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BIOLOGY OF *Paraphytoseius orientalis* (Narayanan et al.) REARED ON THE BROAD MITE, *Polyphagotarsonemus latus* (Banks) (ACARI: PHYTOSEIIDAE, TARSONEMIDAE) IN THE PHILIPPINES[1]

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ABSTRACT

The objective of this work was to briefly describe each of the developmental stages of *Paraphytoseius orientalis* (Narayanan et al.) and to determine its life history parameters and prey consumption on the Broad Mite, *Polyphagotarsonemus latus* (Banks). The incubation period of the eggs was 1.5±0.6 days for the male and 1.5±0.4 for the female. The development time (in days) of the other stages for males and females were respectively as follows: larva, 1.6±0.8 and 1.3±0.4; protonymph, 1.1±0.2 and 1.1±0.3; deutonymphs, 1.0±0.0 for both. Total development time (egg to adult) was 5.6±0.2 for male and 6.3±0.6 for female. Durations of post-development periods of mated female were as follows: pre-oviposition, 3.6±3.3; oviposition, 13.3±5.6 and post-oviposition, 3.4±3.0. Longevity of unmated females (21.5±10.6) was slightly longer than that of mated ones (20.5±5.7). Unmated females did not lay eggs, while mated females laid 13±9 eggs. Adult female *P. orientalis* consumed the greatest number of prey eggs at the highest prey density offered, an important characteristic of a potential biological control agent against the Broad Mite.

Key words: Biological control, predator, prey consumption, *Paraphytoseius orientalis* *Polyphagotarsonemus latus*

INTRODUCTION

The Broad Mite (BM), *Polyphagotarsonemus latus* (Banks), is an invasive worldwide pest that is most important in tropical and subtropical countries, where it reproduces throughout the year and has a wide host range (CABI, 2014). In temperate countries, it is a serious pest on vegetables and ornamental plants in glasshouses. It has been recorded on 62 plant species in the Philippines (Fajardo and Belosillo, 1934;

Corpuz-Raros, 1986, 1989, 2001; Calilung et al., 1994; Navasero and Corpuz-Raros, 2014), and on more than 100 plant species in the world (Gerson, 1992). Due to its high reproductive potential, it can reach damaging densities within a very short time. Heavy infestations of *P. latus* on potato in the Philippines can result in economic yield loss (Eusebio and Bernardo, 1999). The feeding activities of this mite cause the destruction/epidermal and mesophyllic cells, reducing the growth and causing malformation of leaves, flowers and fruits (Schoonhoven et al., 1978; Gerson, 1992; Grinberg et al., 2005), stunting the plant and leading it to premature death (Pena and Bullock, 1994). These symptoms are similar to those caused by virus diseases, herbicide toxicity and micronutrient deficiency (Beattie and Gallatley, 1983; Cross and Basset, 1982). Members of the mite family Phytoseiidae are predators of phytophagous mites belonging to the families Tetranychidae, Tenuipalpidae, Eriophyidae and Tarsonemidae. In the Philippines, 108 phytoseiid species have been reported between the mid 1960's, when taxonomic work on Phytoseiidae started, and 2005 (Corpuz and Rimando, 1966; Corpuz-Raros, 2005). In the early 1990's, the phytoseiids *Neoseiulus longispinosus* (Evans) and *Indoseiulus semirregularis* (Schicha and Corpuz-Raros, 1993) allegedly put the spider mite *Tetranychus kanzawai* Kishida under control on cassava (Corpuz-Raros, 1989) at the Matling Industrial and Commercial Corporation (MICC) in Malabang, Lanao del Sur, in an area of about 1,000 hectares, using laboratory reared predators (Vasquez and Gonzales, 1994).

