LIFE HISTORY AND PREDATION OF THE MITE, *BLATTISOCIUS KEEGANI* FOX (ACARI-ASCIDAE) ON EGGS OF *EPHESTIA KUEHNIELLA* ZELLER (LEPIDOPTERA-PYRALIDAE)

ALY A. YOUNES AND HEBA M. HAMAMA
Department of Entomology, Faculty of Science, Cairo University, Egypt

(Received 11-10-2008)

INTRODUCTION

The predatory mite, *Blattisocius keegani* Fox is a predator on moth eggs. It is primarily found in stored products and it seems cosmopolitan in distribution (Sinah and Kawmoto, 1990 and Rezk, 2000). Laboratory experiments have shown that, *B. keegani* is able to suppress populations of many pests (Beavers *et al.* 1972; Rezk, 2000 and Rao *et al.* 2002).

E. kuehniella is a serious pest in the milling industry and large mills. The status of this insect as a pest comes from the fact that it has the ability to multiply throughout the year and in various combinations of temperature and humidity (Cerutti *et al.*, 1992). For many years, chemical control of this pest was applied and large mills were formerly fumigated at least once a year with methyl bromide. However, methyl bromide was prohibited. This could encourage the use of biological control methods in controlling this pest. Biological control in stored products is expected to become an important component of integrated pest management strategies for many types of stored commodities in the future (Brower *et al.*, 1996 and Scholler, 1998).

The interaction of the predator and prey varies according to the feeding habits of the predator. Several factors are involved in the interaction between predaceous mites and their prey including, effect of changing prey and predator density on the predatory responses. The present study was principally carried out to determine the optimum consumption of the predatory mite, *B. keegani* at different prey densities. As the first step towards the utilization of this predatory mite in biological control of *E. kuehniella*, its life history was evaluated when fed on *E. kuehniella* eggs in the laboratory. This assesses the potential of the mite to suppress population of this insect pest.

Bull. Ent. Soc. Egypt, 85, 2008 (225-232)

MATERIAL AND METHODS

Mite culture

Laboratory culture of the mite was established from samples collected from mills in Cairo. Mite culture was maintained in separate climatic room at 25 ± 2° C, 60-70 % RH under 12:12 h L:D. Mite individuals were reared in tightly covered plastic cup (25 x 15 cm), bottom of which contained a mixture of 9:1 plaster of pairs and charcoal for a depth of 4 mm on which drops of water were added when needed to maintain a suitable humidity. Predator individuals were supplied with eggs of *E. kuehniella* three times per week for two generations at least before the study.

Prey culture

E. kuehniella moths were kept as couples (male and female) in Pyrex dishes (12.5 x 6 x 2 cm) for egg laying. The dishes were covered by glass lids and kept in incubator at 25 ± 2° C. The moths were transferred daily to new clean dishes for oviposition. Eggs laid were collected using black paper and a fine camel's brush. The newly hatched larvae were transferred to plastic cups (12 x 6 x 7 cm) and supplied by a sufficient amount of sterile whole-wheat flour. Larvae were left to complete their development till pupation. The newly emerging adults were transferred (in pairs) to Pyrex dishes for oviposition where the eggs were used for feeding the predatory mite.

Life history of the predator

Twenty-five recently mated females of *B. keegani* were provided with sufficient preys to oviposit. Eggs were collected 24 h later, and kept singly in modified Huffaker cells (Overmeer, 1985 and Sabelis, 1992), reared to adult stage and observed until they died. The rearing cells were examined twice daily to observe the biological aspects of the mite. Reaching adult stage, mites were sexed, then allowed to copulate where females left for egg deposition. The number of deposited eggs, duration of the stages, percentage survival and adult life span were calculated.

Prey consumption and reproductive rate

Feeding capacity of the predatory mite was calculated by offering 15 *E. kuehniella* eggs / day to the different mite stages in the rearing cells which were examined twice daily to calculate the mean egg consumption for each stage.

