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Biological Aspects of *Orius similis* Zheng Reared on Two Preys at Three Constant Temperatures

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Abstract: Mass-rearing of *Orius similis* Zheng on two preys, *Aphis craccivora* Koch and eggs of *Corcyra cephalonica* Stainton at three constant temperatures (22, 26 and 30 °C) and 60% ± 10% RH and 16:8 L/D photoperiod under laboratory conditions was investigated to study the effect of different temperatures and different preys on the biology of *O. similis*. The highest survival rate (%) of nymphal stages was 81.14% and the longest oviposition period for females (20.6 d) was recorded at 26 °C. Also, the highest fecundity of female also recorded at 26 °C. The highest rate of nymphal feeding consumption was (122.5 individuals of *A. cracivora*) also, recorded at 26 °C. As well as, the two preys had significant effects on the biological characteristics of *O. similis*. The highest survival rate for nymphal stage was recorded when *O. similis* nymphs fed on *A. cracivora*. Therefore, the longest survival rate was founded in the nymphs which fed on the individuals of *A. cracivora.* During the nymphal period of *O. similis* which consumed more individuals of *A. cracivora* than the eggs of *C. cephalonica*. These results on the effect of three constant temperatures and two preys on the biology of *O. similis* will share to improve the rearing of *O. similis* in biological control agents in China and share to suppress the population of pests in field and greenhouse.

Key words: *Orius similis* Zheng, biological characteristics, feeding consumption.

1. Introduction

Aphis craccivora Koch (cowpea aphid) (Homoptera: Aphididae) causes momentous damages which depend on sucking plant sap from leaves. As well as, it is considered one of the most widespread pests in china which causing dangerous damages as well as, there were including direct and indirect damages to crops. The direct damage occurs when the aphids cause injury by feeding and when, the indirect damage refers primarily to the transmission of plant viruses [1]. This aphid feeds on large numbers of young leaves, mostly on the undersurface and also on tender parts and cause enormous damage. They suck the cells of the plant leaves, low its vitality, turn them yellow and crinkled. Aphids are usually controlled by different chemical insecticides which may pollute the environmental system. The extensive using of insecticides and repeating it lead to imbalance in the ecosystem between these pests and natural enemies. All scientists must support and enhance the use of safe control methods such as biological control by using natural enemies. Predators are the most useful groups of natural enemies which play an effective role against insect pests. The relationship between the pests as favorable preys and their predators enable to know how these predators can lead to suppression the density of these insect pests and environmental balance occurs. The egg of rice moth *Corcyra cephalonica* and aphids is one of the most laboratory host preys mostly used in rearing *Oruis* species in the world [2].

The bug *Orius similis* Zheng (Hemiptera: Anthocoridae) is one of the most effectiveness biological control agents of insect pests in China [3].

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As well as, it is a polyphagous natural enemy that has a lot of preys such as aphids [4], thrips, spider mites [5] and the eggs of moth [6-8].

Rearing *O. similis* in large numbers at laboratory and then releasing their nymphs and adults in the field will support the biological control of these insect pests, decrease their population in the field and could lead to the reduction of pesticide use [9, 10].

Therefore, the present work was carried out to study the biological aspects of the *O. similis* Zheng and the effect of feeding on different preys at three constant temperatures on biological characteristics at laboratory conditions in Hainan, China.

2. Materials and Methods

2.1 Mass Production of the Cowpea Aphid, A. craccivora Koch

Vicia faba seeds were planted in plastic trays (25 cm × 40 cm × 15 cm) contained (peat moss). The seeds were planted at a depth of 1-2 cm below the soil surface and were irrigated and fertilized these trays. After one week from cultivation, when the first leaflet appeared, bean leaves were infested with *A. craccivora* which distributed over the new leaves.

The infested trays were monitored until the population of *A. craccivora* increased and became suitable for use as prey to *O. similis*. *A. craccivora* colonies were reared under laboratory conditions (22 ± 3 °C and 60% ± 10% RH) on broad beans. Such leaves of beans were infested by different stages of *A. craccivora* and were kept in metallic cages (100 cm × 135 cm × 135 cm) with nylon gauze sides. The infested plants were irrigated and fertilized. This method was described by Mangoud [11]. *A. craccivora* were collected from infested broad beans, cultivated in Hainan, China.

2.2 Mass Production of O. similis Zheng

The experiments were carried out under laboratory conditions at 26 ± 2 °C, 60% ± 10% RH and 16:8 L/D photoperiod. Mass rearing of both prey and predator was carried out in the laboratory, of the *O. similis* were obtained from: Beijing Kuo: Ye Bio-Tec Company (China) and had been reared for several two generations under laboratory conditions. The predators were reared using the methods described by Isenhor and Yeargan [12]. Adults and nymphs of *O. similis* were collected to be kept in plastic jars of 10 cm (diameter) × 20 cm (height) covered with muslin and held in place by means of rubber bands. Each jar was provided with both small balls of white foam to reduce cannibalism behavior and sufficient quantities of *C. cephalonica* eggs as food supply for the enclosed predators. A piece of bean pod (*Phaseolus vulgaris*) was provided in each jar as an ovipostional substrate [13]. Eggs were inserted into the tissue of bean pods. Bean pods with newly deposited eggs inside were kept in plastic jars previously described. Jars were examined daily until hatching. Soon after hatching, newly-hatched nymphs on bean pods were carefully transferred to plastic jars and provided with eggs of *C. cephalonica* and small balls of white foam to reduce cannibalism. The amount of food was increased with the nymphal development. Immediately after emergence of adults, they were sexed and kept in plastic jars provided with food. The procedure was repeated for two successive generations and all records data concerning the different developmental stages, adults longevity, fecundity and other biological investigations were recorded under the laboratory conditions.

2.3 Effect of Different Preys on the Immature Stages

The effect of eggs of *C. cephalonica* and nymphs of *A. cracivora* on the developmental stages of the *O. similis*, percentages of survival rate and predation capacity was determined at three constant temperatures (22, 26 and 30 °C). New nymphs were separated into small Petri dishes (9 cm (diameter) × 1.5 cm (height)) by using a small hair brush and respirator. There were 10 replicates for each prey treatment. Each nymph was provided with the two

investigated prey (eggs of *C. cephalonica* and nymphs of *A. cracivora*). Eggs of *C. cephalonica* were put in small glass Petri dishes and also the container provided with plastic vials (5 mL) filled with cotton and moistened with honey water (70%), were placed inside. Another prey was provided to the predators on small leaf discs of bean leaves cut from host plants used in their colony's maintenance.

Each container was daily observed to study the *O. similis* developmental stages and the number of prey which consumed. Predation capacity was determined by using the binocular microscope. New prey was daily provided until the *O. similis* completed development or died. Data of the developmental time and prey consumption for each instar were mentioned by El-Husseini *et al.* [14]. After adult eclosion, the sex ratio of the *O. similis* was determined and females were reared on the two preys.

2.4 Effect of Different Preys on the Longevity and Female Fecundity of O. similis

The fecundity and longevity for adults emerging from immature developmental stage were determined. Newly emerged adults of *O. similis* for the two prey treatments were paired (one female with one male) and separated in Petri dishes (9 cm (diameter) × 1.5 cm (height)) for mating. To stimulate mating, no prey was added at this time [15]. Twelve hours later, males were removed and separated to other Petri dishes to determine predators capacity. The females were daily supplied with preys on new bean leaves or paper discs and bean pods as oviposition sites until death. Males were also, provided with new preys and bean pods. The number of consumed preys and eggs which females deposited were daily counted under a binocular microscope. Experiments were conducted under three constant temperatures (22, 26 and 30 °C), 60% ± 5% RH and 16:8 L/D photoperiod.

