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COMPARATIVE MORPHOLOGICAL AND BIOLOGICAL STUDIES OF TWO RHAGIDIID MITES : *ROBUSTOCHELES (R.) DELTACUS* AND *RHAGIDIA (R.) QALIUBIENSIS*

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ABSTRACT — The two rhagidiid species: *Robustocheles (R.) deltacus* and *Rhagidia (R.) qaliubiensis* were able to develop successfully from egg to adult on different fungal diets, but failed to lay eggs. When they were reared on larvae of cotton springtail *Lepidocenitus insertus* (Hand.), larvae of housefly *Musca domestica* L. and immatures of the tydeid soil mite *Tydeus aegyptiaca* (Rasmy and El-Bagoury), they laid eggs. They passed through egg, larvae, proto-, deuto-, tritonymph and adult stages. The durations of the immature and adult stages, as well as life table parameters were determined. Feeding on *L. insertus* gave the highest reproductive rate as compared to that on *M. domestica* and *T. aegyptiaca*. Ontogenetic setal development in the comparative study of the life stages of the two rhagidiid species indicated that the dorsal idiosomal chaetotaxy and the number of anal setae remained unchanged throughout the life cycle; a single adanal pair appears only in *R. (R.) qaliubiensis* protonymph and its successive stages. The increase in genital flap length at each moult is accompained by an increase in the number of setae situated on the flaps and the number of setae provides the simplest method of separating the nymphal stages. Patterns of leg chaetotaxy and solenidia also provide a method to separate nymphal stages.

KEYWORDS — biology; ontogeny; *Robustocheles deltacus*; *Rhagidia qualiubiensis*; Rhagidiidae; predacious mites

INTRODUCTION

Predatory mites of the family *Rhagidiidae* were discovered by biospeleologists by the second half of the nineteenth century (Wankel 1861) and frequently occur in various edaphic ecosystems, feeding mostly on collembola and other microarthropods (Zacharda 1987). They are found in the upper most layers of the soil profile and most species are considered hemiedaphic. Unfortunately, no detailed data have been gathered regarding their biology expect for few studies and comments for few species are known throughout their life cycle (Ehrensberger 1974 & 1977; Gless 1977; Edwards and Usher 1987) and consequently there is little information about biological aspects.

The present study was performed to investigate certain aspects of biology for two rhagidiid species *Robustocheles (R.) deltacus* Abou-Awad, El-Sawaf and Abdel-Khalek and *Rhagidia (R.) qaliubien-*

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TABLE 1: Average duration in days (mean ± SD) of the immature and adult stages of *Robustocheles (R.) deltacus* and *Rhagidia (R.) qaliubiensis* on different diets at 23°C.

Diet	Egg	Larva	Q	Protonymph	Q	Deutonymph	Q	Tritonymph	Q	Life cycle	Longevity	Life span
R. deltacus												
Fusarium oxysporum	13.1 ± 0.23	2.7 ± 0.15	2.3 ± 0.15	4.5 ± 0.17	2.5 ± 0.17	5.5 ± 0.17	2.6 ± 0.16	6.5 ± 0.17	3.2 ± 0.2	42.9 ± 0.35c	15 ± 0.54	57.9 ± 0.28c
Fusarium solani	13.5 ± 0.17	2.9 ± 0.1	2.6 ± 0.17	4.6 ± 0.27	2.7 ± 0.15	6.3 ± 0.15	2.8 ± 0.13	7.3 ± 0.15	3.5 ± 0.17	46.2 ± 0.20b	15.4 ± 0.4	61.6 ± 0.40b
Trichoderma harzairum	14.9 ± 0.26	3.3 ± 0.15	2.8 ± 0.13	5.3 ± 0.21	3 ± 0.15	6.9 ± 0.23	3.3 ± 0.15	8 ± 0.26	3.8 ± 0.13	50.4 ± 0.40a	13.9 ± 0.53	64.3 ± 0.62a
R. qaliubiensis												
Fusarium oxysporum	15.8 ± 0.25	3.3 ± 0.15	2.4 ± 0.16	4 ± 0.21	2.5 ± 0.17	4.3 ± 0.21	2.4 ± 0.16	5.7 ± 0.15	2.2 ± 0.13	42.6 ± 0.16c	20.1 ± 0.68a	62.7 ± 0.73 a
Fusarium solani	16 ± 0.21	3.9 ± 0.18	2.6 ± 0.16	4.1 ± 0.23	2.7 ± 0.21	4.6 ± 0.22	2.5 ± 0.17	5.9 ± 0.28	2.8 ± 0.2	45.1 ± 0.28b	15.5 ± 0.37b	60.6 ± 0.78ab
Trichoderma harzairum	16 ± 0.26	4.3 ± 0.15	2.6 ± 0.16	4.4 ± 0.16	2.7 ± 0.15	5.1 ± 0.23	2.7 ± 0.15	5.9 ± 0.28	3.2 ± 0.13	46.9 ± 0.23a	12.4 ± 0.43c	59.3 ± 0.45bc

Means followed by the same letter in the vertical columns do not differ significantly (F-test, P > 0.01).

sis Abou-Awad, El-Sawaf and Abdel-Khalek (2009). Life table parameters and the effects of different microarthropodes prey on development and reproduction were studied. A comparative study of the idiosomal and leg chaetotaxy of the larvae, nymph and adult and the effectiveness of various aspects of the chaetotaxy in separating immatures were also studied.