In order to examine the consumption and reproductive rate per day in relation to prey density, twenty mite females were used for each treatment. Each adult female was given either 5, 10, 15, 20, 25 or 30 fresh *E. kuehniella* eggs for 24 h. the age of the eggs was 0-24 h., a piece of filter paper with the moth eggs was placed in the bottom of a small plastic cup (12.5 ml, inside area 31 cm^2), sealed with filter paper and a lid with a 12 mm hole. Cups with mites were placed in regulated environmental chambers with a temperature of 25 ± 2° C.and 75 % RH. After 24 hours, the numbers of completely or partially deflated eggs were counted. The daily prey consumed and so the reproductive rates / day for female mites were calculated for each prey density. At least 500 eggs of *E. kuehniella* had not been exposed to mites, but were otherwise treated in the same way and served as a control at each experimental condition.

Statistical analysis

Data on life history, consumption and reproductive rate were analyzed using one way ANOVA followed by LSD to compare data means (GraphPad Instat, 2003).

RESULTS AND DISCUSSION

Life history and survival of the mite

The mite, *B. keegani* passes through egg, larval, protonymphal and deutonymphal stages before reaching adult. The eggs were laid singly or in-groups of two or three; duration of both eggs and immature stages are shown in table (1). A mean period of 1.6 days was recorded for egg incubation period. For immature stages, 1.1 days was obtained as a developmental period of the larva. The protonymphal and deutonymphal stages each had the same developmental period (1.7 days). Data also showed that, the mean total developmental period of the immature stages was 4.5 days and the total life cycle of the mite (from egg to adult) was 6.1 days. Survival percentages of the mite stages were 78.6, 75.7 and 92.5 considering larval, protonymphal and deutonymphal stages, respectively. The greatest percentage survival (94.6 %) was obtained for adult stage. Consequently, survival percentage for individuals from hatched larvae to adults was 52.0%.

Various authors studied the biology of the predatory mite, *B. tarsalis* that is the most relative mite to *B. keegani*. These studies showed that, egg incubation period averaged 2.2 days when reared at 25±2°C and 75±3%RH. (Darst & King, 1969). They also recorded developmental period of 1.1, 1.8, and 1.9 days considering larval, protonymphal and deutonymphal stages, respectively. In the present work, *B. keegani* required 6.1 days for complete life cycle. Haines (1981) reported this period to be 5.8 days for *B. tarsalis* on *E. cautella* eggs at 27°C and 73%RH.

TABLE (I)

Mean duration of the immature and adult stages of the predatory mite, *Blattisocius keegani* fed on *Ephestia kuehniella* eggs.

Stage	Duration in days Mean ± SD
Egg	1.6 ± 0.48
Larva	1.1 ± 0.37
Protonymph	1.7 ± 0.48
Deutonymph	1.7 ± 0.48
* Total immature	4.5 ± 0.48
** Total life cycle	6.1 ± 0.90
Male longevity	16.1 ± 3.6
Female longevity	23.1 ± 4.5
Preoviposition period	1.3 ± 0.47
Oviposition period	13.3 ± 3.2
Postoviposition period	7.6 ± 4.1
Mean reproductive rate (eggs/female/day)	2.6 ± 0.89
Egg viability (%)	93.3 ± 7.2

* Larvae, protonymph and deutonymph.
** From egg to adult hatching.

Adult mite longevity

Data considering attributes of *B. keegani* adult females expressed in longevity, pre-oviposition, oviposition and postoviposition periods and reproductive rate are presented in table (1). Obtained adult longevity was 16.1 and 23.1 days for male and female, respectively. The preoviposition period lasted 1.3 days, constituting 5.6% of its longevity. The greater part of female longevity was spent in oviposition (13.3 days) that represented 57.6 % of the female longevity. The mean reproductive rate (eggs/female/day) was recorded as 2.6 eggs with 93.3 % viability. After oviposition, *B. keegani* spent 7.6 days as a postoviposition period.

Reproductive attributes of the predatory mites were prey kind dependent. The predatory mite, *B. keegani* reared on eggs of *Plodia interpunctella* had a pre-oviposition period of 1.4 days (Darst and King, 1969) whereas, *B. tarsalis* showed longer oviposition period (2.4 days) after feeding on *E. cautella* eggs (Haines, 1981). Furthermore, the postoviposition period, recorded in the present study, was almost the same as that recorded by Haines (1981) for the predatory mite, *B. tarsalis* fed on eggs of *E. cautella*.

