Effect of temperature variability on predatory mite, *Hemicheyletia congensis* (Cunliffe) (Acari: Actinidida: Cheyletidae) feeding on *Petrobia tritici* Kandeel, El- Naggar & Mohamed (Acari: Tetranychidae)

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ABSTRACT

Temperature is a vital environmental factor affecting the biological control agent, *Hemicheyletia congensis* (Cunliffe) (Acari: Cheyletidae). Biological aspects and life table parameters of *H. congensis* were studied under laboratory conditions at 20, 25 and 30°C and 65% R.H. It was fed on *Petrobia tritici* Kandeel, El- Naggar & Mohamed (Acari: Tetranychidae), a pest of wheat. Developmental durations of different stages decreased as temperature increased and were fitted to the linear regression model with R^2 values ranged between 0.82 to 0.99 (mean 0.94) and zero developmental time between 5 and 12°C (mean 8.74°C).The maximum oviposition rate of 98.6 eggs/female was at 25°C followed by 86.2 at 30°C and 68.5 at 20°C. Life table parameters showed highest value for the Net reproductive rate (R_o) as 62.84 at 25°C. Highest intrinsic rate of natural increase (r_m) was reached as 0.220 at 30°C while lower r_m values as 0.109 and 0.165 at 20 and 25°C, respectively. The survival rate from egg to adult was 0.75, 0.90 and 0.80, at tested temperatures, respectively. Sex ratios were 0.70, 0.75 and 0.70 respectively. Time for population doubling was determined as 6.35, 4.20 and 3.15 days, respectively. *H. congensis* had the highest predation capacity at 25°C as 419.3 prey immatures per females and 299.7 for males, during predators' life span. The number of prey consumed during predator total immatures averaged 50, 104.5 and 71 prey for predator female and 41.7, 104.2 and 62.1 prey for predator male, respectively. Results indicated the possibility of mass rearing of *H. congensis* at 25°C for further studies.

Key words: wheat, cheyletid, mite, biology, life tables, Tetranychidae.

INTRODUCTION

Wheat, *Triticum aestivum* L. is the main stable food crop in Egypt and source of energy (carbohydrate) and contains high amounts of nutrients such as proteins, fiber, lipids, vitamins, minerals, and phytochemicals which may contribute to a healthy diet (Shewry and Hey 2015).

Various arthropods factors lead to serious damage to wheat crops throughout their life stages. Among these factors, mites of the family Tetranychidae which known as spider mites; pests in agricultural and forestry ecosystems, can be found on many field crop, fruit trees, vegetables, ornamental plants and also in large numbers in wheat crops (Royer 2009). These mites are more likely to cause injury in wheat that is stressed from lack of moisture or nutrients. From those, Brown wheat mite, *Petrobia tritici* Kandeel; El- Naggar and Mohamed (Acari: Tetranychidae) that can build up large populations and infest wheat through feeding on leaves by piercing plant cells from wheat leaf which results in leaf yellowing and in wilting and dying of plants and capable of reducing wheat yields and this species described from wheat, barley, sorghum, sugar beet, clover, lupine, garlic and onion, Sharkeia Governorate, Egypt (Kandeel et al. 2007).

Brown wheat mites usually have different generations per season. It is considered sap-sucking pest of cereals that is most active in dry warm weather (Omar and Mesbah 2015)

Predaceous mites of the family Cheyletidae showed a remarkable variability in their predation habits, including acaridida mites as well as, phytophagous mites such as spider and tenuipalpid mites, (Hassan et al. 2014; Carrillo et al. 2012; Mesbah and Omar 2014).

Listed cheyletid mites published by the genus *Hemicheyletia* have three subgenra, *Cheletominus*, *Hemicheyletia* and *Philippicheyla* (Gerson et al. 1999).

The most recent review of cheyletid mites in Egypt was published by Negm and Mesbah (2014) since Zaher (1986). They reported that the family Cheyletidae (Acariformes: Actinidida) contains twenty-seven nominal species within 15 genera. They indicated that this area is rich in cheyletid species. Further and extensive studies are recommended for other cheyletid genera and species which inhabit different environments.

