BIOLOGY OF *PROPRIOSEIOPSIS ROTENDUS* (ACARI: PHYTOSEIIDAE) REARED ON *TETRANYCHUS URTICAE (ACARI: TETRANYCHIDAE)* OR POLLEN

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ABSTRACT

Proprioseiopsis rotendus (Muma) (Acari: Phytoseiidae) developed and oviposited when provided with all life stages of *Tetranychus urticae* Koch (Acari: Tetranychidae), and pollen of ice plant, *Malephora crocea* (Jaquin), live oak, *Quercus virginiana* Miller, or cattail, *Typha latifolia* (L.), as food sources under laboratory conditions of 26 ± 1°C and 75-85% RH. Developmental times on the different foods were 6.58 ± 0.36, 8.17 ± 0.92, 7.29 ± 0.51, and 7.41 ± 0.89 d (mean ± SD) for females, and 6.12 ± 0.49, 7.96 ± 0.94, 6.68 ± 0.72, and 6.75 ± 0.60 d for males, respectively. When *T. urticae* was provided as the food source, the highest net reproductive rate (R_o = 23.69), female longevity (45.7 ± 6.26 d), mean generation time (T = 19.54), intrinsic rate of increase (r_m = 0.162), and finite rate of increase (e^{rm} = 1.176) were obtained. Pollen of *M. crocea* was the superior food source with R_o = 21.73, female longevity = 44.1 ± 13.3 d, T = 22.57, r_m = 0.136, and e^{rm} = 1.46, followed by *Q. virginiana*. Cattail pollen was the least favorable food source tested with R_o = 15.08, female longevity = 56.1 ± 4.83 d, T = 23.96, r_m = 0.113, and e^{rm} = 1.120. The sex ratio was 57 ± 1:43 ± 1 (female:male) for all diets tested. Male longevity was 47.3 ± 6.08 d when fed *T. urticae* compared with 26.9-35.2 d when fed pollen. *P. rotendus* adult females cannibalized newly hatched larvae. The mean daily ovipositional rate was 1 per d (max. 2) when fed on *T. urticae* or 0.5 per d (max. 1) when fed on cattail pollen. Duration of the oviposition period was 5 times longer than the generation time (egg to egg) of *P. rotendus*.

Key Words: Biology, food range, developmental time, two-spotted spider mites, oviposition

RESUMEN

Proprioseiopsis rotendus (Muma) (Acari: Phytoseiidae) se desarrolló y ovopositó cuando fue alimentado con todos los estadios de *Tetranychus urticae* Koch (Acari: Tetranychidae), y polen de *Malephora crocera* (Jaquin), *Quercus virginiana* Miller, o *Typha latifolia* (L.) en condiciones de laboratorio de 26 ± 1°C y 75-85% RH. Los tiempos de desarrollo en los diferentes alimentos fueron 6.58 ± 0.36, 8.17 ± 0.92, 7.29 ± 0.51, y 7.41 ± 0.89 d (media ± DT) para las hembras, y 6.12 ± 0.49, 7.96 ± 0.94, 6.68 ± 0.72, y 6.75 ± 0.60 d para los machos, respectivamente. Cuando *T. urticae* fue suministrado como alimento, fueron obtenidos los más altos valores de tasa neta de reproducción (R_o = 23.69), longevidad de la hembra (45.7 ± 6.26), tiempo promedio de generación (T = 19.54), tasa intrínseca de incremento (r_m = 0.162) y tasa finita de incremento (e^{rm} = 1.176). El polen de *M. crocera* fue la fuente de alimento superior, con R_o = 21.73, longevidad de la hembra = 44.1 ± 13.3 d, T = 22.57, r_m = 0.136, y e^{rm} = 1.46, seguido por *Q. virginiana*. El polen de *T. latifolia* fue la fuente de alimento menos favorable, con R_o = 15.08, longevidad de la hembra = 56.1 ± 4.83 d, T = 23.96, r_m = 0.113, y e^{rm} = 1.120. La relación sexual fue 57 ± 1:43 ± 1 para todas las dietas probadas. La longevidad del macho fue 47.3 ± 6.08 d cuando fue alimentado con *T. urticae* comparado con 26.9-35.2 d cuando fue alimentado con polen. Las hembras adultas de *Proprioseiopsis rotendus* canibalizaron las larvas recién eclosionadas. La tasa media ovoposicional diaria fue de uno por día (max. 2) cuando se alimentaron con *Tetranychus urticae*, o 0.5 (max. 1) cuando se alimentaron con polen de *Typha latifolia*. La duración del período de ovoposición fue 5 veces más larga que el tiempo de generación (de huevo a huevo) de *P. rotendus*.