Prey consumption

Observations on the number of whole or partially deflated eggs in the control experiments without the presence of the mite, revealed that only very few eggs collapsed with a negligible percentage so no attempt was made to calculate correction for this low control mortality. Data in table (2) show that, egg consumption started at the protonymphal stage, larvae are non-feeding stage. An average of 1.1 eggs of *E. kuehniella* was consumed during the whole protonymphal stage with a daily consumption rate of 0.6 eggs / day. The deutonymphs consumed higher number of eggs with a total average of 3.5 eggs and a daily rate of 2.1 eggs / day. Considering adult stage, the female and male in comparison, consumed a total of 79.8 and 23.1 eggs, respectively. The daily consumption rate of the female was 3.5 eggs while that of male was 1.4 eggs / day. Statistically, significant differences ($P<0.05$) were obtained considering the daily egg consumption or the total egg consumption of the all stages. In the present study the mean number of consumed eggs were much higher than that obtained by Haines (1981) who used fresh eggs of *E. cautella* and Nielsen (2003) who studied *B. tarsalis*. The higher number of egg consumption may be a result that *E. kuehniella* eggs were partially consumed by *B. keegani,* which left much of food content of the prey unutilized. This agrees with the observations of Sabelis (1992) considering arthropod predators.

TABLE (II)

Prey consumption of the predatory mite, *Blattisocius keegani* on the moth, *Ephestia kuehniella* eggs.

Stage	Number of eggs consumed (mean ± SD)	
	Daily	**Totally**
Protonymph	0.6 ± 0.75a	1.1 ± 0.79a
Deutonymph	2.1 ± 1.3b	3.5± 2.1b
Male	1.4 ± 0.68c	23.1 ± 5.2c
Female	3.5 ± 1.6d	79.8± 15.4d

Means followed by the same letter, in the same column, are not significantly difference ($P>0.05$).

Effect of prey density on the consumption and reproductive rates

The mean prey consumption of the predatory mite, *B. keegani* was found to vary with the prey density (table 3). The mean number of destroyed eggs were significantly difference (F=13.67; P<0.0001) among the investigated prey density. Also, significant differences (P<0.05) were obtained considering the mean egg consumption at low and high density.

Data considering the reproductive rate in table (3) show that, the daily reproductive rate ranged from 2.8 to 3.8 eggs / female / day. Statistically, no significant differences (F= 1.489; P>0.05) were obtained between the prey densities and the mite reproductive rates. It was evident that, devouring few eggs daily by the female mite was sufficient for ensuring egg lying and so increasing the consumption rate could not increase the daily reproductive rate, tacking into consideration that the maximum number of eggs laid by the female was 15 eggs during her oviposition period. Thongtab *et al.* (2001) demonstrated that, the reproductive rate of the predatory mite, *Amblyseius longispinosus* did not change upon changing its prey density.

This study showed that, the predatory mite, *B. keegani* demonstrated some characteristics as high percentage of survival, both nymphs and adult stages are egg predators and its ability to destroy large quantities of eggs. These could suggest make it as possible candidate for biological control of *E. kuehniella* in flour mills.

TABLE (III)

Effect of prey density on the daily prey consumption and reproductive rate of the predatory mite, *Blattisocius keegani* female fed on *Ephestia kuehniella* eggs.

Prey density	Daily prey consumed (Mean ± SD)	Reproductive rate (Mean ± SD)
5	2.5 ± 0.7a	2.8 ± 0.63 a
10	3.4 ± 1.1ab	3.1 ± 0.66a
15	3.6 ± 0.84b	3.2 ± 0.65a
20	4.8 ± 0.94bc	3.2 ± 0.78a
25	5.5 ± 1.3c	3.2 ± 0.74a
30	6.4 ± 1.3c	3.8 ± 0.78 a
F	13.67	1.489
P-value	< 0.0001	0.208

Means followed by the same letter, in the same column, are not significantly difference (P>0.05).