MATERIAL AND METHODS

Plastic big cells supplied with confirmed covers of dimensions 2.5 cm in diameter and 2 cm in depth, containing a floor of plaster of paris and activated charcoal (mixed in a 9:1 ratio) were used for both laboratory cultures and biological experiments, to allow more space to the predator and to prevent the escape of mites. The plaster floor was kept moderately moist by adding of distilled water to the surface. Both *Robustocheles (R.) deltacus* and *Rhagidia (R.) qaliubiensis* were maintained on larvae of the cotton springtail as a satisfactory prey. Females of both predatory rhagidiid species were kept in rearing cells to lay eggs and newly hatched larvae were used for biological studies. The first predator was reared on three different prey (larvae of the cotton springtail *Lepidocenitus insertus* (Hand.), larvae of housefly *Musca domestica* L. and immatures of the tydeid soil mite *Tydeus aegyptiaca* (Rasmy and El Bagoury); the latter ones was only reared on the larvae of springtail.

To study the effect of different aforementioned available prey on the post embryonic development and adult fecundity, newly hatched larvae were transferred individually to the experimental cells (35 for every test) and each supplied with surplus known number of different prey till maturity. Observations of the development were done twice a day and reproduction, survival and food consumption once a day.

To study the effect of fungi diets on the post embryonic development and fecundity of the two previous predators, other three allied groups of singly newly eggs were supplied with the fungi *Trichoderma harziarum* (Rifai), *Fusarium oxysporum* (Schlecht.) and *Fusarium solani* (Mart.) and kept until maturity.

Replacement of rearing cells was conducted between new males and females for 24 h to allow insemination of virgin females by spermatophores (not easy to recognize) by new males in rearing cells. Then each adult was transferred back to its original cell. The eggs of the predators were removed daily from the cells. To test the sex ratio,

TABLE 2: Average duration in days (mean ± SD) of the immature stages of *Robustocheles (R.) deltacus* on different foods at 23°C.

Diet	Average duration in days									
	Egg		Larva		Q		Protonymph		Q	
	F	M	F	M	F	M	F	M	F	M
Lepidocenitus insertus (larvae)	12.2 ± 0.25	11.7 ± 0.21	2.2 ± 0.13	2.2 ± 0.13	1.2 ± 0.13	1.1 ± 0.1	3.5 ± 0.22	3.4 ± 0.16	1.2 ± 0.13	1.1 ± 0.1
Tydeus aegyptiaca (immatures)	13 ± 0.21	13.1 ± 0.23	2.4 ± 0.16	2.3 ± 0.15	1.4 ± 0.07	1.2 ± 0.13	4.3 ± 0.15	4.2 ± 0.13	1.3 ± 0.15	1.2 ± 0.13
Musca domestica (larvae)	13.9 ± 0.28	13.9 ± 0.28	2.6 ± 0.16	2.5 ± 0.17	1.5 ± 0.17	1.4 ± 0.16	4.4 ± 0.16	4.3 ± 0.15	1.5 ± 0.17	1.7 ± 0.15

Diet	Deutonymph		Q		Tritonymph		Q		Life cycle	
	F	M	F	M	F	M	F	M	F	M
Lepidocenitus insertus (larvae)	3.3 ± 0.15	3.2 ± 0.13	2.2 ± 0.2	2.3 ± 0.15	4.6 ± 0.16	4.4 ± 0.16	1.6 ± 0.16	1.5 ± 0.17	32.5 ± 0.26c	30.9 ± 0.51c
Tydeus aegyptiaca (immatures)	4.4 ± 0.16	4.3 ± 0.15	2.3 ± 0.15	2.2 ± 0.13	4.9 ± 0.23	4.6 ± 0.16	2 ± 0	1.6 ± 0.16	36 ± 0.50b	34.7 ± 0.26b
Musca domestica (larvae)	4.9 ± 0.23	4.7 ± 0.15	2.5 ± 0.17	2.3 ± 0.15	5.5 ± 0.17	5.4 ± 0.16	2.2 ± 0.13	2.1 ± 0.1	39 ± 0.30a	38.3 ± 0.37a

Means followed by the same letter in vertical columns do not differ significantly (F-test, P > 0.01)

TABLE 3: Average duration in days (mean ± SD) of various periods of the adult stage of *Robustocheles (R.) deltacus* on different foods at 23°C.

	Pre oviposition	Generation	Oviposition	Post oviposition	Longevity		Life span	
Diet	Female	Female	Female	Female	Female	Male	Female	Male
Lepidocenitus insertus (larvae)	1.4 ± 0.16	33.4 ± 0.16c	6.5 ± 0.40	32.6 ± 0.75	40.5 ± 0.76	37.3 ± 098a	73 ± 0.87b	68.2 ± 0.94b
Tydeus aegyptiaca (immatures)	2.7 ± 0.15	38.7 ± 0.40b	7 ± 0.26	28.9 ± 0.32	38.6 ± 0.40	35 ± 0.94ab	74.6 ± 0.50b	69.7 ± 0.94b
Musca domestica (larvae)	2.7 ± 0.15	41.7 ± 0.40a	7 ± 0.26	28.9 ± 0.32	38.6 ± 0.40	35 ± 0.94ab	77.6 ± 0.50a	73.3 ± 0.94a

Means followed by the same letter in the vertical columns do not differ significantly (F-test, P > 0.01)

35 eggs were confined, singly, in new cells and the hatched larvae reared until maturity. An abundance of fresh prey and or fungi was replenished daily.

As to source of different diets:

1. The pure culture of fungi were obtained from Department of Plant Protection, National Research Centre. Each fungus species well grown on potato dextrose agar (PAD) containing 2% starch for 15 days at 25°C in covered Petri-dishes. Matrix of mycellea and spores were grown over the surface of the agar.
2. Larvae of the housefly were obtained from a laboratory culture maintained on cotton pad saturated with milk in Petri-dishes (Afifi, 1980).
3. Larvae of the cotton springtail were obtained from a laboratory culture maintained on pure culture of the fungus, *F. solani*.
4. Immatures of the tydeid soil mites were extracted daily by Berlese funnel from soil mixed with organic matter.

