Acarina 10 (1): 85–89

STUDIES ON *AGISTEMUS INDUSTANI* GONZALEZ-RODRIGUEZ (ACARINA: STIGMAEIDAE), AN EFFICIENT PREDATOR OF *TETRANYCHUS LUDENI* ZACKER ON MULBERRY

ИЗУЧЕНИЕ *AGISTEMUS INDUSTANI* GONZALEZ-RODRIGUEZ (ACARINA: STIGMAEIDAE) — ЕСТЕСТВЕННОГО ВРАГА ШЕЛКОВИЧНОГО ПАУТИННОГО КЛЕЩА *TETRANYCHUS LUDENI* ZACKER

M. Arbabi[1], J. Singh[2]
М. Арбаби[1], Дж. Синг[2]

[1]Department of Agricultural Zoology Research, Plant Pests and Diseases Research Institute, P.O. Box 1454, Tehran-19395, Iran
[2]Department of Agricultural Zoology and Entomology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, India

Key word: *Agistemus industani*, life cycle, predation ability, *Tetranychus ludeni*
Ключевые слова: *Agistemus industani*, жизненный цикл, хищничество, *Tetranychus ludeni*

ABSTRACT

Distribution, biology and feeding behavior of the predatory mite *Agistemus industani* (Acarina: Stigmaeidae) were studied with *Tetranychus ludeni* being the prey mite on mulberry leaves. This predator was observed feeding voraciously on eggs of the prey in the field. One or two individuals of the predators were often recorded on mulberry leaves in the time period between September and February. Under laboratory conditions, a fertilized female produced female and male progeny in the ratio of 3:1 while an unfertilized female produced male progeny only. The ovipositional period ranged from 20 to 43 days when 42–98 eggs were deposited by a female. The total developmental period of a female predatory mite fed on eggs of *T.ludeni* varied from 11 to 17 days but it was 10–16 days in case of the male. The longevity of the adult female varied from 23 to 46 days, whereas the male lived 23–48 days. The feeding rate of the female predator was three times higher than that of the male. On an average 3 predator eggs were deposited per day after consumption of 15 prey eggs. The male predator consumed nearly 6 eggs per day. The occurrence and abundance of *A.indutani* during infestation of *T.ludeni* (March–June) on vegetable crops suggests that it can be an efficient predator of this pest species.

РЕЗЮМЕ

Приводятся данные по распространению, биологии и пищевому поведению хищного клеща *Agistemus industani* (Acarina: Stigmaeidae) — естественного врага паутинного клеща *Tetranychus ludeni*. Одна или две особи хищника часто встречались на листьях шелковицы в период с сентября по февраль. В лабораторных условиях соотношение самок и самцов в потомстве оплодотворенной самки было 3:1, тогда как потомство неоплодотворенной самки состояло только из самцов. Длительность периода яйцекладки 20–43 дня, одна самка откладывает 42–98 яиц. Период развития самки хищника варьирует от 11 до 17 дней, самца — от 10 до 16. Продолжительность жизни взрослой самки 23–46 дней, тогда как самец живет 23–48 дней. Самка потребляет почти в три раза больше пищи, чем самец. В среднем самка *A. industani* откладывает 3 яйца в день после того, как съедает 15 яиц *T. ludeni*. Самец хищника потребляет около 6 яиц жертвы в день. Распространение и обилие *A. industani* в период инвазии деревьев паутинным клещом (март–июнь) говорит о том, что этот вид может быть эффективным хищником, уничтожающим вредителя.

INTRODUCTION

The importance of mites of the family Stigmaeidae as acarine predators has been documented by Gonzalez-Rodriguez [1965] and McMurtry [1984]. More than 200 species of stigmaeid mites have been reported so far from different parts of the world [Kethley, 1990]. The occurrence, biology and feeding behavior of only few species of *Agistemus* and *Zetzellia* have been studied in detail [Santos, Laing, 1985]. This group of predatory mites prefers prey eggs to postembryonic stages [Hafez et al., 1983; Clements, Harmsen, 1990; Santos, 1991]. Rasmy et al. [1984] reported that

rearing of stigmaeid mite *Agistemus exsertus* on eggs of the prey speeds up its development and causes a higher rate of oviposition than when fed on prey larvae and nymphs. In India, very little information is available on stigmaeid mites. Gupta [1991] reported 19 species of this family and identified only six species as predators on plant feeding mites. Effects of abiotic factors on abundance and distribution patterns of 3 *Agistemus* spp. were investigated in Assam and West Bangal of India by Borthakur and Das [1987] and Singh et al. [1989], respectively. The aim of the present study is to provide information on the life history of *Agistemus industani* and its predatory efficiency on *Tetranychus ludeni*.

