

LIFE TABLES AND FEEDING HABITS OF *PROPRIOSEIOPSIS CABONUS*, A SPECIFIC PREDATOR OF TYDEID MITES (ACARI: PHYTOSEIIDAE AND TYDEIDAE)

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ABSTRACT: Biology, life table parameters and predation rates of the predatory mite *Proprioseiopsis cabonus* (Schicha and Elshafie) (Acari: Phytoseiidae) feeding on nymphs of *Neoapolorryia aegyptiaca* El Bagoury and Momen and *Lorryia aegyptiaca* (Rasmy and El Bagoury) (both Acari: Tydeidae), *Ricinus communis* L. (castor bean) pollen and *Phoenix dactylifera* L. (date palm) pollen were studied at $30 \pm 1^\circ\text{C}$, $70 \pm 5\%$ RH and photoperiod of 16: 8 (L:D) hours. Total developmental time of *P. cabonus* females was 9.9 and 11.1 days on nymphs of *N. aegyptiaca* and *L. aegyptiaca*. Survival of immatures of *P. cabonus* was very low on both pollen grains and all failed to develop to adulthood. A total of 47.6 and 40.8 eggs per female, respectively, were obtained when *P. cabonus* was fed on nymphs of above tydeid mites. Life table parameters were estimated as net reproductive rate (R_0) 35.95 and 24.64, intrinsic rate of increase (r_m) 0.213 and 0.174 days⁻¹, finite rate of increase (λ) 1.236 and 1.190, mean generation time (T) 16.9 and 18.4 days and doubling time (DT) 3.2 and 3.9 days when the predator fed on nymphs of *N. aegyptiaca* and *L. aegyptiaca*. Average daily predation of *P. cabonus* females on *N. aegyptiaca* and *L. aegyptiaca* nymphs was 25.6 and 20.3.

KEY WORDS: Acari, life table, Phytoseiidae, pollen grains, Tydeidae

INTRODUCTION

Phytoseiid mites are important biological control agents all over the world where they serve to suppress arthropod pests on cultivated and non-cultivated plants. The acarine family Phytoseiidae includes a large number of generalist predators that can develop and reproduce using various food sources as alternatives to their primary prey, tetranychid mites (McMurtry and Croft 1997). Generalist phytoseiid mites can prey upon insects (e.g. thrips) and mites other than tetranychids (e.g. other phytoseiids, eriophyid, tydeid and tarsonemid mites (Overmeer 1985; Calis et al. 1988; Bonde 1989; Momen and Abdel-Khalek 2009), and they can also exploit honeydew and plant exudates (van Rijn and Tanigoshi 1999; Gnanvossou et al. 2005).

Some tydeids evidently feed to some extent on living green material, as indicated by the green body content of representatives of some species of *Lorryia*, *Paralorryia* and *Tydeus* (Karg 1975; Momen and Lindqvist 1995). Flaherty and Hoy (1972) evaluated the role of tydeid mites (*Prone-matus* spp.) as suitable alternative prey for the predatory phytoseiid mite, *Galendromus occidentalis* (Nesbitt) (Acari: Phytoseiidae) and found that the latter would feed and reproduce on it in the laboratory. In contrast, Ferragut et al., (1987) indicated that the tydeid mite *Lorryia formosa* Cooreman was not a favoured prey for both phytoseiid mites, *Euseius stipulatus* (Athias-Henriot) and *Typhlodromus phialatus* Athias-Henriot. Research by Camporese and Duso (1995) as well as Zaher et al. (2001) revealed that *Tydeus caudatus* Duges and *Tydeus californicus* (Banks) (both Acari: Tydeidae) were the primary food for the phy-

toseiid mite, *Paraseiulus talbii* (Athias-Henriot). Ueckermann and Grout (2007) suggested that both tydeid mites, *T. californicus* and *Pronematus ubiquitous* (McGregor) probably serve as prey for various predatory mites on citrus in many parts of the world.