Experiments were conducted under laboratory conditions at 23±2°C and 6/18 hours light/dark periods. Immature and adult stages were mounted in Hoyer's solutions, for a comparative morphological study of the life stages. Life table parameters were calculated according to Hulting *et al.* (1990).

TABLE 4: Feeding capacity and oviposition rate of *Robustocheles (R.) deltacus* as influenced by prey type at 23°C.

Developmental stages of mite and fecundity	Sex	No. of attacked individuals of *L. insertus* (larvae) Average, mean ± SD	*L. insertus* (larvae) Daily rate, mean	*T. aegyptiaca* (immatures) Average, mean ± SD	*T. aegyptiaca* (immatures) Daily rate, mean	*M. domestica* (larvae) Average, mean ± SD	*M. domestica* (larvae) Daily rate, mean
Larvae	Female	-	-	-	-	-	-
	Male	-	-	-	-	-	-
Protonymph	Female	14.4 ± 0.16	4.11	31.9 ± 1.07	7.42	4.5 ± 0.17	1.02
	Male	13.7 ± 0.15	4.03	30.6 ± 0.37	7.29	4.3 ± 0.15	1
Deutonymph	Female	21 ± 0.56	6.36	41.6 ± 0.16	9.46	13.5 ± 0.67	2.76
	Male	18 ± 0.42	5.63	39.5 ± 1.11	9.19	10.5 ± 0.34	2.23
Tritonymph	Female	34.4 ± 0.54	7.48	65.8 ± 2.09	13.43	29.7 ± 0.93	5.4
	Male	32 ± 0.73	7.27	60 ± 1.02	13.04	26 ± 0.75	4.82
Total	Female	69.8 ± 0.95 b	6.12	139.3 ± 3.36 a	10.24	47.7 ± 1.21 c	3.22
	Male	63.7 ± 0.86 b	5.79	130.1 ± 2.01 a	9.93	40.8 ± 0.80 c	2.83
Pre-oviposition	Female	16.6 ± 0.16	11.86	35.2 ± 0.99	14.08	11.5 ± 0.40	4.26
Generation	Female	86.4 ± 0.89 b	6.75	174.5 ± 3.39 a	10.84	59.2 ± 1.45 c	3.38
Oviposition	Female	98.1 ± 0.38 b	15.09	135.8 ± 2.28 a	18.86	37.4 ± 0.73 c	5.34
Post-oviposition	Female	288.7 ± 1.73	8.86	377.1 ± 3.47	13.19	98 ± 0.50	3.39
Total fecundity	Female	15.1 ± 0.72 a	2.32	11.6 ± 0.72 b	1.61	12.6 ± 0.43 ab	1.8
Longevity	Female	403.4 ± 1.65 b	9.96	548.1 ± 4.64 a	14.31	146.9 ± 0.61 c	3.81
	Male	239 ± 2.97 b	6.41	372.1 ± 7.39 a	11.24	145.1 ± 0.89 c	4.15
Life span	Female	473.2 ± 1.79 b	9.12	687.4 ± 7.11 a	13.24	194.6 ± 1.53 c	3.64
	Male	302.7 ± 3.18 b	6.27	502.2 ± 8.47 a	10.87	185.9 ± 1.13 c	3.76

Means followed by the same letter in the horizontal columns do not differ significantly (F-test, P > 0.01)

RESULTS AND DISCUSSION

Biology

Robustocheles (R.) deltacus Abou-Awad, El-Sawaf and Abdel-Khalek

Robustocheles (R.) deltacus successfully developed from egg to adult when fed on fungi, but failed to lay eggs. When rhagidiid predator was reared on different prey, adult female laid eggs. Thus, fungi diets were found insufficient to induce oviposition.

Table 1 shows that *R. (R.) deltacus* passed through the egg, larva (immobile calyptostatic prelarva and mobile elatostatic larva), proto-, deuto-, tritonymph and adult stages. *F. oxysporum* slightly shortened the period of immature and adult stages than did the two other fungi *F. solani and T. harzairum*.

Life cycle and life span were significantly shorter (42.9 and 57.9 days) when rhagidiid predator fed on *F. oxysporum*, while being longer on other fungal diets.

Feeding *R. (R.) deltacus* on larvae of springtail *L. insertus* accelerated the development by giving significantly shorter period of immature stages than obtained on the tydeid mite *T. aegyptiaca* and the housefly *M. domestica* (Table 2). The quiescent larvae, proto-, deuto- and tritonymph showed almost the same trend of differences and comprised 26.4%, 19.4% and 19.7% of the total duration of the life cycle, when feeding on the three prey, respectively. The whole life cycle averaged 32.5, 36.0 and 39.0 days on each prey, respectively.

Female laid its eggs on walls of plastic cells or slits of substratum in clusters of about 5-9 eggs.

TABLE 5: Effect of different food substances on the life table parameters of *Robustocheles (R.) deltacus* and *Rhagidia (R.) qaliubiensis* at 23°C.

Parameters	*R. deltacus*			*R. qaliubiensis*
	L. insertus	*T. aegyptiaca*	*M. domestica*	*L. insertus*
	(larvae)	(immatures)	(larvae)	(larvae)
Net reproduction rate (*Ro*)	12.82	12.09	8.19	11.58
Mean generation time (*T*)	37.75	43.93	46.03	41.49
Intrinsic rate of increase (*rm*)	0.0676	0.0567	0.0457	0.059
Finite rate of increase (e^{rm})	1.07	1.06	1.05	1.06
Time to 50% mortality (*days*)	70	73	77	74
Sex ratio (*female/ total*)	26/35	25/35	23/35	21/30
Sex ratio (*female/ male*)	2.9:1	2.5:1	1.9:1	2.3:1

Eggs are elongated ovate. They measure about 245–265 μm long and 190 – 210 μm wide in outline. Newly laid eggs are dark orange. As incubation proceeded, the embryo gradually appeared and increased in size; just before hatching a longitudinal split occurred in the egg and subsequently the hatched calyptostatic prelarva pushed its self outside the egg shell. It is translucent white, immobile and nonfeeding. After hours it becomes mobile elatostatic nonfeeding larvae.