Biological control of spider mites is now widely accepted and practiced in many countries on many crops, and this may be expanded to include the BM and other phytophagous mites. Twelve predatory mite species have been reported together with and seem to exert natural control of the BM at varying degrees in the Philippines, the most important of these being phytoseiids (Navasero and Corpuz-Raros, 2014). The phytoseiid *Paraphytoseius orientalis* (Narayanan et al.) has been most frequently collected together with *P. latus* on seven plant species (Navasero and Corpuz-Raros, 2014). This predator is semi-cosmopolitan, with Oriental records from the Philippines (Luzon, Leyte, Mindanao), India, Malaysia, Pakistan, South China, South Japan (Okinawa), Taiwan, and Thailand (as cited in Demite et al., 2014; Navasero and Corpuz-Raros, 2014). It was previously recorded on 72 plant species including ornamentals, weeds, fruit trees and wild forest trees, and recently, it was recorded on five other hosts (Navasero and Corpuz-Raros 2014), including coconut, in association with outbreak populations of *Aspidiotus rigidus* Reyne (Navasero et al., 2015). The objective of this work was to briefly describe each of the developmental stages of *P. orientalis* and to determine its life history parameters and prey consumption on the Broad Mite, *P. latus*.

MATERIALS AND METHODS

Stock colony of *P. latus*

The stock colony of the BM was established with mites obtained from shoots of alugbati, *Basella alba* L. (=*Basella rubra* L.) (Basellaceae), grown in Mayondon, Los Baños, Laguna. The mite was mass reared on young shoots of alugbati kept fresh in tap water (Navasero and Navasero, 2013). After at least one week, the substrate was no longer attractive to the mites for oviposition/feeding and other fresh shoots were prepared for infestation.

Stock colony of *P. orientalis*

The stock colony of *P. orientalis* was established with mites collected from leaves of *Lantana camara* L. (Verbenaceae) growing at the National Crop Protection Center, University of the Philippines Los Baños. This colony served as source of the predators for all experiments. The prey used in rearing *P. orientalis* were the BM and *Suidasia pontifica* Oudemans reared on yeast (Navasero and Calilung, 1997).

Life history of *P. orientalis*

Ten gravid females of *P. orientalis* were confined separately in plexi glass Munger cells measuring 7.8 cm x 2.7 cm with a bore at the center having a diameter of 2.2 cm and a depth of 0.4 cm. The bore was covered above and below with pieces of ordinary glass of the same size as the Munger cell. A piece of 2-ply tissue paper folded as the size of the glass slides was lined to the bottom glass cover. The closed cell was used as arena, each containing a single predator and the prey at different densities. A leaf of *B. alba* with all developmental stages of the BM prey was sandwiched between the bottom glass of the Munger cell. Fresh leaves with prey were replenished daily. Each arena was monitored daily (early morning, noon, and afternoon) under a dissecting microscope to record feeding, molting, mating, egg-laying, and mite death. From the progeny of this parental stock, 50 eggs were similarly confined separately in Munger cells to record life history data. The experiment was set-up under laboratory conditions at 26 to 28°C, 70 to 80% RH and 12D:12L light regime.

Mating and oviposition.

Ten pairs of newly emerged adult males and females were confined separately in Munger cells. The behavior before, during and after copulation was observed under a dissecting microscope. A male was allowed to remain together with a female until the male died, at which time it was removed, retaining the female for monitoring of its egg-laying behavior until it died. Likewise, another set of 10 newly emerged females were confined separately in Munger cells to test whether oviposition would occur in the absence of males.

Consumption of *P. orientalis* at varying prey densities

The consumption of the BM at various densities by *P. orientalis* was determined. Fifteen adult predators were introduced singly into Munger cells containing the following egg densities: 1, 10, 20, 40, and 80 per arena. The number of BM eggs consumed during 24h, as assumed by the difference between the initial and remaining number of prey eggs, was recorded.

RESULTS AND DISCUSSION

Life history of *P. orientalis*

P. orientalis went through the egg, larval, protonymphal, and deutonymphal stages before becoming an adult. Measurements and descriptions of each developmental stage are presented below.

Egg. Oblong, white, and laid singly; attached either to the sides of the Munger cell, plant tissue, or trichome at the abaxial side of the leaf. Each egg measured 130-155 micrometers long (141.7± 8.1) and 100-130 micrometers in diameter (112.1 ± 9.7) (Table 1).

