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Influence of Prey Types on the Biological Characteristics of *Cosmolaelaps qassimensis* (Acarai: Laelapidae)

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ABSTRACT

The present study aims to determine different biological aspects of the new laelapidae mite *Cosmolaelaps qassimensis* which was collected from Qassim area in (2013-2014) and fed on the two acarid mites, *Tyrophagus putrescentiae* (Schrank) and *Caloglyphus rodriguez* Samsinak and compared with the egg masses of root-knot nematode, *Meloidogyne incognita* chitwood as food sources under laboratory conditions of $26\pm 1^{\circ}\text{C}$ and $70\pm 5\%$ RH. The incubation period of male and female eggs averaged 2.7 and 2.99 days, respectively. Female life cycle was significantly shorter when it fed on *T. putrescentiae* followed by *C. rodriguez* and then egg masses of *M. incognita*. Life span of female was sub-equal, when *C. qassimensis* fed on either *T. putrescentiae* or *C. rodriguez* and significantly shorter, than those on *M. incognita*. Male life cycle, longevity and life span were significantly shorter when *C. qassimensis* fed on *T. putrescentiae* followed by *C. rodriguez* and egg masses of nematode. The total number of eggs per female feeding on *T. putrescentiae* was significantly higher than on *C. rodriguez* and followed by *M. incognita*. Mean generation Time (T) and the time required for the population of *C. qassimensis* to double its number (DT) were shorter when it fed *T. putrescentiae* than on *C. rodriguez* and *M. incognita*. Net reproductive rate (R_0), the Gross Reproductive Rate (GRR), intrinsic rate of increase (r_m) and finite rate of increase (e^{rm}) were higher, when *C. qassimensis* fed *T. putrescentiae* and *C. rodriguez* while, these parameters were at their lowest rates, when *C. qassimensis* fed egg masses of *M. incognita*. *Tyrophagus putrescentiae* proved to be the most suitable food source to obtain the largest numbers of offspring of the predatory laelapidae mite *C. qassimensis*.

Key words: *Cosmolaelaps qassimensis*, acarid mites, root-knot nematode, biology, life table parameters

INTRODUCTION

The food sources for different groups of soil mites include nematodes, arthropods and plant roots (Inserra and Davis, 1983; Zaher, 1986). Their numbers could be related to the abundance of their food sources. Some of soil mites are effective predators capable of regulating and suppressing populations of their prey including plant parasitic nematodes (Al Rehiyani and Fouly, 2005; Mostafa *et al.*, 2013).

Beneficial soil mites, especially predatory species, must be conserved in the field to promote a more stabilized pest and natural balance (Abo-Taka *et al.*, 1992; Lobbes and Schotten, 1980).

Among the predatory mites, the mesostigmata represent an important component of the below ground food web, where they are generally considered to be predators feeding on small arthropods, worms and nematodes. Several predatory mites such as *Hypoaspis near aculeifer* (Inserra and Davis, 1983), *Cosmolaelaps simplex* (Berlese) (Al Rehiyani and Fouly, 2005), *Lasioseius scapulatus* (Kennet) (Imbriani and Mankau, 1983), *Lasioseius dentatus* (Fox) (Fouly, 1997) and *Lasioseius athiasae* Nawar and Nasr (Abou-Awad *et al.*, 2001) had the ability to capture, consume and complete its entire life cycle on nematode species.

Cosmolaelaps (Berlese) consists of a large group of free-living predators in soil. The laelapidae mite, *Cosmolaelaps qassimensis* is a new species which was recently recorded and identified by Fouly and Al-Rehiyani (2014), where its biology and life history has never been studied so far.

The objective of the present study was to determine different biological characteristics of *C. qassimensis* fed on the acarid mites, *Tyrophagus putrescentiae* (Schrank) and *Caloglyphus rodriguez* Samsinak in comparison with the egg masses of the root-knot nematode, *Meloidogyne incognita* Chitwood under laboratory conditions.

