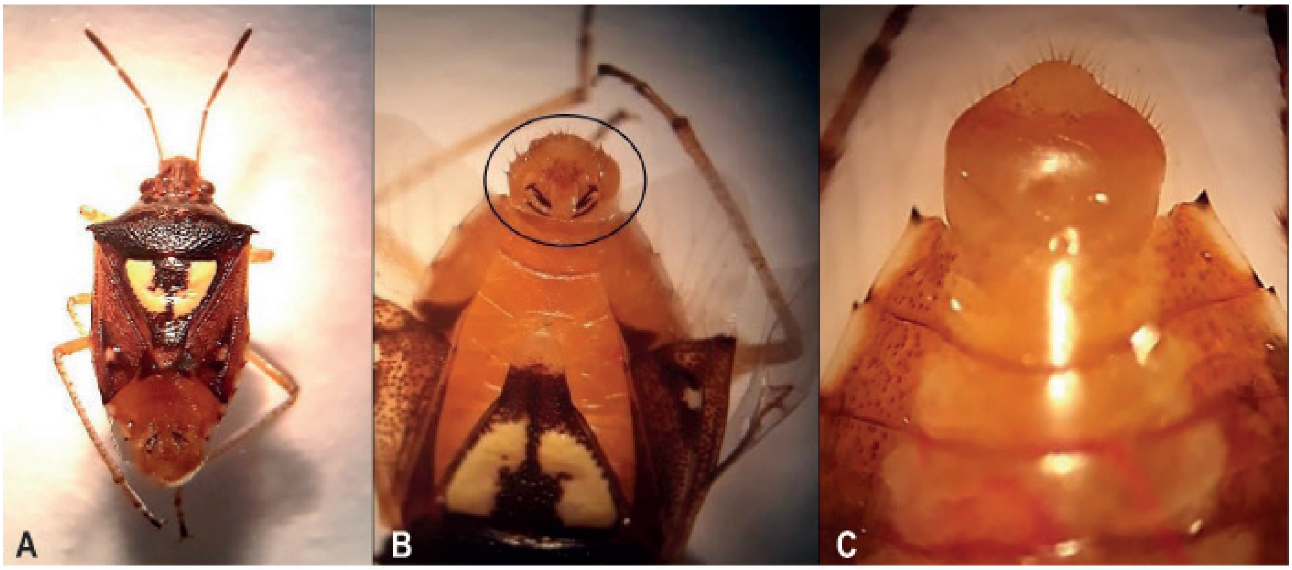

Figure 9. A) Dorsal view of the male. B) Male genitalia - dorsal view. C) Male genitalia - ventral view.

The quality and quantity of food consumed by the insects caused effects on the biology, physiology and behaviour of the phytophagous pests. In this context, when the insects fed on low-nutritional species, they generally need strategies to compensate their needs, being one of them the extension of the feeding period (Queiroz et al., 2022).

3.2. Reproductive parameters of the rice stink bug (O. insularis)

3.2.1. Duration period of the pre-oviposition, oviposition and post-oviposition stages

Statistical differences were observed in adults fed on *O. sativa,* resulting in a shorter time period of the pre-oviposition stage (6.20 a ± SD 2.09) in comparison to the rest of host plants, which were statistically similar (*E. colona* 9.30 b ± SD 2.66; *E. crus-galli* 9.90 b ± SD 2.38 and *C. dactylon* 10.40 b ± SD 2.37). This was favorable to reach the following oviposition previous to the copulation (Figure 10 and 11A, B).

