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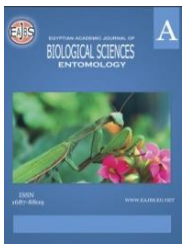

Effect of Temperature and Prey Quality on Aphid-Predator Interrelations in Two Spiders Associated with Aphids on Legumes and Cereal Crops in Egypt

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ABSTRACT

The effect of temperature and prey quality of aphid species life, stage and their basic nutritional components on food consumption, predation rate and duration of development of spiderlings of *Thanatus albini* reared on a monotypic diet of immatures or adult females of each of *Aphis craccivora* and *Rhopalosiphum maidis* were studied at 3 different temperatures of 15, 27 and 35±2˚C and RH of 60-70%. Also, effects of the prey quality of the monotypic diet of each aphid on the tested parameters were studied in spiderlings of *Thomisus spinifer* and on reproduction in adult females of both spider species at 27˚C.

Of the three tested temperatures, 27˚C was considered as the optimum temperature for aphid consumption and predation rate of spiderlings of *Th. albini* when fed on each of the two aphid species, due to increasing the two parameters and prolonging spiderling durations. Also, life, development of spiderlings and female reproduction of each of *Th. albini* and *T. spinifer* were maintained and completed at the optimum temperature of 27 by feeding on immatures or adult female aphids (except the first three spiderlings) of each of *A. craccivora* and *R. maidis* in *Th. albini* and only of *R. maidis* in *T. spinifer*.

The two spider species showed efficacy as predators, consuming higher numbers of immatures than adults of each of the two aphid species with more consumption of *A. craccivora* than *R. maidis* in *Th. albini* and only of *R. maidis* in *T. spinifer* with the refusal of feeding on *A. craccivora*. The number of consumed aphids by each spider species was increased by increasing the age of the spiderling stage.

Quantitative analysis of the basic nutritional components showed a higher concentration of total protein and carbohydrate in adult females than immatures of each aphid species but no significant difference between each of the immatures and adult females of the two aphid species. The significance of the obtained results was discussed.

INTRODUCTION

Aphids are a group of the most injurious insect pests of legumes and cereals in Egypt

(Ismail *et al.,* 1993 and Ali *et al.,* 2013), sucking the plant nutrients, exuding the harmful honeydew and transmitting diseases to the plant crop leading to a reduction of its yield (El-Defrawi *et al.*,2000; Ali,2004 and Swaminathan *et al.,* 2016). Spiders have been considered as potential polyphagous predators which can be used as biological control agents suppressing and regulating (Riechert, 1974; Mansour and Heiewbach, 1993; El-Naggar *et al.,*1999) population of insects and other agricultural pests by feeding as long-lived robust adults and immatures (Agnew and Smith, 1989) on all life stages of the prey (Nyffeler *et al.,* 1994 and Ibrahim *et al.,* 2012).

In Egypt, studies concerning spiders as possible biocontrol agents of aphids, other insects and arthropods (EL- Naggar *et al.,* 1997, 1999; Abo-Zaed, 2008 and Abo-zaed *et al.,* 2018) still need further investigations to provide more information and knowledge which assist a proper selection of spider species that could be used as bio-control agents of aphids on host plants. Ibraheem (2021) recorded 26 spider species belonging to 20 genera and 10 families, associated with the cowpea aphid, *Aphis craccivora* and the corn leaf aphid, *Rhopalosiphum maidis* on the broad bean and maize crop, respectively in Qaha research station, Qalubyia governorate, Egypt in two successive years, 2017 and 2018.*Thanatus albini* (Audouin) (Philiodromidae) was recorded as the most abundant aphidophagous common spider species associated with the two aphid species while *Thomisus spinifer* (Cambridge) (Thomisidae) was one of the most abundant specific spider species only associated with *Rhopalsiphum maidis* on maize crop in the studied site.

In the present study, *Th. albini* and *Th. spinifer* were selected to investigate the effect of temperature (15, 27, 35 ˚**C**) and prey quality of the monotypic diet of the two aphid species *A. craccivora* and *R. maidis*, life stages and of their basic nutritional components on food consumption, predation rate and development of spiderlings. Also, effects of the monotypic diet of aphids on the reproduction of the adult female of the two spiders were tested.

The present study aims to offer basic knowledge on the effects of some physical, biological and biochemical factors on the tested parameters which are required for further understanding and in the assessment of the aphid-predator interrelationships of *A. craccivora, R. maidis* and naturally associated spiders.

