

Rearing the predaceous mite, *Amblyseius swirskii* (Athias-Henriot) (Phytoseiidae) on artificial diets

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ABSTRACT

This study was to develop a suitable artificial diet for mass rearing the economically important phytoseiid predator, *Amblyseius swirskii* which considered one of the most effective phytoseiid species used in agricultural systems for the control of spider mites. The basic artificial diet (AD) was composed of honey, glucose, milk, yeast and fresh egg yolk. This diet was enriched as (AD1) by adding hemolymph from mulberry silkworm, *Bombyx mori*. Predators fed on *Tetranychus urticae* and AD1 had shorter immature and pre-oviposition periods than those fed on the other diets. The total number of deposited eggs was significantly higher for females fed on AD1 than those maintained on the other diets. There weren't significant differences between *T. urticae* and bee bread in the total number of deposited eggs and longevity. This indicates that rearing *A. swirskii* on bee bread was successful. Therefore this artificial diet can serve as a potentially useful food source for the long-term maintenance of *A. swirskii* populations.

Key words: *Amblyseius swirskii*; Artificial diets; Mass rearing.

INTRODUCTION

Mites of the genus *Amblyseius* are characterized as specialized pollen feeders and generalist predators (Abou-Setta and Childers, 1989 and Oliver *et al.*, 1996). Phytoseiid mite species, however clearly differ in their ability to utilize pollen (McMurtry and Croft, 1997) and characterized the life styles on the basis of feeding habits in four major types. Among other aspects, each group differs in the extent to which they utilize pollen as a food source: type I (spider mite specialists) don't feed on pollen at all; type II (less specialized spider mite feeders); type III (generalists) feed on pollen but prefer or have better performance on prey and type IV (pollen feeders) show the highest performance on a pollen diet. Population dynamics of *Euseius* species, which are mostly found in arboreal habitats, are often related to pollens found on the foliage rather than to the presence of any prey species (Grout and Richards, 1992). *Amblyseius swirskii* can feed on various types of food including arthropod prey but also plant materials like pollens and honeydew (Momen and El-Saway, 1993). Previous studies showed that *A. swirskii* can successfully develop and reproduce on a wide range of food sources such as, eriophyid mites (El-Laithy 1998 and Park *et al.*, 2010), spider mites (Xu and Enkegaard, 2010) and plant pollens (Kutuk and Yigit, 2011 and Park *et al.*, 2011). The availability of an effective artificial diet for phytoseiids could eliminate many of the problems associated with their mass rearing (Kennett and Hamai 1980). Whereas a good body of literature exists on artificial diets for insect predators (Thompson, 1999 and Riddick, 2009), relatively few studies have focused on the development of artificial diets for phytoseiid mites. McMurtry and Scriven, 1966 tested several diets for four phytoseiid species: *Amblyseius limonicus* Garman and McGregor, *Amblyseius hibisci* (Chant), *Typhlodromus*

occidentalis Nesbitt, and *Typhlodromus rickeri* Chant. Their results showed that immatures development was poor and oviposition rates were low compared to natural prey or pollen. Shehata and Weismann, 1972 reared *Phytoseiulus persimilis* (Athias-Henriot) on three artificial diets and larva developed to females that deposited eggs. However, the female offspring failed to produce eggs, and had a smaller size and shorter longevity than conspecifics preying on *T. urticae*. Kennett and Hamai, 1980 found that seven out of nine species of phytoseiid mites could develop and reproduce when fed an artificial diet composed of honey, sugar, yeast flakes, yeast hydrolysate, enzymatic casein hydrolysate, and fresh egg yolk. However, the oviposition rate of all species fed on artificial diet was only about one third of that achieved on natural diets. Abou-Awad *et al.*, 1992 showed that *Amblyseius gossipi* El-badry and *A. swirskii* developed, survived and reproduced on several artificial diets consisting of yeast, milk, cystine, proline, arginine, sucrose, glucose, streptomycin sulphate, and sorbic acid. However, females fed on the best performing artificial diet had lower oviposition rates than those on natural diet. Ogawa and Osakabe, 2008 reported that an artificial diet composed of yeast components, saccharides, and egg yolk supported development and survival of *Neoseiulus californicus* (McGregor), but again fecundity on the artificial diet was low. The above studies suggest that, although phytoseiid mites can develop on different artificial diets, fecundity in most cases was negatively affected. Hence, for making a diet suitable for commercial mass rearing of phytoseiids, the factor to be improved is reproduction. Several studies have demonstrated that the use of insect materials in artificial media can enhance survival and oviposition of entomophagous insects (Grenier and De Clercq 2003). For instance, many artificial media for egg parasitoids of the genus