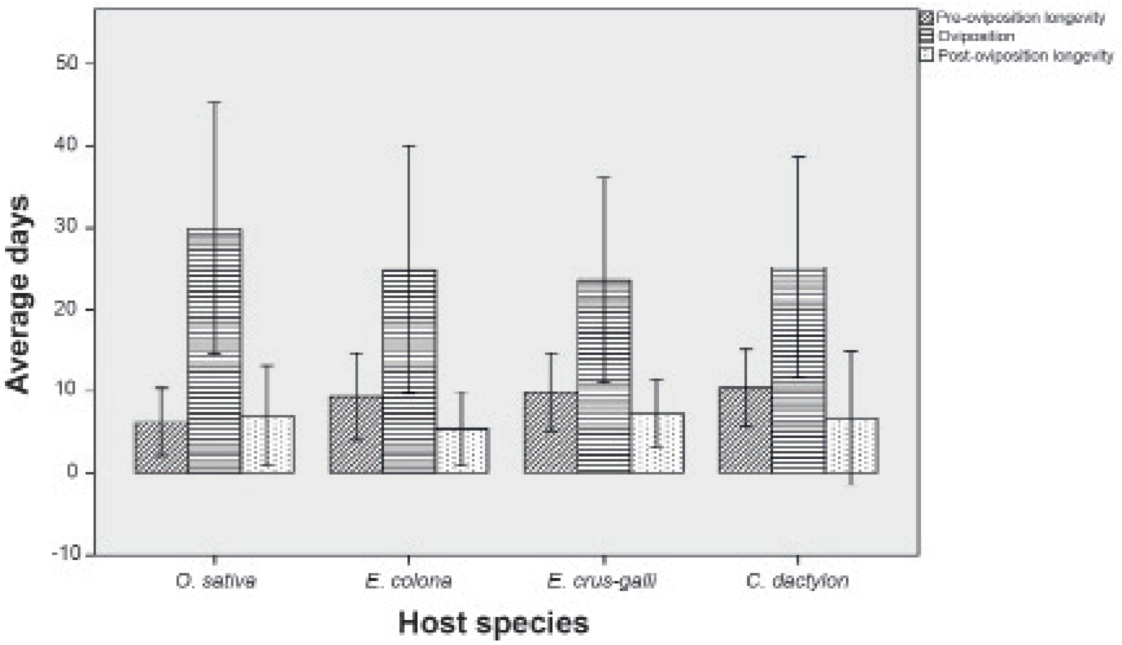

Figure 10. Duration of the pre-oviposition, oviposition and post-oviposition stages of *O. insularis* based on four host species.
* Vertical lines in the bars represent the standard deviation.

Figura 11. A) Copulation. B) Copulation - ventral view.

Regarding the oviposition period, it was statistically similar (*E. crus-galli* 23.60 a ± SD 6.26 days; *E. colona* 24.80 a ± SD 7.57 days; *C. dactylon* 25.20 a ± SD 6.73 days and *O. sativa* 29.90 a ± SD 7.68 days). A similar behaviour was recorded in the longevity variable of post-oviposition (*E. colona* 5.40 a ± SD 2.27; *C. dactylon* 6.70 a ± SD 4.08; *O. sativa* 7.00 a ± SD 3.06 and *E. crus-galli* 7.30 a ± SD 2.06 days) (Figure 10). This study differs with the results obtained by Zachrisson et al. (2014), who determined a longer longevity in the oviposition in adults fed on *O. sativa* (5.00 ± 1.49) in comparison to *E. colona* (4.00 ± 0.47).

3.2.2. Average of egg masses, eggs per oviposition and total number of eggs

The insects fed on the hosts *O. sativa* and *E. crus-galli* exhibited a higher number of egg masses (21.90 a ± SD 5.19; 18.30 ab ± SD 1.49) being statistically equal. However, they were different to the rest of host plants (*E. colona* 15.80 b ± SD 3.46 and *C. dactylon* 16 b ± SD 5.68) (Figure 12).

The highest number of eggs per oviposition was obtained with the host plants *O. sativa* and *C. dactylon* (16.07 a ± SD 4.01; 14.89 ab ± SD 1.83), which were statistically different in relation to the host plants *E. colona* and *E. crus-galli* (11.19 c ± SD 1.37; 13.19 bc ± SD 1.21) (Figure 12).

In addition, the total number of eggs was registered in the host plant *O. sativa* (337.40 a ± SD 84.09), statistically differentiating itself from the other species used (*E. colona* 176.90 b ± SD 45.85; *C. dactylon* 233.20 b ± SD 70.45; *E. crus - galli* 250 b ± SD 26.29). However, *E. colona, C. dactylon* and *E. crus-galli* were statistically equal (Figure 12).

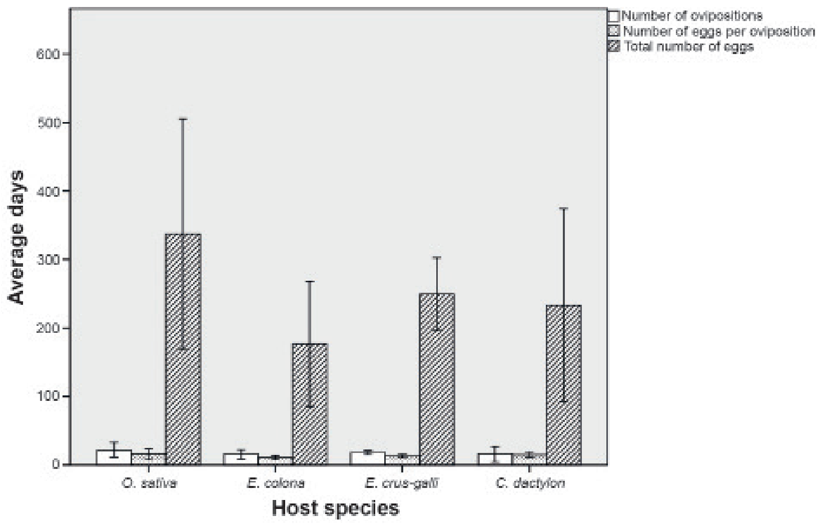

Figure 12. Average number of ovipositions, eggs per oviposition and total number of eggs of *O. insularis* based on four host species.
* Vertical lines in the bars represent the standard deviation.

