BIOLOGY OF SOME PHYTOSEIID PREDATORS (ACARI: PHYTOSEIIDAE) ON EGGS OF *PHTHORIMAEA OPERCULELLA* AND *SPODOPTERA LITTORALIS* (LEPIDOPTERA: GELECHIIDAE AND NOCTUIDAE)

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ACARI, PHYTOSEIIDAE, LEPIDOPTERA, GELECHIIDAE, NOCTUIDAE.

SUMMARY: Five phytoseiid species were tested to evaluate their potential as predators of *Phthorimea operculella* and *Spodoptera littoralis* eggs as an alternative food substance in the laboratory. For *Typhlodromips swirskii*, the development was faster and reproduction was higher, when fed on *P. operculella* eggs, while the developmental time increased and reproduction decreased when *Neoseiulus californicus* fed on both eggs respectively . Females of *T. swirskii* consumed a higher number of *P. operculella* and *S. littoralis* eggs than *N. californicus* did . The number of eggs deposited per day by *T. swirskii* was higher (2.1 and 1.3 eggs /female/day) than for *N. californicus* (1.1 and 0.9 eggs /female/day) on eggs of *P. operculella* and *S. littoralis* respectively. Immatures survival of *Typhlodromus balanites, Paraseiulus talbii* and *Typhlodromus transvaalensi* were low on *P. operculella* and *S. littoralis* eggs and all failed to develop to adulthood.

RÉSUMÉ: Cinq espèces de phytoséiides sont testées pour évaluer leur potentiel de prédation sur les œufs de *Phthorimea operculella* et de *Spodoptera littoralis* comme source alternative de nourriture au laboratoire. Pour *Typhlodromus swirskii*, le temps de développement observé est plus court et la reproduction meilleure sur les œufs de *P. operculla*, alors que le développement est ralenti et la reproduction est déprimée pour *N. californicus* sur les deux types d'œufs. La femelle de *T. swirskii* consomme un plus grand nombre d'œufs de *P. operculla* et *S. littoralis* que *N. californicus*. Le nombre d'œufs produit par jour est plus élevé (2,1 et 1,3) pour *T. swirskii* que pour *N. californicus* (1,1 et 0,9) respectivement pour les deux proies. La survie des immatures est moins bonne pour *Typhlodromus balanites, Paraseiulus talbii* et *Typhlodromus transvaalensi* sur les œufs de ces deux espèces.

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Introduction

The potato tuber moth (PTM) *Phthorimaea operculella* (Zeller) is the most important pest of potatoes in Egypt (Lagnaoui and Lagnaoui 1997; Sheta 1998). The PTM infestation affects both tuber quality and quantity and induces decay which tints the white bulb to brownish black. More damage is caused by the pathogenic fungi and bacteria which are introduced by the tunneling larvae (Doss *et al.* 1994). The cotton leaf worm, *Spodoptera littoralis* Boisduval is one of the major cotton pests in Egypt, since it causes a considerable damage to many of the important vegetables and crops.

Phytoseiid mites have been characterized by their higher intrinsic rate of natural increase (rm) compared with those of their major prey, the Tetranychidae (Takafuji and Chant 1976; Saito and Mori 1981).

McMurtry (1982) emphasized the importance of alternative and supplementary food to the success of biological control with phytoseiid predators. Alternative food sources allow the predator to survive in the absence of prey and to reproduce before the pest attains a high population level (McMurtry *et al.* 1970; McMurtry & Johnson 1966).

Neoseiulus californicus (McGregor) provides an excellent biological control of spider mites on crops over wide ranges of climate and management conditions (McMurtry & Croft 1997; Monetti & Croft 1997). *Typhlodromips swirskii* Athias-Henriot has been considered as important agent for biological control of spider and eriophyid mites (Metwally *et al.* 1984; Momen & El-Sawy 1993). Several species of Phytoseiidae are known to feed on eggs and nymphs of thrips, whiteflies, and scales; these insects may actually be preferred over tetranychid mites (Muma 1971). *Neoseiulus cucumeris* (Oudemans), has been shown in numerous studies to be effective biological control agent for the onion thrips *Thrips tabaci* Lindeman, on greenhouse sweet peppers (Klerk & Ramakers 1986; Ravensberg & Altena 1987). Similarly, *Neoseiulus barkeri* (Hughes) has received considerable attention owing to its capability to control *T. tabaci* in glasshouses with cucumber (Bonde 1989). In Sudan, *Amblyseius aleyrodis* Elbadry was the most important acarine predator of cotton whiteflies, *Bemisia tabaci* (Gennadium) (Elbadry 1968). The three young stages of *Amblyseius limonicus* Garman and McGregor were successfully attacked the first instar caterpillars of *Prays citri* Miller, while moth eggs were observed to be consumed only occasionally (Swirski and Dorzia 1968). Nymphs of *Amblyseius largoensis* Muma preyed well on the moth's eggs, *P. citri* and *Ectomyelois ceratoniae* (Zeller) with a high percentage reaching maturity (Kamburov 1971). *Euseius scutalis* (Athias-Henriot) was able to consume eggs and immature stages of the scale insect *Chrysomphalus aonidum* (L.), *Aonidiella aurantii* (Mask), *Lepidosaphes beckii* (Newn) and the mealybug *Icerya purchasi* (Mask) (Yousef & El-Halwany 1982). *Euseius finlandicus* Oudemans, *Typhlodromus pyri* Schuten and *Kampimodromus aberrans* Oudemans were able to develop and oviposit, when fed on crawlers of the diaspidid San José scale *Quadraspidiotus perniciosus* Comstock (Schausberger 1998). *T. swirskii* feeds not only on eggs of the moths eggs, coccids and mealybugs but also on pollen grains and artificial diets (Swirski *et al.* 1967; Ragusa and Swirski 1975, 1977; Abou-Awad *et al.* 1992).