2.5 Statistical Analysis

Significance of the effects of different temperatures and two preys and prey consumption was determined by analysis of variance (ANOVA) (one-way). The mean values were compared using Tukey's test at the $p = 0.05$ level of significance. Adult prey consumption and adult longevity were analyzed by two-way ANOVA. Statistical analyses were run in SPSS for Windows version 18.

3. Results and Discussion

3.1 Effect of Temperature on the Duration of Immature Stages of O. similis

3.1.1 Incubation Period

Data in Table 1 and graphically in Fig. 1 showed that the shortest mean incubation period was 2.3 ± 0.60 d at 30 °C. At 26 °C, the mean incubation period increased to 5.1 ± 0.51 d. Therefore the longest mean incubation period was 10.7 ± 0.12 d at 22 °C. It was obvious that the incubation period decreased significantly with each increase of temperature. This result agreed with the findings of Zhang *et al.* [3], Isenhor and Yeargan [12] and Askari and Stern [16]. Data of statistical analysis shown that temperature has a highly significant effect on the incubation period ($F = 4.672$ and $p < 0.05$).

3.1.2 Duration of Nymphal Stage

The data in Table 1 and Fig. 1 showed clearly that the longest nymphal developmental period was 23.7 ± 1.1 d at 22 °C and the shortest was 13.1 ± 0.81 d at 30 °C. At 26 °C, the mean nymphal developmental period lasted 17.5 ± 0.94 d. In this case it was clear that the duration of nymphal stage decreased significantly with temperature ($F = 2.413$ and $p < 0.05$). These result agreed with the finding of Zhang *et al.* [3].

3.1.3 Total Developmental Period

Data of the total developmental periods under three constant temperatures are presented in Table 1 and Fig. 1. The shortest mean total developmental period was 15.4 ± 1.17 d at 30 °C. At 26 °C, the mean total developmental periods increased to 22.1 ± 0.63 d,

Table 1 Effect of three degrees of temperatures (22, 26 and 30 °C) on the development of *Orius similis* immature stages at 60% ± 10% RH and 16:8 L/D photoperiod.

Parameters / Temperatures	No. of replicates	Incubation period (d) Mean ± SE	Nymphal period Mean ± SE	Total developmental period Mean ± SE	Survival rate (%) Mean ± SE
22 °C	10	10.7 ± 0.12^{c}	23.7 ± 1.1^{c}	31.0 ± 1.02^{c}	70.59 ± 2.08^{b}
26 °C	10	5.1 ± 0.51^{b}	17.5 ± 0.94^{b}	22.1 ± 0.63^{b}	81.14 ± 1.42^{c}
30 °C	10	2.3 ± 0.60^{a}	13.1 ± 0.81^{a}	15.4 ± 1.17^{a}	38.78 ± 0.98^{a}

Values (mean ± SE) followed by different letters within a column are significantly different based on Tukey's test with $p < 0.05$.

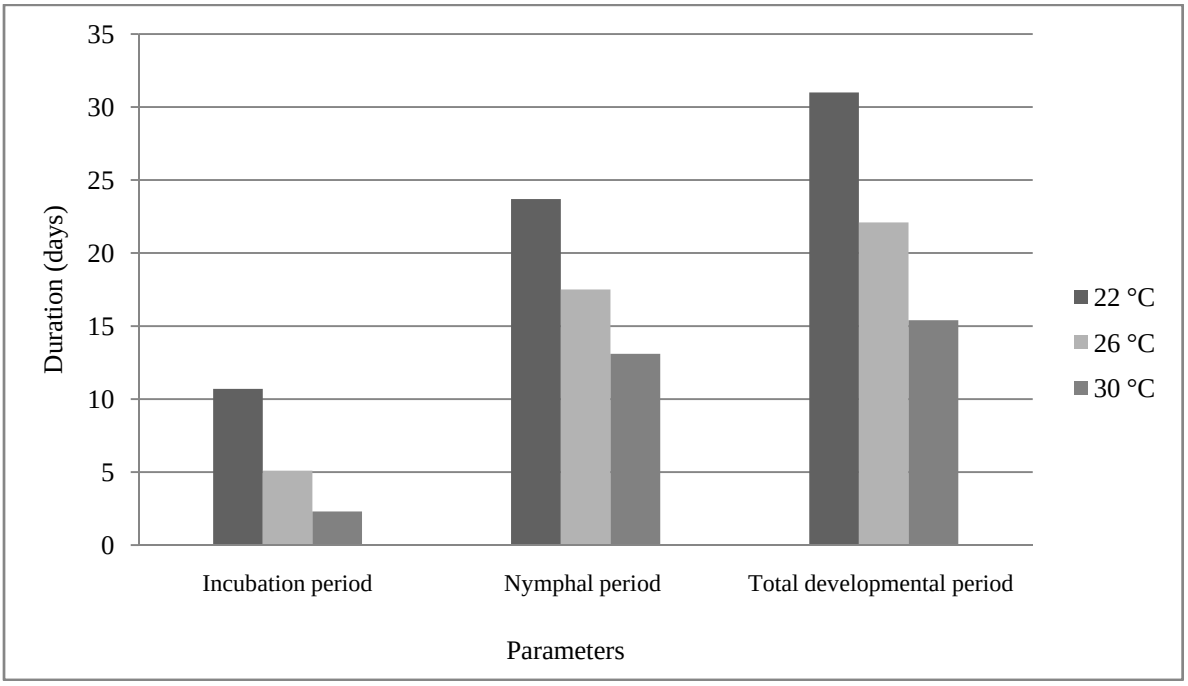

Fig. 1 Effect of different temperatures (22, 26 and 30 °C) on the development of *Orius similis* immature stages.

whereas, the longest mean total developmental period was 31.0 ± 1.02 d at 22 °C. Statistical analysis of data revealed highly significant differences among the total developmental periods under three constant temperatures ($F = 6.175$ and $p < 0.05$).

3.1.4 Survival Rate (%)

Data on Table 1 and Fig. 1 showed the effects of three constant temperatures on the percentage of survival rate. The lowest mean survival rate was 38.78% recorded at 30 °C. While at 22 °C, the mean survival rates increased to 70.59%. On the other hand, the highest mean survival rate was 81.14% at 26 °C. Statistical analysis of the data (*F*-test) has shown that there were significant differences between survival rates among data of all tested temperatures ($F = 21.542$ and $p < 0.05$).

3.1.5 Effect of Temperature on the Percentage of Hatchability of *O. similis* Egg Stages

Data in Table 2 and Fig. 2 showed that the number of hatched individuals was 51.0 ± 5.81 at 26 °C and decreased to reach 38.1 ± 4.83 and 22.9 ± 11.17 at 22 °C and 30 ± 1 °C, respectively. The effect of temperature was studied, i.e., 22, 26 and 30 ± 1 °C, 60% ± 10% RH and photoperiod of 16:8 L/D on the percentage of hatchability of *O. similis* egg stages. The lowest hatchability was 33.8% recorded in 30 °C and increased to reach 58% at 22 °C, while the highest hatchability was 78% recorded at 26 °C. It is clear that the temperature 26 °C was the best temperature for hatchability. The statistical analysis of data revealed highly significant differences among the three temperatures and their effects on hatchability ($F = 12.433$

Table 2 Effect of three degrees of temperatures (22, 26 and 30 °C) on the percentage of hatchability of *O. similis* eggs stage at 60% ± 10 % RH and 16:8 L/D photoperiod.