Cheletomorpha lepidopterorum (Shaw) (Acari: Cheyletidae) was reared on immature stages of different mite diets belonging to suborder Astigmata (*Tyrophagus putrecentiae* (Schrank), *Lepidoglyphus destructor* (Schrank), *Rhizoglyphus echinopus* (Fumouze and Robin) and *Caloglyphus betae* Attiah) at different temperatures (20, 25 and 30°C) and (70 – 80 %R.H.) (Yassin et al. 2008). Also *C. lepidopterorum* was reared on nymphal stages of acarid mite, *Tyrphagus putrescentiae* at three different temperatures (15, 25 and 35°C) and 65 ± 5% R.H. in the laboratory (El-Naggar et al. 2006). The tested temperatures showed a noticeable effect on the individually development of predator and the temperature 15°C was the suitable for predator fertility and food consumption (El-Naggar et al. 2006 and El-Enany et al. 1992).

Biological aspects of *C. lepidopterorumn* were determined on three different immature stages of two acarid mites (the seed wheat mite, *Goheria wahabeii* El-Naggar, Taha & Hoda and the storage grain mite, *Blomia tropicalis* Bronswijk at 20°C and 60% R.H in the laboratory (Mesbah et al. 2017).

The relationship between temperature and the population growth rate of *Cheyletus malaccensis* Oudemans was studied as useful for predicting its population dynamics. Age-stage, two-sex life tables of the predator, *C. malaccensis*, reared on *Acarus siro* were conducted under laboratory conditions at 22, 24, 28, 30, and 32°C, and 75% relative humidity (Sun et al. 2020).

The present study aims to evaluate the ability of the predatory mite, *Hemicheyletia congensis* to feed and development on the brown white mite *P. tritici* as a biocontrol agent under laboratory conditions.

MATERIAL AND METHODS

Stock colonies of *Hemicheyletia congensis*:-

The individuals of the predatory mite, *Hemicheyletia congensis* were maintained for three months before the beginning of the experiment feeding on astigmatid mite stages, *Lepidoglyphus destructor*. It was mass reproduced on a mix of yeast granules-wheat germ-bran as a food source. *L. destructor* taken for rearing on cages filled with a substrate of a mixture of (Cement: Clay: Charcoal) with ratio of (1:2:7) filled on the bottom of cages to depth of 0.5 cm. Its bottom was scratched by using a needle to make convexo-concaved areas used as shelters and was suitable sites for predator mite rearing and laying eggs (Zaher et al. 1981and Hassan et al. 2014). Water drops was added when needed .The experiment was monitored twice daily.

Pure culture of the tetranychid mite, *Petrobia tritici*: The Brown wheat mite reared at 25°C on fresh mulberry leaves, *Morus alba* L. Each leaf was put on a pad of cotton saturated with water as a source of moisture and to prevent mite escaping.

Reproduction of *H. congensis* on *P. tritici*: Pure culture was initiated by transferring males and females of mite species using a fine hair brush to fresh discs of Mulberry leaves in Petri dishes (10cm in diameter). Each leaf was put on a pad of cotton saturated with water as a source of moisture and to prevent mite escaping. The rearing stocks were conducted in an incubator at 25±2°C and 70±5% relative humidity. Immature stages of phytophagous mite were supplied to predator mite when needed and Biological aspects recorded daily.

Statistical analysis: The relationship between temperature and mean developmental rate of each stage under teste temperatures was determined using linear regression (Y= a±bx, where: a = Intercept, b = slope of temperature). The lower developmental threshold t0 = - a/ b (°C) and thermal units K = 1/ b (in degree day units (DDUs)), where: to is developmental threshold °C; b is the developmental rate line slope and K is the developmental heat constant (DDUs) were determined. Life table parameters were done according to Birch (1948) using the Life48, BASIC, Computer Program (Abou-Setta et al. 1986). Food consumption and predation capacity were compared at the three temperatures using one way analysis of variance (ANOVA) using SAS statistical software (SAS Institute, 2003).

