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BIOLOGICAL ASPECTS AND PREDATORY CAPACITY OF *Doru luteipes* WHEN FED WITH *Spodoptera frugiperda*[1]

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ABSTRACT - Biological aspects and predatory capacity of *Doru luteipes* was assessed as a function of predation on *Spodoptera frugiperda*. The experiment was conducted under laboratory conditions of mean temperature of 25 ± 1 °C, relative humidity of 70 ± 10%, and 12:12 h (Light: Dark) photoperiod. To evaluate the biological parameters of *D. luteipes*, artificial diet, eggs and caterpillar (1st, 2nd, 3rd, 4th, 5th or 6th instars) of *S. frugiperda* were supplied. The completely randomized statistical design was used, with 10 replicates for each treatment. The nymphs (1st, 2nd and 3rd instars) and adult males and females of *D. luteipes* were individualized in Petri dish (9 cm diameter), with artificial diet as standard food (control). Nymphs of the 1st and 3rd instars of the predator lasted 4.5 and 6.9, days respectively, but they perished. The survival of *D. luteipes* is high, but there was variation when consuming the different instars of the caterpillar of *S. frugiperda*. Adults of *D. luteipes* did not consume caterpillars of the 4th, 5th and 6th instars of the prey. There was a significant difference for the feeding of *D. luteipes* with artificial diet, eggs and caterpillar of *S. frugiperda* with respect to the parameters number of eggs and preoviposition. Higher consumption of male and female *D. luteipes* occurs when they are fed with prey eggs.

Keywords: Biological control. Predator. Fall armyworm. Corn.

ASPECTOS BIOLÓGICOS E CAPACIDADE PREDATÓRIA DE *Doru luteipes* QUANDO ALIMENTADA COM *Spodoptera frugiperda*

RESUMO – Aspectos biológicos e capacidade predatória de *Doru luteipes* foram avaliados em função do predatismo de *Spodoptera frugiperda*. O experimento foi conduzido em laboratório com condições de temperatura média de 25 ± 1 °C, umidade relativa de 70 ± 10% e fotoperíodo de 12:12 horas (Luz: Escuro). Para avaliação dos parâmetros biológicos de *D. luteipes* foram fornecidos uma dieta padrão, ovos e lagartas (1°, 2°, 3°, 4º, 5º ou 6º instares) de *S. frugiperda*. O delineamento estatístico foi inteiramente casualizado, com 10 repetições para cada tratamento. As ninfas (1°, 2° e 3° instares) e machos e fêmeas adultos de *D. luteipes* foram individualizados em placas de Petri (9 cm de diâmetro), tendo como alimento padrão (testemunha) dieta artificial. Ninfas de 1º e 3º instares do predador duraram 4,5 e 6,9 dias respectivamente, contudo pereceram. A sobrevivência das ninfas de *D. luteipes* é alta, contudo houve variação consumindo os diferentes instares das lagartas de *S. frugiperda*. Adultos de *D. luteipes* não consumiram lagartas de 4º, 5º e 6º instares da presa. Houve diferença significativa para alimentação de *D. luteipes* com dieta artificial, ovos e lagartas de *S. frugiperda* para os parâmetros número de ovos, pré-oviposição. O maior consumo de machos e fêmeas de *D. luteipes* ocorre quando são alimentados com ovos da presa.

Palavras-chave: Controle biológico. Predador. Lagarta-do-cartucho. Milho.

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INTRODUCION

Spodoptera frugiperda (J.E. Smith, 1797), the fall armyworm, is geographically distributed in the regions of South America to North America (MURÚA et al., 2015), Africa (GOERGEN et al., 2016), Germany and Holland (CABI, 2017), India and Malaysia (SHARANABASAPPA et al., 2018; JAMIL et al., 2021). This noctuid is the key pest in maize crop (MACHADO; LEMOS; MEDEIROS, 2014). Its harm to hosts is affected during their larval stage directly and indirectly in the plant (NUNES et al., 2017), extending through all stages of development of the plant, mainly after the formation of the whorl, where the insects lodges, impairing the effectiveness of synthetic control.

Biological agents play a strategic role in pest control (VAN LENTEREN, 2012). In this context, natural processes for pest insects' regulation should be studied, including biological control with Dermaptera, since these predators are present in several regions of agricultural interest and regulate a range of pest species. Among them, the biological agent *Doru luteipes* (Scudder, 1876) stands out, being one of the most important in the suppression of pests in the maize crop, with potential in be applied to the biological control of the pest in question.