MATERIALS AND METHODS

Biological Studies:

a.Aphid Colonies:

Adults of, *Aphis craccivora* and *Rhopalosiphum maidis* were used to establish the laboratory colonies as described by Abo-zaed, (2008). The cowpea aphids and corn leaf aphids were obtained from broad bean and maize crops at Qaha research station, Qalubyia governorate. The two colonies on two selected host plants (broad bean and maize) were established and maintained at 25 ±2˚C and 69±10 % RH.

b.Spider Colonies:

Laboratory colonies of *Thanatus albini* and *Thomisus spinifer* were established according to (El- Erksousy and fawzy, 2001).

c.Determination of the Predation Rate of Immatures and Adult Female Spiders on Adult and Immatures *Aphis craccivora* and *Rhopalosiphum maidis*:

Egg-sacs of *Th. albini* were kept in the laboratory at 15, 27, 35± 2˚C & 60 – 70% RH till spiderlings hatched. The progeny of 10 newly hatched spiderlings of female *Th. albini* were separated individually in suitable glass tubes and fed as a group of the same age with immatures of *A. craccivora* or *R. maidis* and groups were maintained at the 2 temperatures 27 ± 2˚C, 35± 2˚C because no hatching occurred at 15 ˚C. The newly hatched

spiderlings of *T. spinifer* were kept only at 27 ˚C and fed on the immatures of only *R. maidis* because it refused to feed on *A. craccivora* even after starvation of 2 weeks. The first spiderlings were provided daily with 6 preys immatures of *A. craccivora* or *R. maidis*. The number of preys was increased to 10 at the second spiderling then gradually increased according to the stage of spiderling to reach 17 daily at the end of the experiment. At each temperature 27, 35 ˚C, three groups of spiderling stages 4-7 of each species were provided by adult aphids. The number of preys consumed by spiders was determined.

Biochemical Studies:

Biochemical studies of adult females and immatures of *Aphis craccivora* and *Rhopalosiphum maidis* were carried out by quantitative analysis of total carbohydrates, proteins and lipids. The concentration of total carbohydrates, proteins and lipids were determined by the method of Dubois *et al*. (1956), Bradford (1976) and Knight *et al.* (1972), respectively.

Statistical Analysis:

The data of the experiments of the biological and biochemical studies of spiders and aphids were subjected to analysis of variance (ANOVA) and the means were compared by L.S.D. test at 0.05 level, using SAS program.

RESULTS

Thanatus albini (Philodromidae) and *Thomisus spinifer* (Thomisidae) represent two of the most abundant spider families, common and specific species associated with the two aphids, *A. craccivora* and *R. maidis* and only with *R. maidis*, respectively on their host plants at Qaha research station, Qalubyia governorate Egypt for two successive years (Ibraheem, 2021).

1.Effect of Temperature and Prey Quality on Duration, Food Consumption and Predation Rate of Spiderlings of *Th. Albini* Fed on Immatures and Adult Females of *A. craccivora* and *R. maidis* :

The effect of the three different temperatures of 15, 27, 35 ˚C and prey quality of aphid species and life stages varied in spiderlings of *Th. albini.* At 15˚C, no spiderlings were hatched from the egg sacs and the whole life cycle was arrested.

At 27˚C, The duration of the first to the seventh spiderling of *Th. albini* varied and was the shortest ($p<0.05$) in the first and second spiderling when fed on *A. craccivora* (Table, 1)and in the first spiderling when fed on *R. maidis* (Table, 3) in comparison to other spiderlings. The spiderling duration of the stages was gradually increased by increasing the age of spiderling to reach the longest duration in the last spiderling ($p<0.05$). Duration of each spiderling stage was slightly longer ($p<0.05$) when fed on immatures than on adult females of aphids and on *A. craccivora* than *R. maidis.*

Results in table 1 &3, show that the seven immature stages of *Thanatus albini* from the first to the seventh spiderling consumed different numbers of immatures and adult females of each of *A. craccivora* and *R.maidis* during the life period of the tested spiderlings. The number of consumed immatures of *A. craccivora* and *R. maidis* per spider was the least in the first spiderling and gradually increased in the second to the seventh spiderling ($p<0.05$). There was more consumption of immatures than adult females and of *A. craccivora* than *R. maidis* ($p<0.05$) by each of 4-7 spiderlings of *Th. albini* ($p<0.05$). However, there was no consumption of adult aphids by the first three spiderlings but started in the fourth spiderling and gradually increased to reach the highest level ($p<0.05$) of consumption of adult aphids in the seventh spiderling.

The predation rate (no. of preys consumed / spider/ day) was the lowest ($p<0.05$) in the first spiderling of *Th. albini* and gradually increased in the second to the seventh

spiderling when fed on immature *A.craccivora* and was the lowest in the first and second and gradually increased ($p<0.05$) in the third to sixth and seventh spiderlings when fed on *R. maidis* (Table,3). The rate of predation on adult female aphid started in the fourth spiderling and increased gradually till the seventh spiderling mostly with significant difference ($p<0.05$) and with higher predation rates of the corresponding spiderling stages when fed on immatures than adult females ($p<0.05$) of each of *A.craccivora* and *R. maidis*. Generally, the predation rate was higher in the spiderlings ($p<0.05$) when fed on immature *A. craccivora* than on *R. maidis*.

At 35˚C (Table2, 4), The duration of the first to the seventh spiderlings of *Th. albini* varied when fed on each of *A. craccivora* and *R. maidis* . It was the shortest ($p<0.05$) in the first and second spiderlings when fed on *A. craccivora* and the first spiderling when fed on *R. maidis* in comparison to other spiderlings. The duration of each spiderling gradually increased to reach the longest duration ($p<0.05$) in the seventh spiderling when fed on *A. craccivora* and the fifth, sixth and seventh spiderling when fed on *R. maidis*. Generally, the duration of each stage was slightly longer ($p<0.05$) when fed on immature than adult female aphids and noticeably($p<0.05$) in *R. maidis*.

