Experimental & Applied Acarology, 3 (1987) 123-130
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

Biology of *Euseius mesembrinus* (Acari: Phytoseiidae): Life Tables on Ice Plant Pollen at Different Temperatures with Notes on Behavior and Food Range

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Florida Agricultural Experiment Station Journal Series No. 7429.

(Accepted 25 August 1986)

ABSTRACT

Abou-Setta, M.M. and Childers, C.C., 1987. Biology of *Euseius mesembrinus* (Acari: Phytoseiidae): Life tables on ice plant pollen at different temperatures with notes on behavior and food range. *Exp. Appl. Acarol.*, 3: 123-130.

Euseius mesembrinus (Dean) (Acari: Phytoseiidae) was recently reported on Florida citrus for the first time. This mite was able to develop and reproduce when fed plant pollen of Spanish needle, *Bidens pilosa* L. and ice plant, *Malephora crocea* (Jacq.) or three spider mite species (Acari: Tetranychidae) including all stages of *Tetranychus urticae* Koch, *Eutetranychus banksi* (McGregor), and larval and nymphal stages only of *Panonychus citri* (McGregor).

The biology of *E. mesembrinus* was studied under laboratory conditions while being fed pollen of *M. crocea*. The developmental time for immature stages at 18, 22, 26, and 30°C was 11.50, 7.47, 4.54, and 4.40 days, respectively. This pattern fits a log-probit model with $r^2 = 0.940$. Eggs hatched, but mortality in other stages was high at 34°C. The intrinsic rate of natural increase was 0.146, 0.250, and 0.246 at 22, 26, and 30°C. The optimum temperature for this phytoseiid to develop and increase on ice plant pollen was in the range of 26 to 30°C.

INTRODUCTION

Euseius mesembrinus (Dean) was first described in the genus *Typhlodromus* as a new species of the *finlandicus* complex. The mite was found in Texas in association with *Oligonychus pratensis* (Banks) on corn and sorghum leaves (Dean, 1957). *E. mesembrinus* also was reported from Louisiana in 1975 (H.A. Denmark, personal communication, 1984) and recently from Florida citrus (McCoy and Rakha, 1985). This mite was not included in the extensive survey

0168-8162/87/$03.50

for Florida Phytoseiidae by Muma and Denmark (1970). Browning (1983) reported this mite as the prevalent phytoseiid occurring on citrus in the Lower Rio Grande Valley area of south Texas throughout the year. This species may have been established in Florida during the last decade due to movement of citrus seedlings from Texas to Florida.

The redefinition of the genus *Euseius* by McMurtry (1983) included 60 or more species with relatively uniform morphology and biology. All species studied are general feeders that increase more rapidly on pollen than on mite prey. The biology of related species, *E. hibisci* (Chant), and *E. citrifolius* (Denmark and Muma) was studied by McMurtry and Scriven (1964, 1965a), Swirski et al. (1970), and Tanigoshi et al. (1981), and Moraes and McMurtry (1981) using a plant leaf surface. Porres et al. (1975) demonstrated feeding by *E. hibisci* on avocado leaf sap but not on lemon using radioactive phosphoric acid. They concluded that plant juice may provide an alternate source of food and/or moisture.

Life table studies were undertaken to determine the developmental biology and behavior of *E. mesembrinus* at different temperatures when fed ice plant pollen, *Malephora crocea* (Jacq.).

MATERIALS AND METHODS

Observations were made on *E. mesembrinus* behavior and its ability to feed and develop utilizing the following diets: pollen of Spanish needle, *Bidens pilosa* L., ; two-spotted spider mite, *Tetranychus urticae* Koch; Texas citrus mite, *Eutetranychus banksi* (McGregor); and the citrus red mite, *Panonychus citri* (McGregor).

Techniques for rearing phytoseiid mites were reported by Ristich (1956); McMurtry and Scriven (1964, 1965b); Swirski et al. (1967, 1970); Rasmy (1970); Tanigoshi et al. (1981); and Moraes and McMurtry (1981) where a plant leaf surface was used as the rearing substrate and pollen as the food source.