In maize and sorghum plantations, *D. luteipes* has played its natural role in controlling *S. frugiperda*, both controls under field conditions, according to studies conducted by Marucci et al. (2019). In other studies, Reis, Oliveira and Cruz (1988), Cruz, Alvarenga and Figueiredo (1995), Pasini, Parra and Lopes (2007), Pasini et al. (2010) and Araújo et al. (2011) have shown, in the laboratory, the potential of this Dermaptera over the years, preying on pests of agricultural importance of the order Lepidoptera.

According to Souza et al. (2021), who investigated the predation of *D. luteipes* when fed with *S. frugiperda*, the consumption by nymphs of the 5th instar was on average 70 eggs and 43 caterpillars of the newborn prey in 24 hours. It is known that *D. luteipes* is found on maize plants attacking fall armyworm eggs. Therefore, researchers have carried out studies related to the evaluation of its biology, when fed with *S. frugiperda* at different stages of development, and its rate of predation on it, since feeding can directly or indirectly guide the development and behavior of the insect. In this context, it is interesting to know which stages of *S. frugiperda* the predator consumes in greatest quantity, whether as nymphs or adults (male and female). Thus, the objective was to evaluate the biological aspects and the predation capacity of *D. luteipes* when fed with *S. frugiperda*.

MATERIAL AND METHODS

This study was conducted in the Laboratory of Zoology of Invertebrates (LABZOO), Department of Biological Sciences of the Center of Agricultural Sciences of the Federal University of Paraíba - DCB/ CCA/UFPB, Areia – PB, Brazil. The experiment was conducted under laboratory conditions: mean temperature of 25 ± 1 °C, relative humidity of 70 ± 10% and photophase of 12 hours.

The adults and nymphs of *D. luteipes* used in the experiment originated from the rearing at LABZOO/DCB/CCA/UFPB, kept in transparent plastic containers (13 × 20 × 7 cm), having the lid lined with voile, coated with layers of absorbent paper that was moistened daily, with distilled water. In the transparent plastic containers were plastic straws with moistened cotton (5.5 cm high, 0.5 cm diameter) serving as oviposition substrate. The feed of *D. luteipe*s consists of an artificial diet based on cat food (35%), wheat bran (27%), beer yeast (23%), milk powder (14%), nipagin (0.5%) and sorbic acid (0.5%) in containers (5.5 cm in diameter and 0.5 cm in height) and water, replaced every three days (CRUZ, 2009).

The prey *S. frugiperda* was fed with an artificial diet proposed by Poitout and Bues (1974) and modified by Santiago-Alvarez (1977). For evaluating each nymph and adult phase of the predator, the artificial diet, eggs and caterpillar of *S. frugiperda* (1st, 2nd, 3rd, 4th, 5th or 6th instars) were provided, applying the completely randomized design (CRD), with 10 repetitions, containing one nymph or adult. The food was supplied in an amount greater than the daily requirement, as defined in preliminary tests. The change of instars was verified through the exuviae of *D. luteipes*. The evaluated parameters were the duration and survival of the nymphs and adults of Dermaptera. The data for the embryonic and nymphal or adult period parameters were subjected to analysis of variance (Proc GLM; SAS INSTITUTE, 2015) and the treatment means were compared by the Tukey test at 1% probability level.

Biological development

Adults and nymphs of *D. luteipes* were fed with artificial diet, eggs or caterpillar (1st, 2nd or 3rd instars) of *S. frugiperda*. After 24 hours of the emergence *D. luteipes* were separated into couples Each couple was packed individually, in plastic containers according to the aforementioned breeding methodology. In the presence of laying, the eggs and the female inside plastic straw were transferred to Petri dish (9 cm diameter), containing inside an artificial diet, eggs and/or lepidopteran caterpillar and a moistened piece of absorbent paper.

To evaluate the biological parameters of *D. luteipes* the treatments adopted were the artificial diet, eggs or caterpillar (1st, 2nd or 3rd instars) of *S.*

frugiperda. The variables evaluated were the preoviposition period (POP), incubation period (IP), eggs number (EN), laying number (LN), eggs viability (EV), and female and male longevity. To evaluate the period embryonic of *D. luteipes*, a completely randomized design (CRD) was used with five treatments containing 10 repetitions each, using one nymph per repetition.

