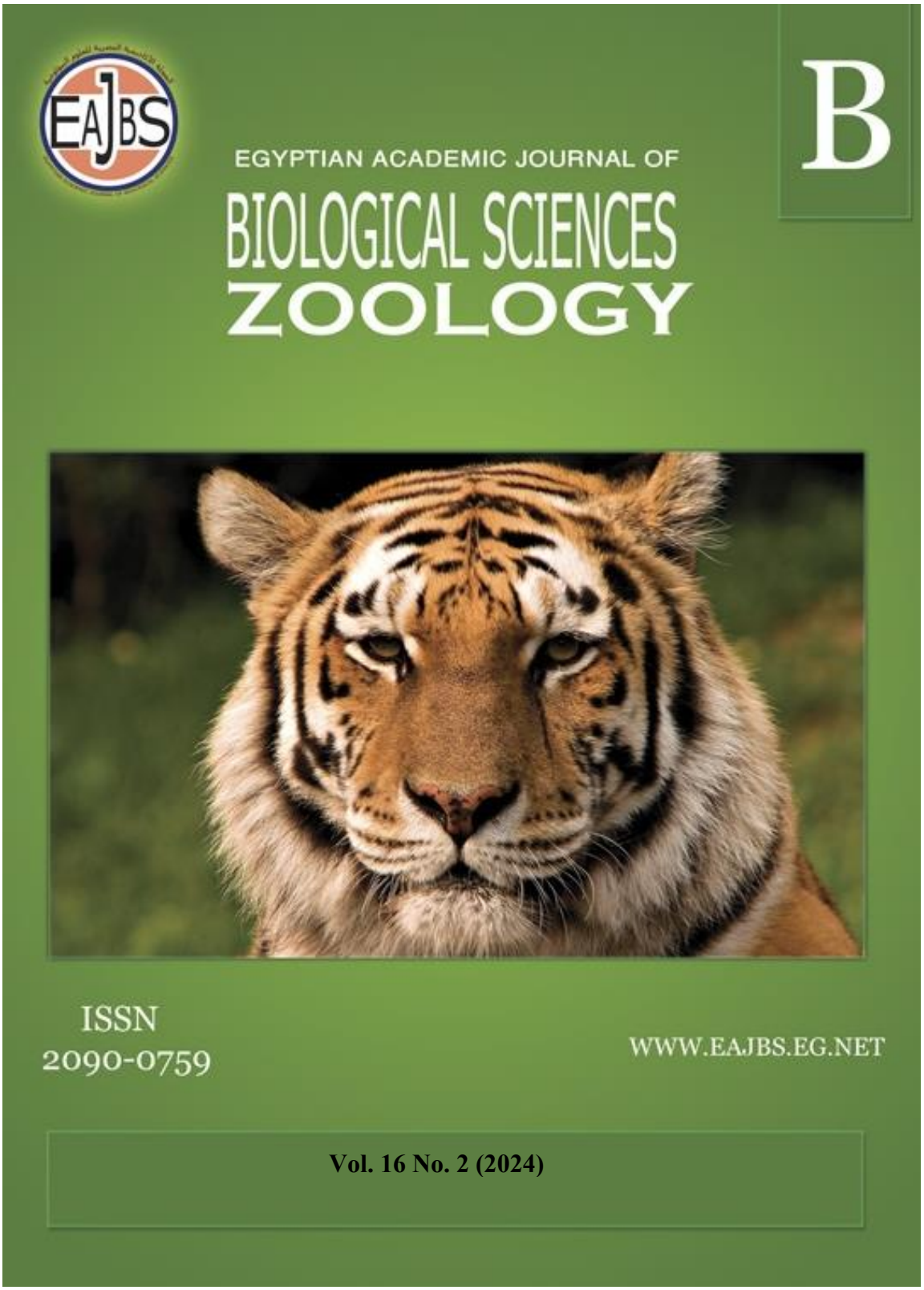

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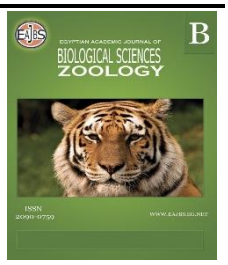

Notes on the Biological Studies of *Filistata insidiatrix* (Forskål, 1775) (Araneae: Filistatidae) As A Predator of Insect Pests

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Abstract

Spiders represent one of the most important natural predatory species, they are completely dependent on predation as a trophic strategy, seizing only live animals. In natural and semi-natural agro-ecosystems, spiders play an important role in pest control. Where they feed on some types of pests and reduce their density. *Filistata insidiatrix* habitats in evergreen, hard-leaved shrubs, tree trunks, under stones, and low woods, it builds irregular webs with retreat tubes.