Parameters / Temperatures	No. of replicates	Initial No. of eggs	Hatched individuals Mean ± SE	Hatchability (%) Mean ± SE
22 °C	10	65	38.1 ± 4.83[b]	58 ± 3.34[b]
26 °C	10	65	51.0 ± 5.81[c]	78 ± 5.68[c]
30 °C	10	65	22.9 ± 11.17[a]	33.8 ± 10.47[a]

Values (mean ± SE) followed by different letters within a column are significantly different based on Tukey's test with $p < 0.05$.

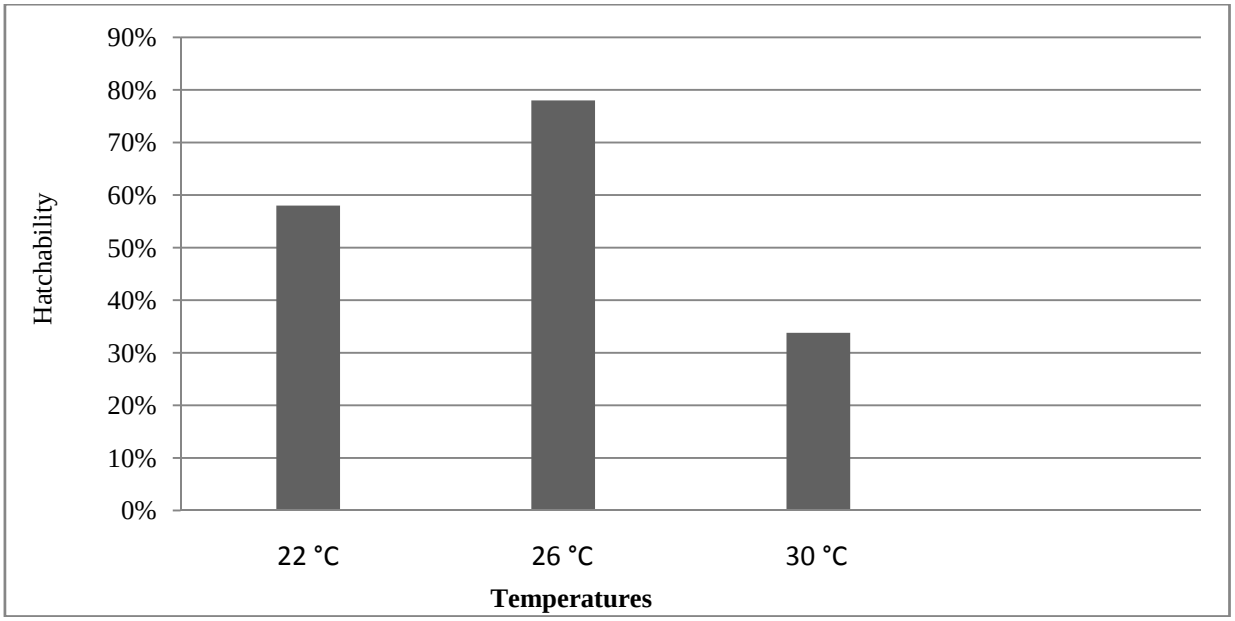

Fig. 2 Effect of different temperatures (22, 26 and 30 °C) on the percentage of hatchability of *O. similis* eggs stage.

and $p < 0.001$) and the number of hatched individuals ($F = 6.897$ and $p < 0.05$). These results agreed with Refs. [16-19].

3.2 Effect of Temperature on Adults

3.2.1 Effect of Temperature on Pre-oviposition and Oviposition Period

Data recorded in Table 3 and Fig. 3 showed that the shortest pre-oviposition period was 3.0 ± 0.23 d at 30 °C and increased to 7.1 ± 0.08 d at 22 °C, when at 26 °C was 5.2 ± 1.04 d. It is clear that pre-oviposition period increased by increasing the temperature ($F = 4.017$ and $p < 0.05$). Data on Table 3 showed that the oviposition period were 20.6 ± 2.24 d and 16.1 ± 1.58 d at 22 °C and 26 °C, respectively. When the oviposition period decreased to reached to 11.4 ± 3.50 d at 30 °C. It was obvious that the pre-oviposition period decreased significantly with each increase of temperature ($F = 6.251$ and $p < 0.05$).

3.2.2 Sex Ratio

The data of sex ratio (females %) are presented in Table 3 and Fig. 4. The lowest sex ratio was 43.0% for nymphs reared at 22 °C. While at 26 °C, the mean sex ratio increased to 50.0%. On the other hand, the highest percent was 66.0% for nymphs reared at 30 °C. Statistical analysis of the data (ANOVA) followed by Tukey's test has shown that there was highly significant effects of the examined temperature on the sex ratio of *O. similis* ($F = 4.104$ and $p < 0.05$) [20].

3.2.3 Female Fecundity

The data obtained of female fecundity are presented in Table 3 and Fig. 5. The lowest mean female fecundity was 40.0 ± 8.08 eggs at 30 °C, while at 22 °C, the mean female fecundity increased to 53.0 ± 10.17 eggs. On the contrary, the greatest mean female fecundity was 62.0 ± 7.19 eggs at 26 °C. It was clear

Table 3 Effect of three degrees of temperatures (22, 26 and 30 °C) on the productivity, longevity and fecundity of adults of *O. similis* at 60% ± 10% RH and 16:8 L/D photoperiod.

Parameters / Temperatures	No. of replicates	Duration (d)		Longevity Mean ± SE		Sex ratio females (%)	Fecundity No. of eggs/female Mean ± SE
		Pre-oviposition period	Oviposition period	Female	Male		
22 °C	10	7.1 ± 0.08[b]	20.6 ± 2.24[b]	36.0 ± 3.17[c]	19.6 ± 7.24[b]	43[a]	53.0 ± 10.17[b]
26 °C	10	5.2 ± 1.04[b]	16.1 ± 1.58[a]	30.1 ± 4.99[b]	15.9 ± 5.89[b]	50[b]	62.0 ± 7.19[c]
30 °C	10	3.0 ± 0.23[a]	11.4 ± 3.50[a]	26.6 ± 5.14[a]	12.1 ± 5.07[a]	66[c]	40.0 ± 8.08[a]

Values (mean ± SE) followed by different letters within a column are significantly different based on Tukey's test with $p < 0.05$.

