Impact of temperature and prey type on biology and life-table parameters of Cheyletus malaccensis Oudemans (Acari: Cheyletidae)

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ABSTRACT
This study deals with biology and life table parameters of the predatory mite, Cheyletus malaccensis Oudemans were evaluated on three astigmatid mites as prey (i.e. Acarus siro Linnaeus), Caloglyphus berlesei (Michael) and Tyrophagus putrescentiae (Schrank) under laboratory conditions. Three constant temperatures (22, 27 and 32 ± 2°C) and constant relative humidity 80 ± 5% were used. Statistical analysis indicated significant difference between prey types and the three different temperatures. The shortest life cycle was recorded on A. siro (11.60 and 8.0 days) at 32°C, while the longest was on C. berlesei (29.5 and 21.2) at 22°C for females and males, respectively. Longest female longevity was on A. siro (43.6 days) at 22°C and shortest was 20.65 days on T. putrescentiae at 32°C. Highest fecundity was found on A. siro (196.50 eggs/female) at 27°C and lowest one was 69.10 eggs/female on C. berlesei at 22°C. The highest net reproduction rate of increase (R0) was 113.2 female/generation at 27°C on A. siro. Obtained results suggested that C. malaccensis could develop and reproduce within a wide range of temperatures and prey types. It can also be used as a biological control agent to reduce the amount of acarid mite pests that infest stored commodities.

Introduction

Stored product mites pollute stored grain products used for human consumption, cheeses, animal feed, and dried fruit [1]. The stored product mites change the quality of infected food by the production of secrets and feces [2]. The mites become an important pest of stored products when populations reach high densities at humid climate. The level of damage caused by mites is related to the size of the population that, in turn, depends on how rapidly the population is able to increase [3].

The acarid mite, Tyrophagus putrescentiae (Schrank) inhabits different natural habitats, infesting many commodities, such as wheat, dried fruits, mushrooms, oil seeds, cheese, dried ham and grain debris [1]. Acarus siro (Linnaeus), also known as the flour mite is an economically important pest of stored food products (e.g. farm products, cheese, harvested cereals, hay, grass, soil, and the nests of birds and mammals) worldwide. This is partly due to its effect on germination and the nutritive value of grain (e.g [1,4]). The two acarid mites, A. siro and T. putrescentiae decreased germination form 20 to 70% for cereals and from 4 to 100% for vegetables [5]. The effect of C. berlesei on some stored products (soybean, wheat, maize and fishmeal) on some chemicals change...
was studied by Gamal Eldin et al. [6]. This mite decreased protein content, but fiber were increased.

_Cheyletus malaccensis_ Oudemans was recorded in Egypt firstly associated with stored grain and seed pests [7]. Also, this mite was recorded associated with stored products and house dust in the Philippines and in India [8,9].

The predatory mite, _C. malaccensis_ commonly found in grain storage, is a potential natural enemy of stored-product pests [10]. It was generalist predator fed on stored-product pests, such as _A. siro_, _Aleuroglyphus ovatus_ (Troupeau), _Caloglyphus redickorzevi_ (Zachvatkin), _Caloglyphus rodriguezi_ Samsinak, _Lepidoglyphus destructor_ (Schrank), _Rhizoglyphus echinopus_ Fumouze and Robin, _T. putrescentiae_, and small insects such as eggs, young larvae or nymphs of moths and beetles [1,11,12].

_Cheyletus malaccensis_ has arrhenotokous reproduction; fertilized females produce offspring of both male and female, while the unfertilized females produce only males. The temperature has an impact on its survival, lifespan, fertility, and activity in biological control [13,14].

Initial studies on the mite life history were carried out by Zaher and Soileman [15]. Various biological aspects were followed by several authors (e.g. [10–12,14,16–19]).

Several researchers used various cheyletid mites in biological control strategies which resulted in significant reduction percentages of insect and mite pests [13,20].

The present study aims to elucidating the influence of three constant temperatures (22, 27 and 32°C) on biology and life table parameters of _C. malaccensis_ feed on three astigmatid mites: _A. siro_, _C. berlesei_ and _T. putrescentiae_.