MATERIALS AND METHODS

Acarid mite and nematode cultures: Stock cultures of both acarid mite species were maintained in laboratory, provided with on mould cheese and pollen as food sources. Egg masses of root-knot nematode were provided from a culture of *M. incognita* maintained on tomato plants in the greenhouse of Nematology Branch, Faculty of Agriculture and Veterinary Medicine, Qassim University in 2013.

Culture of *C. qassimensis* and experiment technique: Laboratory culture of *C. qassimensis* was originated from soil samples under date palm trees at Qassim region, Saudi Arabia in 2013. Mite samples have been maintained on the acarid mite species, *T. putrescentiae* and pollen of date trees as food sources in rearing units which was previously described by Fouly (1996). Newly deposited eggs of *C. qassimensis* had been singly placed in smaller rearing units (5 cm in diameter) using a fine brush. Immature stages and adults of the predator were provided with one of the tested food types (the acarid mites, *T. putrescentiae* and *C. rodriguez*) in addition to the egg masses of the root-knot nematode, *M. incognita*, during their entire life span. All experimental units were kept in an incubator at $26\pm 1^{\circ}\text{C}$ and $70\pm 5\%$ RH. In all cases, incubation period, duration of each stage (in days), number of surviving laelapidae mite individuals and egg production were recorded daily.

Statistical analysis: Data of incubation and developmental time, duration of adult male and female, female reproductive period as well as fecundity were analyzed using one-way ANOVA followed by the LSD test of Duncan multiple range test to compare means by using Costat Software (1990).

Life table parameters: Life table parameters of the predatory mite *C. qassimensis* which was fed on three different prey species, were calculated according to Birch (1948) and Laing (1968) by using the basic computer program Abou-Setta *et al.* (1986) where, L is number of alive females, x is actual female age (time from egg stage till death) (in days), M_x is number of female progeny/female (mothers)/day x (specific fecundity rate), L_x is rate of survival at day x, R₀ net reproductive rate ($\sum L_x M_x$), T mean generation time ($\sum L_x M_x x / \sum L_x M_x$), DT is time required for the

population to double its number, GRR is Gross Reproductive Rate, r_m intrinsic rate of natural increase, e^{r_m} finite rate of increase. Moreover, the Doubling Time (DT) was determined according to Laughlin (1965) and Carey (1993).

RESULTS

Duration of development and fecundity of *C. qassimensis*: Developmental stages and adults of *C. qassimensis* were fed on the three preys *T. putrescentiae*, *C. rodriguez* and egg masses of *M. incognita* during their whole life span and incubated at $26\pm 1^\circ\text{C}$ and $70\pm 5\%$ RH. Results showed that there was no significant difference between the incubation period of eggs for both females ($F = 3.77$ and $p = 0.029$) and males ($F = 3.71$ and 0.033) (Table 1, 2). The durations of larva, protonymph, deutonymph and life span of *C. qassimensis* females were statistically sub-equal when they fed *T. putrescentiae* and *C. rodriguez* while they were significantly shorter than those on *M. incognita* ($F = 18.19, 7.17$ and 18.06 for larvae, protonymph and deutonymph, respectively ($p < 0.01$)) (Table 1). Total immature stages, life cycle, pre-oviposition, oviposition and post-oviposition periods of *C. qassimensis* were significantly shorter when predatory mites fed on *T. putrescentiae* and followed by *C. rodriguez* and egg masses of *M. incognita*, respectively ($F = 37.99, 32.52, 94.98, 132.6$ and 36.78 , respectively and $p < 0.01$). As shown in Table 2, female longevity of *C. qassimensis* did not significantly differ according to prey species ($F = 0.24$ and $p = 0.785$).

Durations of larva, protonymph, total immature development, life cycle, longevity and life span of *C. qassimensis* males were significantly shorter when fed on *T. putrescentiae* in compared with *C. rodriguez* and *M. incognita* ($F = 17.16, 11.32, 49.73, 45.02, 87.95$ and 102.80 , respectively, $p < 0.01$). The deutonymph took the same period when it fed on either *T. putrescentiae* or *C. rodriguez*, while feeding on egg masses of *M. incognita*, caused the longest duration before reaching maturity ($F = 13.20$ and $p < 0.01$) (Table 2).