RESULTS AND DISCUSSION

Mating, egg deposition and hatching: Mating is necessary for egg depositing. It was noticed that *Hemicheyletia congensis* usually present around its prey, *Petrobia tritici*. When touched it, rapidly move backward and went back to attack it again. The predator seized firmly the prey with the aid of its raptorial pulps and sucked its contents by its chelicerae from any part of the body. The new hatched larvae were colorless; changed into yellow, then orange color beings appear at the end of the larval stage, becoming more intense at each succeeding stage. The color of emerging nymphs is usually orange, gradually becomes darker after feeding on *P. tritici*. Before proceeding to the following stage, active immature mites usually enter a quiescent (rest) stage. The mite tries to strip itself from the old skin by twisting movements and subsequently pull out the forelegs and anterior parts of the body from the old skin. Afterwards, it crawls forward trying to pull out the posterior part from the exuviate. Previous results clarified that *H. congensis* females and males were found to pass through one larval and two nymphal stages (protonymph and deutonymph) before reaching the adult stage when reared on *P. tritici* at different temperatures (Mahagoub et al. 2017).

Biological aspects: Mean obtained biological aspects of this predator are presented in Table (1). Increasing temperature showed a remarkable effect on all predator stages. Incubation periods were 5.6, 4.65 and 3.05 days for female at 20, 25 and 30°C, respectively. Life cycle 21.75, 17.97 and 12.23 days for male and 22.95, 18.08 and 12.0 days for female when the predatory mite, *H. congensis* reared on the three tested temperatures, respectively. Adult longevity lasted 28.75, 23.5 and 19.0 days for female and 21.1, 16.5 and 14.4 days for male, respectively. Females' fecundity averaged of 98.6 eggs at 25°C followed by 86.2 eggs at 30°C and 68.5 eggs at 20°C. Thus, 25°C was considered the suitable temperature for rearing of *H. congensis* on *P. tritici.*

Table 1. Mean biological aspects of *H Hemicheyletia congensis* reared on *Petrobia tritici* at different temperatures.

Biological aspects	Female			Male		
	20°C	25°C	30°C	20°C	25°C	30°C
Egg	5.60	4.65	3.05	5.20	5.20	2.90
Active larva	4.80	3.60	2.35	5.05	3.55	2.45
Quiescent larva	1.70	1.30	0.80	1.50	1.23	1.08
Active protonymph	4.40	3.20	2.10	4.30	3.20	2.30
Quiescent Protonymph	1.15	1.25	0.95	1.20	1.05	0.80
Active deutonymph	3.80	3.35	1.85	3.35	2.80	1.70
Quiescent deutonymph	1.50	0.73	0.90	1.15	0.95	1.00
Immature	17.35	13.43	8.95	16.55	12.78	9.33
life cycle	22.95	18.08	12.00	21.75	17.98	12.23
Generation	26.75	20.78	13.60	-	-	-
Preoviposition	3.80	2.70	1.60	-	-	-
Oviposition	20.80	17.40	14.70	-	-	-
Postoviposition	4.15	3.40	2.70	-	-	-
Longevity	28.75	23.50	19.00	21.10	16.50	14.40
Fecundity	68.50	98.60	86.20	-	-	-
Daily rate	3.30	5.72	5.88	-	-	-
Life span	51.70	41.58	31.00	42.85	34.48	26.63

Linear regression analysis values for developmental rates for *H. congensis* reared on *P. tritici* at different temperatures are presented in Table (2). Increasing temperature from 20 to 30°C cased significant reduction on all biological aspects of the predator with mean R^2 value of 0.94 and range of 0.82 to 0.99. The developmental threshold was determined as 12.0 and 9.33°C for female and male, respectively. Required degree days for both sexes were determined as 333.3 degree day units.