Quiescent immature stages occurred in protected sites such as holes, cracks and slits of substratum. Individual spins a copwebby moulting nest or a thin layer of translucent membrane around its self. Moulting process or ecdysis took about 8 hours. Preoviposition and oviposition periods were almost the same on the three preys, but prolonged postoviposition. On *L. insertus*, the adult female life span appeared to be significantly shorter than obtained on *M. domestica* (Table 3).

It is worth mentioning that the food type seemed to affect the predator's colour, as immatures and adult stages were whitish, rosy and dark grey when individuals fed on the fungi *F. solani*, *F. oxysporum* and *T. harziarum* respectively. On larval prey, these individuals acquired a whitish appearance. Predator female and male consumed significantly greater number of *T. aegyptiaca* immatures than those of *L. insertus* and *M. domestica* larvae (Table 4). The daily rate for female prey averaged 10.24, 6.12 and 3.22 individuals and that of male reached 9.93, 5.79 and 2.83 individuals of the three prey species respectively (Table 4).

Individuals were usually seen fast wandering into rearing cells, searching for their prey. When meeting the prey, the predator grasped the prey's appendages using its palps and the first pair of anterior legs, then it inserted its chelicerae into the prey at mid of its body to suck partially the prey content. After a while, the predator returned to attack again the same prey to continue the sucking process and consume entire prey. This process lasted about three minutes.

Zacharda (1980) mentioned that rhagidiid species have cheliceral shears, often arched and evidently adapted to grasping a mobile prey. The subcapitulum of these mites have labra and internal malae conspicuously styletform and probably also piercing a prey grasped with the chelicerae. During life span, the female and male predator fed on an average 687.4 and 502.2 *T. aegyptiaca* immatures, 473.2 and 302.7 *L. insertus* larvae and 194.6 and 185.9 larvae of *M. domestica*, respectively. The total number of deposited eggs/female averaged

TABLE 6: Average duration in days (mean ± SD) of various stages of *Rhagidia (R.) qaliubiensis* on larvae of springtails *L. insertus* at 23°C.

Mite stage	Sex	Duration (days)
Egg		15.60 ± 0.22
		15.50 ± 0.17
Larva	F	2.60 ± 0.16
	M	2.50 ± 0.17
Quiescent	F	1.60 ± 0.16
	M	1.40 ± 0.16
Protonymph	F	3.30 ± 0.15
	M	3.20 ± 0.13
Quiescent	F	1.90 ± 0.18
	M	1.70 ± 0.15
Deutonymph	F	3.40 ± 0.16
	M	3.40 ± 0.16
Quiescent	F	1.60 ± 0.16
	M	1.60 ± 0.16
Tritonymph	F	3.90 ± 0.10
	M	3.80 ± 0.13
Quiescent	F	1.40 ± 0.16
	M	1.30 ± 0.15
Total	F	35.30 ± 0.21
	M	34.40 ± 0.22
Pre–oviposition period	F	2.20 ± 0.13
Oviposition period	F	5.80 ± 0.29
Post–oviposition period	F	31.90 ± 0.77
Life span	F	75.20 ± 0.92
	M	70.70 ± 0.70
% Surviving	F	100
	M	100
Observations	F	25
	M	10

15.10, 12.60 and 11.60 eggs, when fed *L. insertus* and *M. domestica* and *T. aegyptiaca*, respectively(Table 4). Feeding on springtails increased female fecundity more than housefly and tydeid mites.

The data in Table 5 show that the multiplication per generation (RO) was 12.82, 12.09 and 8.19 times in a generation time (T) of 37.75, 43.93 and 46.03 days, while the intrinsic rate of increase (rm) averaged 0.0676, 0.0567 and 0.0457 individuals per days, when *R. (R.) deltacus* fed on *L. insertus*, *T. aegyptiaca* and *M. domestica*, respectively. Thus, it can be concluded that the reproduction rate was the highest on *L. insertus* prey. Larvae of springtail also gave the highest females ratio in the sex ratio as compared to feeding on both other prey (Table 5).

Rhagidia (R.) qaliubiensis **Abou-Awad, El-Sawaf and Abdel-Khalek**

It was found that feeding *R. (R.) qaliubiensis* on *T. harzairum* had accelerated female longevity and life span than those fed on *F. solani* and *F. oxysporum* (Table 1). When feeding the predator on *L. insertus* lar-

TABLE 7: Feeding capacity and oviposition rate of *Rhagidia (R.) qaliubiensis* as influenced by larvae of springtails *L. insertus* at 23°C.

Mite stage	Sex	No.of attacked individuals of springtails Average, mean ± SD	Daily rate, mean
Larvae	F	0	0
	M	0	0
Protonymph	F	15.50 ± 0.17	4.7
	M	15.00 ± 0.26	4.69
Deutonymph	F	22.60 ± 0.52	6.65
	M	21.90 ± 0.28	6.44
Tritonymph	F	30.20 ± 0.25	7.74
	M	29.50 ± 0.34	7.76
Total	F	68.30 ± 0.62	6.44
	M	66.40 ± 0.67	6.39
Pre-oviposition	F	18.00 ± 0.30	8.18
Generation	F	86.30 ± 0.70	6.74
Oviposition	F	61.60 ± 0.67	10.62
Total fecundity	F	13.80 ± 0.55	2.38
Post-oviposition	F	258.60 ± 0.91	8.11
Longevity	F	338.20 ± 1.29	8.48
	M	258.80 ± 0.79	7.13
Life span	F	406.50 ± 1.43	8.05
	M	325.20 ± 0.94	6.96

vae, it was found that the total life cycle being completed in 35.30 days for females and 34.4 days for males. Males emerged earlier than females for a period of one day (Table 6).