Trichogramma contain lepidopteran pupal hemolymph and/or pupal holotissues to stimulate egg laying by the parasitoid females or to provide adequate nutrition for development of the larvae (Liu *et al.*, 1979; Strand and Vinson, 1985; Nettles, 1990 and Lu *et al.*, 2012). Also, the fecundity of the predatory anthocorid *Orius insidiosus* (Say) was significantly increased when the bugs were fed on an artificial diet supplemented with a cell line derived from eggs of the Indian meal moth *Plodia interpunctella* Hu bner (Ferkovich and Shapiro, 2004). Conceivably, insect materials like hemolymph could also be useful to supply nutritional factors for growth and reproduction of predatory mites such as *A. swirskii*. In the present study, we determined the life table parameters of *A. swirskii* when fed on Bee bread, spider mite (*Tetranychus urticae*), or a meridic artificial diet modified from (Ogawa and Osakabe, 2008) and a similar diet supplemented with insect hemolymph.

MATERIALS AND METHODS

Mites' cultures:

Laboratory cultures of the mites were established from field collections of the spider mite *Tetranychus urticae* Koch and *A. swirskii* on *Phaseolus vulgaris* L. in Abou-kaber, Sharkia governorate. Mite cultures were maintained in separate climatic rooms at 27 ± 2 °C and 60-70% R.H. Spider mites were reared on bean plants; while *A. swirskii* was reared on detached bean leaves prepared as follows. Several young fully expanded bean leaves were placed underside up on a wet cotton wool layer in a plastic tray (30×20 cm). The wet cotton wool prevented mite escape and maintain leaf freshness for two weeks. The cotton wool was maintained wet by adding water when necessary. Bean leaves were infested with mixed stages of *T. urticae* and 24h later *A. swirskii* females were added.

Bee bread:

Bee bread was kept in a refrigerator at 5 °C for need.

Preparation of artificial diets:

The artificial diets were composed of (AD): honey (10g), glucose (10g), milk (20ml), yeast (5g) and fresh egg yolk (10ml). During preparation the components were dissolved in appropriate amounts of distilled water. The second diet (AD1): consisted of 75% AD supplemented with 25% (w/w) hemolymph of mulberry silkworm larvae (*Bombyx mori*) originating from a culture at Plant Protection Research Institute. The larval hemolymph was collected from live *B. mori* larvae which were immersed in a water bath at 60 °C for 10 min. to avoid melanization of the hemolymph. The hemolymph was then lyophilized and stored in a deep freeze at -18°C.

The lyophilized hemolymph was redissolved using distilled water before being added to the diet.

Experimental set-up:

The arenas used in this study were 3×3 cm of mulberry leaf discs placed lower surface up on a water saturated sponge pads. Strip of moistened absorbent cotton was placed around the outside edge of the leaves. Thirty newly hatched predator larvae were used for the treatments, AD, AD1, *T. urticae* immatures and bee bread that placed individual on arenas supplied with the food diets to be evaluated. Arenas were examined daily and predator developmental stages were recorded. Each female was paired with a male that was reared on the same diet as the female. Freshly diet was made available to the predator by providing each arena with a small amount of test diet and was replaced at 48-72 h. The diet must be stored well and preferably have a low water content to minimize molding when used as a food source for mite rearing. Observations were made every 24 h until all individuals had reached adulthood. After completing immature development, each female was paired with a male and observed daily to determine the preoviposition and oviposition periods, longevity and fecundity. Progeny from females of the same age were transferred to new ones and fed on the same diet as their parents in order to determine the sex ratio of the offspring for each treatment. The experiments were undertaken in a growth chamber at 27 ± 2 °C, 65 ± 5 % R.H.

Statistical analysis:

Data were subjected to statistical analysis using one way analysis of variance, ANOVA (Duncan's, 1955).

RESULTS AND DISCUSSION

The developmental times of male and female immature stages, larvae and protonymphs didn't differ among diets Table (1). *A. swirskii* of larvae can develop into protonymphs without food but the protonymphs need food for further development. However, the developmental time of female and male deutonymphs were significantly affected by diet. Female deutonymphs reared on AD1, bee bread and *T. urticae* took significantly less time to develop to adulthood than those fed on the other diet, AD. The total developmental time of females fed on AD1 was 4.43 days being significantly shorter than females fed on *T. urticae* and bee bread. The developmental time was the longest 6.06 days for the females fed

Table (1): Developmental time (days) of *A. swirskii* immature stages fed on different diets