Life table parameters

Life table parameters of *H. congensis* reared on *P. tritici* are presented in Table (3) and illustrated in Figure (1). Life table parameters were estimated at tested temperatures as: mean generation time (T) as 31.82, 25.05 and 17.31days; net reproductive rate (R_o) as 33.07; 62.84 and 45.19 per generation; the intrinsic rate of natural increase (r_m) as 0.109; 0.165 and 0.220 individuals/female/day; finite rate of increase (λ) as 1.11, 1.17, 1.24 offspring/ individual/day; gross reproductive rate (GRR) as 45.54, 76.56 and 59.27 eggs/ individuals/ generation and doubling time (DT) as 6.35; 4.20 and 3.15 days, respectively. The results indicated that populations of *H. congensis* are able to reproduce at tested range of temperatures.

The age specific survivorship (l_x) and age-specific fecundity (m_x) curves for *H. congensis* are illustrated in Figure (1), the daily age-specific survival rate was highest at 25ºC and decreased as the temperature decreased. The maximum number of eggs produced at

25ºC (day 26: 5.55 eggs/♀/day, while these values at 30°C was (day 19: 5.25 eggs/♀/day), followed by (day 30: 3.36 eggs/♀/day) at 25°C. After that, egg production decreased gradually. The highest survival rate of females was 0.9% at 25°C, while lowest value was 65.0% at 25°C.

Table 2. linear regression analysis values for developmental rates for *Hemicheyletia congensis* reared on *Petrobia tritici* under laboratory conditions at different temperatures.

Stage	Variety	a	b	t_0	K	R^2
Egg	Female	-0.132	0.014	9.43	71.43	0.91
	Male	-0.098	0.013	7.53	76.92	0.82
Larva	Female	-0.183	0.016	11.44	62.50	0.95
	Male	-0.064	0.01	6.40	100.00	0.99
Protonymph	Female	-0.125	0.014	8.93	71.43	0.95
	Male	-0.055	0.011	5.00	90.90	0.99
Deutonymph	Female	-0.171	0.017	10.06	58.82	0.95
	Male	-0.084	0.014	6.00	71.43	0.94
Immature	Female	-0.05	0.005	10.00	200.00	0.94
	Male	-0.035	0.004	8.75	250.00	0.98
Life cycle	Female	-0.036	0.003	12.00	333.30	0.94
	Male	-0.028	0.003	9.33	333.33	0.93

Table 3. Life-table parameters of *Hemicheyletia congensis* reared on *Petrobia tritici* at different temperatures

Parameter	20°C	25°C	30°C
Mean generation time (T_G)[a]	31.82	25.05	17.31
Gross reproduction rate (GRR)[b]	45.54	76.56	59.27
Survival rate %	75.0	90.0	80.0
50% mortality	43	35	26
Sex ratio (females/total)	0.70	0.75	0.70
Net reproductive rate (R_o)[b]	33.07	62.84	45.19
Intrinsic rate of increase (r_m)[c]	0.109	0.165	0.220
Finite rate of increase (λ)	1.11	1.17	1.24
Doubling generation (DT)[a]	6.35	4.20	3.15

[a] Day, [b] per generation, [c] individuals/female/day

Predator's prey consumption:

The total number of prey consumed was variable according to difference of temperatures, (Table 4). Obtained results indicated that *H. congensis* females and males had highest predation capacity at 25°C as 419.3 for females and 299.7 for males during their life span. Number of prey consumed during predator total immatures averaged 50.0, 104.5 and 71.6 prey/female and 41.7, 104.2 and 62.1 prey/male when fed on tested temperatures, respectively. During adult longevity consumption was 156.3, 314.8 and 240.7 prey/female and 129.5, 195.5 and 131.5 prey/male on the same temperatures, respectively.

Means within rows followed by the same letter were not significantly different at the 5% level.

The present study presented the biology and effects of temperature variability on the biological aspects, life table parameters, predation capacity of cheyletid mite, *H. congensis* on three temperatures 20, 25 and 30°C at 65% R.H under laboratory conditions when fed on *P. tritici* infesting wheat plants. Obtained results should the ability of using it in the control of the wheat crop mite pest from 20 to 30°C at with optimal at 25°C.