MATERIALS AND METHODS

A survey was conducted during 1989–1992 in different parts of the Varanasi region eastern of Uttar Pradesh (India) to explore the occurrence of stigmaeid mites. Leaves from different agro- horticultural plants were collected and examined in laboratory under the stereomicroscope. The mites were preserved in 70 per cent ethyl alcohol and mounted in Hoyer's medium. The final identification of mites was confirmed under the phase contrast microscope. The biology of *Agistemus industani* was studied on 4×4 excised mulberry leaves with eggs of *Tetranychus ludeni* serving as prey and the mean room temperature of 27°C and the relative humidity being 90 per cent. The newly hatched larva of the predator was transferred singly onto fresh leaves having known number of prey eggs. The observations on the entire post-embryonic stages and their rates of predation on prey eggs were recorded every 24 hours and discontinued when an individual predator died accidentally in any particular Petri dish.

RESULTS AND DISCUSSION

Distribution. *Agistemus industani* is one of the most abundant species of the family Stigmaeidae. Its occurrence was noticed throughout the year with different prey mites viz. *Tetranychus* spp. and *Schizotetranychus cajani* Gupta on a variety of plant (i.e. *Solanum melongena* L., *Cicer orientinum* L., *Morus alba* L., *Cajanus cajan* (L.), and *Sesamum indica* L.). Santos and Laing [1985] noticed 13 species of stigmaeid mites associated with plant injurious mites in different parts of the world. The peak population of *A.industani* was observed during September–February. They were mostly present near the vein of midrib of mulberry leaves. This is in agreement with the observation of Santos [1975] who reported 82% of *Zetzellia mali* population occurred along the midrib of leaves. Twenty-nine immature individuals and orange-red adults maximum were recorded on a single *Morus alba* leaf. Collyer [1964] reported the number of more than 100 *Agistemus longistus* per leaf lamina on fruit trees in New Zealand.

Biology. The life cycle of *A.industani* includes egg, larva, protonymph, deutonymph and adult. Each active stage is followed by a quiescent period. The female mite has three quiescent stages whereas the male has only two (Table 1). The details of developmental stages are as follows.