**Materials and methods**

**Prey mite culture**

Three astigmatid mites _Acarus siro_ (Linnaeus), _Caloglyphus berlesei_ (Michael) and _Tyrophagus putrescentiae_ (Schrank) cultures were established from samples pre-collected from stored grains at Qaha city in Qalyubia Governorate. The mites were mass-reared on wheat bran and dried yeast media with ratio of (4:1 wt) in plastic containers (11 × 8 × 3 cm) soaked with distilled water on another plastic containers. The rearing container were covered by muslin to allow ventilation and prevent the mites escaping. The container’s bottoms were covered with a layer of mixture of cement and charcoal with ratio of (9:1) and a depth of one cm. The cells were kept in a climatic chamber at 28°C, 80% RH., for six months before the study started at Qaha Agriculture Research Station, Qalyubia governorate, Plant Protection Research Institute, Agricultural Research Center, Egypt.

**Predator mite culture**

The predatory mite, _Cheyletus malaccensis_ Oudemans was collected from wheat grain at Qaha city, Qalyubia governorate, Egypt. Cultures were maintained in the same containers filled with mixed of three acarid mite diets and wheat bran in the same condition. Mite identification was conducted according to the world references keys [1].

**Experimental unites**

The experimental unites were black plastic cells each was (5 cm diameter and 2 mm in height), covered with glass cover slip. A circular hole was drilled in the center of each plate (1.5 cm in diameter and 1.5 mm in height). The study was conducted in an incubator at three constant temperatures (22, 27 and 32 ± 1°C) and 80 ± 5% RH. The three prey species: _A. siro_, _C. berlesei_ and _T. putrescentiae_ (immature stages) were used to feed _C. malaccensis_ predator.

**Biological aspects of C. malaccensis**

To study the effect of prey species on biology and life table parameters of _C. malaccensis_, three groups of 40 newly deposited eggs were
singly transferred with a fine brush to plastic plate and subjected to different temperatures. After egg hatching, 20 immature stages of the three prey diets were added daily to each *C. malaccensis* until reaching adulthood. The egg incubation period, immature stages, survival rates and fecundity of females were recorded daily. A male was introduced to each plastic plate for mating and removed from the plate after the deposition of the first egg. Every plastic plate was examined daily to record the number of eggs laid until the female died.

**Life-table parameters**

Life-table parameters as defined by Birch [21] were calculated using a BASIC computer program [22]. Sex ratio from each experiment was determined by visual observation and life tables were constructed from the data obtained for developmental time of immature stages and adult characteristics. Whereas: The net reproductive rate is the mean number of female offspring produced per female \( (R_0) = \sum (lx \times mx) \), where 'mx' is female progeny per female; 'lx' is the rate of females survival; the mean length of generation period, expressed in days \( (T) = \sum (x \times lx \times mx)/\sum (lx \times mx) \); intrinsic rate of natural increase is a natural logarithm of the intrinsic rate of increase and indicates the number of times of population multiplication in a time unit \( (rm) = \ln (R_0)/T \); means time of population to double \( (DT) = \ln (2)/\text{rm} \) and the finite rate of increase is the multiplication per female in unit time of a population with a stable age distribution \( (\lambda) = \exp (\text{rm}) \).

**Statistical analysis**

The influence of prey species, developmental time, fecundity and duration of adult female reproductive stages were analyzed using One Way ANOVA and mean compared was conducted using Tukey’s HSD. Significance level was \( P > 0.05 \). Analysis was conducted using SAS program [23]. The relationship between the rate of development \( (Y) \) and temperature \( (X) \) (at a specific range) can be represented by a straight line resembled with the linear equation \( Y = a + bX \ °C \), a (intercept), b (slope of temperature) and \( X \) is the tested temperature °C. The threshold temperature for development \( (t_{\text{d}}) \) can be estimated using the equation, as \(-a/b \) (i.e. when \( Y = 0 \)). The reciprocal of the slope (b) of the straight line (i.e. \(1/b\)) is \( (K) \), which is the number of degree-days (DDUs) above \( (t_{\text{d}}) \) required by an animal to complete its development as physiological time [24,25].

**Results**

The cheyletid predatory mite *Cheyletus malaccensis* Oudemans males passed through four stages (egg, larva, protonymph, and adult) while female’s development passed through two protonymph stages before reaching adult.

