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Temperature Influence on Development and Life Table Parameters of the Acarid Mite, *Caloglyphus manuri* Eraky & Osman Reared on the Root-Knot Nematode, *Meloidogyne* sp.

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ABSTRACT

The effect of temperature on the biology and life table of *Caloglyphus manuri* Eraky & Osman fed on egg masses of the root knot nematode, *Meloidogyne* sp. was determined at 20, 25 and 30 ˚C. Its life cycle durated 13.50, 7.92 and 7.42 days for female and 12.65, 7.82 and 7.11 for male when fed at 20, 25 and 30˚C, respectively. Female life span averaged 40.70, 28.47 and 24.37 days; while that of male was 29.50, 26.22 and 16.41 days reared. The mean generation time (T) averaged 21.85,1 2.27 and 11.23 days; while the net reproductive rate (R_0) value was 106.51, 94.53 and 58.16 at the aforementioned temperature, respectively. The net rate of natural increase (r_m) was 0.213, 0.370 and 0.361 individual / ♀ / day, whereas the finite rate of increase (e^{rm}) averaged 1.23, 1.44 and 1.43 time / ♀ / day at 20, 25 and 35 ˚C, respectively.

Key Words: Biology, life table parameters, Acaridae, *Caloglyphus manure*, *Meloidogyne* sp.

INTRODUCTION

In Egypt, the root-knot nematodes, *Meloidogyne* spp. are considered to be the most economically important plant parasitic nematodes. Use of nematicides is one of the most reliable means of managing these pests but, their negative impact on the environment and human health and their expensive cost and short - term nematode suppression have led to regulatory restrictions in its use. New and more sustainable management strategies for plant-parasitic nematodes are urgently needed (Mahdy *et al*., 2006; Korayem *et al*., 2007 and El-Sherif & Ismail, 2009).

In the last decade, there are a lot of reports, mostly based on casual observations, indicating nematophagy as a common phenomenon among soil acarines. The nematophagous mites have been reported from diverse groups but most belong to order Mesostigmata Walter, (1988). Gerson *et al.* (2003) showed that nematophagous mites may be placed in three functional groups. The first one general feeders do not show preferences and devour any animals. They include members of most that mesostigmatid families. The second group are fungivores that also feed on algae and nematodes; they include the Acaridae, the Ceratozetidae and many prostigmatids. The third group is the specialised predators of nematodes, which placed in the families Eviphididae, Alicorhagiidae and Bimichaelidae.

There is a lack of information on the predatory activity of astigmatid mites on nematodes. Among these mites, *Caloglyphus manuri* Eraky & Osman has been reported preying on plant nematodes; Eraky and Osman (2008). Therfore present work aims to study the different biological aspects of *C. manuri* when fed on the egg mass of *Meloidogyne* spp. at three temperatures 20, 25 and 30 ˚C in the laboratory.

MATERIALS AND METHODS

The root-knot nematode stock:

A pure culture of the root- knot nematode¸ *Meloidogyne* sp. was initiated from a single egg-mass propagated on coleus plant, *Coleus blumei* L. cultivated in pots of 25- cm-d under green house conditions. Egg-masses were dissolved in 0.5% sodium hypochlorite, (Hussey and Barker, 1973) then Counting the collected eggs which amounted about 250 eggs / egg-mass.

The Acaridae mite culture:

Individuals of mite *C. manuri* were extracted from chicken manure in the poultry farm of the Faculty of Agriculture, Mansoura University and then cultured in the laboratory. Two types of plastic cells containing a floor of plaster of paris and charcoal were used. The big rearing cells (2.5 cm diameter and 2 cm deep) were used for laboratory culture. The small ones were (1 cm in diameter and 0.8 cm deep) were used in the biological experiments. A heavy glass cover was used for each cell to prevent mites escape. The plaster of Paris floor was kept moderately moist by adding droplets of water when needed.

Acaridid cultures were kept in big rearing cells representing three major groups according to the tested temperature degrees. 20, 25 and 30±1˚C. All groups were provided daily with egg masses of the root knot nematode, *Meloidogyne* sp. as prey to maintain an ample food supply.

Newly deposited eggs were singly transferred from the cultures to the small cells at the same temperature mentioned.

Data were recorded twice daily for the whole life span. Each experiment was started with 20 newly hatched larvae. Data were analyzed by one-way analysis of variance (ANOVA), and the means were separated using Duncan's multiple range test (CoHort Software 2004).