Results in table 2 &4, show that the seven immature stages of *Th. albini* from the first to the seventh spiderling consumed different numbers of immatures and adult females of each of *A. craccivora* and *R. maidis* during the life period of the tested spiderlings. The number of consumed immatures of *A. craccivora* and *R. maidis* per spider was the least in the first spiderling and gradually increased in the second to seventh spiderling ($p<0.05$) with more consumption of immatures than adults in each of the fourth to the seventh spiderling stage and in *A. craccivora* more than *R. maidis* ($p<0.05$).

The predation rate (no. of preys consumed / spider/ day) was the lowest ($p<0.05$) in the first spiderling and gradually increased in the second and third spiderling till the seventh spiderling fed on immature *A.craccivora* and was the lowest in the first and second spiderling when fed on *R. maidis.* However, no predation of the first 3 spiderlings occurred on adult *A.craccivora* and *R. maidis.* The predation rate on adult aphids gradually increased in the fourth till seventh spiderling of *Thanatus albini* mostly with significant difference ($p<0.05$) and with higher predation rates of the corresponding spiderling stages when fed on immatures than on adults of each aphid species and on *A.craccivora* than *R. maidis.*

In a comparison of the 3 parameters at 27 ˚C, 35 ˚C (Table 1-4), It was found that generally all the tested parameters including stage duration, food consumption and to less extent predation rate were decreased ($p<0.05$) by increasing the rearing temperature of spiderling from 27 to 35 ˚C whether the spider *Th. albini* had been fed on immatures or on adult females of *A. craccivora* or *R. maidis.* Also, results showed that the prey quality of aphid species and life stage affected food consumption, predation rate and to less extent duration of spiderlings of *Th. albini* at each temperature. The number of consumed aphids and of predation rate of spiderlings of *Th. albini* were increased when spiderlings were fed on immatures more than adult females of each aphid species and when fed on *A. craccivora* than *R. maidis.*

Table 1: Duration, food consumption and predation rate of spiderling stages of *Thanatus albini* (F: Philodromidae) fed on immatures and adult females of *Aphis craccivora* at 27± 2˚C.

Spider stage	Stage duration in days (fed on *A. craccivora*)		Food consumption (no. of preys consumed)		Predation rate (no. of preys consumed/ day)	
	Immature *A. craccivora*	Adult *A. craccivora*	Immature *A. craccivora*	Adult *A. craccivora*	Immature *A. craccivora*	Adult *A. craccivora*
1st Spiderling	9± 0.475^{a} (8 -10)	–	49.7 ±1.25^{a} (49- 50)	–	5.7±0.3^{a} (5- 6.2)	–
2nd Spiderling	8.2±0.62^{a} (7- 10)	–	71.7±0.25^{b} (71-72)	–	8.7±0.59^{b} (7.2- 10.2)	–
3rd Spiderling	10.5±0.285^{b} (10- 11)	–	89.2±0.25^{c} (89-90)	–	8.4±0.275^{b} (8- 9)	–
4th Spiderling	12.5±0.285^{c} (12- 13)	11±0.405^{a} (10- 12)	120.7±0.475^{d} (120- 122)	14±0.405^{a} (13- 15)	9.6±0.245^{c} (9.2- 10.2)	1.2±0.085^{a} (1- 1.2)
5th Spiderling	12.2±0.475^{c} (11- 13)	12±0.405^{b} (11-13)	145±0.405^{e} (144-146)	23±1.75^{b} (20- 27)	11.8±0.46^{d} (11.1- 13.1)	1.8±0.15^{b} (1.5- 2.2)
6th Spiderling	14.5±0.25^{d} (14-15)	15±0.475^{c} (14- 16)	177±0.285^{f} (176-178)	32±1.2^{c} (30- 35)	12.2±0.215^{d} (11.8- 12.7)	2.1±0.1^{b} (1.8- 2.3)
7th Spiderling	15.7±0.25^{e} (15-16)	15±0.475^{c} (14-16)	224±0.405^{g} (223-225)	48.7±1.25^{d} (45-50)	14.2±0.255^{e} (13.9-15)	3.1±0.085^{c} (2.8-3.2)

The means with the same letters at the same column are not significantly different at 0.05 level.

Table 2: Duration, food consumption and predation rate of spiderling stages of *Thanatus albini* (F: Philodromidae) fed on immatures and adult females of *Aphis craccivora* at 35± 2˚C.

