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Effects of Diet on the Biology and Life Tables of the Predacious Mite *Agistemus exsertus* (Acari: Stigmaeidae)

F. M. MOMEN

National Research Center, Pests and Plant Protection Department,
Dokki, Cairo, Egypt

The biology of *Agistemus exsertus* Gonzalez was studied using two different insect eggs, *Ephestia kuehniella* Zeller and *Parlatoria zizyphus* (Lucas) as the food source. The development was faster and reproduction was higher when *A. exsertus* fed on eggs of *E. kuehniella.* A total of 97.78 and 75.27 eggs per female were obtained when eggs of *E. kuehniella* and *P. zizyphus* were provided respectively. A diet of *E. kuehniella* (eggs) provided the greatest female longevity and mean total fecundity which resulted in the higher net reproductive rate (Ro) value (61.25), intrinsic rate of natural increase (rm = 0.196) and finite rate of increase (rm = 1.22) per day for *A. exsertus.* A diet of *P. zizyphus* (eggs) resulted in close values of T = 21.70; rm = 0.174; $e^{r}m$ = 1.19. The sex rate of the progeny was strongly female biased (female/total = 0.72 and 0.66) when both eggs of *E. kuehniella* and *P. zizyphus* were provided.

Keywords: Acari, *Agistemus exsertus, Ephestia kuehniella,* life table, *Parlatoria zizyphus.*

Mites of the family Stigmaeidae are live in the soil, stored products and on plants and are usually predators of mites. A few prey on scale insects or parasitize flies (Swift, 1987) and others feeds on mosses (Gerson, 1972). The stigmaeid mite *Agistemus exsertus* Gonzalez has most commonly been recorded in association with spider mites and scale insect in Egypt. The predacious mite *A. exsertus* feeds not only on tetranychid mites and pollen grains, but also on eriophyid and tenupalpid mites (Soliman et al., 1976; Hanna et al., 1980; Oamen, 1982; El-Bagoury and Reda, 1985; Santos and Laing, 1985).

A. exsertus is documented by many authors as an egg predator of tetranychid and tenupalpid mites as well as the tobacco white fly *Bemisia tabaci* (Genn.) (El-Badry et al., 1969; Hafez et al., 1983; El-Bagoury et al., 1989; Abou-Awad and El-Sawi, 1993). It was found that the egg stage was a more favorable food than immature stages. The major objective of this study of life tables was undertaken to investigate the nutritional value of an egg stage of both the stored product moth *Ephestia kuehniella* Zeller and the scale insect *Parlatoria zizyphus* (Lucas) to the predacious mite *A. exsertus,* in order to make a preliminary evaluation to their potential role as food.

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Materials and Methods

Maintenance of mite stock cultures

Adult females of *A. exsertus* used in this study were collected from heavily infested Ploughiman's spikenard plant at Faywam Province, Egypt in 1999; and reared on eggs and immature stages of the two spotted spider mite *Tetranychus urticae* Koch at 27 ºC and 70 ± 75% R.H.

Diets

Two diets were evaluated for their effect on development survival, oviposition and life table parameter:

1. Eggs of the stored product moth *E. kuehniella* were obtained from stock culture kept at the laboratories of N. R. C. for many years.
2. Eggs of the scale insect *P. zizyphus* were collected from commercial citrus orchards.

Effects of diet on development and survival

The rearing arena (3 x 3 cm) of excised raspberry leaves, placed on saturated cotton in plastic petri dishes, were used to confine the predator. A strip of moistened absorbent cotton was placed around the outside edge of the leaves. A single newly deposited egg was transferred to each arena and the newly hatched larvae were supplied with the food resource to be evaluated. All handling of mites and host eggs was performed with a very fine, moistened, squirrel hairbrush. Arenas were examined daily and predator development and survival was recorded. Prey eggs consumed were replaced daily by fresh eggs to maintain an ample food supply.

Effects of diet on longevity, fecundity and life table parameters

Newly emerged female, mated, confined individually on test arenas, along with the food to be tested. A few strands of cotton wool were provided as an ovipositor site on each arenas. Oviposition and survival were recorded as well as stigmaeid eggs were removed daily for sex determination. An egg diet was considered consumed whenever a depression of the chorion was noticed after the predator attack, indicating that at least some feeding had occurred. As piercing the chorion and feeding for only a few seconds resulted in the eventual collapse of an egg.