**Developmental time and longevity of *C. malaccensis* male reared on different prey species at different temperatures**

The predatory mite *C. malaccensis* males completed its development on the astigmatid mites *Acarus siro* (Linnaeus), *Caloglyphus berlesei* (Michael) and *Tyrophagus putrescentiae* (Schrank). The results showed that all of the deposited eggs were hatched (100%). Developmental period (from egg to adult) of males was significantly affected by prey type and temperature (Table 1). Highly significant differences were obtained between the incubation periods of eggs of *C. malaccensis* males, the shortest period was 2.0 days at 32°C on *A. siro*, while the longest one was 5.30 days at 22°C on *C. berlesei*. The *A. siro* shortened the duration of male immature stages to 7.15 and 12.85 days at 27 and 22°C, but the longer immature stages was respectively 12.10 and 15.90 days when fed *C. berlesei*. The short life cycle of *C. malaccensis* male was 8.0 days on *A. siro* at 32°C, while the longest period was 21.20 days on *C. berlesei* at 22°C.
The longevity of *C. malaccensis* male was affected by prey diets and temperature, the longest period was 22.10 days when fed on *A. siro*, while the shortest was 15.80 days when fed on *C. berlesei* (Table 1).

### Effect of prey diets on *C. malaccensis* male

The durations of all developmental stages were longer on *C. berlesei* followed by *T. putrescentiae*, whereas the shorter periods were on *A. siro*. The finding in Table 2 showed that the average immature stages of *C. malaccensis* were affected by prey diets; it was the shortest on *A. siro* (8.66 days) and the longest on *C. berlesei* (11.83 days). While longevity was longest when fed on *A. siro* (17.33 days) and shortest respectively on *C. berlesei* and *T. putrescentiae* (14.16 and 15.03 days). These results indicated that the acarid mite, *A. siro* is more favored prey for *C. malaccensis* than other diets.

### Effect of temperature on *C. malaccensis* male

Results presented in Table 2 clarified that the optimum temperature for development of *C. malaccensis* was 32°C as the predator developed faster than other temperatures. At all three constant temperatures, there were highly significant variations between immature and adult stages. These results indicated that the temperature affected on duration of predator male than prey diets.

### Developmental time and longevity of *C. malaccensis* females reared on different prey species at different temperatures

The results in Table 3 indicated that developmental period (from egg to adult) of females was significantly affected by both prey types. Highly significant differences between different incubation periods of eggs of *C. malaccensis*;
the shortest period was 2.20 days at 32°C on *A. siro*, while the longest one was extended to 5.55 days at 22°C when fed *C. berlesei*. The shortest protonymph and deutonymph periods of predatory mite female was 2.50 and 3.20 days at 32°C when fed *A. siro*, while, the longer period obtained was 7.65 and 7.85 days at 22°C, respectively when fed on *C. berlesei*. The short life span and generation period of *C. malaccensis* female was 11.60 and 13.40 days when prey on *A. siro* at 32°C, while the longest one was 29.50 and 36.50 days when prey on *C. berlesei* at 22°C, respectively.

Significant differences were also found between adult female longevities and oviposition periods. The *A. siro* was more favored to the predatory mite followed by *T. putrescentiae* and *C. berlesei*. In addition, significant differences occurred between the three prey diets on female fecundity, the highest one was observed on *A. siro* was (196.5 eggs/♀) with daily rate of 10.15 eggs/♀/day at 27°C and the lowest rate was on *C. berlesei* was (69.10 eggs/♀) with daily rate of 4.72 eggs/♀/day at 22°C. Also the life span of *C. malaccensis* female was affected by temperature, the longest and shortest periods when fed on *A. siro* (68.05 and 33.80 days) at respectively 22 and 32°C (Table 3).

**Effect of prey diets on *C. malaccensis* female**

The obtained results indicated that biological aspects of a predator could be affected by the nutritional history of its prey, for example, changes in the nutritional components of prey can affect the predator’s growth and reproduction.

Similar results were obtained with males; the durations of all developmental stages were longer on *C. berlesei* followed by *T. putrescentiae* however the shorter periods was when fed on *A. siro*. The finding in Table 4 showed that the average life cycle of *C. malaccensis* was affected by prey diets; it was the shortest on *A. siro* (16.93 days) and longer on *C. berlesei* (22.20 days). Despite female longevity was longer on *A. siro* (31.56 days) and shorter (27.63 days) on *C. berlesei*. The oviposition period was longer for females fed on *A. siro*, with a daily and cumulative fecundity being two times higher than females fed on *C. berlesei*. These results indicated that the acarid mite, *A. siro* is favored prey for the *C. malaccensis* females more than other prey diets.