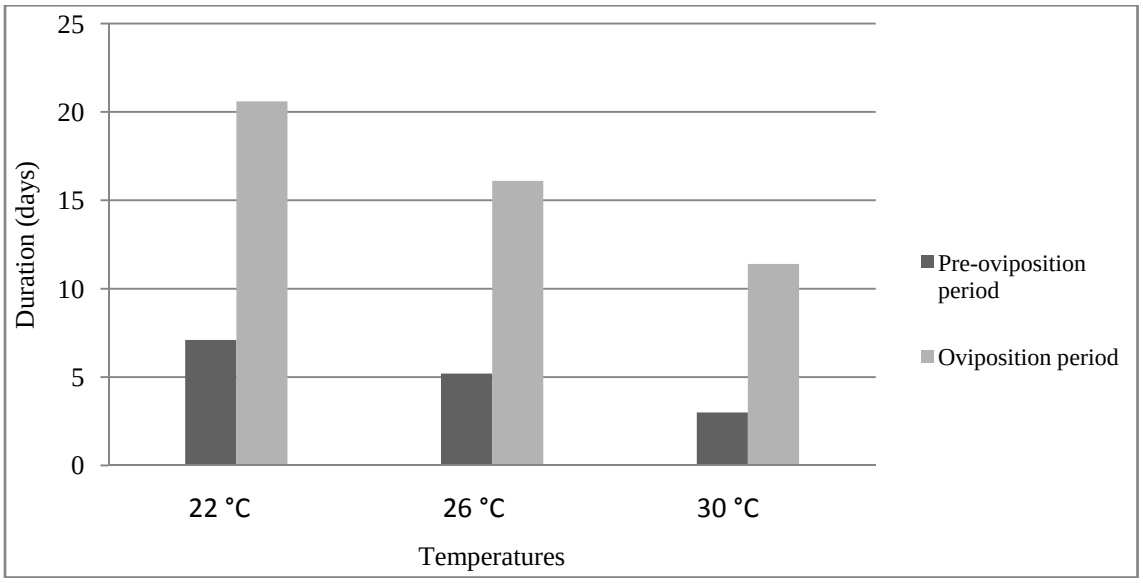

Fig. 3 Effect of different temperatures (22, 26 and 30 °C) on the duration of pre-oviposition and oviposition period of *O. similis* females.

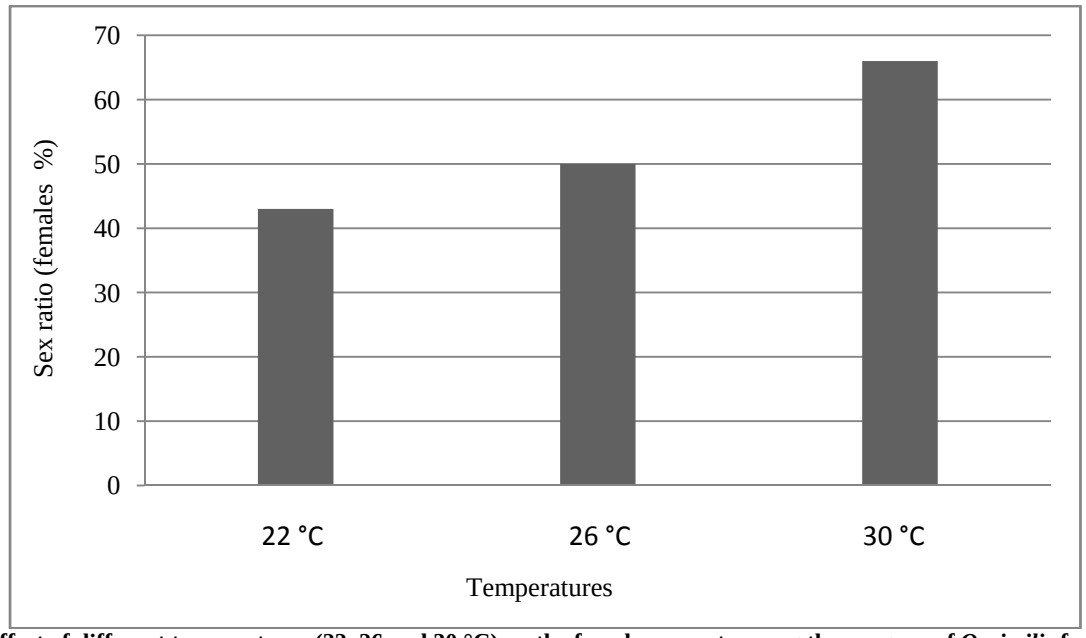

Fig. 4 Effect of different temperatures (22, 26 and 30 °C) on the female percent among the progeny of *O. similis* females.

that the female fecundity differed significantly among investigated temperatures (F = 13.018 and p < 0.05). Here, female fecundity increased with temperature progressed and peaked at 26 °C then decreased gradually. This indicated that 26 °C is the ideal temperature for lab mass rearing. These results in general, agreed with those of Refs. [21-23].

3.2.4 Effect of Temperature on Adult Female Longevity

Data of female longevity are presented in Table 3 and Fig. 6. The shortest average female longevity was 26.6 ± 5.14 d at 30 °C, while at 26 °C, it increased to 30.1 ± 4.99 d. The longest mean female longevity was 36.0 ± 3.17 d at 22 °C. Obviously, the female longevity decreased significantly with temperature increased (F = 3.874 and p < 0.05). These results agreed completely with Alauzet *et al.* [21], Van de Veire and De Gheele [24] and Sengonca *et al.* [25].

3.2.5 Effect of Temperature on Adult Male Longevity

The shortest average male longevity was 12.1 ± 5.07 d at 30 °C, while at 26 °C, these averages increased to

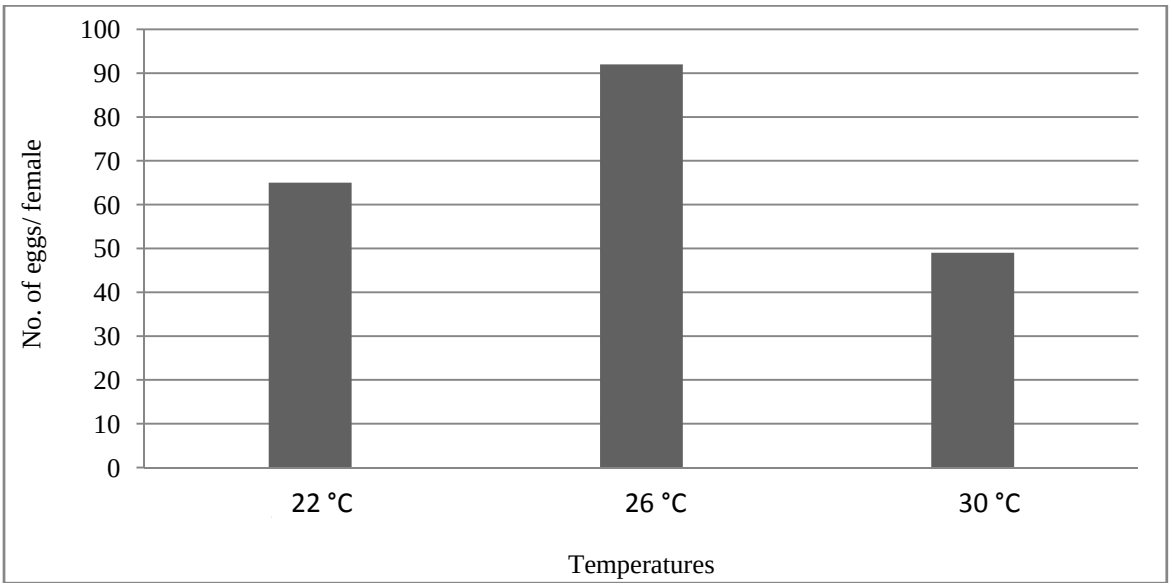

Fig. 5 Effect of three different temperatures (22, 26 and 30 °C) on the fecundity of *O. similis* females.