SUMMARY

The flour moth, *E. kuehniella* has long been recorded as a serious pest of stored-grain products. Commercially, insect pests of stored products are developing resistance to chemical insecticides, the cost of pesticide application is rising rapidly, and there is growing awareness of world food shortages. For these reasons, efforts are being focused on the development of a biological control program using predatory mites. To evaluate their potential role as biological control agents, the present study evaluates the life history and predation of one of those mites, *B. keegani*, when fed on *E. kuehniella* eggs. Duration, survival and consumption rates of the immature and adult stages were recorded. Preoviposition, oviposition and postoviposition periods of the female mite were also recorded. Consumption and reproductive rate of the female mite were determined with different prey densities. Most preyed eggs were only partially consumed, confirming the general theory that predatory mites leave most of the food content unutilized. A mean consumption rate of 2.05 – 6.4 eggs destroyed in 24 h was found, reflecting that a large proportion of the available prey was destroyed. The result supports the view that the predatory mite, *B. keegani* could be a relevant biological control agent against *E. kuehniella* in flour mills.

REFEREENCES

BEAVERS, J. B.; H. A. DENMARK and A. G. SELHIME (1972): Predation by *Blattisocius keegani* on egg masses of *Diaprepes abbreiatus* in the laboratory. *(J. Econ. Entomol., 65: 1483-1484).*

BROWER, J. H.; L. SMITH; P. V. VAIL and P. W. FLINN (1996): Biological control. *In:* Subramanyam, B., Hagstrum, D. W. (Eds.), Integrated management of insects in stored products.*(Mercel Dekker Inc., New York, pp. 223-286).*

CERUTTI; F. BIGLER; E. EDEN and S. BOSSHART (1992): Optimal larval density and quality control aspects in mass rearing of the Mediterranean flour moth, *Anagasta kuehniella* (Lepidoptera-Pyralidae). *(J. Appl. Entomol., 114: 353-361).*

DARST, P. H. and E. W. KING (1969): Biology of *Melichares tarsalis* in association with *Plodia interpunctella. (Ann. Entomol. Soc. Am., 62: 747-749).*

GRAPHPAD INSTAT (2003): *GraphPad software, Inc. version 3.06. Sd, California, USA*

HAINES, C. P. (1981): Laboratory studies on the role of an egg predator, *Blattisocius tarsalis* (Berlese) (Acari – Ascidae) in relation to the natural control of *Ephestia cautella* (Walker) (Lepidoptera-Pyralidae) in warehouses. *(Bull. Entomol. Res., 71: 555-575).*

NIELSEN, P. S. (2003): Predation by *Blattisocius tarsalis* (Berlese) (Acari – Ascidae) on eggs of *Ephestia kuehniella* Zeller (Lepidoptera – Pyralidae). *(J. stored Prod. Res., 39: 395-400).*

OVERMEER, W. P. J. (1985): Rearing and handling. *In:* Helle W., Sabelis, M. W. (Eds.), Spider mites: their biology, natural enemies and control. *(World Crop Pests. Elsvier. pp. 186-245).*

RAO, C. V. N.; B. N. RAO and T. R. BABU (2002): New record of predation on the eggs of cigarette beetle, *Lasioderma serricorne* (Fabricius) (Coleoptera-Anobeiidae), a stored tobacco pest. *(J. Biol. Control, 16: 169-170).*

REZK, H. A. (2002): Mites associated with stored-dates in Egypt and the role of *Blattisocius keegani* Fox as a biological control agent. Alex. *(J. Agric. Res., 45: 179-191).*

SABELIS, M. W. (1992): Arthropod predators. *(In: Crawly, M. J. (Ed.), Natural enemies, the population biology of predators, parasites and disease. Blackwell, Oxford. pp. 225-264).*

SCHOLLER, M. (1998): Integration of biological and non-biological methods for controlling arthropods infesting stored products. *(Post harv. news and Inf., 9: 15-20).*

SINHA, R. N. and H. KAWMOTO (1990): Dynamics and distribution patterns of Acarine populations in stored Oat ecosystem. *(Res. Pop. Ecology, 32: 433-467).*

THONGTAB, T.; A. CHANDRAPATYA and G. T. BAKER (2001): Biology and efficacy of the predatory mite, *Amblyseius longispinosus* (Evans) (Acari-Phytoseiidae) as a biological control agent of *Eutetranychus cendanai* (Rimando) (Acari-Tetranychidae). *(J. Appl. Entomol., 125: 543-549).*