The total numbers of deposited eggs by each female mite was significantly higher for female fed *T. putrescentiae* and followed by *C. rodriguez* and then egg masses of *M. incognita*, which occupied the last rank ($F = 135.0$ and $p < 0.01$) (Fig. 1). Also, the daily rate of eggs per

Table 1: Duration (in days) of *Cosmolaelaps qassimensis* female developmental stages fed on *Tyrophagus putrescentiae*, *Caloglyphus rodriguez* and egg masses of *Meloidogyne incognita* and incubated at $26\pm 1^\circ\text{C}$ and $70\pm 5\%$ RH

Developmental stage	Prey species			LSD	F	p
	<i>T. putrescentiae</i>	<i>C. rodriguez</i>	<i>M. incognita</i>			
Egg	2.99±0.15 ^a	3.05±0.13 ^a	3.34±0.14 ^a	NS	3.77	0.029
Larva	2.63±0.11 ^b	2.95±0.11 ^b	3.61±0.11 ^a	0.32	18.19	0.000
Protonymph	3.00±0.13 ^b	3.25±0.12 ^b	3.67±0.11 ^a	0.34	7.17	0.002
Deutonymph	3.26±0.13 ^b	3.60±0.11 ^b	4.33±0.14 ^a	0.35	18.06	0.000
Total	8.95±0.20 ^c	9.80±0.17 ^b	11.61±0.26 ^a	0.60	37.99	0.000
Life cycle	11.94±0.29 ^c	12.85±0.21 ^b	14.95±0.36 ^a	0.81	32.52	0.000
Pre-oviposition	1.94±0.14 ^c	3.00±0.14 ^b	4.72±0.14 ^a	0.39	94.98	0.000
Oviposition	13.58±0.28 ^c	11.50±0.26 ^b	8.00±0.16 ^a	0.67	132.60	0.000
Post-oviposition	5.58±0.20 ^c	6.25±0.17 ^b	7.89±0.17 ^a	0.53	36.78	0.000
Longevity	20.89±0.36 ^a	20.55±0.32 ^a	20.72±0.25 ^a	NS	0.24	0.785
Life span	32.83±0.57 ^b	33.40±0.42 ^b	35.67±0.66 ^a	1.45	10.28	0.000

Values represented by Mean±SE. Means have the same letter in each row haven't significant differences ($p = 0.05$) by Duncan multiple range test, NS: No significant differences where $df = 2, 54$

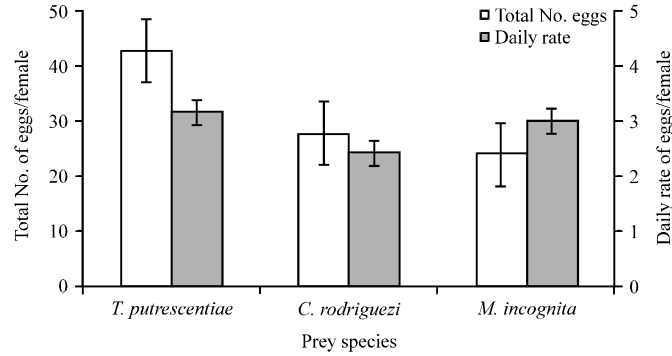


Fig. 1: Total and daily rate of deposited eggs/female of *Cosmolaelaps qassimensis* fed *Tyrophagus putrescentiae*, *Caloglyphus rodriguez* and egg masses of *Meloidogyne incognita* and incubated at 26±1°C and 70±5% RH

Table 2: Duration (in days) of *Cosmolaelaps qassimensis* male developmental stages fed on *Tyrophagus putrescentiae*, *Caloglyphus rodriguez* and egg masses of *Meloidogyne incognita* and incubated at 26±1°C and 70±5% RH