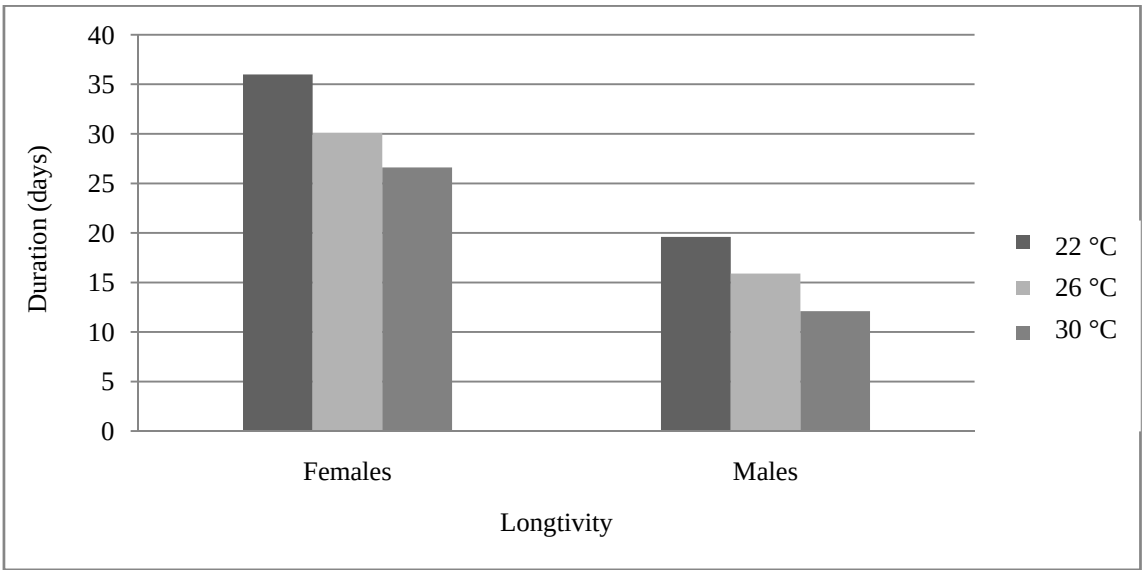

Fig. 6 Effect of different temperatures (22, 26 and 30 °C) on the adult longevity of *O. similis*.

15.96 ± 5.89 d. The longest mean female longevity was 19.6 ± 7.24 d at 22 °C. Also, male longevity decreased significantly as temperature increased (F = 17.198 and $p < 0.05$).

3.3 Effect of Two Preys on the Development of O. similis

3.3.1 Effect of Two Preys on the Development of Immature Stages

Data on Table 4 and Fig. 7 showed the effect of preys on the percentages of survival rate. The lowest mean survival rate was 65.4% ± 0.48% for individuals fed on *C. cephalonica*, while the mean survival rates increased to 77.9% ± 1.03% for individuals fed on *A. cracivora*. On the other hand, the highest mean survival rate was 81.14% at 26 °C. Statistical analysis of the data (F-test) showed that there were significant differences among the survival rates at all the tested temperatures (F = 11.851 and $p < 0.001$).

3.3.2 Effect of Two Preys on the Duration of Pre-oviposition and Oviposition Period

Data in Table 5 and graphically in Fig. 8 showed that the shortest mean pre-oviposition and oviposition period were 4.6 ± 0.08 d and 7.9 ± 0.17 d when females fed on eggs of *C. cephalonica*. Whereas, the longest mean of pr-oviposition and oviposition period

Table 4 Effect of two preys on the development of immature stages of *O. similis* at 26 ± 1 °C, 60% ± 10% RH and 16:8 L/D photoperiod.

Preys	No. of replicates	Incubation period Mean ± SE	Nymphal period Mean ± SE	Survival rate (%) Mean ± SE
C. cephalonica	10	2.8 ± 0.09[a]	18.8 ± 0.99[a]	65.4 ± 0.48[a]
A. cracivora	10	7.9 ± 1.28[b]	29.9 ± 1.05[b]	77.9 ± 1.03[b]

Values (mean ± SE) followed by different letters within a column are significantly different based on Tukey's test with $p < 0.05$.

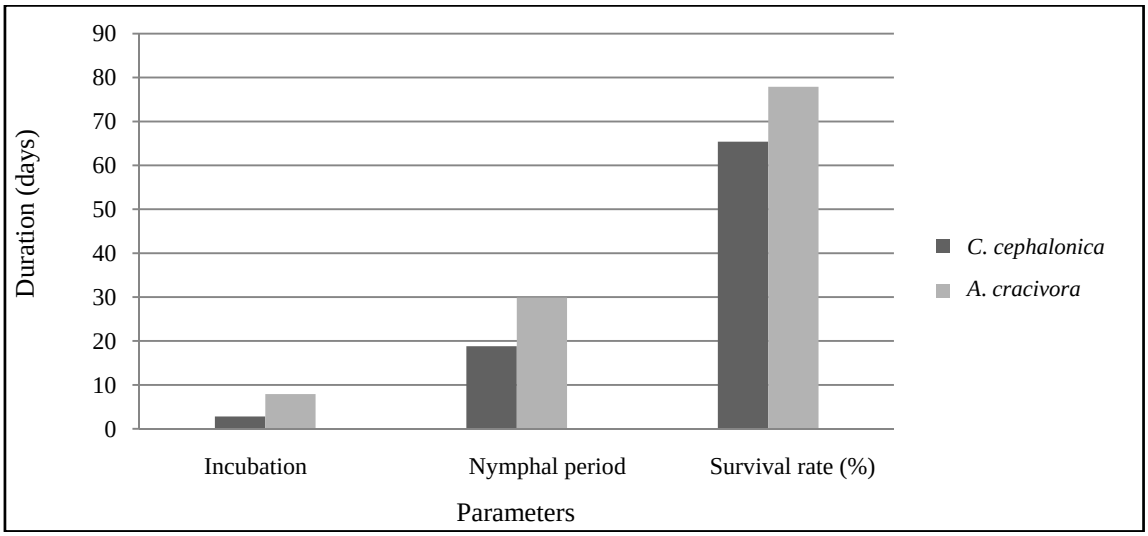

Fig. 7 Effect of different preys on the development of immature stages of *O. similis*.

Table 5 Effect of two preys on the productivity, longevity and fecundity of *O. similis* females at 60% ± 10% RH and 16:8 L/D photoperiod.

Prey	No. of replicates	Duration (d) Mean ± SE		Longevity Mean ± SE		Sex ratio (%)	Fecundity No. of eggs/female Mean ± SE
		Pre-oviposition period	Oviposition period	Female	Male		
C. cephalonica	10	4.6 ± 0.08[a]	7.9 ± 0.17[a]	25.7 ± 2.51[a]	10.0 ± 5.01[a]	38.0[a]	44.7 ± 1.78[a]
A. cracivora	10	8.3 ± 1.15[b]	15.6 ± 0.25[b]	35.1 ± 2.10[a]	14.2 ± 4.21[a]	52.0[b]	85.3 ± 1.18[b]

Values (mean ± SE) followed by different letters within a column are significantly different based on Tukey's test with $p < 0.05$.