This study was conducted to rear *F. insidiatrix* as arthropod predators of different prey species, i.e. *Drosophila melanogaster*, Egyptian cotton leaf worm *Spodopetra littoralis* and greater wax moth or honeycomb moth *Galleria mellonella.*

F. insidiatrix was reared in the laboratory under at room temperature to study the biology and feeding potential. After the egg sac incubation period, males reached maturity after five spiderling instars (172.4 ± 1.82 days), and females after seven spiderling instars (251.3 ± 2.54 days) before reaching adulthood. Thirty-three spiderlings were reared individually (each one alone), and twenty-five spiderlings were reared together (communal rearing).

F. insidiatrix showed promising activities against the Egyptian cotton leafworm *S. littoralis*, and greater wax moth or honeycomb moth *G. mellonella*. Further investigations are still needed to evaluate their efficacy under greenhouse and open-field experiments.

INTRODUCTION

The current direction in agriculture is focused on minimizing the usage of pesticides and promoting environmental preservation and sustainable progress. The increased and more intense use of chemical insecticides is the primary reason behind the emergence of resistance and resurgence in insect pest populations, posing a threat to human health and the environment. So, it is essential to focus on developing environmentally friendly and sustainable approaches to pest management. These approaches involve utilizing parasitoids, predators, and biopesticides. This approach has led to growing attention **on** the study of spiders as potential agents for biological control.

Spiders constitute a large part of the predatory in the ecosystem. They are considered

the generalist predators that constitute one of the most numerous groups of the Animal Kingdom. Taxonomists have identified over 52000 species of spiders, all of which are carnivorous predators. These species belong to about 4400 genera and 134 families (World Spider Catalog, 2024).

Spiders rely entirely on predation as their trophic strategy, capturing only live animals that catch their attention with their movements. Spiders exhibit a wide range of predation behaviors, with some specializing in constructing snares like web spiders, while others actively hunt their prey, such as ground spiders or jumping spiders. In certain agro-ecosystems, spiders serve a crucial function in pest management by consuming significant pest species that harm agricultural crops and decreasing the density of insect pests (Sunderland, 1999).

Filistata insidiatrix is a nocturnal spider and is most active at night. It is a semi-social, wherein they initially live together in a group, but eventually disperse and establish individual nests. It is common to find clusters of their nests.

Filistata insidiatrix has a wide distribution and it's known from the Mediterranean to Turkmenistan. Introduced to the Azores, Cape Verde, Angola, Yemen (Socotra), and Venezuela (World Spider Catalog 2024), and its distribution in Egypt is from Alexandria, Assiut, Cairo, El-Giza, El-Menoufyia, Lower Egypt, Sadat City, Sinai, and Siwa Oasis (El-Hennawy, 2017).

The Family *Filistatidae* Ausserer, 1867, includes 191 species, within 18 genera (World Spider Catalog, 2024). Genus *Filistata* Latreille, 1810, is the fifth big genus, in the number of species of family *Filistatidae*. It includes14 species from the World (World Spider Catalog 2024), mainly in tropical and subtropical regions; *Filistata insidiatrix* is the only species of its genus in Egypt (El-Hennawy, 2017; World Spider Catalog, 2024).

MATERIALS AND METHODS

Spider Cultures:

For culturing spiders, several adult and immature males, and females of *F. insidiatrix* were collected by hand from El-Khatatba, Sadat District, Menoufiya Governorate, Egypt. 30°21'12.0"N 30°49'20.8"E (Fig. 1). It was found in tree trunks at mango orchard (Figs. 2-3) and in the malformed mango panicles for last season (Fig. 4) during April and June 2021. Also, adult and immature females were found at El-Khalil Farm Cairo - Alexandria desert road, Sadat District, Menoufiya Governorate, Egypt. 30°16'32.5"N 30°39'15.3"E (Fig. 1) on a wall in June 2021 (Fig. 5).

Fig. 1: Map of the two localities visited during this study (Shorthouse, 2010).

Fig. 2: Mango orchard in El-Khatatba, habitat of *F. insidiatrix*.