It is of interest to note that the feeding habits, oviposition and hatching process were similar to that of *R. (R.) deltacus.* Insemination took place after female emergence from the last quiescent stage. Unfertilized females were found to produce only female offspring, similar to other previous allied species, while both males and females were produced by fertilized females.

Eggs are oval in outline, females laid their eggs either singly or in clusters of about 2-3 eggs. Females deposited an average number of 13.80 eggs (Table 7) during an average oviposition period 5.8 days and then survived an average post-oviposition period 31.9 days (Table 6). During the pre-oviposition period, adult female ate an average of 18.00 *L. insertus* larvae. This rate of consumption increased during short egg laying period to 61.60 individuals and greatly increased to 258.6 prey during post-oviposition period (Table 7). The mean generation time of population (T= 41.49 days), would increase 11.58 times (Ro = 11.58) (Table 5).

It is noticeable that cannibalism constitutes a great problem in rhagidiid rearing. It was observed in immature and adult stages. This phenomenon did not relate to scarcity of suitable prey, but it seems that it is a specific character among the individuals of rhagidiid predators.

It can be concluded that the previous data

TABLE 8: Idiosomal, genital flap and leg lengths of the different active stages in the two rhagidiid predators, *Rhagidia (R.) qaliubiensis* and *Robustocheles (R.) deltacus.*

Stage	Idiosomal length		Genital flap length	
	R. (R.) qaliubiensis	*R. (R.) deltacus*	*R. (R.) qaliubiensis*	*R. (R.) deltacus*
Larva	207 (195-207)	197 (193-200)	_____	_____
Protonymph	302 (290-302)	311 (297-320)	22 (22-27)	18 (18-20)
Deutonymph	383 (375-389)	392(342-392)	56 (56-63)	36 (36-41)
Tritonymph	648 (630-648)	517 (498-517)	72 (65-74)	49 (48-52)
Adult Female	1116 (765-1116)	554 (509-585)	135 (101-135)	86 (62-86)
Adult Male	998 (987-998)	510 (505-520)	98 (85-98)	75 (70-75)
	Leg length *R. (R.) qaliubiensis*			
	PI	PII	PIII	PIV
Larva	144 (144-156)	108 (95-108)	113 (102-113)	
Protonymph	230 (221-230)	167 (156-167)	180 (172-180)	203 (203-210)
Deutonymph	333 (313-333)	234 (210-234)	243 (243-251)	306 (306-318)
Tritonymph	365 (710-765)	540 (513-540)	576 (561-576)	648 (641-648)
Adult Female	1193 (1026-1215)	885 (885-885)	946 (931-946)	1149 (963-1215)
Adult Male	1118 (1110-1115)	759 (750-770)	900 (900-910)	1010 (1000-1010)
	Leg length *R. (R.) deltacus*			
	PI	PII	PIII	PIV
Larva	135 (132-135)	98 (95-98)	120 (117-120)	
Protonymph	219 (219-223)	164 (163-171)	171 (171-180)	203 (203-215)
Deutonymph	275 (273-275)	176 (171-176)	189 (198-195)	257 (240-257)
Tritonymph	333 (305-333)	275(261-275)	288 (281-288)	360 (360-374)
Adult Female	599 (405-1215)	441 (409-885)	433 (411-946)	528 (405-1215)
Adult Male	550 (550-555)	397 (395-402)	391 (390-397)	491 (483-495)

showed that both rhagidiid mites *R. (R.) deltacus* and *R. (R.) qaliubiensis* may be considered as predacious not fungivorus mites. To the contrary, Abou-Awad *et al.* (2008) confirmed that the eupodid mites *Benoinysus momeni* (Abou-Awad) and *Eupodes bakeri* A. E. & A. could successfully feed and develop on several fungi diets. However, the examined rhagidiid species might play an important role in affecting the population of soil pests, but this might encourage to carry further investigations to determine the biological rate.

Ontogeny

Developmental stages of the two rhagidiid species, *R. (R.) deltacus* and *R. (R.) qaliubiensis* were examined in detail, to evaluate the effectiveness of var-

TABLE 9: Ontogeny of coxal and leg setae (excluding solendia) in the two rhagidiid predators, *Rhagidia (R.) qaliubiensis* and *Robustocheles (R.) deltacus*.

	Coxa	Trochanter	Femur	Genu	Tibia	Tarsus	Species
Larva	2-1-2	0-0-0	6-6-5	4-4-5	4-4-5	14-10-9	*R. (R.) qaliubiensis*
	2-1-2	0-0-0	6-4-4	5-4-4	5-5-5	10-10-9	*R. (R.) deltacus*
Protonymph	3-1-3-1	0-0-1-1	6-7-5-0	5-5-5-0	5-5-5-1	16-11-9-8	*R. (R.) qaliubiensis*
	3-1-3-1	1-1-1-1	6-5-4-0	6-5-4-0	6-5-5-1	11-11-9-8	*R. (R.) deltacus*
Deutonymph	3-1-4-3	1-1-2-2	9-11-8-5	8-6-5-4	9-5-5-6	16-13-11-12	*R. (R.) qaliubiensis*
	3-1-4-3	1-1-2-2	9-10-6-5	9-5-5-3	7-5-5-5	17-13-11-10	*R. (R.) deltacus*
Tritonymph	3-1-5-3	1-1-2-2	9-11-8-6	9-6-6-7	9-6-6-6	16-14-11-12	*R. (R.) qaliubiensis*
	3-1-5-3	1-1-2-2	9-10-7-6	9-8-6-5	9-6-5-6	17-16-13-13	*R. (R.) deltacus*
Adult	3-1-6-3	1-1-2-2	10-13-8-7	11-7-7-7	10-6-7-7	17-14-13-12	*R. (R.) qaliubiensis*
	3-1-5-3	1-1-2-2	10-11-8-6	11-8-7-7	11-6-6-6	17-16-14-15	*R. (R.) deltacus*

TABLE 10: Chaetotaxy of *Rhagidia (R.) qaliubiensis* and *Robustocheles (R.) deltacus* legs. Dorsal and ventral refer to surfaces of the leg segments. Leg segments indicated by C, T, F, G, T, T are coxa, trochanter, femur genu, tibia and tarsus, in that order.