Spider stage	Stage duration in days (fed on *A. craccivora*)		Food consumption (no. of preys consumed)		Predation rate (no. of preys consumed/ day)	
	Immature *A. craccivora*	Adult *A. craccivora*	Immature *A. craccivora*	Adult *A. craccivora*	Immature *A. craccivora*	Adult *A. craccivora*
1st Spiderling	7.7±0.475^{a} (7- 9)	–	41±0.575^{a} (40- 42)	–	5.3±0.39^{a} (4.4- 6)	–
2nd Spiderling	7.5±0.285^{a} (6- 7)	–	58.7±1.4^{b} (55-88)	–	7.8± 0.395^{b} (6.8- 8.7)	–
3rd Spiderling	8.2±0.25^{b} (8-9)	–	66±1.6^{c} (62-70)	–	8±0.30^{b} (7.3-8.7)	–
4th Spiderling	10±0.405^{c} (9-11)	7.2±0.25^{a} (7- 8)	72±0.8^{d} (70-74)	12±0.405^{a} (11-13)	7.2±0.275^{c} (6.7-8)	1.5±0.085^{a} (1.3-1.7)
5th Spiderling	10.2±0.475^{c} (9-11)	10.2±0.25^{b} (10-11)	89±0.575^{e} (88-90)	18±0.405^{b} (17-19)	8.7± 0.47^{d} (8-10)	1.7±0.025^{a} (1.7-1.8)
6th Spiderling	11.5±0.285^{d} (11-12)	12.2±0.405^{c} (12-13)	92.2±1.6e (89-95)	30±1.75^{c} (27-35)	8±0.226^{b} (7.5-8.6)	2.4±0.09^{b} (2.2-2.6)
7th Spiderling	12.5±0.285^{e} (12-13)	12.5±0.475^{c} (12-14)	115±1.75^{f} (112-120)	44±1.15^{d} (42-46)	9.2±0.13^{d} (8.8-9.4)	3.5±0.165^{c} (3-3.8)

The means with the same letters at the same column are not significantly different at the 0.05% level.

Table 3: Duration, food consumption and predation rate of spiderling stages of *Thanatus albini* (F: Philodromidae) fed on immatures and adult females of *Rhopalosiphum maidis* at 27± 2˚C.

Spider stage	Stage duration in days (fed on *R. maidis*)		Food consumption (no. of preys consumed)		Predation rate (no. of preys consumed/ day)	
	Immature *R. maidis*	Adult *R. maidis*	Immature *R. maidis*	Adult *R. maidis*	Immature *R. maidis*	Adult *R. maidis*
1st Spiderling	7.5±0.285^{a} (7-8)	–	34±0.575^{a} (33-35)	—	4.5±0.20^{a} (4.1-5)	–
2nd Spiderling	9.7±0.285^{b} (9-10)	–	43.5±0.7^{b} (42-45)	–	4.4±0.175^{a} (4.2-5)	–
3rd Spiderling	9.2±0.25^{b} (9-10)	–	57.5±1.4^{c} (55-60)	–	6.1±0.135^{b} (6-6.6)	–
4th Spiderling	11±0.405^{c} (10-12)	10±0.405^{a} (9-11)	64±1.2^{d} (62-67)	11±0.405^{a} (10-12)	5.8±0.155^{c} (5.5-6.2)	1.1±0.07^{a} (1-1.3)
5th Spiderling	12±0.405^{d} (11-13)	10.2±0.475^{a} (9-11)	70±1.15^{d} (68-72)	20±0.8^{b} (18-22)	5.8±0.23^{c} (5.5-6.5)	1.9±0.095^{b} (1.8-2.2)
6th Spiderling	12.5±0.5^{d} (11-13)	11.5±0.285^{b} (11-12)	82±0.8^{e} (80-84)	29.2±0.475^{c} (28-30)	6.5±0.29^{d} (6.1-7.4)	2.5±0.085^{c} (2.3-2.7)
7th Spiderling	14.2±0.285^{e} (14-15)	12.7±0.405^{c} (12-14)	94±0.7^{f} (92-95)	38±0.95^{d} (36-40)	6.5±0.095^{d} (6.3-6.7)	2.9±0.16^{c} (2.5-3.3)

The means with the same letters at the same column are not significantly different at 0.05% level.

Table 4: Duration, food consumption and predation rate of spiderling stages of *Thanatus albini* (F: Philodromidae) fed on immatures and adult females of *Rhopalosiphum maidis* at 35± 2˚C**.**

Spider stage	Stage duration in days (fed on *R. maidis*)		Food consumption (no. of preys consumed)		Predation rate (no. of preys consumed/ day)	
	Immature *R. maidis*	Adult *R. maidis*	Immature *R. maidis*	Adult *R. maidis*	Immature *R. maidis*	Adult *R. maidis*
1st Spiderling	6.5±0.28^{a} (6-7)	–	29±0.9^{a} (27-31)	–	4.4±0.275^{a} (3.8-5.1)	–
2nd Spiderling	8.7±0.75^{b} (7-10)	–	36.7±0.75^{b} (35-38)	–	4.2±0.37^{a} (3.5-5.1)	–
3rd Spiderling	9.2±0.47^{b} (8-10)	–	43.2±1.95^{c} (40-48)	–	4.7±0.43^{b} (4-6)	–
4th Spiderling	10.5±0.25^{c} (10-11)	8.7±0.47^{a} (8-10)	52.2±1.03^{d} (50-54)	9.7±0.40^{a} (9-11)	4.7±0.125^{b} (4.5-5.1)	1.02±0.08^{a} (0.8-1.2)
5th Spiderling	11±0.40^{d} (10-12)	9.5±0.28^{b} (9-10)	56.7±1.15^{d} (55-60)	18±1.2^{b} (15-20)	5.17±0.17^{c} (5-5.7)	1.8±0.09^{b} (1.6-2)
6th Spiderling	11.2±0.47^{d} (10-12)	10.7±0.25^{c} (10-11)	62.5±1.4^{e} (60-65)	26.5±0.85^{c} (25-29)	5.5±0.23^{c} (5-6)	2.4±0.11^{c} (2.2-2.9)
7th Spiderling	11.7±0.47^{d} (11-13)	12±0.40^{d} (11-13)	72±0.8^{f} (70-74)	32±0.9^{d} (30-34)	6.1±0.215^{d} (5.5-6.1)	2.6±0.15^{c} (2.3-3)

The means with the same letters at the same column are not significantly different at 0.05% level.