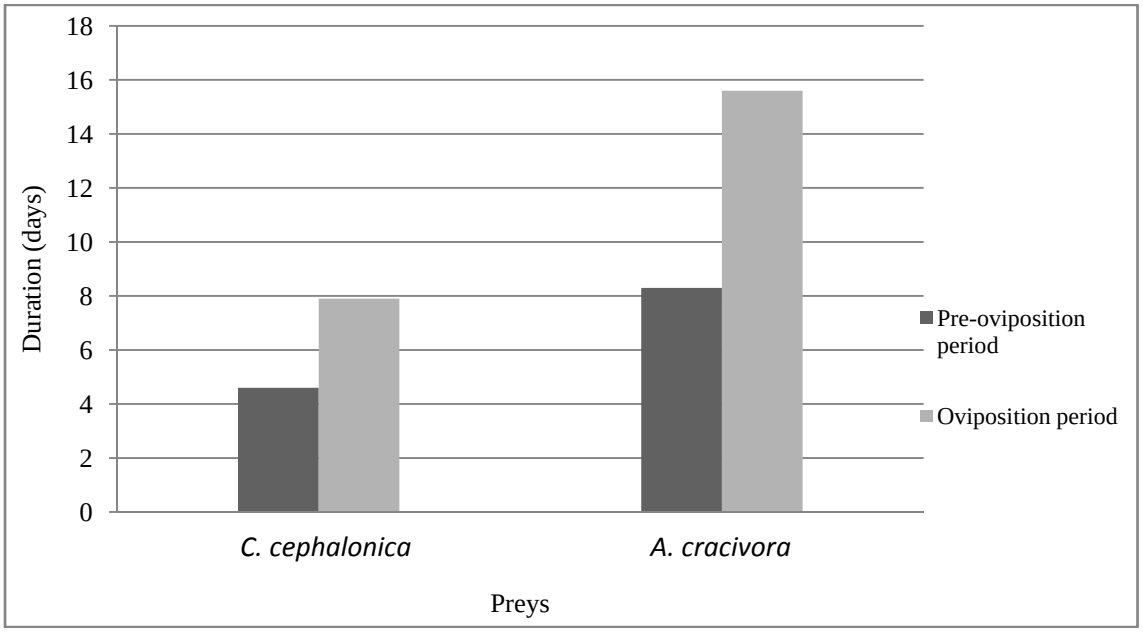

Fig. 8 Effect of two preys on the duration of pre-oviposition and oviposition period of *O. similis*.

were 8.3 ± 1.15 d and 15.6 ± 0.25 d when females fed on *A. cracivora*. There were significant differences between pre-oviposition and oviposition period and all tested preys ($F = 2.247$ and $p < 0.05$; $F = 5.752$ and $p < 0.05$). These results agreed with Calixto *et al.* [8] and Tommasini *et al.* [26].

3.3.3 Effect of Two Preys on the Female Longevity

The data of female longevity is summarized in Table 5 and Fig. 9. The shortest mean female longevity was 25.7 ± 2.51 d when females fed on eggs of *C. cephalonica* and increased to 35.1 ± 2.10 d when females fed on A. *cracivora*. This agrees with that recorded by Tommasini and Nicoli [27], Kim *et al.* [28] and Nishimori *et al.* [29]. Statistical analysis (*F*-test) showed that there was significant difference on the female longevity when females fed on eggs of *C. cephalonica* or *A. cracivora* ($F = 4.285$ and $p < 0.05$).

3.3.4 Effect of Two Preys on the Male Longevity

The effect of different preys on male longevity was also shown in Table 5 and Fig. 9. The shortest mean male longevity was 10.0 ± 5.01 d when males fed on eggs of *C. cephalonica* and increased to 14.2 ± 4.21 d when males fed on *A. cracivora*. Statistical analysis of the data (*F*-test) shown that there were low significant effects on the male longevity when fed on two tested preys ($F = 2.017$ and $p < 0.05$). This agrees with that recorded by Zhang *et al.* [3] and Tommaini *et al.* [9].

3.3.5 Effect of Two Preys on the Female Fecundity

The lowest mean female fecundity was 44.7 ± 1.78 eggs when the females fed on *C. cephalonica* and increased to 85.3 ± 1.18 eggs when the females fed on *A. cracivora*. Statistical analysis of the data (*F*-test) showed that there were highly significant effects on the females fecundity when fed on two tested preys ($F = 14.187$ and $p < 0.001$) (Table 5 and Fig. 10). These data are agreed with Tommasini and Nicoli [27], Richard and Schmidt [30].

3.3.6 Effect of Two Preys on the Sex Ratio

The data obtained of sex ratio are presented in Table 5 and Fig. 11. The lowest sex ratio was 38.0% when the females fed on *C. cephalonica* and increased to 52.0% when the females fed on A. *cracivora* [10, 31]**.** Statistical analysis of the data (*F*-test) has shown that tested preys have significant effects on the sex ratio (females %) of *O. similis*, so there was significant effect on the sex ratio when adults fed on eggs of *C. cephalonica* and *A. cracivora* ($F = 5.317$ and $p < 0.05$).

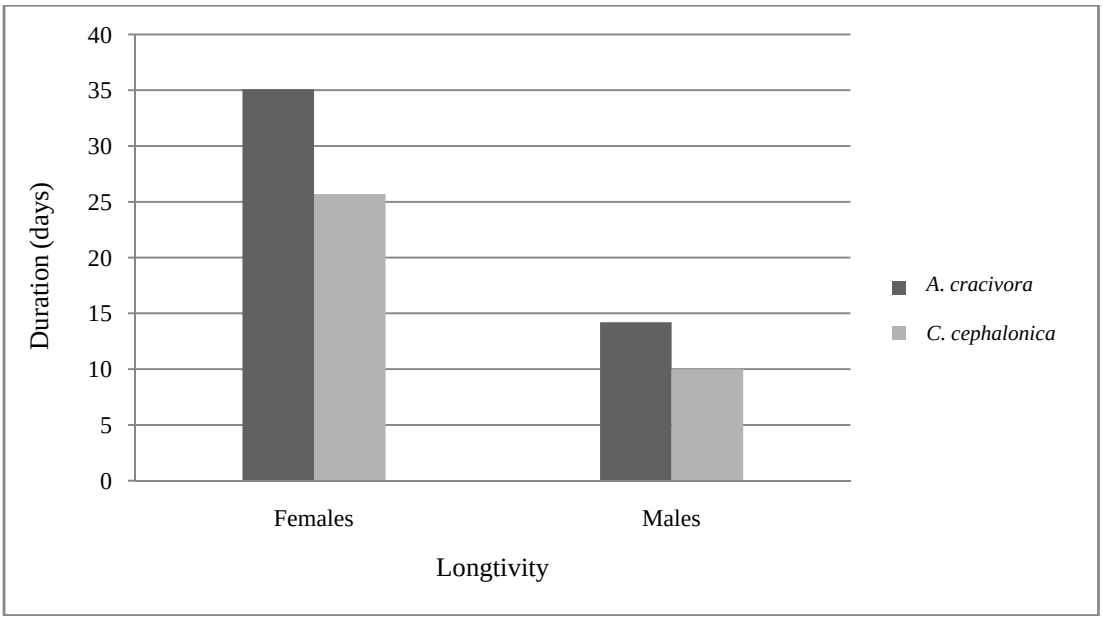

Fig. 9 Effect of two preys on the adult longevity of *O. similis*.