Legs	Larva		Protonymph		Deutonymph		Tritonymph		Adult	
	qaliubiensis	*deltacus*	*qaliubiensis*	*deltacus*	*qaliubiensis*	*deltacus*	*qaliubiensis*	*deltacus*	*qaliubiensis*	*deltacus*
Dorsal	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T	C-T-F-G-T-T
I	0-0-4-2-2-5	0-0-4-2-3-5	0-0-4-2-3-5	0-0-4-3-4-5	0-0-6-5-4-5	0-0-6-6-4-5	0-0-6-6-4-5	0-0-6-6-4-5	0-0-6-8-5-5	0-0-7-8-6-5
II	0-0-3-3-2-4	0-0-3-2-2-4	0-0-3-4-3-4	0-0-3-2-2-4	0-0-6-4-3-5	0-0-6-2-2-6	0-0-6-4-3-5	0-0-6-5-3-7	0-0-8-5-3-5	0-0-7-5-3-7
III	0-0-3-3-3-3	0-0-2-2-3-4	0-0-3-3-2-3	0-0-2-2-3-4	0-0-5-3-3-5	0-0-3-3-3-4	0-0-5-4-3-3	0-0-3-3-2-4	0-0-5-5-3-3	0-0-4-3-2-4
IV			0-0-0-0-0-3	0-0-0-0-0-3	0-0-2-2-3-4	0-0-2-1-2-3	0-0-4-4-3-4	0-0-2-2-2-4	0-0-5-4-4-4	0-0-2-3-2-4
Ventral										
I	2-0-2-2-2-9	2-0-2-3-2-5	3-0-2-3-2-11	3-1-2-3-2-6	3-1-3-3-5-11	3-1-3-3-3-12	3-1-3-3-5-11	3-1-3-3-5-12	3-1-4-3-5-12	3-1-3-3-5-12
II	1-0-3-1-2-6	1-0-1-2-3-6	1-0-4-1-2-7	1-1-2-3-3-7	1-1-5-2-2-8	1-1-4-3-3-7	1-1-5-2-3-9	1-1-4-3-3-9	1-1-5-2-3-9	1-1-4-3-3- 9
III	2-0-2-2-2-6	2-0-2-2-2-5	3-1-2-2-3-6	3-1-2-2-2-5	4-2-3-2-2-6	4-2-3-2-2-7	5-2-3-2-3-8	5-2-4-3-3-9	6-2-3-2-4-10	5-2-4-4-4-10
IV			1-1-0-0-1-5	1-1-0-0-1-5	3-2-3-2-3- 8	3-2-3-2-3-7	3-2-2-3-3-8	3-2-4-3-4-9	3-2-2-3-3-8	3-2-4-4-4-11

ious aspects of the chaetotaxy in separating immatures. Measurements of the idiosoma, genital flap, leg lengths and the number of specimens observed in each stage are given in Table 8. The calyptostatic prelarva (Ehrensberger 1977) is immobile and enclosed in apoderme (Travé 1976), without appendage segmentation, with reduced and after nude chaetotaxy on both dorsal and ventral side of opisthosoma. The rhagidial organs, anal and genital opening are missing.

The elatostatic larva (Ehrensberger 1974) of both species is easily recognized because it is a hexapod; the anal opening is present; the genital opening is still undeveloped; chaetotaxy of the idiosomal venter and appendages are considerably reduced in its number. Number of rhagidial setae is reduced.

It was not possible to differentiate between males and females during nymphal stages. Even, for adults, the same difficulty was notified unless oviposition led to distinguish both sexes, as females reproduce parthenogenetically. Males may also be recognized by the presence of an internal sperm sac just anterior to the genital pore (Figure 1). The discussion of comparative morphology in limited to characteristics of idiosoma and legs.

Gnathosoma — No detectable difference exist in chelicerae and subcapitulum, but a ventral seta is added to the palp tarsus in the tritonymph for both rhagidiid species. Edwards and Usher (1987) reported that this seta is added to the palp tarsus in the deutonymph of *Rhagidia gerlachei*.

Idiosoma dorsum and anal region — No addition of setae occurs during ontogeny of the two rhagidiid species; a single adanal pair appears only in the protonymph of *R. (R.) qaliubiensis* and its successive stages.

Idiosoma venter — Larval and three nymphal stages have a ventrally located genital pore that is covered by a longitudinal flaps (Figure 2). The greatest increase in genital flap length of both rhagidiid species occur between the tritonymph and adult with the increase in the female proportionately greater than male.