Predation capacity

Predatory capacity on *S. frugiperda* eggs and caterpillars by *D. luteipes* was evaluated according to the consumption of the phases of egg and caterpillar of 1st, 2nd or 3rd instars of the pest. Each treatment consisted of 10 males and 10 adult females of the *D. luteipes* predator. The statistical design adopted was completely randomized. The experiment consisted of eigth treatments (male and female × four types of food) with 10 repetitions. Data on prey consumption as a function of predator sex were submitted to polynomial regression analysis (Proc REG, SAS INSTITUTE, 2015), and compared by Tukey test at 1% probability.

RESULTS AND DISCUSSION

There was no significant difference when 1st instar nymphs of *D. luteipes* were fed artificial diet, eggs and prey caterpillars. 2nd instar nymphs of *D. luteipes* had longer duration when fed with artificial diet. The duration of the 3rd instar was lower when consuming caterpillars of 3rd and 4th instars of the prey, differentiating it from the artificial diet; however it was analogous when consuming 1st, 2nd and 5th instars, and eggs. Nonetheless, nymphs of the 1st and 3rd instars of the predator attacked and if they fed or not caterpillar of the 6th instar, they died (Table 1). This behavior of nymphs and adults of *D. luteipes* may occur due to the preference for eggs and younger caterpillars because of the prey's body structure, as the cuticle of the caterpillar becomes more rigid as it develops. These differences in the duration of *D. luteipes* nymphs were also found by researchers when they provided an artificial diet and lepidopteran (REIS; OLIVEIRA; CRUZ, 1988; CRUZ; ALVARENGA; FIGUEIREDO, 1995; PASINI; PARRA; LOPES, 2007; PASINI et al. 2010; MARUCCI et al. 2019).

Table 1 also shows the high rates of *D. luteipes* preying on eggs and neonate caterpillar of *S. frugiperda*. Predator survival in caterpillar was 00 to 90% for 1st instar nymphs, 20 to 100% for 2nd instar nymphs and 00 to 100% for 3rd instar nymphs. These variations in the survival of *D. luteipes* probably show a nutritional adequacy when it ingested the hemolymph and/or parts of prey to the nutritional needs of the predator. In addition to food sources, the relative humidity of the containers may have favored the high survival rates of the Dermaptera using straws with moistened cotton as a refuge. In the maize crop, the entomophagous *D. luteipes*, controls *S. frugiperda* species by capturing and consuming eggs and younger caterpillars. Research on predators fed with eggs of *S. frugiperda* has found high viability rates, indicating that they can be a source of food in the laboratory, which was highlighted by Auad et al. (2003), Pasini, Parra and Lopes (2007) and Nunes et al. (2017).

D. luteipes adults do not consume caterpillars of 4th, 5th and 6th ínstar, as they did not attack, leading them to death. Such behavior can be explained because the caterpillars in more advanced stages and harder seed coat hinder its handling during capture (Table 2). The longevity of females was longer when fed with artificial diet, while for males there was no statistical difference in the food provided. It was found that the survival of females and males of *D. luteipes* was 100% for all food sources. This result differs from that found by Reis, Oliveira and Cruz (1988), when adults of *D. luteipes* were fed with eggs and newborn caterpillar of *S. frugiperda* reaching 77.8 and 111.2 days for female and 87.0 and 132.0 days for male respectively.

There was a significant difference in the parameters number of eggs and preoviposition period of *D. luteipes* fed with artificial diet, eggs and caterpillars of *S. frugiperda* (Table 3). The number of *D. luteipes* eggs was higher when fed with the artificial diet and *S. frugiperda* eggs, and lower for 2nd instar caterpillar, but there was no statistical difference when compared to caterpillar of 1st and 3rd instars. There was no significant difference in the laying number, eggs viability and incubation period when the predator was fed with different food sources. The preoviposition period was longer when the predator was fed with artificial diet. Variations in reproductive aspects of females of this species have been noted by Marucci et al. (2019), when *D. luteipes* was fed with an artificial diet containing or not pollen. It was found that *D. luteipes* females oviposited more than once, even when not fertilized. These authors verified the feasibility of using pollen only in the adult stage of *D. luteipes* with greater rate in eggs/female, total number of eggs and percentage of fertile females. Such differences in the reproductive aspects of *D. luteipes* are probably related to the lack of nutrients, such as proteins, necessary in adulthood, which help in the production of eggs, as they are omnivorous predators that in the natural environment need pollen and nectar of plant origin.