Life table analyses:

Life table parameters were calculated using a BASIC computer program (Abou-Setta and Childers 1986) for females reared on various tested temperature degrees. This computer program is based on Birch's method (1948) for the calculation of an animal's life table. Constructing a life table, using rates of age-specific (Lx), fecundity (Mx) for each age interval (x) was assessed. The following population growth parameters were determined: the mean generation time (T), gross reproductive rate (GRR), the net reproductive increase (R0), the intrinsic rate of increase (r_m) and the finite rate of increase (e^{rm}). The doubling time (DT), cohort generation time (T_c), capacity of increase (r_c), annual rate of increase (ARI) and weekly multiplication of the population (r_w) were calculated according to Laughlin (1965), May (1976) and Carey (1993). The life tables were prepared from data recorded daily on developmental time (egg to first egg laid), sex ratio, the number of deposited eggs, the fraction of eggs reaching maturity and the survival of females. An interval of one day was chosen as the age class for constructing the life table.

RESULTS AND DISCUSSION

Immature stages:

Table 1 showed that *C. manuri* female and male larvae hatched after 4.20 and 4.3 days at 20 °C; while 25 and 30 °C clearly accelerated. On the other hand, life cycle of *C. manuri* durated 13.50, 7.92 and 7.42 days for female and 12.56, 7.82 and 7.11 days for male at 20, 25 and 30 °C, respectively. Generally, male immatures had a shorter life cycle than the female immature. Similar results were obtained by Eraky (1987) when reared *Caloglyphus berlesei* (Mich.) on yeasted Drosophila, as life cycle durated 7.5 day at 26°C, Woodring (1969) stated that life cycle of *Caloglyphus anomalus* averaged 6.5 days at 23°C whereas, Walia and Mathur (1998) indicated that *Tyrophagous putrescentiae* (Schrank) female life cycle durated 13.12 days when reared on juveniles of root the knot nematode (*Meloidogyne javanica*). Chmielewski (2000) reported that female *C. berlesei* life cycle was 19.90 when feed on bee-bread; while in 2003, he found that its life cycle decreased to 17.7when reared on buckwheat sprouts at 20°C, and 95-100% R.H. Also, Eraky and Osman (2008) reported that female and male life cycle of *C. manure* was 10.40 and 8.10, respectively when reared on *Meloidogyne* sp. at 25°C**.**

Adult stage:

Table 2 showed that *C. manuri* females lived for longer time than males. Female began to deposit eggs after1.90, 1.35 and 1.10 days laying an average of 193.05, 168.80 and 111.70 eggs at 20, 25 and 30°C, respectively (Tables 2 and 5). The sex ratio was 0.58, 0.59 and 0.56 at the same temperatures. The adult female lived for 27.20, 20.55 and 16.95 days, and the lifespan averaged 40.70, 28.47 and 24.37 days for females and 29.50, 26.22 and 16.41days for males at 20, 25 and 30°C, respectively. Szlendak and Boczek (1992) showed that males of *Acarus siro* lived longer than females, since female lived about 15 days and males about 20 days at 25°C and 85% R.H. On the other hand, Woodring (1969) found that *C. anomalus* average female laid 930 and 545 eggs and lived for 23.4 and 18.5 days when fed on mealworms and yeast, respectively. In 1987, Eraky reported that *C. berlesei* deposited an average of 755.7 eggs in an average of 15.9 days. Walia and Mathur (1998) reported that *T. putrescentiae* (Schrank) female laid an average of 171.40 eggs when reared on juveniles of the root knot nematode, *M. javanica*.. Chmielewski (2000) recorded that mean total deposited eggs per female of *C. berlesei* was 221.70 when reared on bee-bread whereas in 2003, he reported that its fecundity averaged 237.4 eggs when reared on buckwheat sprouts. Also, Eraky and Osman (2008) stated that *C. manure* female of laid 601.40, 535.00 and 159.10 and lived 15.70, 11.60 and 17.80 days when fed on yeast, dry cheese and *Meloidogyne* sp., respectively.