2-Effect of Prey Quality on Duration, Food Consumption and Predation Rate of Spiderlings of *Thomisus spinifer* Fed on Immatures and Adult Females of *Rhopalosiphum maidis* at 27 ˚C.

Thomisus spinifer was reared at 27 ˚C by feeding spiderlings on immatures and adult females of only the aphid *R. maidis* because this spider refused to feed on *A. craccivora* even after 2 weeks of starvation.

Similar to *Th. albini*, the spiderling, duration, food consumption and predation rate of *T. spinifer* were affected by the prey quality of the aphid life stage at 27 ˚C (Table, 5).

The duration of the first to seventh spiderlings of *T. spinifer* varied and was the shortest ($p<0.05$) in the first spiderling in comparison to other spiderlings then increased gradually ($p<0.05$) in the second to reach the longest duration in the sixth and seventh spiderling. Also, the spiderling duration of stages gradually increased from the fourth to

seventh spiderling and was slightly longer ($p<0.05$) when fed on immature than adult female *R. maidis.*

Results in table (5), show that the 7 immature stages of *T. spinifer* from the first to the seventh spiderling consumed different numbers of immatures and adult females *R. maidis* during the life period of the tested spiderlings. However, the first three spiderlings did not feed on adult female *R. maidis*. The number of consumed immatures of *R. maidis* per spider was the least in the first spiderling and gradually increased in the second to seventh spiderling ($p<0.05$) with more consumption of immatures than adults *R. maidis* ($p<0.05$) during the fourth to the seventh spiderlings.

The predation rate (no. of preys consumed / spider/ day) was the lowest ($p<0.05$) in the first and second spiderlings and gradually increased ($p<0.05$) in the third spiderling to remain constant ($p>0.05$) to the seventh spiderling when fed on immature *R. maidis* with more predation rates on immatures than adult females. Also, the predation rates showed no significant difference ($p>0.05$) between spiderlings of the fourth to fifth and of the sixth to seventh spiderlings of *T. spinifer* when fed on adult *R. maidis.*

In a comparison of spiderlings of *T. spinifer* (Table, 5) with spiderlings of *Th. albini* which were fed on *R. maidis* at 27 ˚C (Table, 3), duration of spiderling stages were significantly ($p<0.05$) longer in *T. spinifer* than corresponding stages in *Th. albini*. However, There was no significant difference in the number of food consumption and predation rate of most corresponding spiderlings in the two spider species fed on *R. maidis* ($p>0.05$).

Table 5: Duration, food consumption and predation rate of spiderling stages of *Thomisus spinifer* (F: Thomisidae) fed on immatures and adult females of *Rhopalosiphum maidis* at 27± 2˚C

Spider stage	Stage duration in days (fed on *R. maidis*)		Food consumption (no. of preys consumed)		Predation rate (no. of preys consumed/ day)	
	Immature *R. maidis*	Adult *R. maidis*	Immature *R. maidis*	Adult *R. maidis*	Immature *R. maidis*	Adult *R. maidis*
1st Spiderling	8.5±0.285^{a} (8-9)	–	35.7±0.575^{a} (35-37)	—	4.1±0.20^{a} (3.8-4.6)	–
2nd Spiderling	10.5±0.285^{b} (10-11)	–	47±0.7^{b} (46-49)	–	4.4±0.175^{a} (4.1-4.6)	–
3rd Spiderling	11.2±0.25^{c} (11-12)	–	60.2±1.2^{c} (58-62)	–	5.5±0.135^{b} (5.1-5.7)	–
4th Spiderling	12±0.405^{c} (11-13)	10.7±0.405^{a} (10-12)	68.5±1.2^{d} (66-70)	14.2±0.405^{a} (13-15)	5.6±0.155^{b} (5.3-6)	1.3±0.07^{a} (1.3-1.6)
5th Spiderling	13.2±0.405^{d} (12-14)	13±0.475^{b} (12-14)	77.2±1.15^{e} (75-79)	23.7±0.8^{b} (22-26)	5.8±0.23^{b} (5.5-6.3)	1.8±0.095^{a} (1.8-2.3)
6th Spiderling	16±0.5^{e} (15-17)	15.3±0.285^{c} (15-16)	88.2±0.8^{f} (87-90)	37.2±0.475^{c} (36-38)	5.6±0.29^{b} (5.2.-5.8)	2.4±0.085^{b} (2.3-2.7)
7th Spiderling	16.5±0.285^{e} (16-17)	16.7±0.405^{d} (16-18)	99.7±0.7^{g} (98-101)	44.7±0.95^{d} (43-46)	5.9±0.095^{b} (5.6-6.1)	2.6±0.16^{b} (2.5-3.3)

The means with the same letters at the same column are not significantly different at 0.05% level.