Table 1. Mean values ± standard error for the duration period (days) and survival (%) for nymphs of *Doru luteipes* fed with artificial diet, eggs and caterpillars of *Spodoptera frugiperda*.

Food	Duration		
	1st instar	2nd instar*	3rd instar**
Artificial diet	5.9 ± 0.6 a	17.7 ± 2.5 a	14.4 ± 3.1 a
Spodoptera frugiperda eggs	3.8 ± 0.4 a	4.9 ± 1.1 b	9.4 ± 2.1 ab
1st instar caterpillar of *S. frugiperda*	2.3 ± 0.7 a	7.1 ± 0.3 b	10.5 ± 0.5 ab
2nd instar caterpillar of *S. frugiperda*	3.9 ± 1.2 a	7.5 ± 1.6 b	11.6 ± 1.0 ab
3rd instar caterpillar of *S. frugiperda*	3.4 ± 1.1 a	5.8 ± 1.7 b	5.0 ± 2.7 b
4th instar caterpillar of *S. frugiperda*	3.2 ± 0.4 a	5.3 ± 1.1 b	5.6 ± 2.6 b
5th instar caterpillar of *S. frugiperda*	4.7 ± 0.7 a	6.6 ± 1.1 b	8.2 ± 2.3 ab
6th instar caterpillar of *S. frugiperda*	4.5 ± 0.5 a	4.9 ± 1.4 b	6.9 ± 3.7 b
CV (%)		31.81	
	Survival		
	1st instar	2nd instar*	3rd instar**
Artificial diet	100.0	100.0	100.0
Spodoptera frugiperda eggs	100.0	80.0	100.0
1st instar caterpillar of *S. frugiperda*	80.0	100.0	100.0
2nd instar caterpillar of *S. frugiperda*	60.0	100.0	100.0
3rd instar caterpillar of *S. frugiperda*	50.0	30.0	20.0
4th instar caterpillar of *S. frugiperda*	80.0	80.0	10.0
5th instar caterpillar of *S. frugiperda*	90.0	80.0	20.0
6th instar caterpillar of *S. frugiperda*	00.0	20.0	00.0

Means followed by the same lowercase letter in the column do not differ statistically by Tukey test, at 1% probability level. *Nymphs of *D. luteipes* of 1st instar fed with artificial diet; **Nymphs of *D. luteipes* 1st and 2nd instars fed with artificial diet.

Table 2. Mean values ± standard error for the female and male longevity (days) and survival (%) of *Doru luteipes* fed with artificial diet, eggs and caterpillars of *Spodoptera frugiperda*.

Food	Longevity		Survival	
	Female*	Male*	Female*	Male*
Artificial diet	58.3 ± 4.2 a	58.3 ± 0.4 a	100.0	100.0
Spodoptera frugiperda eggs	45.0 ± 1.2 b	44.5 ± 0.4 a	100.0	100.0
1st instar caterpillar of *S. frugiperda*	44.8 ± 0.4 b	44.5 ± 0.0 a	100.0	100.0
2nd instar caterpillar of *S. frugiperda*	45.1 ± 0.7 b	46.0 ± 0.0 a	100.0	100.0
3rd instar caterpillar of *S. frugiperda*	41.9 ± 6.3 b	39.5 ± 0.0 a	100.0	100.0
CV (%)	7.36	12.74		

Means followed by the same letter in the column do not differ statistically by Tukey test, at 1% probability level. *Nymphs of *D. luteipes* of 1st, 2nd, 3rd and 4th instars fed with artificial diet.

Table 3. Mean values ± standard error for the eggs number (EN), laying number (LN), eggs viability (EV), preoviposition period (POP), and incubation period (IP) of females of *Doru luteipes* fed with artificial diet, eggs and caterpillars of *Spodoptera frugiperda*.