Phytoseiid mites of the genus *Proprioseiopsis* spp. have been found in ground surface litter or on grass (Muma and Denmark 1970). Very little is known about the biology of this genus, *P. temperellus* (Muma and Denmark) was fed *Tetranychus urticae* Koch (Acari: Tetranychidae) eggs alone at various temperatures (Ball 1980), *P. mexicanus* (Garman) population increase when fed *T. urticae* eggs (Megevand et al. 1993), *P. rotundus* (Muma) fed on all stages of *T. urticae* and pollen of various plants (Abou-Setta et al. 1997), *P. aetus* (Chant) was fed *Eutetranychus orientalis* (Klein) (Acari: Tetranychidae) or *T. urticae* (Fouly 1997). Recently, Lawson-Balagbo et al. (2008) demonstrated the presence of *P. canaensis* on attached coconuts, leaflets and fallen coconuts leaflets and fallen coconuts in northern and northeastern Brazil, probably feeding on *Aceria guerreronis* Keifer (Acari: Eriophyidae). Also, Emmert et al. (2008) determined the intrinsic rate of increase for *P. aetus* when fed cattail pollen *Typha latifolia* L., *T. urticae* and *Frankliniella occidentalis* (Pergande) (family: Thripidae). From the perusal of the literature, nothing is known about the biology of *Proprioseiopsis cabonus* (Schicha and Elshafie), with the exception of Momen (1999, 2009) and Momen and El-Borolossy (1999), whom reported that the predator failed to feed and develop on eggs and

nymphs of *T. urticae* as well as nymphs of *E. orientalis* and the grass eriophyid mite *Aceria dioscoridis* (Soliman and Abou-Awad).

The objective of this study was to predict the relative nutritional value of *Ricinus communis* L. (castor bean) pollen (Euphorbiaceae), *Phoenix dactylifera* L. (date palm) pollen (Arecaceae), nymphs of *Neopapillorhiza aegyptiaca* El Bagoury and Momen and *Lorryia aegyptiaca* (Rasmy and El Bagoury) (both Acari: Tydeidae) to the predatory mite *P. cabonus*, in order to make a preliminary evaluation to their potential role as food. In particular, the survival as well as the reproductive potential of the phytoseiid mite was evaluated and compared, under laboratory conditions, using the above diets.

MATERIALS AND METHODS

Host and phytoseiid predatory mite culture

Adult females of *P. cabonus* were obtained from soil associated with roots of *Pelargonium graveolens* Ait at Tanta Governorate in January 2009. The stock cultures of *P. cabonus* were maintained using *N. aegyptiaca* as the food source. Feeding experiments were conducted in the laboratory at $30 \pm 1^\circ\text{C}$ and $70 \pm 5\%$ RH, in arenas (3×3 cm) of excised raspberry leaves, placed on water-saturated cotton in plastic Petri-dishes. Females were left 24-h and eggs laid were used for the subsequent experiments.

Diets

Four diets were evaluated for their effect on development, survival, fecundity and life-table parameters.

1. Nymphs of *N. aegyptiaca*, were found in soil associated with roots of *P. graveolens*.
2. Nymphs of *L. aegyptiaca*, were collected from debris under palm trees surrounding the farm where *P. graveolens* is cultivated.

Both tydeid mites were extracted with an extraction apparatus as described by Cusack, Evans and Brennan (1975) every 2 days as food for *P. cabonus* and various biological data.

3. Castor bean *R. communis* pollen
4. Date palm *P. dactylifera* pollen

Pollen collected from *R. communis* and *P. dactylifera* was poured into vials and stored at 4°C before being applied to clean raspberry discs.

Effect of diets on the development, prey consumption and survival rates of the predatory mite *P. cabonus*

Predator eggs were randomly chosen and placed singly on the rearing disc, and the newly hatched lar-

vae were supplied with six nymphs of each of *N. aegyptiaca* and *L. aegyptiaca* or each arena was supplied with a small amount of *P. dactylifera* and *R. communis* pollen grains and was replaced at 48–72 hours intervals. Replacement of the mite prey was carried out daily and records of development, survival, prey consumption and reproduction were recorded twice a day. Observations made were: incubation period of the egg stage, duration of larval, protonymphal and deutonymphal stages and survival rate. A male *P. cabonus* was introduced to each leaf disc with a deutonymph just before it moulted to become a female. After copulation, the male was removed. Every 5–6 days, a new male was introduced to fertilize female for repeated mating.

Effect of diets on the fecundity, prey consumption, longevity and life table statistics of the predatory mite *P. cabonus*

Newly emerged mated females of *P. cabonus* were confined individually to test arenas (as described above) and were provided daily with sufficient number of tydeid nymphs. Daily observations were made to determine the pre-oviposition, oviposition and post-oviposition periods as well as to gather data on consumption rate, fecundity and sex ratio of offspring and mortality.