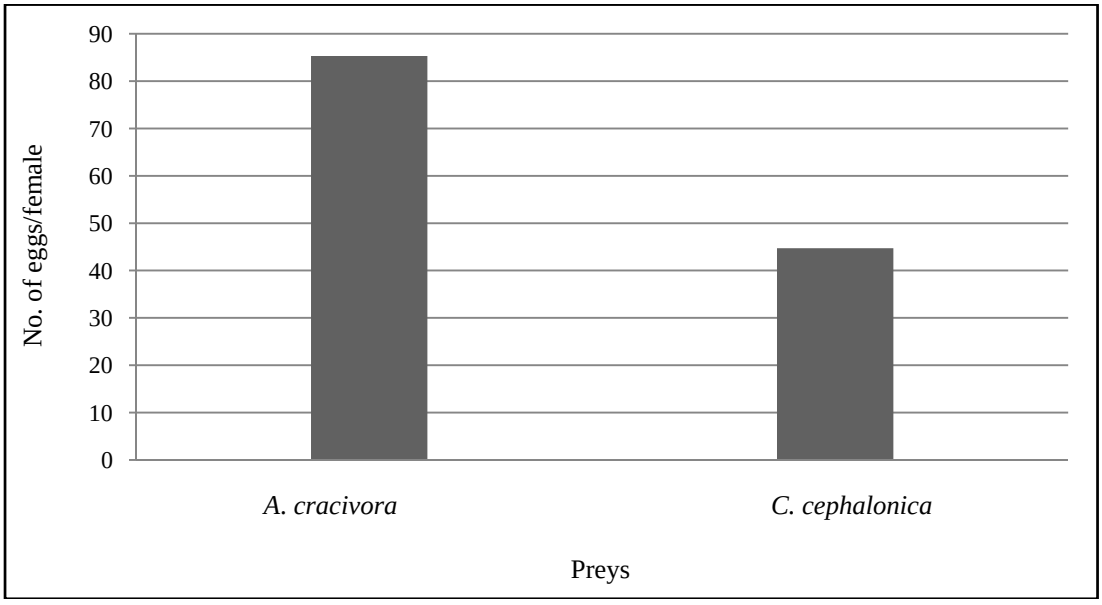

Fig. 10 Effect of two preys on the fecundity of *O. similis* females.

3.4 Effect of Three Temperatures and Two Preys on the Feeding Consumption of O. similis

3.4.1 Effect of Temperature and Eggs of *C. cephalonica* on the Feeding Consumption of *O. similis*

3.4.1.1 Nymphal Feeding Consumption

The data obtained of the feeding consumptions of nymphal stage are presented in Table 6 and Fig. 12. The lowest mean feeding consumption of nymphal stages was 43 ± 1.02 eggs at 22 °C, while at 26 °C and 30 °C, the mean feeding consumptions of nymphal stages increased to 67.0 ± 0.05 eggs and 51.0 ± 0.08 eggs, respectively. So the greatest mean feeding consumption of nymphal stage was at 26 °C. There was highly significant effects of the examined temperatures on the feeding consumption of nymphal stage ($F = 4.080$ and $p < 0.05$). These results agreed with Wang [31] and Sobhy *et al.* [32] who found that feeding consumption was

positively correlated with temperature up to 30 °C.

3.4.1.2 Male Feeding Consumption

The lowest mean feeding consumption of males was 20.7 ± 1.06 eggs at 22 °C, while at 26 °C and 30 °C, the mean of the feeding consumption of males stage increased to 39 ± 3.24 eggs and 28.5 ± 2.18 eggs, respectively. The highest mean of male consumption was occurred on 26 °C, the statistical analysis recorded high significance between the tested temperature and the male feeding consumption (F = 6.227 and $p < 0.05$).

3.4.1.3 Female Feeding Consumption

The lowest mean of male feeding consumption was 78.9 ± 4.31 eggs at 22 °C, while at 26 °C and 30 °C, mean of the feeding consumption of male stage increased to 143.9 ± 2.54 eggs and 102.9 ± 6.14 eggs, respectively. The highest mean of male consumption was occurred on 26 °C (F = 23.114 and $p < 0.001$).

3.4.2. Effect of Temperature and Nymphs of *A. craccivora* on the Feeding Consumption of *O. similis*

3.4.2.1 Nymphal Feeding Consumption

Data obtained in Table 6 and Fig. 13 showed that the lowest mean consumption of the total nymphal stage was 72.0 ± 5.18 nymphs at 22 °C, while at 26 °C and 30 °C, the mean feeding consumption of male stage increased to 122.5 ± 3.12 nymphs and 79.1 ± 5.88 nymphs, respectively (F= 3.451 and $p < 0.05$).

3.4.2.2 Male Feeding Consumption

The lowest mean consumption of the males was 45.8 ± 1.85 nymphs, while the highest mean consumption of the males was 98.4 ± 1.04 nymphs at 26 °C and the mean consumption of males consumption at 30 °C was 58.9 ± 2.07 (F = 6.441 and $p < 0.05$).

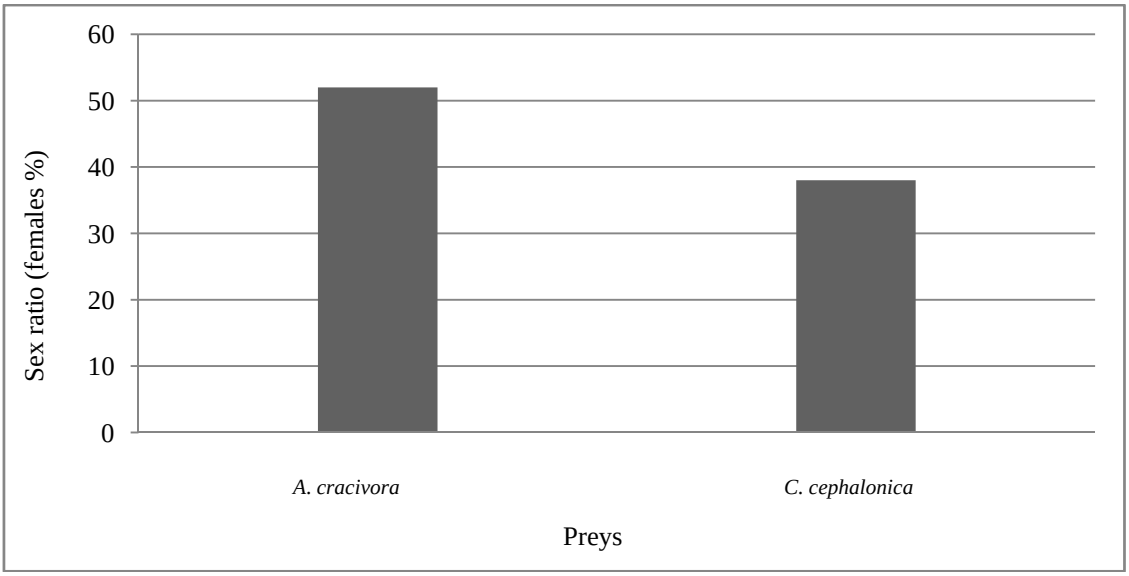

Fig. 11 Effect of two preys on the female percent among the progeny of *O. similis*.

Table 6 Effect of three degrees of temperatures (22, 26 and 30 °C) on predation capacity of *O. similis* reared on two different preys.