Twenty five eggs of *A. exsertus* in each experiment were observed daily, and each experiment was repeated twice.

Life table parameters as defined by Birch (1948) were calculated according to a BASIC computer program (Abou-Setta et al., 1986).

Results and Discussion

Effects of diet on development and survival

Individuals of *A. exsertus* successfully developed from larva to adult when fed on eggs of either of *E. kuehniella* and *P. zizyphus (Table 1).* The developmental period was significantly rapid on eggs of *E. kuehniella* than on *P. zizyphus* (significant at 5% level). Several authors showed that an egg stage of *P. zizyphus* provides enough nutrition for various predacious mites of the family Phytosiidae to complete development (Aly, 1994; Abou-El-ella, 1998; Momen, 1999; Momen and Hussein, 1999). Ragusa and Tsolakis (1994) reported that when eggs of *E. kuehniella* were offered to the predacious phytoseiid mite, *Amblyseius andersoni* (Chant), the percentage of individuals attaining adulthood was 8%, as well as the young stages were in a very poor condition, thin, not mobile. The fraction of *A. exsertus* eggs reaching maturity was similar with both diets (0.88).

Table 1

Comparative duration ($x \pm$ S.E.) of female of *A. exsertus* at 27 °C on test food

Developmental stages	*P. zizyphus* (eggs)		*E. kuehniella* (eggs)	
Egg	2.0 ± 0.0		2.0 ± 0.0	
Larva	2.3 ± 0.1	a	1.6 ± 0.1	b
Protonymph	4.6 ± 0.2		4.1 ± 0.2	
Deutonymph	6.1 ± 0.2	a	5.1 ± 0.2	b
Life cycle	15.0 ± 0.4	a	13.0 ± 0.3	b
Preoviposition period	2.6 ± 0.1		2.1 ± 0.1	
Oviposition period	18.4 ± 0.9	a	25.4 ± 1.0	b
Adult longevity	23.6 ± 0.9	a	31.2 ± 0.8	b
Life span	38.6 ± 1.1	a	44.2 ± 0.8	b

Different letters in a horizontol column denote significant differences (F test. $P \leq 0.05$).

Effects of diet on longevity, fecundity and life table parameters

The preoviposition period was almost the same with the two different insect diets *(Table 1). A. exsertus* females reared on *E. kuehniella* eggs had a significantly longer oviposition period and a significantly greater total fecundity than *A. exsertus* females reared on *P. zizyphus* eggs *(Tables 1* and *2).* Higher oviposition rates were associated with longer oviposition period and lower oviposition rates were associated with shorter oviposition period. Mean total fecundity was 97.78 eggs/♀ over a mean oviposition period of 25.4 days for *A. exsertus* reared on *E. kuehniella* eggs compared to 75.27 eggs/♀ over a mean oviposition period of 18.7 days for *A. exsertus* reared on eggs of *P. zizyphus.* Longevity of females *A. exsertus* was significantly different when reared and maintained on eggs of *E. kuehniella* eggs compared to eggs of *P. zizyphus.* Longevity of *A. exsertus* adult females ranged from 24 to 36 days ($\bar{x}$ = 31.21 days) when reared on a diet of *E.*

Table 2

Effect of diet on the life table parameters of *A. exsertus* at 27 ºC

Parameters	*P. zizyphus* (eggs)	*E. kuehniella* (eggs)
Mean total fecundity (eggs/ ♀)	75.27	97.78
Net reproductive rate (Ro)	43.71	61.25
Generation time (days) (T)	21.70	20.99
Intrinsic rate of increase (rm)	0.174	0.196
Finite rate of increase (e^rm)	1.19	1.22
Sex ratio (females/total)	0.66	0.72