Similar results were obtained by Mesbah et al. (2017) they studied biological aspects of *Cheletomorpha lepidopterorum* on the tetranychid brown wheat mite, *P. latens* at 20°C and 60% R.H under the laboratory. Mesbah and Omar (2014) reared *Cheletogenes ornatus* (Canestrini & Fanzago) on eggs and immatures of Tenuipalpid mite, *Raoiella indica* Hirst at (35± 2°C and 50±5% R.H.). Mahagoub et al. (2017) studied the effect the acarid mite, *Tyrophagous putrescentiae* and the free living nematodes, *Rhabditi scanica* (Allegan) as food at 25 and 35°C, and relative humidity 70% RH. on the biological aspects of *H. congensis*. Hassan et al. (2014) explained that *C. ornatus* (C&F) reproduced on crawlers of scale insect, *Hemberlisia lataniae* (Signoret); immatures of tetranychid mite, *Eutetranychus orientalis* (Klein) and acarid mite, *T. putrescentiae* at 20 and 25±2°C and 65±5% RH. Mesbah (2016) evaluated cheyletid mite, *C. ornatus* early release for overcoming *Tetranychus urticae* Koch on Soybean plants in Sharkia governorate.

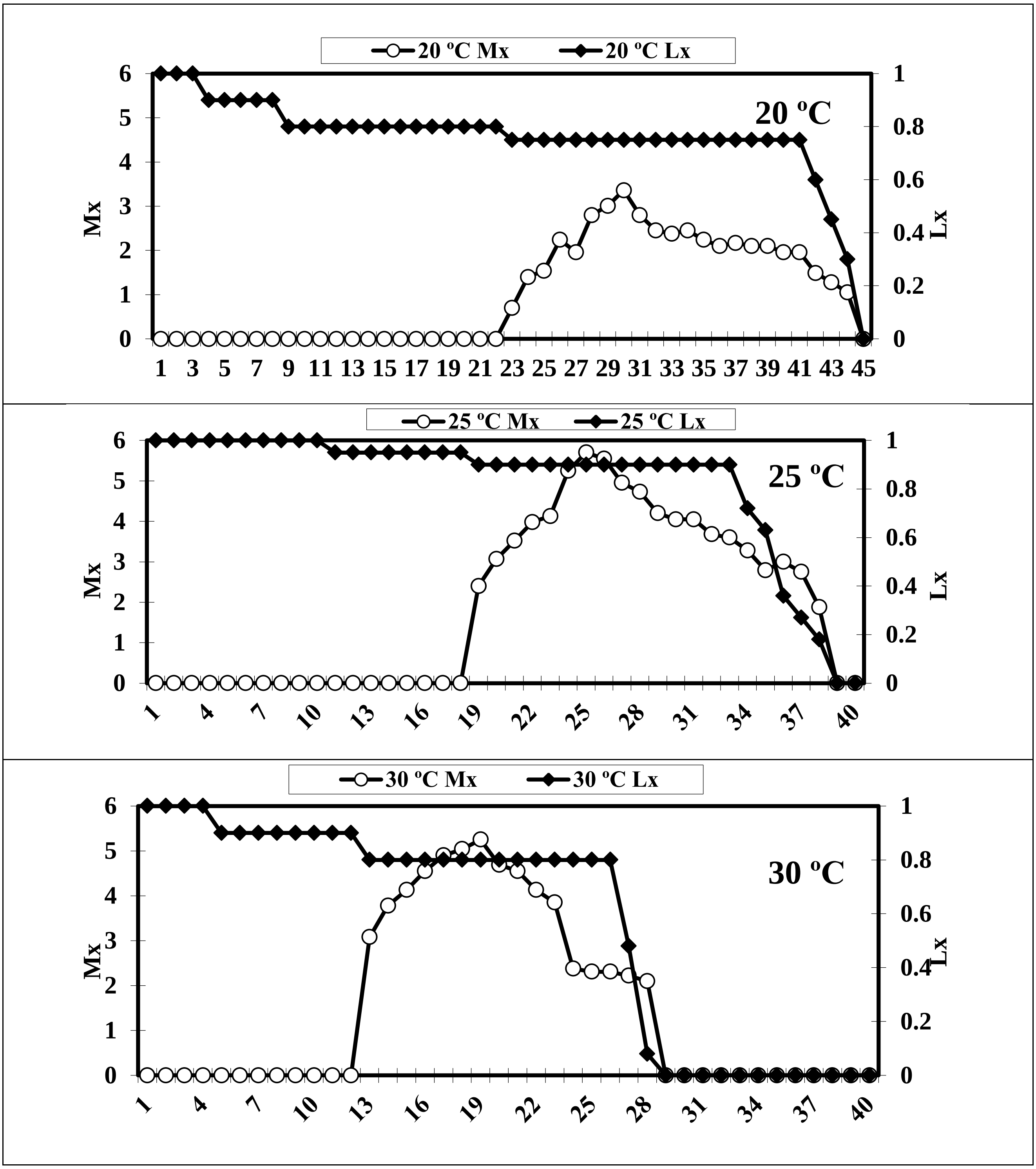

Figure 1. Age specific survivorship (l_x) and age-specific fecundity (m_x) for *Hemicheyletia congensis* reared on *Petrobia tritici* at different temperatures at 20, 25 and 30°C.

Table 4. Prey consumed (Mean ± SD.) of predatory mite *Hemicheyletia congensis* per female and male reared on *Petrobia tritici* under laboratory conditions at different temperatures

Developmental stages	20°C	25°C	30°C	F-value	P-value	L.S.D at $_{0.05}$
Female						
Larva	15.30 ± 1.16 c	25.00 ± 2.36 a	19.10 ± 0.88 b	93.48	0.0001	1.46