Stage	Prey species			LSD	F	p
	<i>T. putrescentiae</i>	<i>C. rodriguez</i>	<i>M. incognita</i>			
Egg	2.70±0.16 ^a	2.83±0.15 ^a	3.00±0.11 ^a	NS	3.71	0.033
Larva	2.00±0.18 ^c	2.53±0.13 ^b	3.36±0.19 ^a	0.41	17.16	0.000
Protonymph	2.87±0.20 ^c	3.33±0.12 ^b	4.07±0.22 ^a	0.44	11.32	0.000
Deutonymph	3.19±0.19 ^b	3.47±0.13 ^b	4.36±0.19 ^a	0.41	13.20	0.000
Total	8.06±0.29 ^c	9.33±0.25 ^b	11.79±0.27 ^a	0.66	49.73	0.000
Life cycle	10.76±0.37 ^c	12.16±0.31 ^b	14.79±0.48 ^a	0.91	45.02	0.000
Longevity	9.75±0.70 ^c	13.87±0.37 ^b	15.21±0.51 ^a	0.76	87.95	0.000
Life span	20.51±0.58 ^c	26.03±0.52 ^b	30.00±0.61 ^a	1.28	102.80	0.000

Values represented by Mean±SE. Means have the same letter in each row haven't significant differences (p = 0.05) by Duncan multiple range test, NS: No significant differences where df = 2 and 42

female was higher on *T. putrescentiae* (3.14 eggs) followed by egg masses of *M. incognita* (2.98 eggs/female/day) and was lowest on *C. rodriguez* (2.41 eggs/female/day) (Fig. 1).

Life table parameters of *C. qassimensis*: Data represented in Table 3 clarified that sex ratio and survival (%) of *C. qassimensis* were at their highest values, when the predatory mites fed *T. putrescentiae* and followed by *C. rodriguez* and *M. incognita*. While, mean generation Time (T) and the time required for *C. qassimensis* population to double its numbers (DT) were shorter when it fed *T. putrescentiae* in comparison with *C. rodriguez* and *M. incognita*. With regard to the survivorship of the laelapidae mite, *C. qassimensis*, Lx curves followed the I pattern in which survival of immature stages was 92, 90 and 86% when fed on *T. putrescentiae*, *C. rodriguez* and egg masses of *M. incognita*, respectively. Death of *C. qassimensis* females started after the longest period of oviposition (13 days) on *T. putrescentiae*, while by feeding on *C. rodriguez* and egg masses of *M. incognita*, female death started after 9 days of oviposition (Fig. 2). As shown in Fig. 3, the age specific fecundity (M_x) of *C. qassimensis* was clearly affected by prey species. Moreover, results showed that the net reproductive rate (R_0) of *C. qassimensis* reached its highest rate of 30.99 female egg/female/day, when it was provided with the acrid mite *T. putrescentiae*.

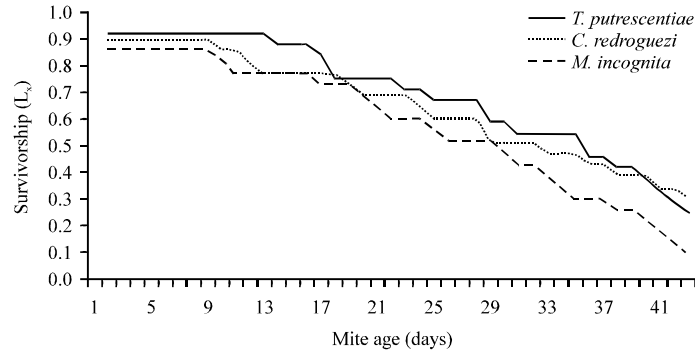


Fig. 2: Survivorship (L_x) of *Cosmolaelaps qassimensis* fed on *Tyrophagus putrescentiae*, *Caloglyphus rodriguez* and egg masses of *Meloidogyne incognita* at $26\pm 1^\circ\text{C}$ and $70\pm 5\%$ RH