Table 1. Body measurements (in micrometers) of *Paraphytoseius orientalis* (Narayanan et al.) at different stages of development under laboratory conditions, reared on *Polyphagotarsonemus latus* (Banks) as prey.

LIFE STAGE	SAMPLE SIZE	LENGTH	WIDTH
		MEAN ± SD	MEAN ± SD
Egg	12	141.7 ± 8.1	112.1 ± 9.6
Larva	10	199.0 ± 10.2	120.0 ± 9.4
Protonymph	10	229.0 ± 17.9	127.0 ± 7.2
Deutonymph	10	282.0 ± 28.5	156.5 ± 19.2
Adult			
Male	10	294.3 ± 26.4	162.9 ± 25.0
Female	10	341.5 ± 25.2	180.0 ± 18.7

Larva. The body is white; if newly molted, it looks weak when moving, staying immobile after few steps; after a few hours, its short legs become more steady; it bears a pair of elongate and curved setae on its lower back (seta *Z4*).

Protonymph. The body is white, but darker than that of the larva; it remains immobile when newly molted, moving faster than the larva after a few minutes; the legs are slender and longer; seta *Z4* not as distinct as in larva.

Deutonymph. The body is darker but bigger than that of the protonymph, with longer legs; it stays motionless for a few minutes after molting but later moves fast around the Munger cell; the prey is voraciously consumed when caught. The sex can already be distinguished at this stage, with the posterior end of idiosoma being broadly rounded in female and narrowly rounded in the male.

Adult. Females are larger than the males and can be easily distinguished even when alive, given that females are more oval than the males, and have a wide and rounded posterior end when gravid. Both sexes turn darker (yellowish) with time due to the yellowish pigmentation of the adult prey.

Male. Translucent when newly molted, turning light yellow after a few hours, a little bigger than the deutonymph but smaller than the female. Pair of curved setae, *Z5,* on posterior end longer and more prominent than in the female. It moves faster than the deutonymph and the female.

Female. Translucent when newly molted, becoming light yellow after a few hours.

Duration of development at each stage

The egg and larva of both sexes had the longest duration (Table 2); they are about one and a half times as long as those of the protonymphal and deutonymphal stages. Females took longer to complete development than males. The developmental period of *P. orientalis* is slightly longer than that of *Neoseiulus calorai* (Corpuz & Rimando), which averages about 5.8 days for the females and 5.3 days for the males at 27-29 °C (Malveda and Corpuz-Raros, 2006).

Table 2. Durations of the different developmental stages of *Paraphytoseius orientalis* (Narayanan et al.) reared on *Polyphagotarsonemus latus* (Banks) using *Basella alba* leaf discs in Munger cells. (Temperature = 26-28°C, RH = 70-80%, 12D:12L).

DEVELOPMENTAL STAGE	DURATION (days)	
	MALE	FEMALE
Egg	1.4 ± 0.6	1.5 ± 0.5
Larva	1.6 ± 0.8	1.2 ± 0.5
Protonymph	1.1 ± 0.2	1.1 ± 0.3
Deutonymph	1.0 ± 0.0	1.0 ± 0.0
Total developmental period	5.6 ± 0.9	6.2 ± 0.6

Post developmental period of adult female

Pre-oviposition and post-oviposition periods were similar, each corresponding to about a fourth of the duration of the oviposition period.

Fecundity and longevity of adult females and males

Unmated females did not lay eggs; mated females laid 13.0 ± 8.90 eggs throughout their lifetime. Unmated females lived slightly longer than mated females (respectively 21.5 ± 10.61 and 20.1 ± 5.72 days). This most probably reflects the cost of oviposition in terms of life span. Adult male longevity was about 11.6 ± 5.3 days. Shorter male longevity is a general pattern in arthropods.