The laboratory culture of *E. mesembrinus* used in this study originated from grapefruit and orange leaves collected from commercial groves located near Lake Alfred and Wauchula in central Florida during February and March, 1984. The culture was colonized on the underside of excised leaves from grapefruit, *Citrus paradisi* Macf. seedlings and held at 26°C. Ice plant, *M. crocea*, flowers were collected daily from plants maintained in the greenhouse. The anthers were cut, frozen, and used in mite feeding as needed. Ice plants were obtained from a culture plot maintained at the University of California, Riverside.

Ice plant pollen was evaluated in California for rearing *E. hibisci* and found to be a suitable and prolific food source (McMurtry and Scriven, 1964; Tanigoshi et al., 1981). Use of the same pollen in our studies provides for better comparison of results with other species in the genus *Euseius*. Pollens from different plant species do not have the same nutritional value and the intensity of pollen production may vary (Baker and Baker, 1979). The pollen must store well and preferably have a low water content to minimize molding when used as a food source for mite rearing.

The inverted lid of a 9 cm diameter plastic Petri dish was fitted with an absorbent cotton disc, lined with a filter paper, and saturated with deionized water. Water content was maintained daily by weight. Twelve 4-mm diameter holes were drilled in the cover or the bottom half of the Petri dish to allow air exchange and to prevent relative humidity from reaching saturation. Two clean mature grapefruit seedling leaves, each 7–8 cm length, were placed with the lower surface up on the saturated bed. Each leaf petiole was covered with saturated cotton to allow water uptake. This technique allowed the entire leaf to be usable for about 8 weeks at 26°C. The leaf edges were surrounded with a thin layer of Canada Balsam and castor bean oil (ratio 1.5:1) using a fine brush. This provided an effective barrier to prevent the predatory mite from escaping. For individual mite studies, the leaf surface was divided into three parts using the same barrier. The barrier of Canada Balsam and castor bean oil was patterned after Swirski et al. (1967), since the saturated filter paper alone was inadequate in containing this mite. Ice plant pollen was supplied as food and cotton fibers were placed under cover slips for resting and egg laying sites (McMurtry and Scriven, 1965b).

The units were held in an environmental chamber which provided constant temperature, fluorescent lighting, and air circulation. The relative humidity inside the chambers ranged between 50 and 80%. However, at 1 cm above the leaf surface inside the rearing unit, relative humidity ranged between 75 and 85% as measured by a thermocouple probe for temperature and humidity (Digi-Sense®). Light intensity was adjusted to provide ca. 30 μE s^{-1} m^{-2} at the leaf surface with 12 h of light per day (Shibles, 1976).

Twenty newly mated females were confined one per arena at 22, 26, and 30°C to study age-specific fecundity rates. A cohort of 50 eggs from each temperature-group was collected at 8-h intervals for individual developmental time studies. Newly deposited eggs from the main culture held at 26°C were collected at 8-h intervals and held at 18 and 34°C to study development. Development of the eggs was observed daily at 0600, 1400, and 2200 h until the males reached maturity or each female deposited its first egg.

The quiescent stage and subsequent molt following each motile immature life stage was averaged with the preceeding motile stage. Development time was calculated as half the time interval between observations.

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

RESULTS

Behavior and feeding observations

E. mesembrinus is a typical phytoseiid mite, developing through egg, larva, protonymph, deutonymph, and adult stages for both sexes. The larval stage may feed on pollen or tetranychid mite eggs and larvae. *E. mesembrinus* was able to develop to maturity and reproduce utilizing a wide range of food substances under laboratory conditions. Food sources included pollen of Spanish needle, *B. pilosa*, ice plant, *M. crocea*, all stages of *T. urticae, E. banksi*, and larval and nymphal stages only of *P. citri. E. mesembrinus* stages were not able to feed on the egg or adult female stages of *P. citri.* The color of this fast moving phytoseiid mite from either field samples or the pollen-fed culture was waxy white. Individuals that fed on tetranychid mites varied in color from yellow to dark brown. Development to the protonymph stage occurred on citrus leaves when no other food was available. Cannibalism was observed when food was scarce. Mature stages tried to feed on younger stages excluding the egg stage.

Mating was essential for egg laying and occurred as early as the first few hours after maturity. Females mated once or several times before oviposition began. Males were observed attempting to mate with adult females of any age.