Fig. 3: *F. insidiatrix* nests in a mango tree trunk.

Fig. 4: *F. insidiatrix* nest in the malformed mango panicles for last season.

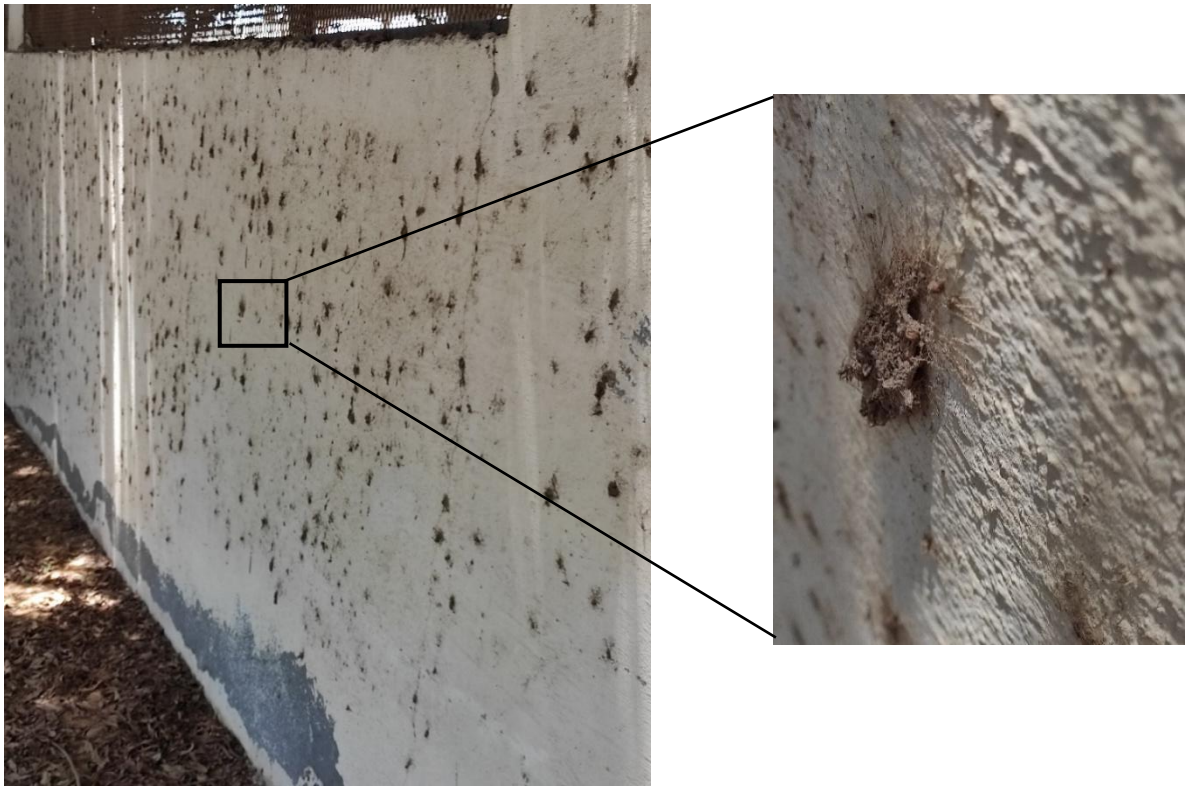


Fig. 5: *F. insidiatrix* nests on a wall at El-Khalil Farm.

Fig. 6. Female of *F. insidiatrix* in her nest beside her egg sacs.

Seven females were collected (red arrow), two of them with an egg sac (blue arrow) **(**Fig. 6**),** four sub-adult females and three males from El-Khatatba, and one female, six sub-adult females from El-Khalil Farm.

The females were kept in plastic vials of 7 cm diameter x 12 cm height and covered

with a piece of muslin. The females were supplied with prey and kept in the laboratory at room temperature until the eggs hatching.

The spiders were daily fed with a known number of different kinds of prey, i.e., fruit fly *Drosophila melanogaster*, larvae of the greater wax moth or honeycomb moth *G. mellonella*, Egyptian cotton leaf worms *S. littoralis* and cutworm *Agrotis ipsilon*

The time taken for the eggs to hatch, the number of eggs that hatched in each egg sac and feeding potential were recorded.

Fig. 7: Female of *F. insidiatrix* with her egg sac (in laboratory).