kuehniella compared to a range of 18 to 30 days ($\bar{x}$ = 23.6 days) when reared on a diet of *P. zizyphus* eggs *(Table 1).* As noted by some authors that maximum fecundity of 134.5, 97.0 and 90.50 eggs/female of *A. exsertus* was recorded at 27–29 °C, respectively, when fed on eriophyid mite *Eriophyes dioscoridis* Soliman and Abou-Awad, artificial diet composed (milk + yeast + amino acids + sugar) and eggs of *T. urticae* (El-Bagoury and Reda, 1985; Reda, 1990; Abou-Awad and El-Sawi, 1993). *A. exsertus* has been reported to feed on dates pollen and the acarid mite *Tyreophagous casei* Oudemans and the daily rate of reproductivity averaged 3.0 eggs / ♀/ day for both diets (Abou-El-ghar et al., 1969; Rasmy et al., 1987). The reproductive rate of *A. exsertus* feed on eggs of *P. zizyphus* in this study, fall within the range of the predator known to feed on eggs of *Eutetranychus orientalis* klein, *Brevipalpus plucher* (C. and F.) and *Bemisia tabaci* (Genn.), respectively (Abou-Awad and El-Sawi, 1993). Eggs of *P. zizyphus* were unsuitable for the predator *Amblyseivs lindquisti* Schuster and Pritchard feeding and reproduction (Momen, 1999), while the rate of reproduction of *Typhlodromus transvaalensis* (Nesbitt) was very low (1.54/ ♀) when fed on the same diet. No oviposition occurred or it was unsatisfactory when *A. andersoni* fed on eggs of *E. kuehniella.*

Life table parameters

Mean generation time (T) of *A. exsertus* did not vary much between two egg diets *(Table 2).* The net reproductive rate (Ro), which is a product of mean total fecundity, survival rate and sex ratio, followed the same pattern as total fecundity. The higher (Ro) value of 61.25 expected females per female was obtained with a diet of *E. kuehniella* eggs. The lower (Ro) value of 43.71 expected females per female was obtained with a diet of *P. zizyphus* eggs *(Table 2).* The intrinsic rate of increase (rm) and, subsequently, the finite rate of increase (e^rm) were relatively higher (0.196 and 1.22 respectively) when individuals were fed *E. kuehniella* eggs and lower when fed *P. zizyphus* eggs (0.174 and 1.19). The higher (rm) for *A. exsertus* reared on eggs of *E. kuehniella* could be attributed to differences in nutritive quality. The consumption of more suitable prey (i.e. egg/ larva/nymph), favouring a high conversion of food into egg biomass, determined higher intrinsic rates of increase (Sabelis, 1985; Bruce-Oliver and Hoy, 1990).

Comparison of life table parameters of *A. exsertus* on tetranychoid egg diets or eggs of whitefly (Abou-Awad and El-Sawi, 1993), may be possible because they were conducted under similar conditions (temperature and technique). The intrinsic rate of increase is higher on diet of *E. kuehniella* eggs than those of tetranychoid and whitefly eggs. The (Ro) value of *A. exsertus* fed eggs of *E. kuehniella* fall within the range of the predator known to control *T. urticae* eggs, while the (Ro) value of the predator fed eggs of *P. zizyphus* fall whithin the close range of predator known to control eggs of *E. orientalis, B. pulcher* and *B. tabaci.*

This study indicated clearly that the pyralid eggs of *E. kuehniella* favored the full expression of the reproductive potential of the predacious mite *A. exsertus.*

Conclusions

This study indicated that *A. exsertus* developed and reproduced successfully on either eggs of *E. kuehniella* (Fa. Pyralidae) and *P. zizyphus* (Fa. Diaspididae). The use of life table values to predict potential efficacy of this biological agent for augmentation or classical biological control programs requires caution. In our experiments, varying the egg diets produced substantial differences in life table values, which underscores the importance of the biotic test conditions.

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 *(E. kuehniella),* adequate food *(P. zizyphus).* The interest in the stored product moth *E. kuehniella* is due to its possible function as basic diet for the predacious mite *A. exsertus,* which has not been investigated before for family Stigmaeidae.

From this it can be concluded that *A. exsertus* consider as an egg-predator and is promising biological control agent of insect pests such as stored product moth or scale insect (in the present study) and the tobacco whitefly (Abou-Awad and El-Sawi, 1993). I would suggest further studies to develop method for determining predation rates by the predator on both pyralid and diaspidid eggs.

More investigation is needed also on the predatory impact and responses of *A. exsertus* to different insect and mite species (e.g. Thrips–Lepidoptera–Tarsomemid)

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