Thirty-eight species of phytoseiid mites have been reported on Florida citrus; however, the biology of only a few have been studied (Muma & Denmark 1970, Abou-Setta & Childers 1987, 1989, Caceres & Childers 1991, Yue et al. 1994, Fouly et al. 1995). *Proprioseiopsis rotendus* (Muma) (Acari: Phytoseiidae) was recorded from Florida citrus litter and bark (Muma & Denmark 1970) as well as from a wide range of plants in Arizona and Pennsylvania (Moraes et al. 1986).

Some phytoseiid mites (especially in the genus *Euseius*) can use alternative food sources such as pollen. This phenomenon increases species survival when animal prey are scarce. Such species are considered low density regulators, density independent, and have the ability of population increase in advance of their prey in late spring and early summer (McMurtry & Johnson 1965, Kennett et al. 1979, Abou-Setta & Childers 1987, Flechtmann & McMurtry 1992). To our knowledge, the biology of this genus has not been previously studied.

This study was conducted to determine the impact of different diets on the biology and life table parameters of *P. rotendus*. Two spotted spider mites, *Tetranychus urticae* Koch (Acari: Tetranychidae), and pollen of ice plant, *Malephora crocea* (Jaquin), live oak, *Quercus virginiana* Miller, or cattail, *Typha latifolia* (L.) were selected for this purpose.

T. urticae is a common phytophagous mite that feeds on more than 150 species of host plants (Jeppson et al. 1975). It is only an occasional pest on Florida citrus under greenhouse conditions (Childers 1994). *M. crocea* pollen has been used as a diet for other phytoseiid mites in studies which were conducted in California and Florida (McMurtry & Johnson 1965, Abou-Setta & Childers 1987, Fouly et al. 1995). *T. latifolia* and *Q. virginiana* are annual and perennial plants, respectively, that occur in and around citrus groves in Florida. Their pollens may be natural food sources for *P. rotendus* during flowering.

This study was part of an ongoing effort to understand the biology of natural enemies associated with citrus in Florida.

MATERIALS AND METHODS

The *P. rotendus* culture was established from individuals collected on lower canopy leaves in a 'Pineapple' orange grove at Fort Ogden, DeSoto County, Florida in March 1993. The main culture was maintained on plastic arenas similar to ones used by Swirski et al. (1970). The rearing arena consisted of a water wick and a black painted plastic surface surrounded with a sticky barrier to prevent mites from escaping. Arenas were covered with plastic Petri dish bottoms to provide an enclosed environment about 2 cm high. A small piece of black construction paper was provided as arresting place and a few non-absorbent cotton fibers were attached to the water wick as egg deposition sites. The culture was provided with ice plant pollen obtained from the University of California-Riverside.

The food sources evaluated included all stages of *T. urticae* (on small pieces of Lima bean leaves), or pollen of *M. crocea*, *Q. virginiana*, or *T. latifolia*. Pollens were collected when available in the field and stored in the refrigerator at 5°C; small amounts were added to the arena as needed using a fine 5-0 sable hair brush.

The newly deposited eggs were transferred individually to 2.5 cm diam arenas. Newly hatched larvae were provided with one of the food sources listed. As new females matured, they were exposed to males from the same food group or from the main culture. A male was present with each female until her death.

The arenas were held in an environmental chamber at 26 ± 1°C with a photoperiod of 12:12 (L:D). Relative humidity (75-85%) was measured at 1 cm height above the arena surface using a thermocouple for temperature and relative humidity (Abou-Setta & Childers 1987).

Individual development, survival, and egg deposition were observed daily. Life table parameters were calculated using a BASIC computer program (Abou-Setta et al. 1986).

RESULTS

Behavioral Observations

Rearing of *P. rotendus* was successful using the plastic rearing arena with either one of the pollens or motile stages of *T. urticae* as the food source. Eggs, larvae, nymphs and adults of *T. urticae* were consumed by adult *P. rotendus*.

P. rotendus eggs were whitish, crystalline, elongate-oval, and with a sticky surface when newly deposited. Their color changed to light reddish-brown before hatching. Larvae were whitish and slightly larger than the egg.

The protonymph and deutonymph stages were progressively larger than the larval stage with developing body color becoming increasingly brownish. Males were smaller than females and with the same brown coloration. Morphology of this species was considered by Fouly et al. (1994).

TABLE 1. EFFECT OF DIFFERENT FOOD SOURCES ON THE DEVELOPMENTAL TIME AND ADULT LONGEVITY OF *PROPRIOSEIOPSIS ROTENDUS* AT 26°C BY SEX.