RESULTS

Egg Sac and Incubation Period:

The female of *Filistata insidiatrix* lays an egg sac that is lenticular, flat, yellowish, containing about 40-70 eggs (Fig. 7). The eggs inside the egg sac are spherical and white at the beginning and become dark before hatching. The incubation period of eggs lasted for 29 days inside the egg sac. Fifty-eight individuals hatched and emerged from the egg sac. All spiderlings were divided into two groups, first one spiderlings were separated and reared individually, while the second group of spiderlings were reared together.

Using a fine camel-hair brush, thirty-three newly hatched spiderlings were transferred and reared individually in plastic vials of 3 cm diameter x 6 cm height, each spiderling alone, under the same conditions for individual rearing. On the other side, we put 25 newly hatched spiderlings together, to test the social living of this species and food preferences.

In individual rearing, each spiderling was daily fed with a known number of 1^{st}-3^{rd} instars of larvae of the Egyptian cotton leafworm *S. littoralis* as prey for the first to fourth spiderlings. From 5^{th} spiderlings to all immature spiderlings, they were fed on different stages of *S. littoralis*. All adult male and female spiders were supplied with a mixture of the larvae and adults of *S. littoralis*. The attempt to breed *Filistata insidiatrix* using the cutworm

Agrotis ipsilon was unsuccessful, resulting in the death of all individuals who consumed this worm.

In group rearing, twenty-five spiderlings were reared together and daily fed with a known number of different kinds of prey, i.e., fruit fly *Drosophila melanogaster*, larvae of the greater wax moth or honeycomb moth *G. mellonella* and the Egyptian cotton leaf worms *S. littoralis* and reared up to the adult stage in glass cage (40 cm length x 20 cm width x 35 cm height) and covered with a piece of muslin (Fig. 8).

The study of group rearing showed the ability of individuals to live together in a group and cooperate in hunting prey (Figs. 9-10) until the fourth spiderlings, then the individuals disperse and establish individual nests.

Fig. 8. Second instar spiderlings of *F. insidiatrix* in a group rearing with their mother.

Fig. 9: 1st instar spiderlings of *F. insidiatrix* feeding and cooperating in catching *D. melanogaster* prey.

Fig. 10: Group feeding and cooperation in catching prey by *F. insidiatrix* spiderlings.

The Life Cycle:

The life cycle of *F. insidiatrix* lasted (280.3 ±2.22) and (201.4 ±1.51) days for females and males respectively. The longest duration was the 5th instar with values (50.55 ±2.16) and (55.29 ±2.36) days for females and males respectively. The shortest instar was the first instar with values (22.45 ±1.51) and (21.14 ±1.29) days for both females and males respectively, when fed on the larval stage of the cotton leaf worm, *S. littoralis* (Table 1).

Lifespan:

The lifespan differs according to sex. Generally, adult females of *F. insidiatrix* lived longer than males when both sexes fed on the different stages of *S. littorales* recording 372.4±5.6 days for females and 241.9±6.7 days for males (Table 1).

Sex Ratio:

After hatching, the 58 spiderlings were reared, 14 individuals died before reaching the adult stage, and 36 individuals reached the adult stage. The 36 adults were 14 males (38.9%) and 22 females (61.1%). The spiderlings passed through 5 instars for males and 7 instars for females during their development (Table 1). The total period of spiderlings development differed according to sex which was shorter for males (172.4±1.82) than females (251.3±2.54).

Adult males and females were transferred to petri plates (10 cm dia.) or plastic vials (7 cm diameter x 12 cm height) to observe their mating behavior.

Table 1. Duration of the different developmental stages of *Filistata insidiatrix*.