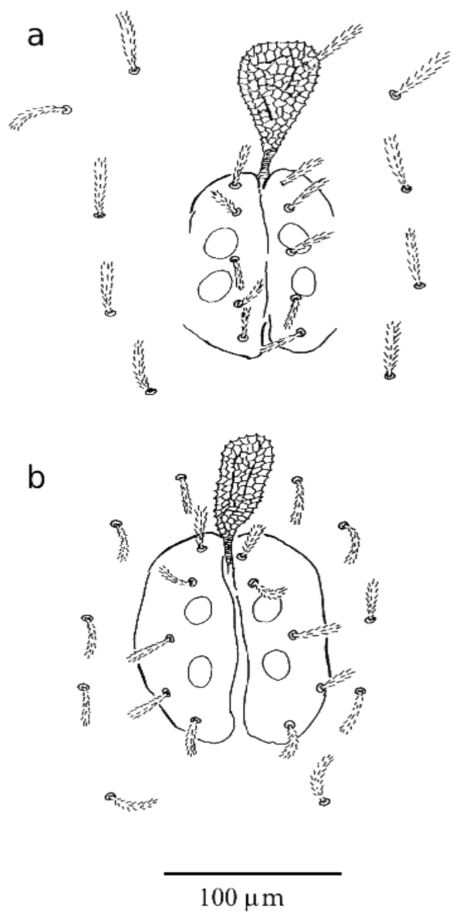

FIGURE 1: Genital male area of the two rhagidiid species: a – *R. (R.) qaliubiensis* and b – *R. (R.) deltacus*.

The same relationship also applies to the length of idiosoma (Table 8). On the other hand, the increase in genital flap length at each moult is accompanied by an increase in the number of setae situated on the flaps. One pair of genital setae is present in the protonymph. At each of the moult to deutonymph and tritonymph, an additional pair is added (Figure 2). In passing from tritonymph to mature female and male of *R. (R.) qaliubiensis* and *R. (R.) deltacus* 2 pairs of genital setae are added for the total complement of 5 pairs, for each respectively. The number of genital setae provides the simplest method of separating the nymphal stages.

The protonymph posseses 1 pair of genital papillae below the genital shields. Aggenital setae bracket the genital flaps in all stages except the protonymph. There are 2 pairs in the deutonymph and 4 pairs in the tritonymph, whilst 1 pair of these setae are added for the total complement of 5 pairs on *R. (R.) qaliubiensis* and *R. (R.) deltacus* female and male. This is effective in distinguishing the various stages of some rhagidiid species.

Leg chaetotaxy

Tables 9 and 10 show the number of coxal and leg setae (rhagidial and spiniform solenidia excepted). Setae located on the dorsal and ventral surfaces of the leg segments in each stage are also illustrated in Figure 3. Dorsal setae are represented by black circles.

Ventral idiosoma — The larval complement of podosomal setae in *R. (R.) qaliubiensis* and *R. (R.) deltacus* is evidently 2(1a,b)-1(2b)-2(3a,b). Setae (1c), (3c) and (4a) are added in the protonymph, (3d) and (4b,c) in the deutonymph, but (4b) is not added until the tritonymph (Baker 1995). Where the adult setal complement of coxa III is more than four, the additional ones are added in the tritonymph (3-1-5-3) and adult (3-1-6-3) of *R. (R.) qaliubiensis* and *R. (R.) deltacus* (Table 9). Trochanter setae first appear in the protonymph. Trochanteral setation 0-0-1-1 in the protonymph, and 1-1-2-2 in the deutonymph and tritonymph for both species. In the larval stage, the total setae of femora, genu and tibiae I-III are 43 and 42 for *R. (R.) qaliubiensis* and *R. (R.) deltacus*, respectively. At the moult protonymph, 6 and 5 setae are added at femora, genua and tibiae segments for the two species, respectively. No setae on the femur and genu of protonymphal leg IV for both species. The increase from one to 14 and or 12 on the femur, genu and tibia of leg IV is an effective critirion for distinguishing between protonymph and deutonymph for both rhagidiid species, respectively.

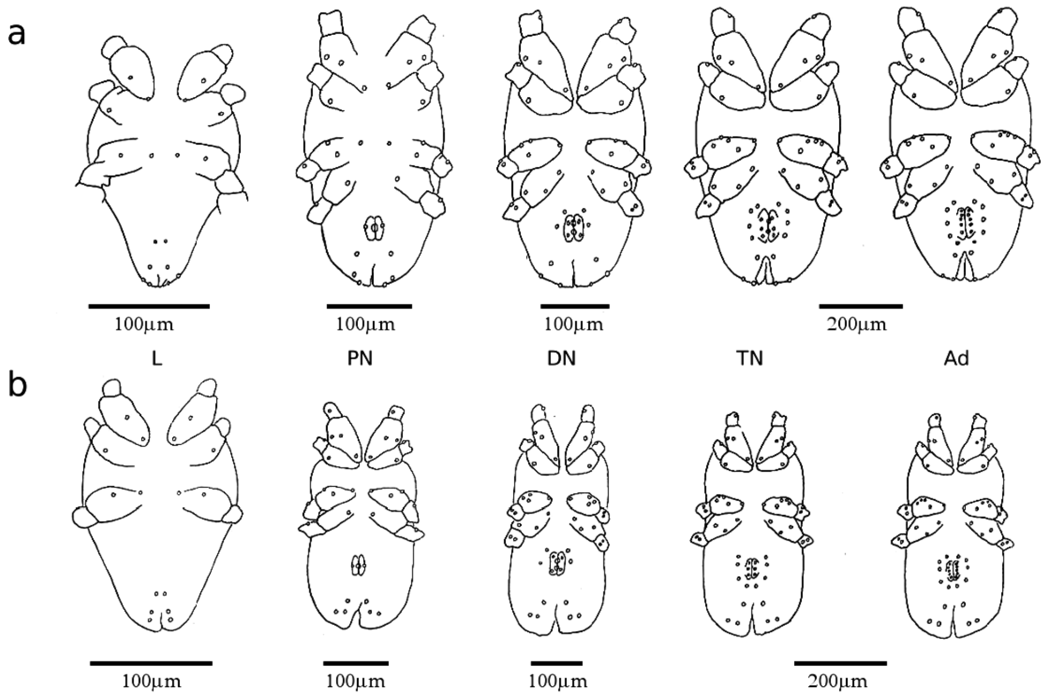

FIGURE 2: Ventral chaetotaxy of the larval, three nymphal and adult stages of a – *R. (R.) qaliubiensis* and b – *R. (R.) deltacus*.