**Table 3. Mean durations in days of Cheyletus malaccensis females reared with different prey diets at different temperatures and 80 ± 5% R.H.**

| Variable                  | A. siro | C. berlesei | T. putrescentiae |
|---------------------------|---------|-------------|-----------------|
| Incubation period         | 22°C    | 27°C        | 32°C            |
|                           | 5.35    | 3.25        | 2.20            |
| Larva                     | 8.80    | 4.20        | 3.70            |
| Protonymph                | 5.10    | 3.15        | 2.50            |
| Deutonymph                | 5.20    | 4.15        | 3.20            |
| Immature stages           | 19.10   | 11.50       | 9.40            |
| Life cycle                | 24.45   | 14.75       | 11.60           |
| Generation period         | 29.85   | 18.80       | 13.40           |
| Pre-oviposition           | 5.40    | 4.05        | 1.80            |
| Oviposition               | 25.30   | 19.40       | 17.20           |
| Post-oviposition          | 12.90   | 5.45        | 3.20            |
| Longevity                 | 43.60   | 28.90       | 22.20           |
| Mean fecundity (eggs/♀)   | 118.0   | 196.5       | 167.5           |
| Daily rate (eggs/♀/day)   | 4.68    | 10.15       | 9.80            |
| Life span                 | 68.05   | 43.65       | 33.80           |
Table 4. Effect prey diets on durations of Cheyletus malaccensis females at different temperatures.

| Stage             | Prey diets             | Temperatures |
|-------------------|------------------------|--------------|
|                   | A. siro               | 22°C         | 27°C         | 32°C         |
| Egg               | 3.60 a                 | 5.46 a       | 3.30 b       | 2.46 c       | 574.5 | 0.0001 |
| Larval            | 5.56 b                 | 8.35 a       | 5.30 b       | 3.98 c       | 332.4 | 0.0001 |
| Protonymph        | 3.58 c                 | 6.58 a       | 4.76 b       | 3.18 c       | 197.5 | 0.0001 |
| Deutonymph        | 4.18 c                 | 6.58 a       | 5.11 b       | 3.70 c       | 173.9 | 0.0001 |
| Immature stages   | 13.33 c                | 21.51 a      | 15.18 b      | 10.86 c      | 462.0 | 0.0001 |
| Life cycle        | 16.93 c                | 26.98 a      | 18.48 b      | 13.33 c      | 777.3 | 0.0001 |
| Generation        | 20.68 c                | 33.28 a      | 23.60 b      | 16.35 c      | 1024  | 0.0001 |
| Pre-oviposition   | 3.75 c                 | 6.58 a       | 5.11 b       | 3.70 c       | 173.9 | 0.0001 |
| Oviposition       | 20.63 a                | 20.16 a      | 16.50 b      | 15.01 c      | 60.56 | 0.0001 |
| Post-oviposition  | 7.18 b                 | 12.56 a      | 5.85 b       | 4.55 c       | 329.0 | 0.0001 |
| Longevity         | 31.56 a                | 39.03 a      | 27.46 b      | 22.60 c      | 225.4 | 0.0001 |
| Fecundity         | 160.66 a               | 121.9 b      | 139.2 a      | 93.46 c      | 90.39 | 0.0001 |
| Daily rate        | 8.21 a                 | 8.04 a       | 8.04 a       | 4.66 c       | 112.4 | 0.0001 |
| Life span         | 48.50 a                | 66.01 a      | 45.95 b      | 35.93 c      | 698.7 | 0.0001 |

Means followed by same letters do not differ significantly by Tukey’s HSD (P < 0.05).

Effect of temperature on biological aspects of C. malaccensis female

The developmental time of C. malaccensis was significantly decreased as the temperature increase. Results obtained in Table 4 explained that the optimum temperature for development was 32°C as the predator developed faster than other temperatures. The results also showed that developmental time, lifespan, oviposition period, and fecundity of C. malaccensis were all affected by temperature.

The mean total and daily fecundity of C. malaccensis fed on various diets are given in Table 4. The highest total egg production was at 27°C (139.2 eggs/♀) with a daily rate of (8.04 eggs/♀/day), followed by (121.9 eggs/♀/day) at 22°C and the lowest at 32°C (93.46 eggs/♀). These results indicated that the temperature affected the duration of predator females than prey diets.

Table 5. The accumulated day degrees (K) ranged between 37.37 and 301.06 DDUs from egg to adult. The values of coefficient of determination (the proportion of variation in the dependent variable that can be explained by the independent variable) R² of C. malaccensis ranged between 0.92 and 1.0.