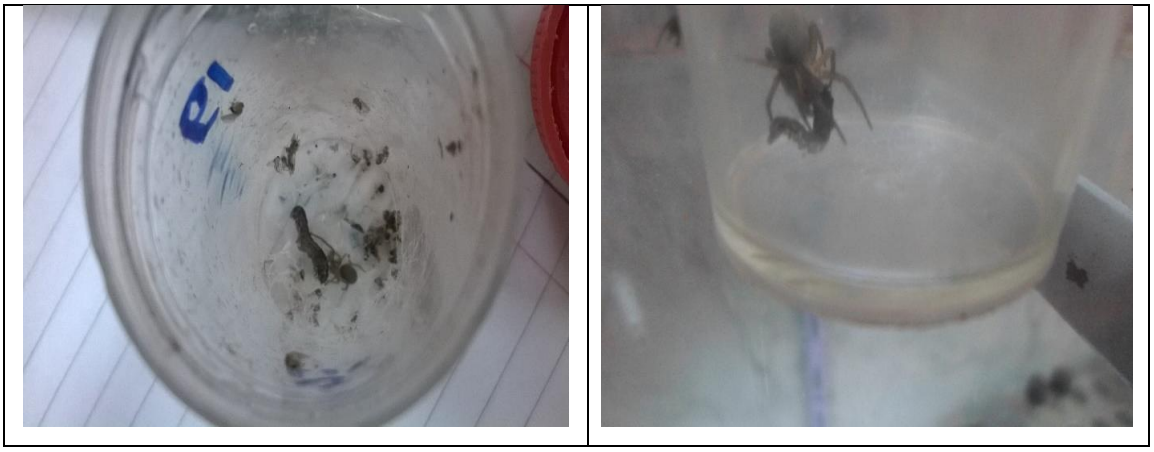
Developmental Stage	Female				Male			
	Min.	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**
Incubation period of eggs	**--**	**--**	**29**	**--**	**--**	**--**	**29**	**--**
1st spiderling instar	21	25	**22.45**	1.51	21	24	**21.14**	1.29
2nd spiderling instar	25	31	27.91	2.07	25	29	27.14	2.04
3rd spiderling instar	43	54	48.91	3.94	44	50	46.86	3.02
4th spiderling instar	21	28	23.09	2.34	21	22	22.00	0.38
5th spiderling instar	48	53	**50.55**	2.16	53	59	**55.29**	2.36
6th spiderling instar	38	46	40.91	3.24				
7th spiderling instar	35	40	37.50	2.52				
Total spiderling duration	231	277	251.3	2.54	164	184	172.4	1.82
Life cycle	260.0	306.0	280.3	2.22	193.0	213.0	201.4	1.51
Longevity	85	97	92.1	3.3	34	49	40.4	5.2
Life span	345	403	372.4	5.6	227	262	241.9	6.7

Food Consumption of *Filistata insidiatrix* Reared in The Laboratory:

During the study of food consumption of *F. insidiatrix*, different spiderling instars and adults were daily fed with a known number of 1st-3rd instars of larvae of the Egyptian cotton leafworm *S. littoralis* as prey for the first to fourth spiderlings. From 5th spiderlings to all immature spiderlings, they were fed on different stages of *S. littoralis*. All adult male and female spiders were supplied with a mixture of the larvae and adults of *S. littoralis* (Figs. 11 -13). A number of consumed prey species by different spiderling instars is shown in (Table 2).

Table 2. Food consumption of *Filistata insidiatrix* fed on cotton leaf worm *S. littoralis.*

Developmental Stage	Prey	Male				Female			
		Min.	Max.	Mean	S.D	Min.	Max.	Mean	S.D
1st Instar	**1st – 3rd instar larvae of *S. littoralis***	25	29	27	2.83	30	38	34	5.66
2nd Instar		37	39	38	1.41	47	52	49.5	3.54
3rd Instar		113	120	116.5	4.95	130	141	135.5	7.78
4th Instar		76	79	77.5	2.12	85	92	88.5	4.95
5th Instar	**larvae and adults of *S. littoralis***	83	88	85.5	3.54	92	97	94.5	3.54
6th Instar		--	--	--	--	68	72	70	2.83
7th Instar		--	--	--	--	63	70	66.5	4.95
Total		334	355	344.5	14.85	515	562	538.5	33.234



Figs. 11-12: *F. insidiatrix* feeding on larvae of the Egyptian cotton leaf worm *S. littoralis.*