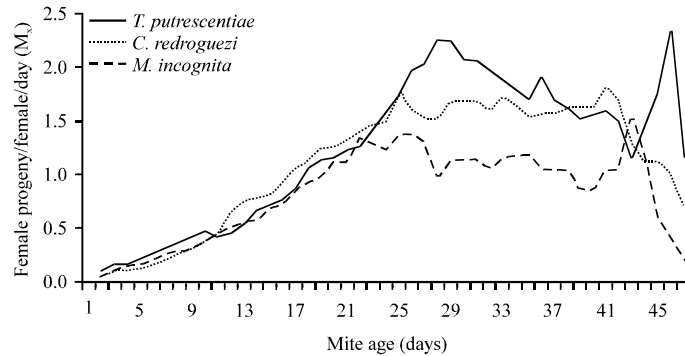


Fig. 3: Age specific fecundity (M_x) of *Cosmolaelaps qassimensis* fed on *Tyrophagus putrescentiae*, *Caloglyphus rodriguez* and egg masses of *Meloidogyne incognita* at $26\pm 1^\circ\text{C}$ and $70\pm 5\%$ RH

Table 3: Life table parameters of *Cosmolaelaps qassimensis* fed on *Tyrophagus putrescentiae*, *Caloglyphus rodriguez* and egg masses of *Meloidogyne incognita* at $26\pm 1^\circ\text{C}$ and $70\pm 5\%$ RH

Prey species	Sex ratio	Survival (%)	Mean generation		Net reproductive		Intrinsic rate of increase (r_m)	Finite rate of increase (e^{r_m})
			time (T)	DT	rate (R_0)	GRR		
<i>T. putrescentiae</i>	0.58	92	28.69	2.53	30.99	56.56	0.119	1.127
<i>C. rodriguez</i>	0.56	90	31.17	2.86	27.12	49.44	0.105	1.111
<i>M. incognita</i>	0.52	86	32.84	3.46	17.82	35.71	0.087	1.090

Survival (%): Percentage of immature stages reached maturity, GRR: Gross reproductive rate, DT: Time required for the population to double its number

This value clearly decreased to 27.12, when the laelapidae mite fed on *C. rodriguez*, while eggs of nematode occupied the last rank in food preference with only 17.82 eggs/female/day (Table 3). Similar trend was noticed with the intrinsic rate of natural increase (r_m) and finite rate of increase (e^{r_m}), where *T. putrescentiae* proved to be the most preferable prey and followed by *C. rodriguez*, while nematode eggs came last.

DISCUSSION

Biology of *C. qassimensis*: The incubation period of *C. qassimensis* eggs was not affected by prey species. These findings agree with those of Foully (1997) who reared the ascid mite *L. dentatus* on

both acarid mites *T. putrescentiae* and *C. rodriguez* in addition to the green mould fungus *Penicillium digitatum* Sacc. and egg masses of root-knot nematode, *M. javanica* Treub. Also, Abou-Awad *et al.* (2001) mentioned that the incubation period of the ascid mite, *L. athiasae* Nawar and Nasr did not change by prey species. Moreover, Al Rehiayani and Fouly (2005) found similar results when *C. simplex* (Berlese) fed acarid mites and nematodes.