Adult mating

Mating occurred at any time of the day, but seemingly most often in mid-morning or early afternoon. Initially, the male followed the female continuously. When the female accepted mating, the male mounted her from her back and remained in that position for a few minutes before moving backwards over the female, attaining a venter-to-venter position, both oriented in the same direction. While underneath, the male grasped the anterior region of the body of the female with its first two pairs of legs and the posterior region of her body with its third and fourth pairs of legs, and mating took place. The male remained underneath up to a few hours, even after the female started moving again. A similar mating behavior was reported by Malveda and Corpuz-Raros (2006) for *N. calorai*, according to the "*Amblyseius-Typhlodromus*" pattern originally described by Amano and Chant (1978).

Consumption of *P. orientalis* at varying prey densities

Even at the lowest prey density (one egg per arena), *P. orientalis* was able to detect and prey on BM, consuming an average of 0.4 egg (Figure 1). An increase in the number of prey consumed was observed throughout the range of number of prey items offered, showing its high predation capacity. This result suggests that *P. orientalis* could have a significant impact on the BM under field conditions.

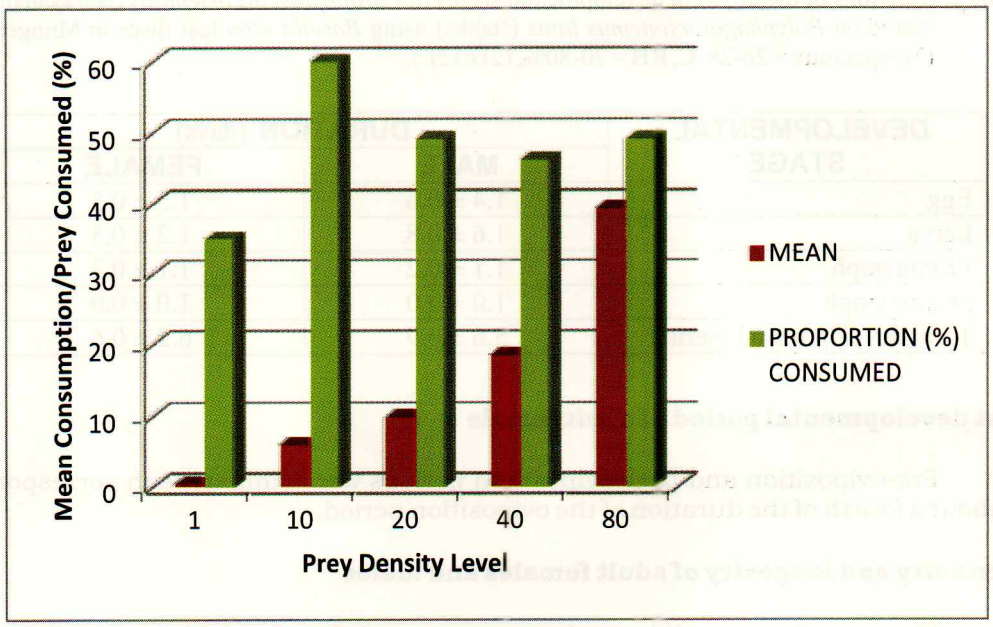

Figure 1. Mean egg consumption and proportion consumed by *Paraphytoseius orientalis* (Narayanan et al.) of *Polyphagotarsonemus latus* (Banks).

CONCLUSION

The life history of *P. orientalis* was studied on the Broad Mite, *P. latus*. Mating habits of the male and female adult predators were observed and the prey consumption of adult *P. orientalis* at varying densities of *P. latus* (1, 10, 20, 40, and 80 eggs per arena) was determined. Predation tests were conducted on *B. alba* leaf discs inside Munger cells over a 24 h period at 27°C. The results showed that *P. orientalis* is an r-strategist and an effective predator of eggs of *P. latus*. The high predation rates of *P. orientalis* on *P. latus* suggests the potential of this predator as a biological control agent of that prey.

This study is the first contribution to knowledge of biological details of *P. orientalis* as a predator of *P. latus* in the country. As the biological aspects and predatory capacity of this predator are better understood, appropriate approaches can be developed such as field augmentation and conservation. The first step in conserving the population of predators and improving their impacts is to integrate cultural methods to existing practices in crop production to provide refuge to the predator.

Subsequent works should evaluate the effect of this predator on *P. latus* directly on plants of different species, under controlled conditions.

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