On the other hand, tables 3&4 showed that feeding capacity of immature stages and adult of *C. manure* when reared on egg masses of the root knot nematode, *Meloidogyne* sp. was affected by different temperatures. Concerning prey consumption, data in table (3) clearly indicated that larva fed on an average of 1.37, 0.55 and 1.37 prey egg masses for female and 1.30, 0.50 and 0.82 for male at 20, 25 and 30°C, respectively. The same trend was also observed with the first nymphal stage where it devoured preys averaged 1.75, 0.60 and 1.75 egg massess for female and 1.65, 0.55. and 1.65 for male These values were 1.75, 0.60 and 1.75 for the predator deutonymph

Table (1): Duration in days of *Caloglyphus manuri* Eraky & Osman develomental stages fed on Meloidogyne sp. at different temperature

Temp.	Sex	Egg	Larva		Protonymph		Deutonymph		Total immature stage	Life cycle
			A	Q	A	Q	A	Q		
20	♀	4.20 ± 0.82^{a}	2.35 ± 0.97^{a}	1.10 ± 0.61^{a}	1.75 ± 1.93^{a}	1.15 ± 0.73^{a}	2.00 ± 1.29^{a}	1.05 ± 0.44^{a}	9.30 ± 2.43^{b}	13.50 ± 2.63^{a}
	♂	4.30 ± 0.94^{a}	2.05 ± 0.44^{a}	1.10 ± 0.61^{c}	1.35 ± 0.97^{a}	1.15 ± 0.73^{a}	1.60 ± 0.97^{a}	1.10 ± 0.61^{a}	8.35 ± 2.07^{a}	12.65 ± 1.75^{a}
25	♀	2.10 ± 0.61^{b}	$0.95 \pm 0.30_{b}$	0.87 ± 0.44^{b}	1.00 ± 0.55^{b}	1.05 ± 0.44^{a}	0.95 ± 0.30^{c}	1.00 ± 0.56^{a}	5.82 ± 1.13^{b}	7.92 ± 0.74^{b}
	♂	2.25 ± 0.88^{b}	0.92 ± 0.36^{b}	0.75 ± 0.51^{b}	0.95 ± 0.30^{b}	0.87 ± 0.44	1.15 ± 0.73^{b}	0.92 ± 0.67^{b}	5.57 ± 0.93^{b}	7.82 ± 1.03^{b}
30	♀	1.85 ± 0.73^{c}	1.10 ± 0.61^{b}	0.51 ± 0.25^{c}	1.30 ± 0.94^{b}	0.47 ± 0.15^{b}	1.70 ± 0.94^{b}	0.48 ± 0.41^{b}	5.57 ± 0.96^{b}	7.42 ± 0.77^{b}
	♂	1.61 ± 0.97^{c}	1.05 ± 0.44^{b}	0.47 ± 0.15^{c}	1.25 ± 0.88^{a}	0.51 ± 0.25^{c}	1.65 ± 0.97^{a}	0.52 ± 0.22^{c}	5.46 ± 1.33^{b}	7.11 ± 1.83^{c}

Table (2): Duration in days of *Caloglyphus manuri* Eraky & Osman adult stage fed on *Meloidogyne* spp. at different temperatures

Temp.	Sex	Preovi.	Ovip.	Postovi.	Longevity	Lifespan
20	♀	$1.90 \pm 0.70_{a}$	$19.30 \pm 1.79_{a}$	6.00 ± 0.91	$27.20 \pm 2.22_{a}$	40.70 ± 6.26
	♂	----------	----------	----------	$16.85 \pm 1.11_{a}$	$29.50 \pm 3.02_{b}$
25	♀	$1.35 \pm 0.97_{b}$	$11.65 \pm 1.18_{b}$	$7.55 \pm 1.15_{b}$	$20.55 \pm 1.86_{b}$	$28.47 \pm 6.24_{b}$
	♂	----------	----------	----------	$18.40 \pm 1.91_{a}$	$26.22 \pm 4.30a$
30	♀	$1.10 \pm 0.10_{b}$	$6.35 \pm 2.30_{c}$	$9.05 \pm 0.60_{a}$	$16.95 \pm 3.13_{b}$	$24.37 \pm 4.26_{b}$
	♂	----------	----------	----------	$9.30 \pm 2.36_{b}$	$16.41 \pm 3.02_{b}$

Table (3): Number of consumed *Meloidogyne* sp. egg masses by adult females and males of *Caloglyphus manuri* at three different temperatures