Both sexes of *C. qassimensis* passed through larval, protonymphal and deutonymphal stages before reaching adulthood. Larvae did not feed on any of the tested prey species. Similar results were previously obtained with *Hypoaspis vacua* (Micheal) (Abou-Awad *et al.*, 1989), *Pachylaelaps aegyptiaca* Hafez and Nasr (Gomaa *et al.*, 1989), *C. claviger* (Berlese) (Affifi and Van der Geest, 1991), *L. athiasae* (Abou-Awad *et al.*, 2001), who reported that larval feeding did not seem to be necessary for successful development. Contradictory, it was mentioned before that larval stage of most mesostigmatid mites must feed to develop into protonymphs (Osman *et al.*, 1988; Walter and Lindquist, 1989; Fouly *et al.*, 1994, 1995; Fouly, 1997; Abou-Setta *et al.*, 1997). The previous data indicate that a diet of egg masses of the plant parasitic nematode, *M. incognita* obviously prolonged the developmental periods of both sexes of *C. qassimensis* in comparison with the acarid mites. Data also showed that there were significant differences between the effects of both acarid mite species as preys on the developmental period of the tested predaceous mite. Freira and de Moraes (2007) found that *C. paulista* Freire and Moraes took only 8.6 days to develop from egg to adult when it was provided with *T. putrescentiae* and kept at 26°C. From the previous results, it can be concluded that *C. qassimensis* can be considered as a polyphagous predatory mite which can survive and reproduce on a wide range of prey species. These results agree with those of Al Rehiayani and Fouly (2005) who found that *C. simplex* had been successfully reared on both acarid mite *C. rodriguez* and egg masses of two plant parasitic nematodes, *M. javanica* and *Tylenchulus semipenetrans* (Cobb). Also, Affifi and Van der Geest (1991) reported that *C. claviger* fed and reproduced when it was provided with the bulb mite, *Rhizoglyphus echinopus*, collembolan, eggs and larvae of house fly as well as free living nematodes.

Also, it was found that *C. qassimensis* reproductive potentiality was higher by feeding on mites or insects than on nematodes (Affifi and Van der Geest, 1991). Moreover, it was found that about 18 mesostigmatid mite species fed vigorously on the nematode species *Cephalopus* sp. (Rhabditida) under laboratory conditions. Most of these species preferred the vermiform nematodes and showed also a positive response to the obese-form like females of *Meloidogyne* spp. and cyst nematodes *Heterodera* spp. that were sedentary (Muraoka and Nobuyoshi, 1976). Also, it was experimentally proved that *L. dentatus* survived and successfully reproduced by feeding on fungi, acarid mites and root-knot nematodes (Fouly, 1997). In contrast, Rodriguez (1964) found that the mite species *Macrocheles muscadomestica* (Scopoli) did not reproduce when it was supplied with acarid mites or collembolans but it had a successful biology on nematodes.

As in most mesostigmatid mites, *C. qassimensis* female lived for a longer time than male, (female lived for an average of 20.89, 20.55 and 20.72 days while males lived for 9.75, 13.87 and 15.21 days), when they were fed on *T. putrescentiae*, *C. rodriguez* and egg masses of *M. incognita*, respectively. Similarly, Al Rehiayani and Fouly (2005) reported that females of *C. simplex* lived for longer time (35.4, 33.3 and 34.7 days) than males (29.2, 33.2 and 34.3 days), when they were fed on *C. rodriguez* and both nematodes *M. javanica* and *T. semipenetrans*, respectively. Also, Ydergaard *et al.* (1997) mentioned that males of *H. miles* Berlese had a slight tendency to develop faster than females.

Our results showed that the total percentage of daughter females of *C. qassimensis* represented 58, 56 and 52% from the whole mite populations, when the predatory mite fed on *T. putrescentiae*, *C. rodriguez* and egg masses of *M. incognita*, respectively. These results are in agreement with those of Lobbes and Schotten (1980) and Enkegaard *et al.* (1997) who found that the sex ratio was influenced by the prey type offered to *H. miles* while, Al Rehiyani and Fouly (2005) reported that the total percentage of daughter females of *C. simplex* was 61, 54 and 56% feeding on *C. rodriguez*, *M. javanica* and *T. semipenetrans*, respectively. Also, Ydergaard *et al.* (1997) mentioned that thermal factor highly affected female proportion of *H. miles* which exhibited its highest percentage of daughter females (90.3%) when it was incubated at 25°C in comparison with 15, 20 and 30°C. Each adult female of *C. qassimensis* was able to lay a total amount of 42.68, 27.70 and 23.83 eggs during 13.58, 11.5 and 8.00 days when it was fed on *T. putrescentiae*, *C. rodriguez* and *M. incognita*, respectively. So, *C. qassimensis* fed and successfully reproduced when it was provided with these diets. Also, it was previously found that the ascid mite *L. scapulatus* fed and reproduced on juvenile stages and adults of the nematode *Aphelenchus avenae* where each female laid an average of 23 eggs during only 6 days (Imbriani and Mankau, 1983). While, Shereef *et al.* (1980) found that the mean number of eggs per female was 38.6, 16.4 and 47.0 for *H. miles* fed on bulb mites, collembola and mould mites, respectively. Moreover, the present study showed that the daily deposited eggs per female per day ranged between 2.41 and 3.14 eggs. Similar results were obtained on *H. miles* by Ydergaard *et al.* (1997) who mentioned that the mean number of eggs per female per day reached 2.3 eggs when the laelapidae mite fed on a mixture of *Bradysia pauper* Tuomikoski (Diptera: Sciaridae) and *B. tritici* Coquillet larvae at 25°C.