Influence of temperature on developmental time

Duration (in days) of immature stages of *E. mesembrinus* fed ice plant pollen is shown in Table 1. At 34°C, the egg stage was able to develop while other stages incurred high mortality. Total developmental time was almost equal in both sexes. Females required an average of 11.51, 7.47, 4.54, and 4.40 days to develop from egg to adult at 18, 22, 26, and 30°C, respectively. Duration of the egg stage was the longest and required 33% of total developmental time. The other three immature stages required approximately equal developmental times of the remaining interval.

Longevity, fecundity, and life table parameters

Life table parameters at 22, 26, and 30°C (Table 2) showed that this mite reached maximum adult longevity for 50% of the population at 26°C in 29.1 days. The highest net rate of reproduction (R_o) was 16.6 per female, also at 26°C. The time for 50% mortality was 26.0 and 23.4 days at 22 and 30°C, respectively, and the corresponding R_o values were 9.01 and 9.15. The preoviposition period and generation time (T) declined as temperature increased from 22 to 30°C. The intrinsic rate of natural increase (r_m) values were 0.146, 0.250, and 0.246 at 22, 26, and 30°C, respectively. The age-specific survivorship curve (l_x) and the age specific fecundity rate (m_x) for the tested temperatures are shown in Fig. 1.

TABLE 1

Duration (days) of different stages of *Euseius mesembrinus* (Dean) at constant temperature

Temp. (°C)	Female					Male				
	Min.	Max.	Mean	SD	*N*	Min.	Max.	Mean	SD	*N*
Egg										
18	3.00	4.00	3.64	0.35	11	8.00	4.67	3.81	0.33	20
22	2.00	2.80	2.44	0.25	27	2.33	2.83	2.35	0.25	13
26	1.00	1.90	1.48	0.35	18	1.25	2.00	1.78	0.19	18
30	1.00	1.70	1.38	0.25	25	1.00	1.67	1.45	0.19	16
Larva										
18	2.00	3.00	2.49	0.47	11	1.67	3.67	2.33	0.53	20
22	1.00	2.00	1.28	0.28	27	1.00	1.33	1.18	0.18	13
26	0.667	1.33	1.00	0.12	28	0.75	1.46	0.92	0.19	30
30	0.667	1.33	0.91	0.23	25	0.50	1.33	0.89	0.25	16
Protonymph										
18	1.92	3.33	2.71	0.25	11	1.83	4.33	2.70	0.63	20
22	1.00	2.33	1.70	0.37	27	1.00	1.83	1.27	0.30	13
26	0.83	1.17	1.05	0.14	28	0.92	1.50	1.05	0.19	30
30	0.67	1.67	1.03	0.22	25	0.67	1.67	1.10	0.35	16
Deutonymph										
18	1.92	3.00	2.67	0.47	11	1.92	3.92	2.65	0.58	20
22	1.33	3.50	2.05	0.65	27	1.00	2.17	1.60	0.43	13
26	0.83	1.33	1.01	0.07	28	0.67	2.00	1.05	0.12	30
30	0.67	1.33	1.08	0.15	25	0.67	1.67	1.10	0.29	16

TABLE 2

Effect of temperature on the life table parameters of *Euseius mesembrinus* (Dean)

Parameter	Temperature (°C)		
	22	26	30
Developmental time (days)	7.47	4.54	4.40
Preoviposition period (days)	2.60	1.63	1.68
Time to 50% mortality (days)	26.00	29.10	23.40
Mean total fecundity (eggs/♀)	13.35	33.10	15.00
Net reproductive rate (R_o)	9.01	16.55	9.15
Generation time (T)	15.04	11.23	9.01
Intrinsic rate of increase (r_m)	0.146	0.250	0.246
Finite rate of increase (e^{r_m})	1.157	1.284	1.279
Sex ratio (females/total)	0.675	0.500	0.610