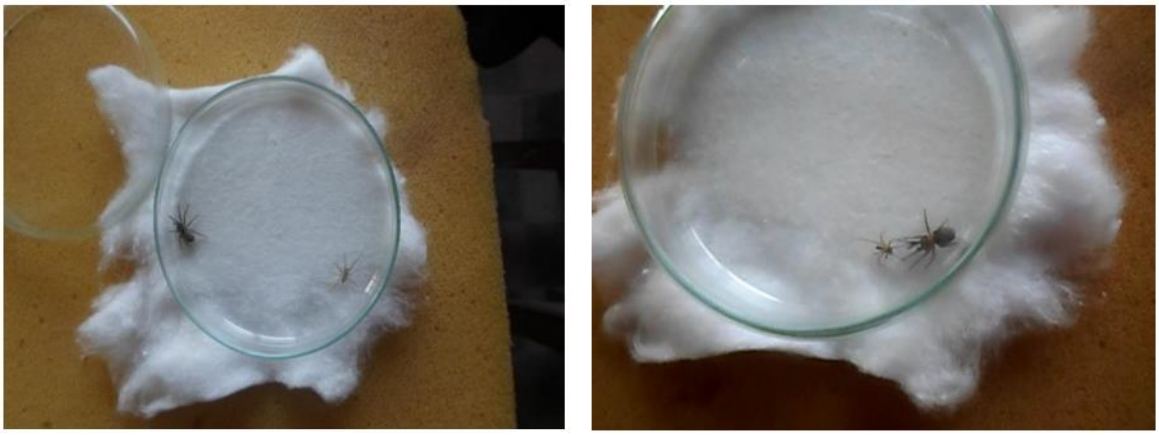
Fig. 13. *F. insidiatrix* feeding on adult (moth) of the Egyptian cotton leaf worm *S. littoralis.*

Mating:

Copulations of the *F. insidiatrix* were observed three times in May, August, and December 2022. Observations were conducted for approximately an hour each. In this species, females are larger than males, and the males display a cautious approach when interacting with females to avoid being mistaken for prey. As a result, male spiders have developed a special courtship behavior that precedes mating, which is crucial for them to avoid potential danger (Foelix 2011).

To initiate the observation, the female spider was placed first in a petri dish where she prepared her web. Subsequently, the male was introduced into the same petri dish (Figs. 14–15). During this stage, both the female and the male remained motionless for several minutes. As courtship commenced, the male cautiously moved towards the female, engaging in a careful display involving alternating movements of his front legs and pedipalps. The female responded by reciprocating these movements with her forelegs and palps. This courtship ritual continued until the female acknowledged the male's advances. Upon successful courtship, copulation took place. The male inserted his palpal organ into

the female's genital opening, depositing his sperm in her seminal receptacles. The mating process lasted approximately 40 minutes, after which the male made his escape.



Figs. 14-15: Courtship of a male and female of *F. insidiatrix* in the laboratory.

DISCUSSION

The fitness and feeding capacity of a predator are of utmost importance in the predator-prey interaction, and numerous factors can influence this relationship. These factors include prey size and density (Kalinoski and DeLong 2016), climatic conditions (Tazerouni *et al.* 2016), and ecosystem complexity (Barbosa *et al.* 2019).

During the group rearing of the spider species *Filistata insidiatrix*, its feeding behavior was examined using a diverse range of hosts, including *Drosophila melanogaster*, Egyptian cotton leafworm *Spodoptera littoralis*, greater wax moth or honeycomb moth *Galleria mellonella*, and Egyptian locust *Anacridium aegyptium*, to determine its food preference. However, to specifically evaluate the food consumption of *Filistata insidiatrix*, individual rearing was conducted using only one type of prey, the Egyptian cotton leafworm *S. littoralis*. This particular prey was selected based on the spider's demonstrated food preference during social rearing. In the present study, the spider *F. insidiatrix* has emerged as a promising biocontrol agent against *S. littoralis*, a major insect pest. Being a polyphagous predator, *F. insidiatrix* consumes various insect pests, making it a potential solution for pest management. Understanding the growth, development, and feeding habits of this predator can help assess its effectiveness against different insect pests.As the spiderling instars progressed, there was an increase in the number of larvae killed by *F. insidiatrix*. However, when attempting to study the biology and prey preference of *F. insidiatrix* on the cutworm *Agrotis ipsilon*, all individuals who consumed this worm died**.**

To utilize *F. insidiatrix* effectively in controlling the Egyptian cotton leafworm *S. littoralis*, it is essential to evaluate its performance under field conditions. This requires large-scale release and continuous monitoring of both the predator and the pest.

CONCLUSION

This study is the first of its kind to investigate the biology and feeding potential of *F. insidiatrix* on *S. littoralis*, revealing its efficient prey consumption and suggesting its potential use in integrated pest management programs for *S. littoralis*. Nevertheless, further research is needed to explore the predator's behavior under natural conditions and assess its compatibility with other biocontrol agents.

Declarations:

Ethical Approval: Not applicable.

Competing interests: The authors declare no conflict of interest.

Availability of Data and Materials: All datasets analysed and described during the present study are available from the corresponding author upon reasonable request.
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