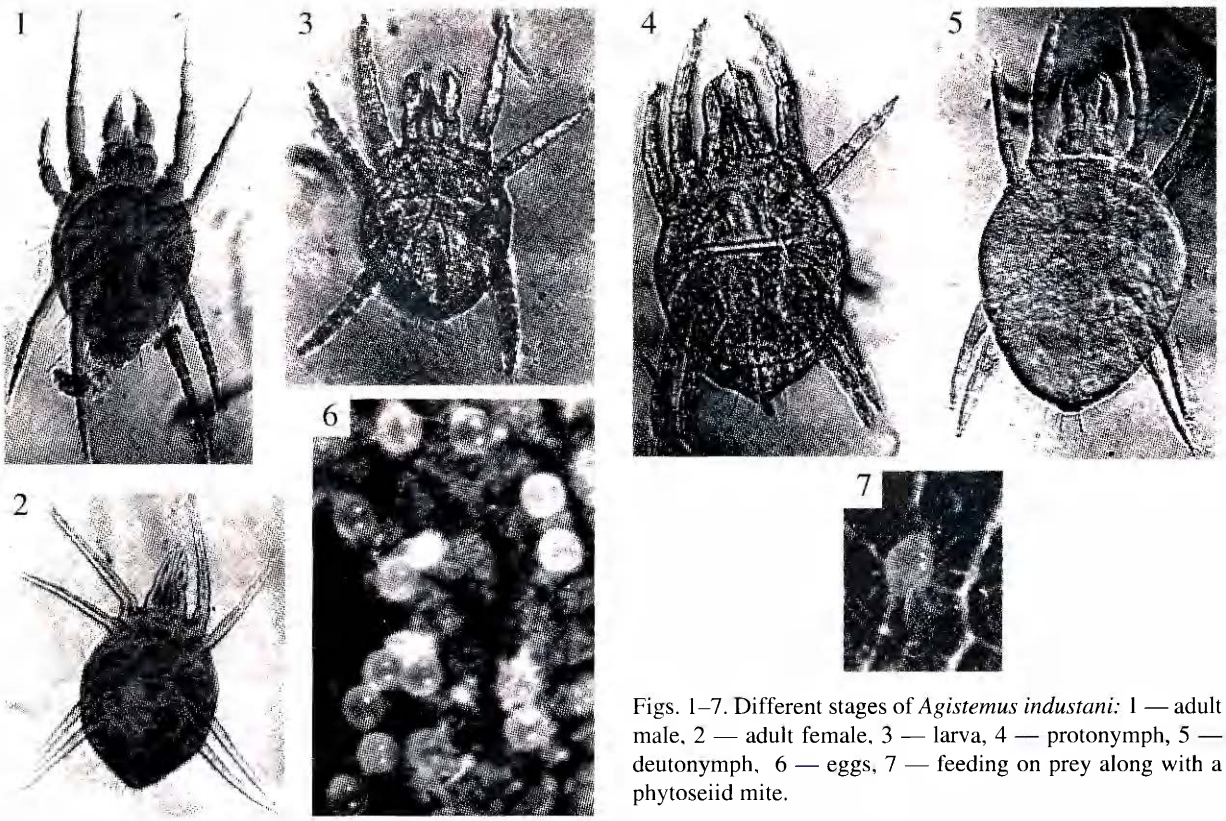
Egg. The freshly laid egg (Fig. 1) is yellow in color, which gradually changes into amber yellow. A pair of distinct red eyes appears before it hatchs. The eggs are mostly deposited singly and hatch after 3.83±0.36 days (Table 1). This is in agreement with the finding of Borthakur and Das [1987] who reported a hatching period 4–5 days for *Agistemus* sp. during the winter season, which is identical to the Varanasi climatic condition.

Larva. The larva emerges yellow in color with a pair of red eye spots on propodosoma (Fig. 2). Santos and Laing [1985] observed similar appearance in immature stages of *Z.mali* when fed on *Bryobia praetiosa*. The mean larval duration of 2.55±1.04 days was found to be longer than that of other immatures (Table 1).

Nymphs. The daily prey eggs consumption of 2.83 preys at larval stage reaches 4.79 preys at second nymphal stage. The length of the mean protonymphal period was 1.85±1.03 days whereas deutonymphal period was 1.77±0.77 days. Hafez et al. [1983] reported that *A.exsertus* completed its development from larva to adult within 6–7.5 days when reared on eggs of *Tetranychus* spp. However this period is prolonged by 7–11 days when immature preys are supplied as food.

Quiescent stages. Each active stage of this predator is followed by a molting process and is subsequently adhered to leaf surface with well-stretched legs on anterior and posterior side of the body. The smaller difference was observed in the duration of all the three quiescent stages of the female, which attains maturity after the final molt (third quiescent stage). However the male attained maturity after the second quiescent stage, which is 75.22% longer than that of the quiescent female (Table 1).

Adults. The yellow color of immatures (Fig. 3,4) turned into orange-reddish in mature adults



Figs. 1–7. Different stages of *Agistemus industani:* 1 — adult male, 2 — adult female, 3 — larva, 4 — protonymph, 5 — deutonymph, 6 — eggs, 7 — feeding on prey along with a phytoseiid mite.

(Fig. 5,6). A shorter duration of 1–3 days was common in the development of male than that of the females. The mean duration of the development from an egg to an adult was found to be 11.21±1.85 days for male and 13.30±1.80 days for female (Table 1). This is not similar to longer developmental time (13–24.1 days) reported for *Z. mali* fed on *Aculus schlehtendali* [White and Laing, 1977].

Mating and sex ratio. Arrhenotokous sexual reproduction is commonly found in this mite. White and Laing [1977] observed same mechanism in the reproduction of *Zetzellila mali*. The mating is initiated by process slipping of the male under the female between her legs. The male holds first two pair of legs with his front legs and simultaneously raises the pointed opisthosoma towards the genital opening of the female. This process lasts 3–7 seconds. Th › higher increase in the sex ratio of female progeny › mainly due to the mating frequency and availabili y of males during the female life span. This phen ›menon was observed for those females, which losi their male partners within first three days of the oviposition period, as compared to those, which had male partners in their entire oviposition period.