Life table parameters of *C. qassimensis*: The survivorship (L_x curves) of *C. qassimensis* followed (I) pattern in which survival of immature stages reached 92, 90 and 86% when fed on *T. putrescentiae*, *C. rodriguez* and egg masses of *M. incognita*, respectively. Both parameters L_x and fecundity (M_x) were affected by prey species; however they showed higher values feeding on *T. putrescentiae* in comparison with *C. rodriguez* or egg masses of nematode. It was also noticed that L_x values and M_x of *L. dentatus* and *C. simplex* were affected by prey species.

Similar results were obtained by Al Rehiyani and Fouly (2005) who mentioned that L_x curves for *C. simplex* followed I pattern. On the other hand, the mean generation Time (T) and the time required for the population of *C. qassimensis* to double its number (DT) were affected by prey species. However, T and DT time were shorter when *C. qassimensis* was fed *T. putrescentiae* in comparison with *C. rodriguez* and *M. incognita*. Similarly, Al-Rehiyani and Fouly (2005) mentioned that T time of *C. simplex* was shortened when *C. simplex* fed egg masses of *T. semipenetrans* and prolonged by feeding on the acarid mite *C. rodriguez* or egg masses of *M. javanica*. Net reproductive rate (R_0), the Gross Reproductive Rate (GRR), intrinsic rate of increase (r_m) and finite rate of increase (e^{rm}) were at their highest values feeding on *T. putrescentiae* and followed by *C. rodriguez* while a diet of egg masses of nematode caused the lowest values. Al Rehiyani and Fouly (2005) also found that R_0 of *C. simplex* was lower feeding on *M. javanica* and *T. semipenetrans* in comparison with *C. rodriguez*. Also, they noticed that r_m and e^{rm} of *C. simplex* were highest on acarid mites in comparison with egg masses of nematodes.

Fouly (1997) reported that R_0 values of *L. dentatus* followed the same trend where they were higher by feeding on acarid mites than feeding on egg masses of root-knot nematode. Moreover, Freira and de Moraes (2007) found that the population of *C. paulista* fed on *T. putrescentiae* was

estimated to increase about 41.5 times (R_0) in 19.8 days (T) and the rate corresponded to a daily population increase of about 24% (e^{r_m}) and to the production of 0.217 female per female per day (r_m).

CONCLUSION

Cosmolaelaps qassimensis Fouly and Al-Rehyiani (2014) was collected from debris and rhizosphere of date palm trees growing in Qassim region. The present results showed that *C. qassimensis* should be provided with acarid mites such as *T. putrescentiae* or *C. rodriguez* to obtain the highest rates of offspring. However, the time required for the population of *C. qassimensis* to double its number were the shortest, it was found that survival percentage, gross reproductive rate, net reproductive rate, intrinsic rate of increase and finite rate of increase were highest when *C. qassimensis* was subjected to acarid mites as food sources. Generally, *C. qassimensis* showed good performance in terms of population growth when compared with other Hypoaspidae at similar conditions.

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