			Developmental Time (days ± SD)					
Food Source	Sex	n	Egg	Larva	Protonymph	Deutonymph	Total	Adult Longevity
Tetranychus urticae	F	12	2.00 ± 0.21	0.76 ± 0.25	1.54 ± 0.33	2.38 ± 0.31	6.58 ± 0.36 c	45.7 ± 6.3 b
Malephora crocea	F	15	2.87 ± 0.52	0.60 ± 0.21	2.27 ± 0.82	2.43 ± 0.98	8.17 ± 0.92 a	44.1 ± 13.3 b
Quercus virginiana	F	14	2.32 ± 0.25	0.57 ± 0.18	2.29 ± 0.58	2.11 ± 0.45	7.29 ± 0.51 b	48.7 ± 6.0 b
Typha latifolia	F	11	2.14 ± 0.32	0.55 ± 0.15	2.23 ± 0.75	2.50 ± 0.39	7.41 ± 0.89 b	56.1 ± 4.8 a
Tetranychus urticae	M	9	2.00 ± 0.25	0.61 ± 0.22	1.39 ± 0.33	2.11 ± 0.22	6.11 ± 0.49 b	47.3 ± 6.1 a
Malephora crocea	M	12	2.75 ± 0.54	0.67 ± 0.25	2.46 ± 0.50	2.08 ± 0.85	7.96 ± 0.94 a	26.9 ± 5.7 c
Quercus virginiana	M	11	1.95 ± 0.55	0.55 ± 0.15	2.00 ± 0.45	2.18 ± 0.34	6.68 ± 0.72 b	35.2 ± 5.0 b
Typha latifolia	M	8	2.06 ± 0.18	0.69 ± 0.26	1.81 ± 0.26	2.19 ± 0.26	6.75 ± 0.60 b	29.0 ± 5.0 c

Means in each column followed by a different letter are significantly different, $P < 0.05$ by SAS, Duncan test.

Mating took place just as a female reached maturity and continued for about 4 h. Mated females became more spherical as the egg developed compared to unmated females. No multiple matings were observed.

Eggs were deposited on the arena's surface close to the water wick, on the construction paper, or on the cotton fibers attached to the water wick. Egg deposition sites were the same regardless of food source.

P. rotendus was easily disturbed in the arena when exposed to bright light after darkness. Avoidance of light may contribute to their inhabiting the inner or lower canopy and surface debris on the ground.

Cannibalism was observed in crowded cultures, especially by adults feeding on newly emerged larvae. Feeding was not observed on any other stage.

Developmental Time and Adult Longevity

Type of diet tested and gender significantly affected individual developmental time and adult longevity. Mean male developmental time (6.95 ± 1.0 d) and longevity (34.20 ± 9.46 d) were significantly shorter than that for female (7.40 ± 0.9d and 48.25 ± 9.5 d respectively).

Both sexes developed significantly slower on ice plant pollen than other diets. Female mean developmental time, 6.58 ± 0.36 d, was the shortest on *T. urticae* (Table 1).

Mean female longevity was significantly longer on cattail pollen than other diets (56.1 ± 4.8 d) while oviposition was the lowest (Tables 1 & 2).

Mean male longevity was significantly longer on *T. urticae* (47.3 ± 6.1 d) followed by live oak, cattail, and ice plant pollens (Table 1).

Life Table Parameters

Sex ratio was not affected by food source (Table 2). Survival curves of *P. rotendus* under laboratory conditions followed a type I pattern in which most eggs developed to maturity and death occurred gradually after an extended ovipositional period (Fig. 1, L_x).

Maximum daily oviposition per female did not exceed 2 eggs per female per day (m_x value of 1.19 expected female progeny per female per day) when fed upon *T. urticae* (Fig. 1). Average daily oviposition ranged from a maximum of 1 egg per day when fed *T. urticae* to a low of 0.5 egg per day on cattail pollen.

TABLE 2. EFFECT OF FOOD SOURCE ON LIFE TABLE PARAMETERS OF *PROPRIOSEIOPSIS ROTENDUS* AT 26°C.

Food Source	Percentage Female (%)	F^1	$R_o{}^1$	T (d)[1]	$r_m{}^1$	e^{rm1}
Tetranychus urticae	57	41.46	23.69	19.54	0.162	1.176
Malephora crocea	56	39.11	21.73	22.57	0.136	1.146
Quercus virginiana	56	29.16	16.33	21.41	0.130	1.139
Typha latifolia	58	26.05	15.08	23.96	0.113	1.120

[1]F, mean total fecundity (eggs per female); R_o, net reproductive rate; T, mean generation time; r_m intrinsic rate of increase; e^{rm}, finite rate of increase.