Statistical analysis

A Student's t-test was used to test the effects of *N. aegyptiaca* and *L. aegyptiaca* nymphs on various developmental parameters of *P. cabonus*. Assessment of significance was taken at 0.05 and 0.01 level probabilities.

Life table

The life-history data for *P. cabonus* ($n = 16$ for *N. aegyptiaca* and $n = 15$ for *L. aegyptiaca*) obtained from daily observations of immature stages and adults were used to construct the life table for the predator. Life table parameters were calculated using the method recommended by Birch (1948). The life table statistics were calculated using software developed by Abou-Setta et al. (1986).

The life table parameters were calculated as follows:

- The age specific survival (L_x)
- The age specific fecundity (m_x) = born female/female
- The net reproductive value (R_0) = $\sum (L_x m_x)$ (Birch 1948)
- The intrinsic rate of increase (r_m) which is calculated by iteratively solving the Euler equation, $\sum (e^{-r_m x} L_x m_x) = 1$ (Birch 1948)

Table 1

Comparative duration (Mean \pm SE in days) of female stages of *Proprioseiopsis cabonus* fed on nymphs of *Neoapolorryia aegyptiaca* and *Lorryia aegyptiaca* at 30°C and 75% RH

Developmental stages	Prey species		T (value)	Probability (at 0.05 and 0.01)
	<i>N. aegyptiaca</i>	<i>L. aegyptiaca</i>		
Egg	2.19 \pm 0.10	2.27 \pm 0.12	0.512	0.613
Larva	1.44 \pm 0.13	1.67 \pm 0.12	1.273	0.213
Protonymph	3.06 \pm 0.14	3.54 \pm 0.13	2.396*	0.023
Deutonymph	3.25 \pm 0.11	3.60 \pm 0.13	2.041	0.050
Total life cycle	9.93 \pm 0.21	11.07 \pm 0.21	3.796**	0.001
% Reaching maturity	100	96		
Pre-oviposition period	2.43 \pm 0.13	2.33 \pm 0.12	0.579	0.567
Oviposition period	23.56 \pm 0.49	21.93 \pm 0.48	2.361*	0.025
Post-oviposition period	8.87 \pm 0.26	5.60 \pm 0.41	6.848**	0.000
Adult longevity	34.87 \pm 0.55	29.87 \pm 0.65	5.905**	0.000
Life span	44.81 \pm 0.63	40.93 \pm 0.61	4.389**	0.000

*P \leq 0.05; **P \leq 0.01

* Significant, ** highly significant

Table 2

Average consumption rate (Mean \pm SE) per day of *Proprioseiopsis cabonus* fed on nymphs of *Neoapolorryia aegyptiaca* and *Lorryia aegyptiaca* at 30°C and 75% RH

Stages of <i>P. cabonus</i>	Prey species		T (value)	Probability (at 0.05 and 0.01)
	<i>N. aegyptiaca</i>	<i>L. aegyptiaca</i>		
Larva	Non feeding	Non feeding	–	–
Protonymph	3.37 \pm 0.12	3.13 \pm 0.16	1.176 ^{NS}	0.249
Deutonymph	6.12 \pm 0.34	4.07 \pm 0.21	5.092**	0.000
Total life cycle	9.50 \pm 0.41	7.00 \pm 0.35	4.543**	0.000
Pre-Oviposition period	3.43 \pm 0.24	3.13 \pm 0.16	1.028 ^{NS}	0.313
Oviposition period	16.06 \pm 0.65	12.73 \pm 0.57	3.805**	0.001
Post-oviposition period	6.06 \pm 0.42	4.40 \pm 0.32	3.101**	0.004
Adult longevity	25.56 \pm 0.75	20.27 \pm 0.67	5.222**	0.000

** Highly significant, Ns: not significant

— The mean generation time (T) = $\frac{hRo}{m}$
(Birch 1948)— The finite rate of increase (λ) = e^{rm}
(Birch 1948)— The doubling time (Dt) = $\frac{h2}{m}$
(Kairo and Murphy 1995)— Gross reproductive rate (GRR) $\sum m_x$

RESULTS

Effect of diets on the development, prey consumption and survival rate of the predatory mite *P. cabonus*

Individuals of *P. cabonus* successfully developed from larva to adult when fed on nymphs of

N. aegyptiaca and *L. aegyptiaca*, while the predator failed to develop beyond the protonymphal stage when offered pollen grains of *P. dactylifera* and *R. communis* (Table 1).