In passing from deutonymph to tritonymph, 8 and 12 setae are added at all segments except tarsi I-IV; and from tritonymph to adult, 14 setae are added at all segments for both species. At the moults to adult, 4,4,3 and 3 as well as 3,5,3 and 3 setae are added for *R. (R.) qaliubiensis* and *R. (R.) deltacus* on femur, genu, tibia and tarsus, respectively. This provides a reliable means of differentiating deutonymph, tritonymph and adult.

In addition to setae, rhagidial solenidia and famuli occur on the genu, tibia and tarsus for both rhagidiid species. In mature stages of *R. (R.) qaliubiensis,* tarsus I with 4 rhagidial solenidia lying in tandem in confluent depressions, stellate famulus inserted latered to 1st proximal rhagidial solenidion; tarsus II with 4 rhagidial solenidia and small spiniform famulus subtends proximal rhagidial solenidion.

Tibia I with one small erect spiniform latered dorsoproximal solenidion and one dorsodistal rhagidial lanceolate setae. Tibia II with one small erect spiniform latered dorsoproximal solenidion and one lanceolate dorsodistal solenidion recessed in deep pit. Genu I with one erect spiniform ventromedial solenidion. In the present study, there is 1,1,2 and 3 rhagidial solenidia on the larva, protodeuto- and tritonymph of tarsus I and II, respectively. Fourth rhagidial organ is added to tarsus I and II of adult. The erect stellate seta of tarsus I and small spiniform famulus of tarsus II first appear in the tritonymph and deutonymph, respectively. On the tibiae I and II of larva, there is one small spiniform, famulus; whilst the erect lanceolate dorsodistal solenidian of tibia II and spiniform ventromedial solenidion of genu I first appear in the protonymph.

In the *R. (R.) deltacus*, tarsus I with four rhagidial solenidia lying obliquely in separate pits for adult stages. Stellate famulus inserted between first and second proximal rhagidial solenidia. Tarsus II with

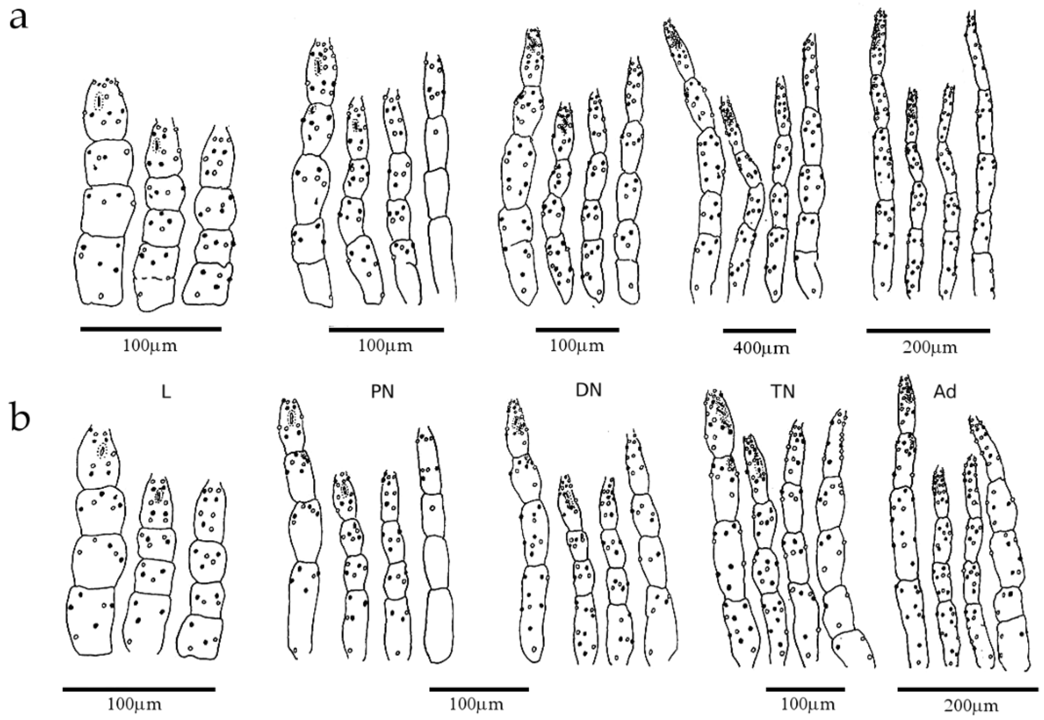

FIGURE 3: Chaetotaxy of the dorsal and ventral leg surfaces of the larval, three nymphal and adult stages of a – *R. (R.) qaliubiensis* and b – *R. (R.) deltacus*.

three rhagidial solenidia lying in tandem in confluent depressions and small spiniform famulus, subtending proximal rhagidial solenidion. Tibia I with one dorsodistal spiniform solenidion lying proximad of one dorsodistal rhagidial solenidion. Tibia II with one small lanceolated dorsodistal solenidion. In the larva, proto-, deuto- and tritonymph of tarsus I, there is 1,1,2 and 3 rhagidial solenidia, respectively. Fourth rhagidial organ is added to tarsus I of adult stage. The erect stellate seta of tarsus I first appear in the tritonymph. Also, there is 1,1,2,3 and 3 rhagidial solenidia on tarsus II of larva, proto- , deuto- and tritonymph and adult stages, respectively. On tibia I of larva, there is one spiniform solenidion. At the moult to protonymph, a dorsorhagidial solenidion and a lanceolate dorsodistal solenidion are added to tibiae I and II, respectively. Spiniform famulus is also added to tibia II.

These results indicate clearly that the patterns of setal additions and solenidia, throughout the life cycle, may help in separating rhagidiid immatures.

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