Food	*Doru luteipes**				
	EN	LN	EV (%)	POP (days)	IP (days)
Artificial diet	22.1 ± 3.0 a	1.2 ± 0.4 a	71.7 ± 36.2 a	32.4 ± 2.6 a	8.0 ± 0.0 a
Spodoptera frugiperda eggs	20.3 ± 3.0 a	1.1 ± 0.4 a	36.6 ± 45.2 a	24.3 ± 1.2 b	7.9 ± 0.6 a
1st instar caterpillar of *S. frugiperda*	20.0 ± 0.0 ab	1.0 ± 0.0 a	78.8 ± 36.14 a	24.3 ± 1.5 b	8.0 ± 0.0 a
2nd instar caterpillar of *S. frugiperda*	12.8 ± 6.0 b	1.0 ± 0.0 a	62.5 ± 40.2 a	24.8 ± 0.4 b	7.7 ± 0.8 a
3rd instar caterpillar of *S. frugiperda*	16.9 ± 4.5 ab	1.0 ± 0.0 a	43.4 ± 47.0 a	25.1 ± 0.9 b	7.9 ± 0.9 a
CV%	20.64	26.60	73.16	6.07	7.84

Means followed by the same letter in the column do not differ statistically by Tukey test, at 1% probability level. *Nymphs of *D. luteipes* of 1st, 2nd, 3rd and 4th instars fed with artificial diet.

As illustrared in Figure 1, the sources of variation, sex of *D. luteipes* × *S. frugiperda* foods, had significant interaction. The accumulated daily consumption by males and females of *D. luteipes* increased linearly when they fed on eggs and caterpillars of 1st, 2nd and 3rd instars of *S. frugiperda*, although there was a higher consumption of eggs from the prey.

The male adult of *D. luteipes* had higher daily consumption accumulated for eggs of *S. frugiperda*, making a total consumption of about 1385.1 eggs, which resulted in 30.78 eggs per day (Figure 1A). For caterpillars: *D. luteipes* consumed 1st instar caterpillar (Figure 1C), on average, 272.6 individuals; in relation to 2nd instar caterpillar, the males consumed a total of 189.9 individuals (Figure 1E) and, finally, the predator consumed 73.4 3rd instar caterpillars (Figure 1G) of *S. frugiperda*. Similarly, this occurred with the accumulated daily consumption of *S. frugiperda* eggs and caterpillar by female adults of *D. luteipes*.

When the food provided was eggs of *S. frugiperda* (Figure 1B), *D. luteipes* females consumed 1382.3 eggs, resulting in 30.71 eggs per day. The consumption of 1st instar caterpillar (Figure 1D) was an average of 271.6 individuals. The ingestion of 2nd instar caterpillar by adult females of *D. luteipes* was on average 189.3 prey (Figure 1F). The predation of adult females on 3rd instar caterpillar of *S. frugiperda* was on average 72.8 insects (Figure 1H). This result was similar to those found by Tavares et al. (2011) and Nunes et al. (2017), when lacewing species were fed eggs and newborn caterpillar of *S. frugiperda*, showing an increased consumption by 1st instar caterpillar according to the development of predatory caterpillar.

This predatory behavior observed in females and males of *D. luteipes* on eggs and caterpillar of 1st instar highlights its importance as a natural regulator of *S. frugiperda* in the maize crop, as this predator demonstrated its potential with high voracity under laboratory conditions. Nonetheless, the reduction in the consumption of females and males of *D. luteipes* of more developed caterpillars (2nd and 3rd prey instars) is explained by the size and mobility of the prey, making it difficult to capture and predate this prey. Research on *D. luteipes* fed with Lepidopteran has reported it as promising in the control of pests of economic importance, that is, a key predator, a fact highlighted by Reis, Oliveira and Cruz (1988), Cruz, Alvarenga and Figueiredo (1995), Araújo et al. (2011) and Souza et al. (2021). In this research, preliminary tests confirmed that female and male adults of *D. luteipes* do not consume caterpillar of 4th, 5th and 6th instars of *S. frugiperda*.