Temp (°C)	Sex	Larva		Protonymph		Deutonymph		Total immature stages	
		Total average	Daily mean	Total average	Daily mean	Total average	Daily mean	Total average	Daily mean
20	♀	1.37 ± 0.63^{a}	0.60 ± 0.36^{a}	1.75 ± 1.62^{a}	1.32 ± 1.13^{a}	1.75 ± 1.57^{a}	0.95 ± 0.93^{a}	4.87 ± 2.80^{a}	0.52 ± 0.27^{a}
	♂	1.30 ± 0.82^{a}	0.64 ± 0.42^{a}	1.65 ± 1.49^{a}	1.20 ± 0.05^{a}	1.60 ± 1.50^{a}	1.06 ± 1.01^{a}	4.55 ± 2.19^{a}	0.92 ± 0.92^{a}
25	♀	0.55 ± 0.20^{b}	0.52 ± 0.49^{a}	0.60 ± 0.34^{b}	0.60 ± 0.93^{b}	0.60 ± 0.43^{b}	0.62 ± 0.80^{a}	1.82 ± 0.82^{b}	0.32 ± 0.22^{b}
	♂	0.50 ± 0.22^{b}	0.50 ± 0.43^{a}	0.55 ± 0.38^{b}	0.60 ± 0.05^{b}	0.65 ± 0.47^{b}	0.62 ± 0.60^{b}	1.70 ± 0.66^{b}	0.56 ± 0.21^{b}
30	♀	1.37 ± 0.63^{a}	0.60 ± 0.36^{a}	1.75 ± 1.62^{a}	1.32 ± 1.13^{a}	1.75 ± 1.57^{a}	0.95 ± 0.93^{a}	4.87 ± 2.80^{a}	0.52 ± 0.27^{a}
	♂	1.30 ± 0.82^{a}	0.64 ± 0.42^{a}	1.65 ± 1.49^{a}	1.20 ± 0.05^{a}	1.60 ± 1.50^{a}	1.06 ± 1.01^{a}	4.55 ± 2.19^{a}	0.92 ± 0.92^{a}

Table (4): Number of consumed *Meloidogyne* sp. egg masses by adult females and males of *Caloglyphus manuri* at three different temperatures

Temp (°C)	Sex	Preovi.		Ovip.		Postovi.		Longevity		Lifespan	
		Total Average	Daily mean	Total Average	Daily mean	Total Average	Daily mean	Total Average	Daily mean	Total Average	Daily mean
20	♀	2.30 ± 0.84^{a}	1.50 ± 0.20^{a}	58.00 ± 4.55^{a}	4.07 ± 0.73^{a}	7.56 ± 0.82^{b}	2.06 ± 0.03^{b}	67.95 ± 4.80^{a}	2.89 ± 0.33^{b}	72.82 ± 4.78^{a}	2.12 ± 0.02^{a}
	♂	-------	-------	-------	-------	--------	--------	23.15 ± 1.52^{a}	0.78 ± 0.06^{b}	27.70 ± 1.20^{a}	1.78 ± 0.12^{a}
25	♀	$1.5 \pm 0.02b$	$1.22 \pm 0.09a$	$35.65 \pm 3.56b$	$3.71 \pm 0.52a$	18.15 ± 1.58	$5.52 \pm 0.30a$	55.30 ± 4.07^{b}	3.13 ± 0.29^{a}	57.12 ± 4.06^{b}	2.31 ± 0.16^{a}
	♂	-------	-------	-------	-------	--------	--------	$15.60 \pm 1.72b$	1.99 ± 0.64^{ab}	17.30 ± 1.63^{b}	1.32 ± 0.21^{a}
30	♀	$1.70 \pm 0.21b$	1.32 ± 0.08^{a}	12.10 ± 0.71^{c}	2.00 ± 0.07^{b}	8.65 ± 0.63^{b}	0.99 ± 0.08^{b}	22.45 ± 1.62^{c}	1.36 ± 0.07^{a}	$23.87 \pm 2.75c$	1.07 ± 0.05
	♂	-------	-------	-------	-------	--------	--------	9.70 ± 0.84^{c}	1.07 ± 0.08^{ab}	11.12 ± 1.01^{c}	1.34 ± 0.16^{a}

Means in each column having different letters are significantly different ($p < 0.05$)

Table (5): Effect of different temperatures on *Caloglyphus manuri* Eraky & Osman the life table parameters