3-Effect of Prey Quality on Reproduction of Female *Thanatus albini* and *Thomisus spinifer* Reared on Immatures of *Aphis craccivora* and *Rhopalosiphum maidis*.

Results presented in table (6) show that rearing of adult females of *Th. albini* on immatures of *A. craccivora* and *R. maidis* had no significant effect ($p>0.05$) on longevity (sum of pre-oviposition, oviposition and post-oviposition periods) and fecundity (mean number of eggs/ female). However, a comparison of the two spider species showed that *T. spinifer* longevity (76.5±1.15 days) and fecundity (175.7 egg/female) were significantly

higher than ($p<0.05$) those (57.9±1.15 days& 64.25 egg/female) of *Th. albini* reared on *R. maidis* at 27 ˚C.

Table 6: Biological aspects of reproduction of adult female *Thanatus albini and Thomisus spinifer* reared on immatures of *Aphis craccivora* and *Rhopalosiphum maidis* at 27± 2˚C.

Biological aspects	*Thanatus albini*		*Thomisus spinifer*
	Aphis craccivora Mean ±SE	*Rhopalosiphum maidis* Mean ±SE	*Rhopalosiphum maidis* Mean ±SE
Incubation period (in days)	11.5± o.285[a] (11-12)	11.75±0.62[a] (10-13)	19±0.62[b] (18-21)
Pre-oviposition (in days)	12.2± 0.6[a] (11-14)	14± 0.25[a] (14-15)	10.3± 0.475[b] (9-11)
Oviposition (in days)	15± 0.475[a] (14-16)	12.2± 0.475[a] (11-13)	26± 0.285[b] (25-26)
Post- oviposition (in days)	33.2± 1.15[a] (30-35)	31.7± 1.3[a] (29-35)	40.2± 1.15[b] (37-41)
Longevity (in days)	60.4±1.2[a]	57.9±1.15[a]	76.5±1.15[b]
Total no. of eggs\ sac	28.2± 1.65[a] (25-32)	25.7± 0.475[a] (25-27)	50.2± 0.475[b] (49-51)
No. of egg sac\ female	2.7± 0.25[a] (2-3)	2.5±0.285[a] (2-3)	3.5±0.285[b] (3-4)

The means with the same letters at the same raw are not significantly different at 0.05% level.

4-Quantitative Analysis of Basic Nutritional Components of Immatures and Adult Females of *Aphis craccivora and Ropalosiphum maidis*

Data presented in table (7) show the concentrations of total proteins, carbohydrates and lipids in the supernatant of homogenated adult females and immatures of *A. craccivora* and *R. maidis.*

Table 7: Total proteins, carbohydrates and lipids of adult females and immatures *Aphis craccivora* and *Rhopalosiphum maidis*.

Biochemical aspects	*Aphis craccivora* (Mean ±SE in mg/g b. wt)		*Rhopalosiphum maidis* (Mean ±SE in mg/g b. wt)	
	Adult	Immature	Adult	Immature
Protein	37.76± 1.42[a] (35.7-40.5)	30.76± 0.87[b] (29.7-32.5)	35.96±1.09[a] (33.8-37.3)	29.5±1.93[b] (27.1-33.4)
Carbohydrates	72.5± 2.03[a] (69.5- 76.4)	58.83± 1.80[b] (55.4-61.5)	67.5±2.13[a] (63.5-70.8)	56.5±2.33[b] (52.5-60.6)
Lipids	15.2±1.56[a] (12.9- 18.2)	10.83±0.77[a] (9.5- 12.2)	13.83±1.27[a] (11.8-16.2)	10.5±0.4[a] (9.8-11.2)

The means with the same letters at the same raw are not significantly different at 0.05% level.

The concentration of each of total proteins and carbohydrates was significantly higher ($p<0.05$) in adult females than immatures of each aphid species and carbohydrates were of the highest recorded level in both life stages in the two aphids. However, no significant difference ($p>0.05$) was found between each of the 3 basic nutritional components in each of the adult females and immatures of the two aphid species.

DISCUSSION

Thanatus albini (Philodromidae) and *Thomisus spinifer* (Thomisidae) were recorded as two of the most important aphidophagous (Swaminthan, 2016) spiders associated with the cowpea aphid, *A. craccivora* and the corn leaf aphid, *Rhopalosiphum maidis* on broad bean and maize crop, respectively, in Egypt (EL-Defrawi et al., 2000; Mannaa, 2000; and Ali et al., 2013). Ibraheem (2021) found that *Th. albini* was the most abundant common spider species collected in association with the two aphid species on broad bean and maize crop, respectively while *T. spinifer* was one of the most abundant specific spider species only associated with *R. maidis* on maize in Qaha station, Qalubyia, Egypt throughout two successive years, 2017 and 2018.

In the present study, *Thanatus albini* was selected to investigate effects of three temperatures (15, 27 and 35± 2 ˚C) and prey quality of aphid species, life stage and their basic nutritional components in monotypic diets of immatures or adult females of each of the two aphid species on food consumption, predation rates and development duration of spiderlings in *Th. albini.* Also, effects of prey quality of the monotypic diet of aphids on the tested parameters were studied in spiderlings of *T. spinifer* and on reproduction of adult females of both spider species.