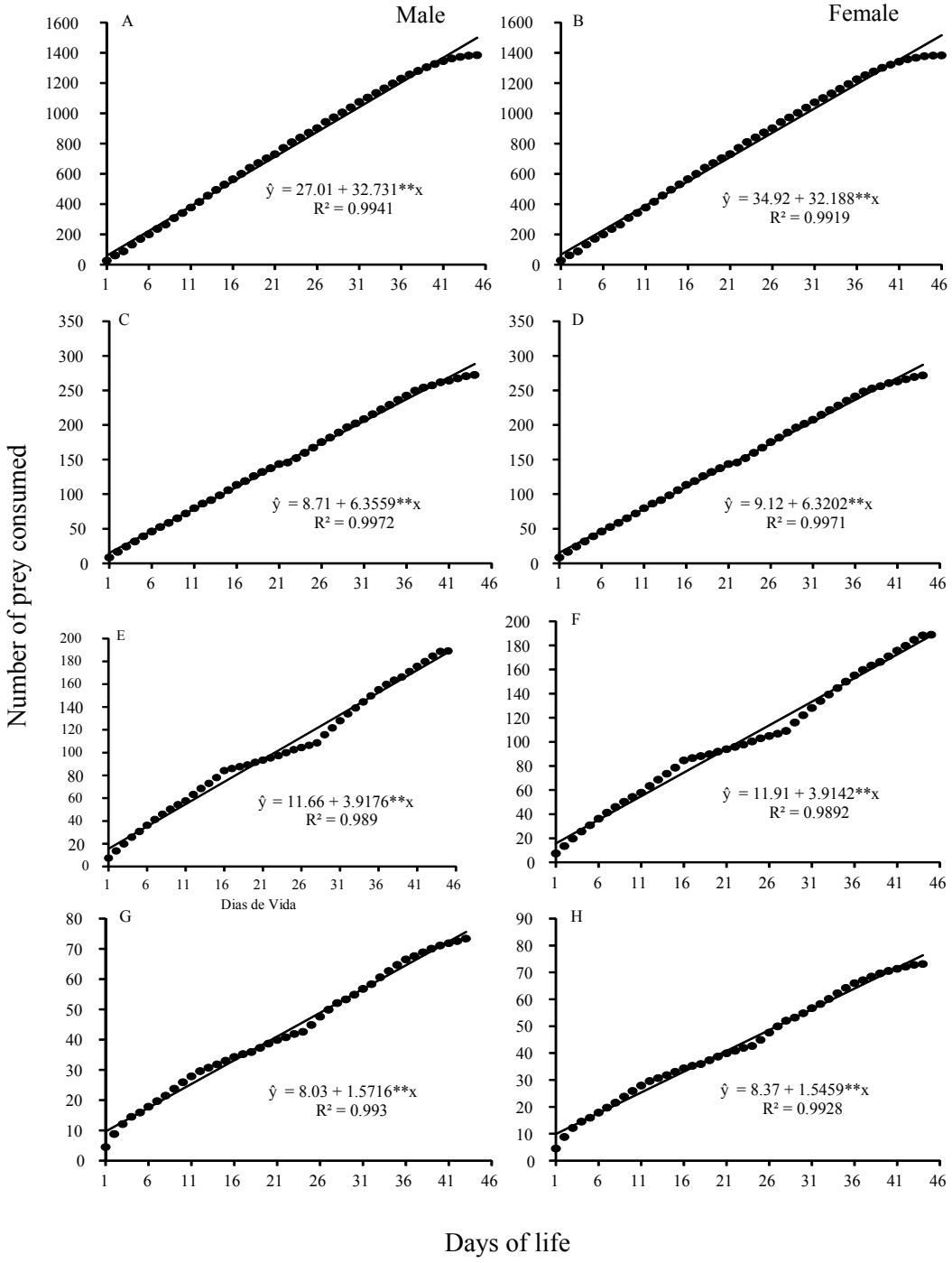

Figure 1. Regression curves fitted for the average number of eggs of *Spodoptera frugiperda* (A and B), caterpillars of 1st (C and D), 2nd (E and F) and 3rd (G and H) instars consumed by adults (male and female) of *Doru luteipes*. *Nymphs of *D. luteipes* of 1st, 2nd, 3rd and 4th instars fed with artificial diet.

CONCLUSIONS

Nymphs of 1st and 3rd instars of *D. luteipes* do not consume caterpillar of 6th instar and adults do not feed on caterpillar of 4th, 5th and 6th instars of *S. frugiperda*.

Nymphs and adults of *D. luteipes* have high survival when fed with eggs, and caterpillar of 1st, 2nd and 3rd instars of *S. frugiperda*.

Males and females of *D. luteipes* consume more eggs than newborn caterpillars of *S. frugiperda*.

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