Protonymph	17.20 ± 1.03 c	36.50 ± 2.42 a	23.90 ± 1.10 b	355.2	0.0001	1.50
Deutonymph	17.50 ± 2.80 c	43.00 ± 3.50 a	28.60 ± 1.26 b	266.5	0.0001	2.46
Immature	50.00 ± 2.58 c	104.50 ± 4.9 a	71.60 ± 1.90 b	645.8	0.0001	3.13
Preoviposition	8.10 ± 2.33 c	12.10 ± 2.02 b	14.30 ± 2.45 a	19.07	0.0001	2.08
Oviposition	139.50 ± 4.5 c	291.5 ± 38.9 a	214.2 ± 10.4 b	105.7	0.0001	21.45
Postoviposition	8.70 ± 0.95 b	11.20 ± 1.69 a	12.20 ± 3.05 a	7.48	0.0002	1.91
Adult longevity	156.30 ± 4.8 c	314.8 ± 38.8 a	240.7 ± 12.1 b	112.6	0.0001	21.68
Life span	206.30 ± 6.6 c	419.3 ± 40.8 a	312.3 ± 13.1 b	181.03	0.0001	22.96
Male						
Larva	11.60 ± 0.97 c	20.00 ± 2.36 a	15.10 ± 0.74 b	75.94	0.0001	1.40
Protonymph	13.60 ± 0.52 c	41.50 ± 6.69 a	20.00 ± 2.36 b	126.8	0.0001	3.76
Deutonymph	16.50 ± 1.96 c	42.70 ± 2.91 a	27.00 ± 1.63 b	348.8	0.0001	2.04
Immature	41.70 ± 1.57 c	104.20 ± 8.7 a	62.10 ± 3.28 b	340.1	0.0001	5.01
Adult longevity	129.50 ± 3.7 b	195.50 ± 7.6 a	131.5 ± 8.18 b	305.0	0.0001	6.23
Life span	171.20 ± 4.5 c	299.7 ± 10.7 a	193.60 ± 9.6 b	621.7	0.0001	7.98

Omar and Mesbah (2015) investigated that *Amblyseius. cydnodactylon* (Shehata &Zaher) may be a considerable value for controlling *P.tritici* in Egypt.

In conclusion, obtained results determined the possibility of using the tetranychid mite species *P. tritici* as fprey for the mass-rearing of cheyletid predator *H. congensis*. Complementary studies for that species, as other factors could influence the suitability of spider mite, *P. tritici* and 25°C as optimal temperature for integrated pest management.

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