The larvae of *P. cabonus* moult to protonymphal stage without feeding. The consumption rate increased through the developmental stages respectively (Table 2).

The immature stages of *P. cabonus* consumed more *N. aegyptiaca* nymphs than *L. aegyptiaca* nymphs (T = 4.543, p = 0.000). Development (egg-adult female) was significantly faster on a diet of *N. aegyptiaca* nymphs than on a diet of *L. aegyptiaca* nymphs (T = 3.796; p = 0.001) (Table 1). Survival was (100%) when fed *N. aegyptiaca* than *L. aegyptiaca* (96%), respectively.

Table 3

Life table parameters of *Proprioseiopsis cabonus* fed on nymphs of *Neopolorryia aegyptiaca* and *Lorryia aegyptiaca* at 30°C and 75% RH

Life table parameters	Prey	
	<i>N. aegyptiaca</i>	<i>L. aegyptiaca</i>
Net reproductive rate (R_0)	35.95313	24.64
Intrinsic rate of increase (r_m)	0.2126064	0.174252
Finite rate of increase (λ)	1.236898	1.190356
Mean generation time (T)	16.84905	18.38924
Doubling time (DT)	3.237	3.977
Gross reproductive rate (GRR)	38.45	26.05
**Mean total number of eggs deposited per female	47.62 ± 0.96 a	40.80 ± 0.66 b
*Mean daily number of eggs deposited per female	2.03 ± 0.06 a	1.84 ± 0.04 b
Sex ratio (F/ F+M)	0.75	0.6

Different letters in a transverse row denote a significant difference (T-test for total number of eggs deposited / female = 5.807**, $p = 0.000$; T-test for daily number of eggs deposited / female = 2.672*, $df = 29$), $p = 0.12$

* Significant, ** Highly significant

Effect of diets on the fecundity, prey consumption, longevity and life table statistics of the predatory mite *P. cabonus*

The pre-oviposition period was likewise for *P. cabonus* fed on both tydeid mites. *Proprioseiopsis cabonus* had significantly longer oviposition and highly significantly post-oviposition periods and adult longevity when fed on nymphs of *N. aegyptiaca* (23.56, 8.87 and 34.87 days) than on nymphs of *L. aegyptiaca* (21.93, 5.60 and 29.87 days), respectively (Table 1). Adult females of *P. cabonus* consumed more of both tydeid nymphs during the oviposition periods than on pre-oviposition or post-oviposition periods, respectively (Table 2). The highest rate of oviposition was recorded on nymphs of *N. aegyptiaca* (47.62 eggs / female), and the lowest on nymphs of *L. aegyptiaca* (40.80 eggs / female) (Table 3).

Table (3) summarizes the effect of *N. aegyptiaca* and *L. aegyptiaca* nymphs as natural /alternative food on the life table parameters of *P. cabonus*. The age-specific survival rate L_x (percent of surviving females at the instant x) and the age-specific fecundity rate m_x (number of female eggs laid per female per day) for *P. cabonus* reared on *N. aegyptiaca* and *L. aegyptiaca* are shown in Fig. (1). The intrinsic rate of natural increase (r_m) of *P. cabonus* increased from 0.1742 on *L. aegyptiaca* to 0.2126 on *N. aegyptiaca*. Similarly the net reproductive rate (R_0) increased from 24.64 times per individual per generation on *L. aegyptiaca* to 35.953 times per individual per generation on *N. aegyptiaca* (Table 3). The mean generation time ranged between (16.84 and 18.38 days), the dou-

bling time (Dt) was 3.23 and 3.97 while the gross reproductive rate (GRR) was 38.45 and 26.05, respectively when the predator was fed nymphs of *N. aegyptiaca* and *L. aegyptiaca*. The sex ratio of the progeny was strongly female biased when females of *P. cabonus* were fed *N. aegyptiaca* nymphs (female / total = 0.75).