Effect of prey types on life table parameters

The evaluation of C. malaccensis life table parameters at various temperatures are shown in Table 6. The shortest mean generation time (T₀) was observed when fed on A. siro was (18.6 days) at 32°C, while the longest (36.26 days) was recorded when fed on C. berlesei at 22°C. Whereas, the shortest time for population density doubling (DT) was 2.70 days at 27°C when fed on T. putrescentiae, while the longest period (7.70 days) was at 22°C when fed on C. berlesei. The maximum net reproductive rate (R₀) (113.2 ♀/♀/generation) was occurred on A. siro at 27°C recorded, while the lowest value (26.94 ♀/♀/generation) when fed on C. berlesei at 22°C.

The maximum intrinsic rate of natural increase (r_m) when the difference between birth rate and death rate was obtained at 27°C when fed on T. putrescentiae was (0.256 individuals/♀/day) followed by (0.233 individuals/
Table 5. Parameters of linear regression model for temperature-dependent developmental rates of immature stages of Cheyletus malaccensis females reared on different prey species.

| Stage          | Prey           | a      | b    | t₀    | K     | R²  |
|---------------|----------------|--------|------|-------|-------|-----|
| Egg           | A. siro        | -0.406 | 0.027 | 15.18 | 37.37 | 1.00|
|               | C. berlesei    | -0.230 | 0.019 | 12.12 | 52.58 | 0.98|
|               | T. putrescentiae | -0.294 | 0.022 | 13.48 | 45.83 | 1.00|
| Larval        | A. siro        | -0.216 | 0.016 | 13.76 | 63.84 | 0.90|
|               | C. berlesei    | -0.150 | 0.012 | 12.55 | 83.51 | 0.98|
|               | T. putrescentiae | -0.135 | 0.012 | 11.41 | 84.24 | 0.99|
| Protonymph    | A. siro        | -0.246 | 0.020 | 12.07 | 49.04 | 0.99|
|               | C. berlesei    | -0.157 | 0.013 | 12.46 | 79.56 | 0.92|
|               | T. putrescentiae | -0.251 | 0.017 | 14.36 | 57.27 | 0.97|
| Deutonymph    | A. siro        | -0.076 | 0.012 | 6.32  | 83.20 | 0.99|
|               | C. berlesei    | -0.140 | 0.012 | 11.98 | 85.83 | 0.91|
|               | T. putrescentiae | -0.099 | 0.011 | 8.70  | 87.79 | 1.00|
| Immature stages | A. siro       | -0.064 | 0.005 | 11.84 | 185.09| 0.97|
|               | C. berlesei    | -0.050 | 0.004 | 12.35 | 248.67| 0.94|
|               | T. putrescentiae | -0.052 | 0.004 | 11.74 | 225.24| 0.99|
| Life cycle    | A. siro        | -0.057 | 0.005 | 12.66 | 220.72| 0.99|
|               | C. berlesei    | -0.041 | 0.003 | 12.34 | 301.06| 0.97|
|               | T. putrescentiae | -0.045 | 0.004 | 12.14 | 270.00| 1.00|

Table 6. Life-table parameters of Cheyletus malaccensis reared on different prey species and different temperatures.

| Parameter                          | A. siro | C. berlesei | T. putrescentiae |
|-----------------------------------|---------|-------------|------------------|
| Mean generation time (TG)b        | 33.05   | 21.89       | 18.06            |
| Survival rate %                   | 70.0    | 80.0        | 60.0             |
| 50% mortality                     | 49.0    | 34.0        | 28.0             |
| Sex ratio (females/total)         | 0.70    | 0.72        | 0.65             |
| Net reproductive rate (R₀)b       | 58.21   | 113.2       | 67.66            |
| Intrinsic rate of increase (r₀)c  | 0.122   | 0.216       | 0.233            |
| Finite rate of increase (λ)       | 1.13    | 1.24        | 1.26             |
| Doubling generation (DT)a         | 5.68    | 3.20        | 2.97             |
| Gross reproduction rate (GRR)d     | 85.65   | 147.6       | 117.4            |

22°C when fed on A. siro. Daily age-specific survival rate ranged from 60.0 to 80.0%. The sex ratio ranged from 0.60 to 0.72 female/total not affected by temperature and prey diet (Table 6).