This condition is attributed to the concentration of nutrients present in rice grains (starch, amylopectin, proteins and others) which can cause visual and olfactory stimuli for insect feeding (Bhavanam & Stout, 2022; Cato et al., 2020; Fuentes-Rodríguez & Dellapé, 2023) unlike plant tissues, which do not contribute to nutritional requirements to reach the development and reproduction in adults (Panizzi & Lucini, 2022).

It was proven that during the reproductive stage, the female showed high energetic demand to ensure copulation (Figure 12), the maturation of oocytes and oviposition (Weber et al., 2020).

The present study coincides with the results obtained by Zachrisson et al. (2014), who determined that *O. insularis* had a higher number of egg masses in *O. sativa* (6.50 ± 0.40) in comparison to *E. colona* (5.50 ± 0.50). However, when analyzing other reproductive variables, the insect in interaction with *E. colona* presented a higher number of eggs per egg mass and total number of eggs, confirming the trophic adaptation to the weed (Zachrisson et al. 2014).

3.2.3. Hatching rate (%)

The hatching rate did not present significant differences with the host plants used (*E. colona* 96.25 a ± SD 4.59 %; *C. dactylon* 96.63 a ± SD 7.29 %; *E. crus-galli* 96.77 a ± SD 4.43 % and *O. sativa* 98.48 a ± SD 2.86 %) (Figures 13 and 2A). This investigation differs from a study where *O. insularis* presented a higher hatching rate in the host *E. colona* (81 %) than in the host *O. sativa* (74 %) (Zachrisson et al., 2014) which could be attributed to some nutritional difference in the nutritional content of the hosts used during that study in comparison to a very similar nutritional quality of the hosts in the present study. As it was explained before, host nutrition influence in different biological development variables of the arthropods.

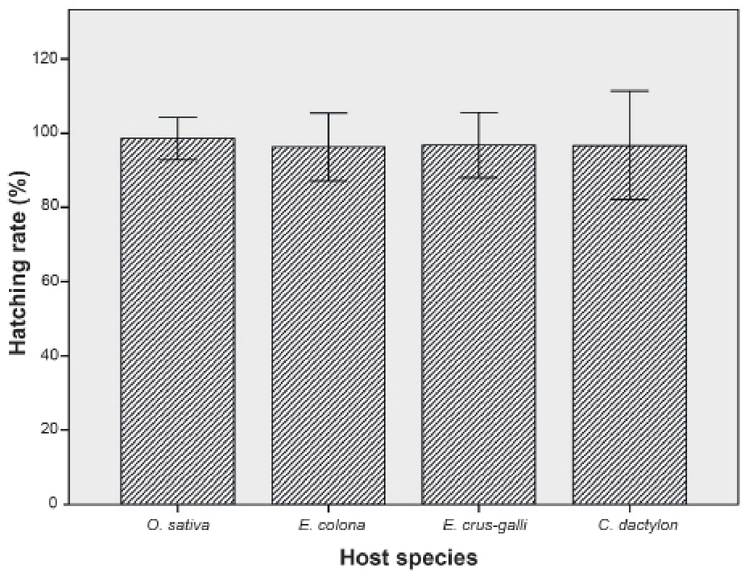

Figure 13. Hatching rate (%) of *O. insularis* based on four host species.

* Vertical lines in the bars represent the standard deviation.

4. Conclusions

Although the shortest cycle was completed by the arthropod feeding on *C. dactylon*, the highest total number of eggs was produced when feeding on *O. sativa,* which is why it is important to remove the hosts from the rice field.

The knowledge of the biological and reproductive behaviour of the pest is important information for the implementation of sustainable management programs. Through the present study it was observed that the stink bug thrives in the used host plants, which is why it is suggested to carry out a prompt control of the weeds to keep the population under activity thresholds.

It is evident that the shorter the time period of nymphal development, the better the host plant. On the contrary, the higher the adult longevity, the better the host plant. In this context, the nutritional quantity and the quality of the host plants influence the metabolic processes, which is why the host plants are key for the permanence of the insect in the field. Therefore, studies on the role of the host in the insect ecology in rice crops should continue promoting an efficient management of the population.

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Author contribution

- Jessica Daniela Zambrano Mero: conceptualization, investigation, methodology, data curation, writing – original draft.
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- Carmen Isabel Castillo Carrillo: validation, writing – review & editing.
- Alex Gabriel Delgado Párraga: data curation, formal analysis.
- Roberto Evaristo Celi Herán: supervision, resources, project administration.

Ethical Implications

Ethics approval not applicable.

Conflicts of interest

The authors declare that they have no affiliation with any organization with a direct or indirect financial interest that could have appeared to influence the work reported.

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