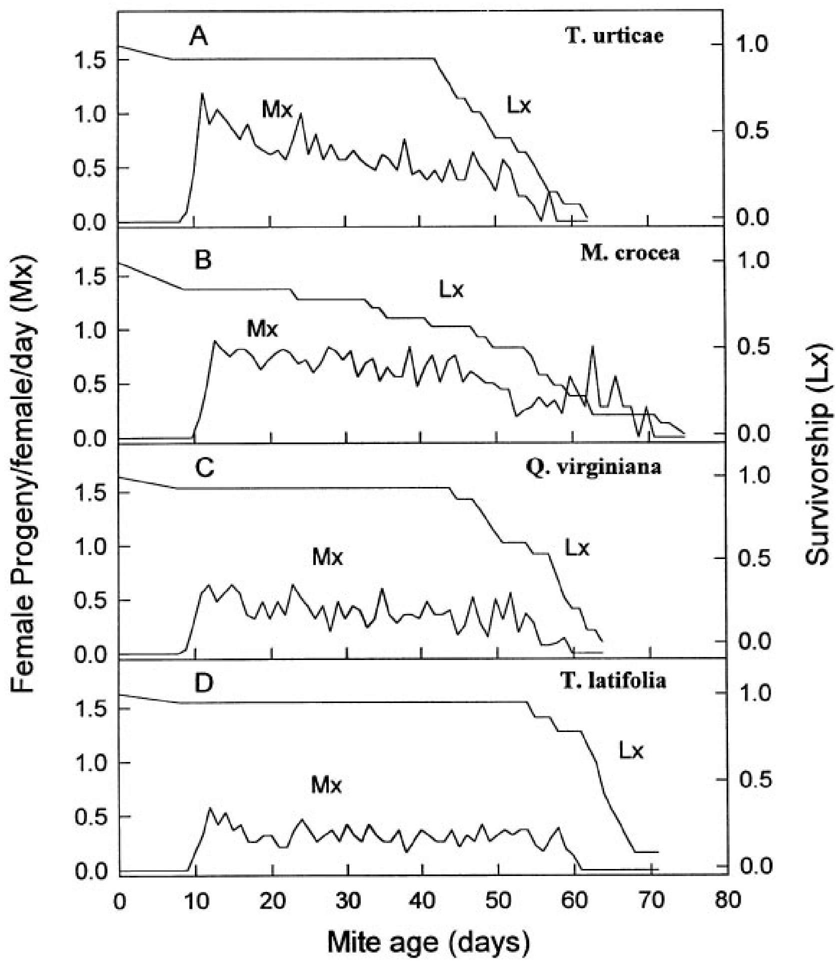

Fig. 1. Age-specific fecundity (M_x) and survivorship (L_x) of *Proprioseiopsis rotendus* feeding on different sources of food at 26°C. (A) *Tetranychus urticae* (mite); (B) *Malephora crocea* (pollen); (C) *Quercus virginiana* (pollen); (D) *Typha latifolia* (pollen).

Feeding on *T. urticae* resulted in the highest mean total fecundity of 41.46 eggs per female, net reproductive rate (R_o) value of 23.69 expected females per female, and shortest mean generation time (T) of 19.54 d. Feeding on pollen of different plant species resulted in lower r_m values with ice plant providing the maximum r_m (Table 2). A similar ranking for the diets was observed for *Typhlodromalus peregrinus* (Muma) (Fouly et al. 1995).

DISCUSSION

P. rotendus developed more slowly than most species of Phytoseiidae previously studied. This slow development may be a requirement to compensate for lower levels of available food in both litter and the lower tree canopy than more arboreal phytoseiid species. Other phytoseiid species completed their development from egg to adult female at a constant temperature of 25-26°C within a range of 4-6 d (Sheriff 1982, Abou-Setta & Childers 1987, 1989, Bonde 1989, Caceres & Childers 1991, Fouly et al. 1995) compared with 6.58-8.17 d for *P. rotendus*.

The ovipositional period for *P. rotendus* was about 5 times greater than the generation time with a maximum ovipositional rate of 2 eggs per female per day. This ratio did not exceed 3-4 times for other phytoseiid species studied from Florida citrus (*Euseius mesembrinus* (Dean), *Galendromus helveolus* (Chant) and *T. peregrinus*) with maximum oviposition rates of 3-4 eggs per female per day at the same temperature (Abou-Setta & Childers 1987, Caceres & Childers 1991, Yue et al. 1994, Fouly et al. 1995). The number of eggs produced by a female over a period equal to one or two generation times was responsible for most of the calculated r_m value for mites and insects (Abou-Setta & Childers 1991). The longest survival of *P. rotendus* adult females occurred on cattail pollen, the least suitable food source.