Age specific survival rate of C. malaccensis reared on different prey and temperature

Age specific survival rate (lx) and fecundity (mx) curves for C. malaccensis are shown in Figure 1. The daily age-specific survival rate was highest at 27°C and decreased as the temperature
increased on the three prey species, all of the deposited eggs hatched (100%). The maximum number of eggs produced (day 23: 10.99 egg/♀/day) when fed on A. siro at 32°C, the lowest (day 38: 3.66 egg/♀/day) when fed on C. berlesei at 22°C. The highest survival rate of females was 80% when fed on A. siro at 27°C, while lowest value was 0.60% when fed on C. berlesei at 22°C.

Discussion

The predatory mite C. malaccensis abled to survive and reproduce on A. siro, T. putrescentiae and C. berlesei. The findings agree with that of [11] who found T. putrescentiae immatures are more preferable food for C. malaccensis. On the contrary, Aleuroglyphus ovatus (Troupeau) and Caloglyphus redickorzev Zach. are more preferable than T. putrescentiae [16]. In the current study, C. malaccensis feed well on A. siro than other prey species. The optimum temperature for its development was 32°C as developed faster than other on other temperatures. Whereas, the survival rate was highest at 27°C then decreased as the temperature increased on all prey species. Similar results obtained by [19] indicated the values of age-specific fecundity (high to low) were 28°C > 24°C > 30°C > 32°C > 22°C. Previously published works on C. malaccensis [12] indicated a significant difference in the duration of the egg–adult period which was shorter when feeding on T.

Figure 1. Age-stage specific survival rate ($L_x$) and fecundity ($M_x$) curves of Cheyletus malaccensis at different temperatures.
putrescentiae than Caloglyphus rodriguezi Samsinak. The shortest life cycle averaged 16.3 days at 24°C and 85%RH, while the longest was 18.6 days at 24°C and 65% RH. The female fecundity, oviposition period and daily fecundity were respectively 493.0, 46.2 d, and 10.3 at 85% RH [10]. The shortest incubation period was at 32°C and the longest was at 22°C in both females and males. The life cycle ranged from 11.10 to 27.50 days for females and 8.80 to 22.71 days for males at 22°C [19].

In this study the thermal factor had a negative relationship with duration of each stage as increasing temperature rapped development and shortened egg-adult duration. The present results are almost agree with the findings of [17] who indicated that lower and upper developmental thresholds ranged between 11.6–12.0 and 37.4–37.8°C, respectively. The thermal constant ranged between 238.1 and 312.5 degree-days. Based on the data of the total pre-imaginal period, immatures survival peaked at 25°C and $R^2$ ranged between 0.94 to 0.99.

The relationship between temperature and rate of development in insects and mites is typically estimated as linear, whereas it is really curved [26].

According to effect of temperature and prey diet on life table parameters of C. malaccensis in the current study, the highest ($r_m$) and finite rate of increase ($\lambda$) was obtained at 27°C when fed on T. putrescentiae. These results are in coincidence with that of [13] who found that rising temperature faster the natural increase of C. malaccensis feed acarid mites and helped to double its numbers in a shorter time. The intrinsic rate of population increase ($r_m$) of C. malaccensis was strongly affected by temperature increase from 17.5°C to 32.5°C, while the ($r_m$) was 0.213 individuals/♀/day for C. malaccensis at 32.5°C [14]. The prey species obviously affected $r_m$ value of C. malaccensis (0.059 individuals/♀/day) when feed T. putrescentiae. The highest finite rate of increase ($\lambda$) was (1.062) when C. malaccensis individuals feed T. putrescentiae [12]. The mean generation time was 30.3 and the finite rate of increase was 1.09 when feed T. putrescentiae and A. siro [18]. The highest net reproductive rate ($R_0 = 290.25$) and highest fecundity (544.52) occurred at 28°C, as temperature significantly affected the intrinsic rate of increase ($r_m$) and fecundity [19]. The sex ratio of C. malaccensis offspring and mortality were not significantly influenced by temperature [17].

**Conclusion**

From the obtained results it can be concluded that 27°C is satisfactory temperature than 22 and 32°C for population increased of C. malaccensis when reared on A. siro. These findings can be used to forecast population dynamics, as well as to guide mass rearing and use of C. malaccensis predator to reduce stored-product pests. It can also be used in Egypt as a biological control agent to reduce the amount of acarid mite pests that infest stored commodities.

**Disclosure statement**

No potential conflict of interest was reported by the author(s).

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