Fecundity and longevity. There were no differences between the ovipositional period, average daily fecundity and life span of fertilized and unfertilized females of *A. industani* recorded (Table 1).The results indicated that 40.68 % of the total fecundity occurred during first 10 days of the oviposition with a peak oviposition of 5–7 eggs from 3rd to 8th day. Maximum 98 eggs were deposited by fertilized female, whereas 88 eggs were laid down by unfertilized female. The average daily fecundity of unfertilized female was similar to that of fertilized ones (Table 1). There was no statistically significant difference between the longevity of male and female (Table 1). El-Badry et al. [1969 a] recorded female longevity of *A.exsertus* as 28–30 days and 18 days with an average fecundity of 80–81 eggs and 33–40 eggs when fed on eggs or immatures of tetranychids mites. Rasmy et al. [1984] reported the average fecundity of *A.exsertus* reared on eggs of *T.urticae* being similar to present finding.

Feeding habit. It was observed in the present experiment that the female predator of *A.industani* was able to attack on any prey stages (Fig. 7). In contrast, Santos [1975] reported that *Z. mali* does not attack adult females of tetranychids. Therefore, it cannot maintain population of phytophagous mites population below economic injury level on unsprayed apple trees. This predator mostly preferred to feed on prey eggs by sucking out fluid content. Rasmy et al. [1984] also reported that prey eggs were preferred by *A.exsertus* when fed on different stages of *T. urticae*. The total number of

Table 1.
Life cycle of *Agistemus industani* when reared on *Tetranychus ludeni* at room temperature.
Таблица 1.
Параметры жизненного цикла *Agistemus industani,* культивируемых при комнатной температуре на паутинных клещах *Tetranychus ludeni.*

Stages	Mean	Range	S. D.	Stages	Mean	Range	S. D.
Developmental duration (in days)							
Incubation period	3.83	3–4	0.36	Larva	2.55	0.5–5	1.24
I quiescent	1.07	0.5–2	0.36	Protonymph	1.85	1–4	1.03
*II quiescent (male)	1.91	1–3	0.32	Male	11.21	10–16	1.85
II quiescent (female)	1.09	0.5–2	0.36	Deutonymph	1.77	1–3	0.77
III quiescent	1.14	1–2	0.34	Adult female	13.30	11–17	1.80
Longevity (in days)							
Pre-oviposition	2.43	1–7	1.63	Oviposition	29.60	20–43	5.87
Post oviposition	2.00	1–7	1.50	Longevity of female	33.48	23–48	5.50
Longevity of male	34.84	23–48	6.91	Fertile eggs sex ratio (male:female)	1:3		
Fecundity (Number of eggs)							
Number of eggs laid by fertilized female	69.00	42–98	15.30	Daily fecundity	2.38	1–7	0.40
*Number of eggs laid by unfertilized female	70.30	40–88	17.78	Daily fecundity	2.41	1–5	0.50

Mean of temperature C 27° (26–29°) and mean of relative humidity 90% (85–97%).
*Male has 2 quiescent stages.
**Unfertilized female produce male progeny only. Figures in parenthesises are range.

Table 2.
Eggs consumption of *Tetranychus ludeni* by different stages of *Agistemus industani.*
Таблица 2.
Потребление яиц паутинного клеща *Tetranychus ludeni* различными стадиями *Agistemus industani.*

Predator stages	Mean	Range	S. D.
Larva	7.15	5–9	0.52
Protonymph	7.29	5–10	0.92
Deutonymph	8.48	6–12	0.96
Adult male	170.50	146–203	23. 55
Pre-oviposition female	16.50	13–23	3.85
Ovipositon female	515.80	399–623	61.26
Post-oviposition female	12.75	11–16	2.25
Unfertile female	495.33	466–533	37.85

Mean of temperature C 27° (26–29°) and mean of relative humidity 90% (85–97%).

prey eggs consumed during different developmental stages constituted only 4.21 % in total life span consumption, while the prey eggs consumption during the ovipositional period was 90% of total predation (Table 2). A female predator on an average had more than three time feeding capacity (17.5 eggs/ day) of its male counterpart (4.28 eggs/ day). The maximum number of 49 prey eggs was consumed on the forth day of oviposition. El-Badry et al. [1969 b] noticed that the prey eggs consumption

capacity of both female and male of *A.exsertus* was a total of 566 and 217 eggs of *Tetranychus cinnabarinus* respectively, which figures are identical to the present finding. However, both sexes of same predator consumed only 400 and 132 eggs of *Eutertranychus orientalis*.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. S K Gupta, Joint Director, Zoological Survey of India, Calcutta for identification of predatory mites.