DISCUSSION

Proprioseiopsis cabonus is found in soil under *P. graveolens* in some areas of Egypt in association with different Acari and insects, including *N. aegyptiaca*, *L. aegyptiaca*, *T. caudatus* (all Acari: Tydeidae). Tydeid mites appeared to be suitable as prey for *P. cabonus*. Feeding habits of *P. cabonus*: a comparison with other species of the genus *Proprioseiopsis* in the family Phytoseiidae are possible. The feeding habits of the *P. cabonus* appear to be substantially different from those of the most common members of the genus *Proprioseiopsis* found in soil surface litter or on grass (e. g. *P. temperelus*, *P. cannaensis* and *P. rotundus*). Development and reproduction failed when fed on *R. communis* and *P. dactylifera* pollen grains which were efficient for rearing *P. cannaensis* and *P. rotundus* (Abou-Setta et al. 1997). Pollen grains vary in their chemical composition and not all pollen types are efficient food for phytoseiids (McMurtry and Rodriguez 1987). Spider and eriophyid mites were never associated with *P. cabonus* and also were not favoured food for rearing the predator since high mortality rates were recorded on these prey (Momen 1999, 2009). In contrast, *T. urticae* and *E. orientalis* were favoured by *P. tem-*

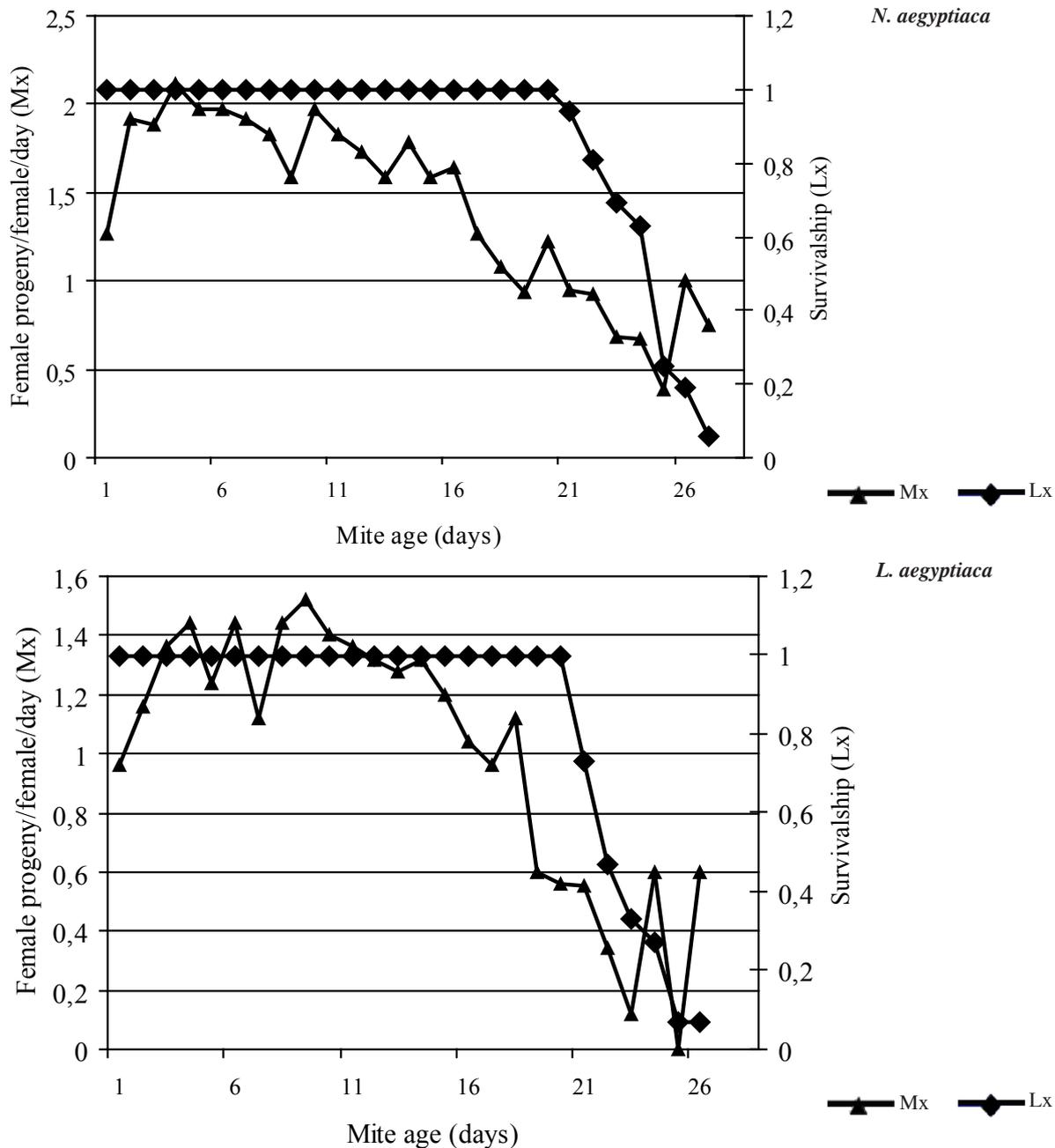


Fig.1. Age-specific fecundity (Mx) and survivorship (Lx) of *Proprioseiopsis cabonus* reared on *Neapolorryia aegyptiaca* and *Lorryia aegyptiaca*

perellus, *P. mexicanus*, *P. aetus* and *P. canaensis* (Ball 1980; Megevand et al. 1993, Lawson-Balagbo et al. 2008). The feeding behavior of *P. cabonus* is similar to that of *P. talbii* since tetranychid and eriophyid mites as well as date palm and castor oil pollen grains were also unsuitable diet for the predator, while it successfully developed on tydeid mites (Camporese and Duso 1995; Zaher 2001). Nassar (1976) also indicated that *T. californicus* was more suitable prey for the cunaxid mite *Cunaxa setirostris* (Hermann) (Acari: Cunaxidae) than tetranychids and tenuipalpids. In the present work, development was successful on both tydeid mites

and developed more rapidly on *N. aegyptiaca* than on *L. aegyptiaca*. The preference of tydeids over tetranychids, eriophyids and pollen grains by *P. cabonus* constitutes the most important difference in feeding habits between this predator and the above — mentioned *Proprioseiopsis* species. Suitability of soil tydeid mites (associated with *P. cabonus*) as a prey may be due to the small size, soft body and tendency to aggregate in clusters, characteristics that make *N. aegyptiaca* and *L. aegyptiaca* easier to attack. Moreover, these species might have kairomones that attract the predator. The reason for the unsuitability of tetranychid mites for the phytosei-