Endnote

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References Cited

ABOU-SETTA, M. M., AND C. C. CHILDERS. 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.

ABOU-SETTA, M. M., AND C. C. CHILDERS. 1989. Biology of *Euseius mesembrinus* (Acari: Phytoseiidae): life tables and feeding behavior on tetranychid mites on citrus. Environ. Entomol. 18: 665-669.

ABOU-SETTA, M. M., AND C. C. CHILDERS. 1991. Intrinsic rate of increase over different generation time intervals of insects and mite species with overlapping generations. Ann. Entomol. Soc. America 84: 517-521.

ABOU-SETTA, M. M., R. W. SORRELL, AND C. C. CHILDERS. 1986. Life 48: a BASIC computer program to calculate life table parameters for an insect or mite species. Florida Entomol. 69: 690-697.

BONDE, J. 1989. Biological studies including population growth parameters of the predatory mite *Amblyseius barkeri* (Acari: Phytoseiidae) at 25°C in the laboratory. Entomophaga 34: 275-287.

CACERES, S., AND C. C. CHILDERS. 1991. Biology and life tables of *Galendromus helveolus* (Acari: Phytoseiidae) on Florida citrus. Environ. Entomol. 20: 224-229.

CHILDERS, C. C. 1994. Biological control of phytophagous mites on Florida citrus utilizing predatory arthropods, pp. 255-288 *in* D. Rosen, F. D. Bennett and J. L. Capinera [eds.]. Pest management in the subtropics—Biological control—A Florida perspective. Intercept Ltd., Andover, UK.

FLECHTMANN, C. H. W., AND J. A. MCMURTRY. 1992. Studies on how phytoseiid mites feed on spider mites and pollen. Intern. J. Acarol. 18: 157-162.

FOULY, A. H., M. M. ABOU-SETTA, AND C. C. CHILDERS. 1995. Effects of diet on the biology and life tables of *Typhlodromalus peregrinus* (Acari: Phytoseiidae). Environ. Entomol. 24: 870-874.

FOULY, A. H., H. A. DENMARK, AND C. C. CHILDERS. 1994. Description of the immature and adult stages of *Proprioseiopsis rotendus* (Muma) and *Properioseiopsis asetus* (Chant) from Florida (Acari: Phytoseiidae). Intern. J. Acarol. 20(3): 199-207.

JEPPSON, L. R., H. H. KEIFER, AND E. W. BAKER. 1975. Mites injurious to economic plants. Univ. California Press, Berkeley.

KENNETT, C. E., D. L. FLAHERTY, AND R. W. HOFFMANN. 1979. Effect of wind-borne pollens in the population dynamics of *Amblyseius hibisci* (Acarina: Phytoseiidae). Entomophaga 24: 83-98.

MCMURTRY, J. A., AND H. G. JOHNSON. 1965. Some factors influencing the abundance of the predaceous mite *Amblyseius hibisci* in southern California (Acarina: Phytoseiidae). Ann. Entomol. Soc. America 58: 49-56.

MORAES, G. J. DE, J. A. MCMURTRY, AND H. A. DENMARK. 1986. A catalog of the mite family Phytoseiidae: references to taxonomy, synonymy, distribution and habitat. Brasilia: EMBRAPA-00T. 353 pp.

MUMA, M. H., AND H. A. DENMARK. 1970. Arthropods of Florida and neighboring land areas, Vol. 6. Phytoseiidae of Florida. Florida Dept. Agric. and Consumer Services, Div. Plant Ind., Gainesville.

SHERIFF, A. A. 1982. Comparative studies on the influence of temperature on phytoseiid mites (Acarina: Phytoseiidae). Ph.D. Thesis, Rutgers, New Jersey.

SWIRSKI, E., S. AMITAI, AND N. DORZIA. 1970. Laboratory studies on the feeding habits, post-embryonic survival and oviposition of the predaceous mites *Amblyseius chilenensis* Dosse and *Amblyseius hibisci* Chant (Acarina: Phytoseiidae) on various kinds of food substances. Entomophaga 15: 93-106.

YUE, B., C. C. CHILDERS, AND A. H. FOULY. 1994. A comparison of selected plant pollens for rearing *Euseius mesembrinus* (Acari: Phytoseiidae). Intern. J. Acarol. 20: 103-108.

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