REFERENCES

Borthankur M. and Das S. C. 1987. Studies on Acarine predators of phytophagous mites on tea in northeast India // Two and Bud. No.34. P.21–24.

Clements D. R. and Harmsen R., 1990. Predatory behavior and prey stage preference of stigmaeid and phytoseiid mites and their potential compatibility on biological control // Can. Entomol. Vol.122. No.3–4. P.321–328.

Collyer E. 1964. Phytophagous mites and their predators in News Zealand orchards // N. Z. J. Agric. Res. Vol.7. P.551–568.

El-Badry E. A., Abo-Elghar M. R., Hassen S. M., and Kilany S. M. 1969a. Life history studies on the predatory mite *Agistemus exsertus* // Ann. Ent. Soc. Am. Vol.62. No.3. P.649–651.

El-Badry E. A., Abo-Elghar M. R., Hassen S. M., and Kilany S. M. 1969b. Life history studies on the predatory mite *Agistemus exsertus* as a predator of two tetranychid mites // Ann. Ent. Soc. Am. Vol.62. No.3. P.660–661.

Gonzalea-Rodriguez R. H. 1965. A taxonomic study of the genera of *Mediolata, Zetzellia and Agistemus* (Acarina: Stigmaeidae) // Univ. Calf. Berkeley, Pub. Entomol. No.41. P.1–64.

Gupta S. K. 1991. The mites of agricultural importance in India with remarks on their economic status. In: Dusbabek F. and Bukva V. (eds.) Modern Acarology, Prague and SPB Academic Publ., The Hague, I. P.1–18.

Hafez S. M., Rasmy A. S., and Elsawy S. A. 1983. Effect of a prey species and stages of predatory efficiency and development of stigmaeid mite *Agistemus exsertus* // Acarologia. Vol.24. No.3. P.281–283.

Kethley J. 1990. Acarina: Prostigmata (Actinedia). In: Soil Biology Guide. Dindal D. L. (ed.). A Wiley Interscience Publ., John Wiley and Sons, New York. P.667–756.

McMurtry J. A. 1984. A consideration of the role of predators in the control of the acarine pests. In: Griffiths D. A. and Bowman C. E. (eds.), Acarology VI. Ellis Horwood Publ., I. P.109–121.

Rasmy A. H., Hafez S. M., and Elsawy S. A. 1984. Biology and predatory efficiency of predaceous mites as affected by various biotic factors. In: Griffiths D. A. and Bowman C. E. (eds.), Acarology, VI Ellis Harwood Publ., 2. P.699–702.

Santos M. A. 1975. Evaluation of *Zetzellia mali* as predator of *Panonychus ulmi* and *Aculus schelchttendali* // Environm. Entomol. Vol.5. No.1. P.187–191.

Santos M. A. 1991. Searching behavior and associational response of *Zetzellia mali* (Acarina: Stigmaeidae) // Exp. Appl. Acarol. Vol.11. No.1. P.81–87.

Santos M. A. and Laing J. E. 1985. Stigmaeid predators. In: Helle W. and Sabelis M. W. (eds.), Spider mites, their biology, natural enemies and control. Elsevier Science Publ., Amsterdam. Vol. B. P.197–203.

Singh P., Somchoudhury K. A., and MuKherjee A. B. 1989. The influence of natural enemy complex on the population of *Aceria litichii* (Acari: Eriophyidae). In: Channa Basavanna G. P. and Viraktamath C. A., (eds.), Progress in Acarology, Oxford and IBH Pub., Co., New Delhi. Vol.2. P. 361–367.

White N. D. G. and Laing J. E. 1977. Some aspects of the biology and laboratory life table of the acarine predator *Zelzillia mali* // Can. Entomol. Vol.109. No.9. P.1275–1281.