The temperature has a profound effect on development, food consumption and predation rates of spiderlings of *Thanatus albini* fed on a monotypic diet of immatures or adult females of each of *A. craccivora* and *R. maidis* at the three tested temperatures (15, 27 and 35˚C). At 15˚C, no spiderlings were hatched from egg sacs and the whole life cycle was arrested. At 27 and 35˚C, the newly hatched spiderlings of *Th. albini* developed into seven stages to give females in accordance with results of Hendawy and El-Mezayyen (2003). Duration of spiderlings fed on each aphid species gradually increased by increasing age of the spiderlings to reach the longest duration in the last spiderling and to less extent in the last two or three stages. This conforms to findings in the most studied spiders fed on aphids (El-Erksousy and Fawzy, 2001; Abo-zaed, 2008 and Abo-zaed et al., 2018) or other prey species (El-Naggar et al.,1997 and El-Erksousy and Amer, 2007). On the other hand, Hendawy and El-Mezayyen (2003) on *Th. albini* and Ahmed and Abdel-Maaboud (2014) on *Theridion incanscens* recorded the longest duration (and highest number consumed) during the 1st spiderling and demonstrated a decrease of durations to the shortest in the 3rd spiderling, then a gradual increase up to the last spiderling. Disagreement with the present study and fluctuation of durations (and consumption) in these two studies could be attributed to the feeding of the 1st spiderling on *Tetranychus urticae* and the next spiderling stages on different or mixed insect species. In the present study, the duration of each of the 4th to 7th spiderlings of *Th. albini* was slightly longer by feeding on immatures than adult females of each aphid and on *A. craccivora* than *R. maidis* mostly at 27 ˚C. Also, the increase of the rearing temperature of spiderlings to 35 ˚C caused an enhancement of their development where the duration of each and total spiderling stage (s) was generally shorter than at 27 ˚C. These results were in accordance with findings on the enhancement effect of increasing temperature on the development and shortening of the life cycle in spiders (Li Daquin and Jackson, 1996) and other arthropods (Shanbaky et al.,1989, 2016 and Chown & Nicolson, 2004).

At 27 and 35 ˚C, early spiderlings of *Th. albini* from the 1st to 3rd stage could not feed on adult aphids but only on the immatures of each of *A. craccivora* and *R. maidis*. This could be due to the smaller size and easier hunt of immature aphids than adults. Also, each of the 4th to 7th spiderlings consumed more immatures and showed generally higher predation rate when fed on immature aphids than adults of each aphid species, consumed more of *A. craccivora* than *R. maidis* and at 27 ˚C more than 35 ˚C. Therefore, of the tested

temperatures, 27 ˚C could be considered as the optimum temperature for food consumption and predation rate on the two aphid species. However, at each temperature, food consumption (the number of preys consumed / spider) and to less extent predation rate (the number of preys consumed / spider/ day) was gradually increased by increasing age of the spiderlings from the 1st to the 7th spiderling to reach the highest number of prey consumption and predation rates in the 7th spiderling. This pattern of prey consumption was similar to those in previously studied spiders fed on aphids (El-Erksousy and Fawzy, 2001 and Abo-zaed et al., 2018) or on other preys (El-Erksousy and Amer, 2007 and Rashwan, 2017). Furthermore, the patterns of food consumption and predation rates in *Th. albini* were in agreement with those obtained in the present study in *T. spinifer* spiderlings reared on *R. maidis* at 27 ˚C where mostly no significant difference ($p > 0.05$) was observed between each of food consumption or predation rates on this aphid species in the two spider species. On the other hand, the duration of each spiderling was longer in *T. spinifer* than *Th. albini* fed on *R. maidis* at 27 ˚C. Moreover, *T. spinifer* was fed only on *R. maidis* because it refused to feed on *A. craccivora* even after two weeks of starvation. Similar situations were reported by Toft (1995, 2005) on the low quality of some aphid species as food for the spider, where the aphid consumption capacity was not only low but was also independent of the predator hunger state. The lower consumption of adult females than immatures and of *R. maidis* than *A. craccivora* in *Th. albini* and the refusal of *A. craccivora* as food in *T. spinifer* might be attributed to their low nutritional value, low quality of the aphid as food and intolerance and aversion due to the presence of toxic or deterrent compounds (Toft, 2000 and 2005). Toft (2005) suggested that the low quality of cereal aphids as food for spiders compared to alternative prey types was associated with low consumption capacity and low utilization efficiency and had been related to the prey nutritional value (Toft, 2000) and quantity of food consumed. In the present study, immatures appeared as if they had higher food value than adult aphids which induced more food consumption, predation rates and prolongation of life duration of spiderlings when fed on immature than on female adult aphids. However, quantitative analysis of the basic nutritional components showed that immatures of each of *A. craccivora* and *R. maidis* had significantly lower concentrations ($p<0.05$) of each of the total proteins and carbohydrates than adult females. But no significant difference ($p>0.05$) was found in the basic nutrients in each of the immatures and adult females of the two aphid species. Therefore, spiderlings might have tried to compensate for the smaller size and lower nutritional value of immature aphids by consuming more numbers of immature aphids which were easy to hunt, manipulate and ingest than adult aphids until the predator reached satiation. In adult females of *Th. albini* reared on immatures of *A. craccivora* and *R. maidis* at 27 ˚C longevity and fecundity of the spider were not significantly affected by rearing on *A. craccivora* or *R. maidis* where both aphid species had similar ($p>0.05$) concentration of each basic nutritional component and size. However, a comparison of the two spider species showed that longevity and fecundity of *T. spinifer* were significantly higher in *T. spinifer* (76.5 days &175.7 egg/female) than *Th. albini* fed on *R. maidis* (57.9 day&64.25 egg/female) at 27 ˚C.