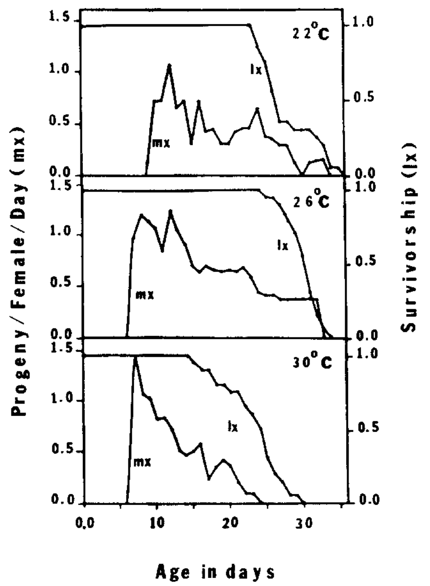

Fig. 1. Age-specific survival and age-specific fecundity rates of *Euseius mesembrinus* (Dean) at constant temperatures.

DISCUSSION

The developmental time declined as temperature increased from 18 to 30°C with the optimal range occurring between 26 and 30°C. No significant reduction in developmental time occurred in this range. Abou-Setta et al. (unpublished data) developed a log-probit BASIC computer program linear model for the relationship between temperature and both developmental time and finite rate of increase in Tetranychidae and Phytoseiidae. This model considers this relationship between temperature and developmental time or finite rate of increases as:

$$\text{Probit}\ (Y) = a_0 + b \ln\ (T)$$

where Y = developmental time or finite rate of increase, a_0, b = constants, and T = temperature.

The relationship between temperature and developmental time for this mite fits the log-probit model with $r^2 = 0.940$ for total developmental time. The range of regression r^2 values for immature stages was 0.888–0.989 (Table 3). The regression values and the expected developmental time for each stage and the total female developmental time at selected temperatures using this model are also included (Table 3).

Similar observations for the developmental time of *E. citrifolius* were reported by Moraes and McMurtry (1981). Tanigoshi et al. (1981) reported 35°C as

TABLE 3

The results of applying the log-probit model for developmental time to different stages of *Euseius mesembrinus* (Dean)

Stage	Regression values			Expected developmental time (days)					
	r^2	a_0	b	10°C	20°C	25°C	30°C	35°C	37°C
Egg	0.989	6.82	−1.03	8.79	3.13	2.06	1.42	1.01	0.88
Larva	0.986	6.22	−0.94	5.70	1.83	1.17	0.80	0.56	0.49
Protonymph	0.935	6.53	−1.00	6.54	2.11	1.34	0.90	0.63	0.55
Deutonymph	0.880	6.364	−0.97	6.90	2.20	1.14	0.95	0.66	0.58
Total	0.940	8.468	−1.40	23.3	9.15	5.86	3.84	2.57	2.20

the optimum developmental temperature for *E. hibisci* reared on ice plant pollen. They indicated that the larval stage incurred high mortality at 38°C. Their conclusion depended on using the linear model between temperature and developmental velocity. Applying the log-probit to their results indicated that a lower range of temperature (i.e. 28–30°C) should be considered as optimum.

E. concordis (Chant) was able to develop and reproduce when fed the tomato russet mite, *Aculops lycopersici* (Massee) or *Ricinus communis* L. pollen at 25±4°C under laboratory conditions. The total female developmental time was 5.0±0.7 and 5.3±0.5 days, respectively (Moraes and Lima, 1983).

The finite rate of natural increase (e^{r_m}) of *E. mesembrinus* followed the log-probit model with $r^2=0.756$ (which is relatively low because of the low number of temperatures tested). This model indicated 15.1°C as the lower threshold temperature for this species to increase (where the estimated $e^{r_m}=1$).

The thermal tolerance range of temperatures for this species seemed to be less than that indicated for *E. hibisci* by Tanigoshi et al. (1981). *E. mesembrinus* is the most abundant phytoseiid mite occurring on Texas citrus (Browning, 1983). Its occurrence on Florida citrus and its ability to utilize different types of available food, including weed pollen and tetranychid mites, suggests it may have a promising role for biological control in Florida citrus groves.

ACKNOWLEDGEMENTS

The authors wish to thank Mr. Harold A. Denmark, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, and Dr. James A. McMurtry, University of California, Riverside, for their helpful assitance in identifying *E. mesembrinus*. This paper was in partial fulfillment of requirements for the Ph.D. degree by the first author. Also, thanks to the AMIDEAST Peace Fellowship Program for supporting the first author during this study.

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