Prey	Temperature	Consumption efficiency		
		Nymphal feeding consumption	Male feeding consumption	Female feeding consumption
C. cephalonica	22 °C	43.0 ± 1.02[a]	20.7 ± 1.06[a]	78.9 ± 4.31[a]
	26 °C	67.0 ± 0.05[c]	39.0 ± 3.24[b]	143.9 ± 2.54[c]
	30 °C	51.0 ± 0.08[b]	28.5 ± 2.18[b]	102.9 ± 6.14[b]
A. cracivora	22 °C	72.0 ± 5.18[a]	45.8 ± 1.85[a]	151.7 ± 8.71[c]
	26 °C	122.5 ± 3.12[c]	98.4 ± 1.04[b]	218.9 ± 17.68[a]
	30 °C	79.1 ± 5.88[b]	58.9 ± 2.07[c]	179.5 ± 10.31[b]

Values (mean ± SE) followed by different letters within a column are significantly different based on Tukey's test with $p < 0.05$.

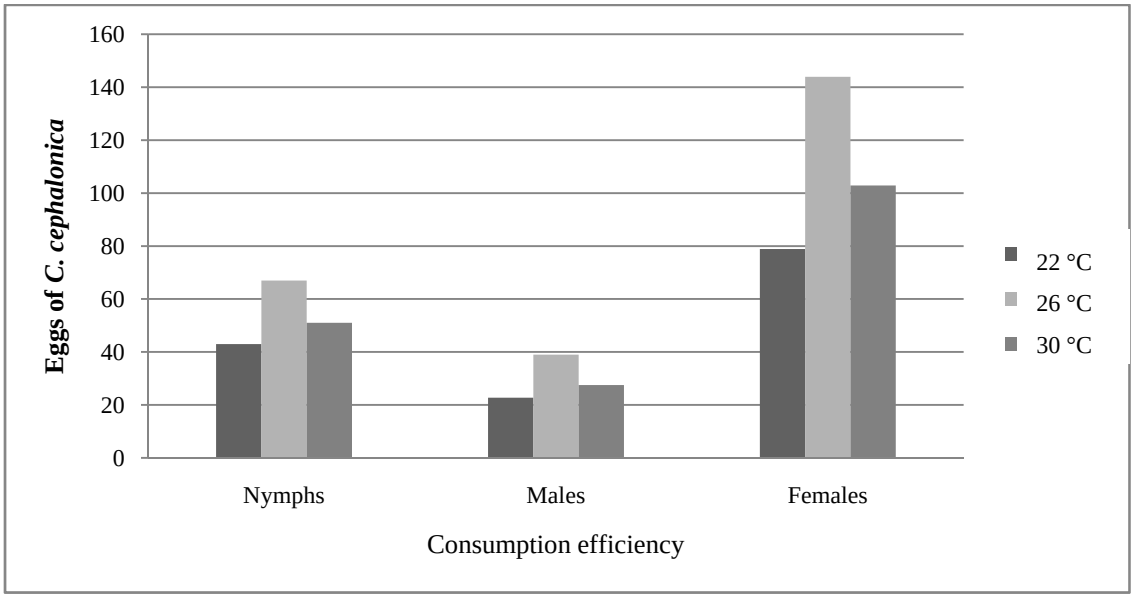

Fig. 12 Effect of different temperatures (22, 26 and 30 °C) on the feeding consumption of *O. similis* on eggs of *C. cephalonica*.

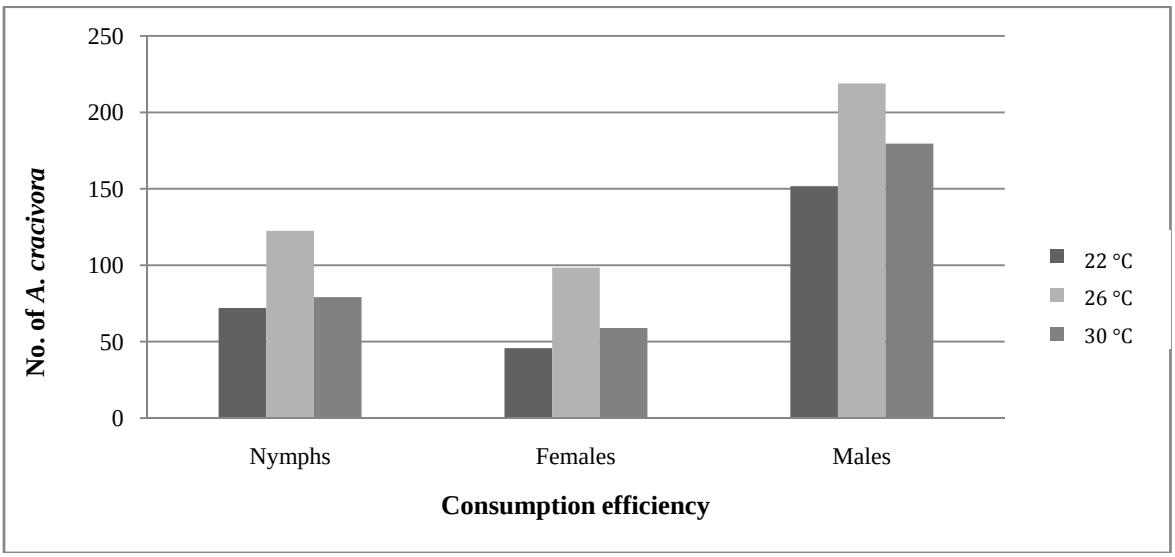

Fig. 13 Effect of different temperatures (22, 26 and 30 °C) on the feeding consumption of *O. similis*on nymphs of *A. cracivora*.

3.4.2.3 Female Feeding Consumption

The lowest mean feeding consumption of female was 151.7 ± 8.71 nymphs, while the highest mean consumption of the females was 218.9 ± 17.68 nymphs at 26 °C and the mean of the female consumption at 30 °C was 179.5 ± 10.31 nymphs (F = 12.701 and $p < 0.001$).

The highest mean consumptions of nymph, male and female were all founded at 26 °C. In accordance with these results, Mccaffrey and Horsburgh [33, 34] found that feeding consumption was positively correlated with temperature; the feeding consumption was higher when the nymph, male and female fed on *A. cravivora* compared with eggs of *C. cephalonica* [8].

4. Conclusions

In this paper, the obtained results showed that the development of immature stages (eggs and nymphs) of *O. similis* was decreased with each increase of

temperature; the longest mean developmental period of nymphal stages was 31.0 ± 1.02 d at 22 °C. At 30 °C, the mean developmental periods of nymohal stages was increased to 15.4 ± 1.17 d. The shortest mean incubation period was 2.3 ± 0.60 d at 30°C. At 26 °C, the mean incubation period increased to 5.1 ± 0.51 d. The survival rate (%) was 81.14% at 26 °C and decreased to 38.78% at 30 °C. About the effect of temperatures on hatchability of eggs, the highest hatchability was 78% recorded at 26 °C and the number of hatched individuals was increased in each increased of temperatures. As well as, the pre-oviposition and oviposition period and longevity were decreased significantly with each increase of temperature. The highest female fecundity was recorded at 26 °C (62.0 ± 7.19 eggs). Regarding to the effect of two preys on the development of immature stages, the data showed that, the longest mean of pre-oviposition and oviposition period were 8.3 ± 1.15 and 15.6 ± 0.25 when females fed on *A. cracivora* and the longest female longevity was 35.1 ± 2.10 d when females fed on *A. cracivora*.

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