In conclusion, *Th. albini* and *Th. spinifer* showed efficacy as predators in consuming noticeable numbers of immatures and adults of the two aphids, *A. craccivora* and *R. maidis* and only of *R. maidis*, respectively. Most spiderlings of *Th. albini* were equally efficient to correspondings of *T. spinifer* in consuming similar ($p>0.05$) numbers of *R. maidis* at 27 ˚C. Also, spiderlings development and female reproduction of each of *Th. albini* and *T. spinifer* were maintained and completed at an optimum temperature of 27 ˚C by feeding on immature and adult females of each of *A. craccivora* and *R. maidis* in *Th. albini* and only of *R. maidis* in *T. spinifer*. Therefore, both spider species represent probable suitable

biocontrol agents for their palatable prey-aphid of the two studied aphids. However, *Th. albini* may represent an efficient biocontrol agent for *A. craccivora* and to less extent for *R. maidis* on legumes and cereal crops at seasons with mild temperatures (around 27 ˚C) and not as high as 35 ˚C at which prey consumption was reduced. Further investigations are needed to provide more information and knowledge about the interrelationships of the predatory spiders with their aphid prey and the surrounding environment.

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ARABIC SUMMARY

تأثير الحرارة وجودة الفريسة على بعض العلاقات المتبادلة بين حشرة المّن والمفترسات فى نوعين من العناكب المرافقة على محاصيل البقول والحبوب فى مصر

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تم دراسة تأثير الحرارة وجودة الفريسة لنوع ومراحل حياة المّن ومكوناتهم الغذائية الأساسية علي إستهلاك الغذاء ومعدل الإفتراس للمّن فى المراحل غير البالغة للعنكبوت *زاناتس البيني* والذي تم تربيته علي نظام غذائى موحد من الأطوار غير البالغة أو الإناث البالغة للمّن لكل من نوعي *آفيس كراسيفورا* و *روبالوسيفم ماييدس* عند ثلاث درجات حرارة مختلفة (15و27 و35±2°م) ورطوبة نسبية من 60 إلي70%. كذلك تم دراسة تأثير جودة الفريسة بالنظام الغذائي الموحد من المّن لتلك المعايير المختبرة علي العنكبوت *تومیساس سبینیفر* وعلي معدل تكاثر الأنثي البالغة لكلا العنكبوتين عند درجة حرارة 27°م.

من بين الثلاث درجات حرارة المختبرة تعتبر درجة حرارة 27 هي درجة الحرارة المثلى لإستهلاك المّن ومعدل إفتراس المّن في الأطوار غير البالغة للعنكبوت *زاناتس البيني* عند تغذيتها علي كل من نوعي المّن و ذلك لزيادة المعيارين وإطالة مدة الأطوار غير البالغة من العناكب.كما أن درجة الحرارة المثلي 27°م قد أبقت على حياة العناكب التى أتمت عندها تطور المراحل غير البالغة و تكاثر الإناث البالغة بتغذيتهم على الأطوار غير البالغة والإناث البالغة للمّن (ماعدا أول ثلاث أطوار غير بالغة للعناكب) لكل من *آفيس كراسيفورا* و *روبالوسيفم ماييدس* في العنكبوت *زاناتس البيني* ومن *روبالوسيفم ماييدس*فقط في العنكبوت *تومیساس سبینیفر*.

أظهر النوعان من العناكب كفائتهما كمفترسات وقد إستهلكا اعدادا كبيرة من الأطوار غير البالغة عن الإناث البالغة لكل من نوعي المن وقد كان إفتراس *آفيس كراسيفورا* أعلى من من *روبالوسيفم ماييدس* في العنكبوت *زناتاس البيني*و إفتراس *روبالوسيفم ماييدس*فقط في العنكبوت *تومیساس سبینیفر* لرفضه التغذية على *آفيس كراسيفورا* وكانت الأعداد المستهلكة من المن بواسطة العنكبوت تزيد بزيادة عمر الأطوار الغير بالغة.

أظهر التحليل الكمي للمكونات الغذائية الأساسية تركيزات عالية لكل من البروتين و الكربوهيدرات في الإناث البالغة للمّن عن الأطوارغير البالغة ولكن لم يكن هناك فرق معنوي بين كل من الأطوار غير البالغة والإناث البالغة فى النوعين من المّن .وقد تمت مناقشة دلالات النتائج المتحصل عليها.