Diet	Sex	Developmental stages			
		Larva	Protonymph	Deutonymph	Total immatures
<i>T. urticae</i>	♂	0.83 ^a	2.16 ^a	2.08 ^{ab}	5.07 ^b
		0.77 ^a	1.88 ^a	1.94 ^a	4.59 ^a
AD	♂	1.14 ^a	2.28 ^a	2.64 ^a	6.06 ^a
		1.11 ^a	1.83 ^a	2.00 ^a	4.94 ^a
AD1	♂	0.80 ^a	1.90 ^a	1.73 ^c	4.43 ^{bc}
		0.70 ^a	1.80 ^a	1.40 ^b	3.90 ^b
Bee bread	♂	0.86 ^a	1.81 ^a	2.18 ^{ab}	4.85 ^b
		0.87 ^a	1.75 ^a	1.87 ^a	4.49 ^a

Table (2): Longevity and reproduction of *A. swirskii* fed on different diets

Parameter	Diets			
	<i>T. urticae</i>	AD	AD1	Bee bread
Pre-oviposition period (days)	1.58±0.07	2.18±0.84	1.52±0.12	1.77±0.12
oviposition period (days)	18.25±0.37	11.22±0.22	15.73±0.29	17.29±0.18
Post-oviposition period (days)	2.60±0.11	1.86±0.14	2.10±0.07	1.61±0.10
Female longevity (days)	22.43 ^a	15.26 ^b	19.35 ^a	20.67 ^a
Fecundity (total deposited eggs)	41.05±0.68 ^b	30.81±0.55 ^c	49.05±0.42 ^a	37.64±0.51 ^b
Oviposition (eggs/female/day)	2.24	2.74	3.11	2.17

Means in columns followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range tests.

Table (3): Hatchability, survival and adult emergence of *A. swirskii* on different diets

Diets	Hatchability %	Immatures survival %	Development %
<i>T. urticae</i>	94.28 ^a	97.41 ^a	92.42 ^a
AD	90.00 ^a	90.69 ^b	74.60 ^c
AD1	92.85 ^a	96.82 ^a	90.76 ^a
Bee bread	91.42 ^a	93.92 ^b	82.81 ^b

Means in columns followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range tests.

on AD. Nearly all individuals reached adulthood on the different diets. The artificial diets tested were modified from that formulated by Ogawa and Osakabe, 2008 that compared with bee bread and the spider mite *T. urticae* (Xu and Enkegaraan, 2010). Our findings indicated that *A. swirskii* could develop with similar or even better success on an artificial diet AD1 as compared to *T. urticae*.

Oviposition period and female longevity were longer on *T. urticae*, than on bee bread, AD1 and AD Table (2). The total number of eggs was significantly higher for females offered AD1 with mean 49.05 eggs versus the other diets that were 41.05, 37.64 and 30.81 eggs for *T. urticae*, bee bread and AD, respectively. There wasn't significant difference between *T. urticae* and bee bread in fecundity and longevity. The daily oviposition rate of *A. swirskii* reared on AD1 was significantly higher (3.11 eggs) than that of females reared on the other diets.

Table (3) indicated that hatchability percentage didn't differ significantly on the different diets. The highest intrinsic rates of increase was observed when

A. swirskii fed on *T. urticae* and this value was similar to that reported for *A. swirskii* when fed on the two spotted spider mite (El-Laithy and Fouly, 1992). Adults' development of *A. swirskii* was significantly affected by the different diets tested and there wasn't significant difference between feeding *A. swirskii* on *T. urticae* and AD1. This indicated the importance of the nutritional quality of a diet on the development of *A. swirskii*. The artificial diet developed by (Ogawa and Osakabe, 2008) supported immatures development and survival of the predatory mite, *N. californicus* but its oviposition rate on this diet was negligible compared with a diet of *T. urticae*. However, a slightly modified version of this artificial diet used in our study (AD, without hemolymph) proved suitable to support development of *A. swirskii* and also, allowed some reproduction. The oviposition rate of *A. swirskii* on AD1 was higher than that on an artificial diet designed by Abou-Awad *et al.*, 1992.

The relatively good performance of *A. swirskii* on artificial diet AD1 might be due to the generalist feeding habits of this phytoseiid mite (Momen and El-Saway, 1993). Nettles, 1990 and Grenier and Declercq, 2003) noted that adding insect components such as hemolymph to artificial media enhanced their acceptability and improved their nutritional quality for a number of entomophagous insects. Hemolymph of lepidopteran larvae or pupae was used in artificial media for parasitoid especially for *Trichogramma* species (Strand and Vinson, 1985). Our study indicates, that supplementing artificial diets with insect hemolymph may also be useful to improve their nutritional value for predatory arthropods. Further research is needed to identify the components of the insect hemolymph which are responsible for

the increased performance. The artificial diet AD1 supported development and reproduction of *A. swirskii* to the same extent as a factitious prey which was routinely used in the mass rearing of the phytoseiid, indicating the potential of artificial diets to rationalize the mass production of this economically important biological control agent.

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