id predators is unknown, but might be attributed to the mouthparts of the predatory not adapted to rupture the cuticle of larger prey or the webbing produced by spider mites.

Indeed, some phytoseiid predators are specialist, while others are generalist (McMurtry and Croft 1997). The feeding habits of *P. cabonus* are similar to those of two other phytoseiid species: *Typhlodromina conspicuus* (Garman) was abundant on avocado in California and associated with the primarily prey *T. californicus* (Fleschner and Ricker 1954). *Paraseiulus talbii* occurs in vineyards and mango orchards were reported to be a specific predator of *T. caudatus* and *T. californicus* (Comprese and Duso 1995; Zaher et al. 2001). Life history parameters were more favorable for *P. cabonus* on a *N. aegyptiaca* diet compared to a *L. aegyptiaca* diet. This is confirmed by the net reproductive rate which was 1.5 times higher on *N. aegyptiaca* than on *L. aegyptiaca*. Fouly (1997) also reported a greater mean generation time (T) and lower net reproductive rate (R_0) for *P. asetus* at 26°C on *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae). Zaher et al. (2001) reported lower (R_0) and higher (r_m) values of *P. talbii* feeding on *T. californicus* at 32°C. Prey consumption is broadly defined as prey captured, killed and fed upon, because the volume of fluids extracted from a prey can vary considerably depending on duration of feeding on an individual prey (McMurtry and Rodriguez 1987). *Proprioseiopsis cabonus* immatures killed 7.0–9.5 nymphs per day of both tydeid mites to reach adulthood, and increased to 20.27–25.56 nymphs per day during female stages. This number of consumed prey was higher than that reported for *P. talbii* (4.83 and 8.6 nymphs of *T. californicus*) killed per day at similar temperature and humidity (Zaher et al. 2001).

CONCLUSION

This study indicated that *P. cabonus* developed and reproduced successfully on tydeid mites, *N. aegyptiaca* and *L. aegyptiaca*. Muma (1971) divided candidate food offered to various female phytoseiids in the laboratory into four categories: optimal, adequate, survival and inadequate foods. According to these criteria, food tested in the present work could be divided as follows: optimal food (both tydeid mites tested) and inadequate food (both pollen grains tested). I would suggest further studies on the predatory impact and responses of *P. cabonus* to various mite and insect species associated with the predator in its habitat.

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