Temp. °C)	Mean Total Fecundity	T	DT	R_0	r_m	e^{rm}	GRR	T_c	r_c	ARI	r_w
20	193.05 ± 13.39	21.85	3.25	106.51	0.213	1.23	127.21	24.95	0.187	7.20×10^{33}	4.25
25	168.80 ± 14.95	12.27	1.68	94.53	0.370	1.44	100.89	13.30	0.342	5.66×10^{58}	12.83
30	111.70 ± 4.62	11.23	1.91	58.16	0.361	1.43	61.68	11.79	0.344	2.24×10^{57}	12.22

female and 1.60, 0.65 and 1.60 for male at 20, 25 and 30°C, respectively (Table 3). Accordingly, *C. manure* immature consumed daily average of 4.87, 1.82 and 4.87 egg masses of *Meloidogyne* sp. for female and 4.55, 1.70 and 4.55 egg masses at the aforementioned temperatures, respectively. During oviposition period, the previous data showed no significant difference between 20, 25 and 30°C for the predator female feeding capacity. Adult female consumed 72.82, 58.12 and 23.87 egg masses of *Meloidogyne* sp. during its whole lifespan at 20, 25 and 30°C, respectively; while male consumed 27.70, 17.30 and 11.12 egg masses at the aforementioned temperatures, respectively.

Sell (1988) reported that *Sancassania* (= *Calaglyphus*) sp. fed on the root-knot nematodes *Meloidogyne* spp. Also, Walia and Mathur (1995) found that two nematophagous mites, *T. putrescentiae* and *Hypoaspis calcuttaensis,* were voracious feeders of nematodes consuming as many as 726 and 811 juveniles *Meloidogyne javanica* (Treub), respectively.

Life table parameters:

The calculated life table parameters which have been taken into consideration were: mean generation time (T), net reproductive rate (R_o), doubling time (DT), intrinsic rate of natural increase (rm), finite rate of increase (e^{rm}), gross reproductive rate (GRR), cohort generation time (T_c), capacity of increase (r_c), annual rate of increase (ARI) and weekly multiplication of the population (r_w) (Table 5).

Concerning life table parameters of *C. manure*, the present study indicated that thermal factor has a great influence. Table 5, obviously showed that the mean generation time (T) was significantly affected by temperature as (T) values averaged 21.58, 12.27 and 11.23days when *C. manure* was kept at 20, 25 and 30°C, respectively. These results revealed that increasing temperature shortened the mean generation time. The population of *C. manure* had the capacity to double every 3.25, 1.68 and 1.91 days when reared at aforementioned temperatures. Also, the net reproductive rate (R_o) was significantly affected by temperature as (R_o) values averaged 106.51, 94.53 and 58.16 when *C. manure* reared at 20, 25 and 30 °C, respectively. However, the intrinsic rate of natural increase (r_m) is a key demographic parameter useful for predicting the population growth potential of an animal under given environmental conditions (Birch 1948), because r_m reflects an overall effect on the development, reproduction and survival. Table (5) showed that r_m values were 0.213, 0.370 and 0.361 individuals/ female/day when *C. manure* was reared at 20, 25 and 30°C, respectively. Therefore, it could be concluded that the net rate of natural increase was highly influenced by thermal factor. As soon as the finite rate of increase ranged between 1.23 and 1.44 at the same temperatures. On the other hand, GRR of *C. manure* was 127.21, 100.89 and 61.68 at the same temperatures. Eraky (1995) found that net reproductive rate (R_o) and intrinsic rate of increase (r_m) were 80.24 and 0.09 whereas, the mean generation time (T) and doubling time (DT) were 49.29 and 7.70 when *T. putrescentiae* (Schrank) reared on the bird – cherry aphid *Rhopalosiphum padi* L. at 18°C; while, Al-Rehiayani and Fouly (2006) showed that *M. javanica* eggs was the most suitable food and supported the highest net reproductive rate (R_o) to two acarid mites *Mycetoglyphus qassimi* Fouly and Al-Rehiayani, and *T. putrescentiae*.

Pakyari and Maghsoudlo (2011) showed that the intrinsic rate of increase (r_m) and the net reproductive rate (R_o) for *T. putrescentiae* when reared on phytonematode, *Ditylenchus destrutor* Thome at 25°C were 0.16 and 22.28, respectively.

In the present study, cohort generation time (T_c) of *C. manure* was 24.95, 13.30 and 11.97 at 20, 25 and 30 °C, respectively; while capacity of increase (r_c) ranged between 0.187 and 0.344. Also, annual rate of increase (ARI) ranged between 7.20×10^{33} and 2.24×10^{57}. Whereas, weekly multiplication of the population (r_w) of *C. manure* was 4.25, 12.83 and 12.22 at 20, 25 and 30°C, respectively. As a result, it can be concluded that temperature has a considerable effect on the number of females, which can be added daily to the population that is represented by e^{rm} values.

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