Many phytoseiid mite species of the genera *Typhlodromus* and *Amblyseius* are not such specialized predators. Eriophyid, tydeid and tarsonemid mites may serve as alternative prey (Lindquist 1983; McMurtry *et al.* 1984; Momen 1995).

Eriophyid mites were reported to be more favorable food for *Typhlodromus balanites* El-Badry and *Typhlodromus transvaalensis* (Nesbitt) than tetranychids (El-Bagoury & Momen 1989 ; Momen & Hussein 1999), while *Paraseiulus talbii* (Athias-Henriot) was an effective predator against the tydeid mites *Tydeus caudatus* (Dugés) and *Tydeus californicus* (Banks) (Comparese & Duso 1995 ; Zaher *et al.* 2001).

From the perusal of literatures, it is seen that the above mentioned phytoseiid species were not reported earlier as predators of *P. operculella* as well as *S. littoralis* (eggs) and this is the first record.

The purpose of this study was to investigate under laboratory conditions the nutritional quality of *P. operculella* and *S. littoralis* eggs as an alternative food in terms of postembryonic development and oviposition in five phytoseiid mites. Alternative food can be of importance since it may be of value for rearing the predators in the laboratory.

The generic concepts we follow are those of de MORAES *et al.* 1986 and CHANT & MCMURTRY 1994.

MATERIAL AND METHODS

Five species of Phytoseiidae were tested: *T. swirskii*, *P. talbii*, *T. transvaalensis*, *T. balanites* and *N. californicus*. Four species were collected from Egypt, *T. swirskii*, the common phytoseiid found on cucumber and apple leaves at Giza Provience, *P. talbii* was collected from heavily infested mango leaves at Faywam Provience. *T. balanites* was obtained from the plant *Pluchea dioscoridis* (L.), *T. transvaalensis* was found on heavily infested eggplant leaves at Tanta governorate. *N. californicus* used in the present study was collected from France in 1999 from an apple orchard in Montpellier, by Dr. A. El-Lethy. This species was introduced to Egypt for biological control on roses and strawberry and tested in this study for comparing with the other species collected from Egypt.

Maintenance of mite stock cultures. Adult females of *T. swirskii* and *N. californicus* were taken from stock colonies maintained on larvae and nymphs of *Tetranychus urticae* Koch as prey in the laboratory of the N.R.C., Cairo since 1999. The laboratory colonies of *T. balanites* and *T. transvaalensis* were fed *Eriophyes dioscoridis* Soliman and Abou-Awad. Females of *P. talbii* was fed *Tydeus caudatus* Duges in the laboratory. Females were left 24 hours and their oviposited eggs were used for different biological tests. Feeding experiments were conducted in the laboratory at 27 ± 2°C and 70-75% r.h.

Arenas (3 × 3 cm) of excised raspberry leaves, placed on saturated cotton in plastic Petri dishes, were used to confine predators. To be sure that no mixing of any species occurs, weekly, female and male of each species from each colony were mounted and cheeked for the genus and species studied.

Diets Eggs of the *P. operculella*: Infested potatoes with PTM have kept in wooden cage, which its floor has covered with thin layer of clean sand. The cage has kept on the laboratory conditions (27 ± 2C and 70-75% r.h.) for pupation. Pupae has collected and introduced to clean cylinder glasses covered with a piece of muslin. The newly emerged moths have fed on sugar solution 10% (a piece of cotton saturated with sugar solution hanged inside the glasses using a threat). Moths laid their eggs on the muslin, which can be easily collected by very fine brush and transferred to rearing arenas for feeding experiments. New pieces of muslin have added every 2 days for having fresh eggs.

Eggs of the *S. littoralis*: Egg patches of *S. littoralis* was collected from the farm of Faculty of Agriculture, Cairo University. Egg patches have introduced into glass jars for hatching, and then castor bean leaves has added for feeding which its floor has covered with saturated water sawdust for pupation. Pupae have collected and introduced to clean jars contains *Nerium oleander* for laying eggs. After moth's emergence, sugar solution 10% has added inside the jars for feeding moths and laying eggs. All jars have kept under laboratory conditions (25 ± 2C and 70-75% r.h.). Egg patches have collected and transferred to the rearing arenas for feeding experiments.

Effect of diet on development and survival rate: Eggs of each predator were transferred singly to the rearing discs, and the newly hatched larvae (0-12h. age) were supplied separately by each diet to be evaluated. As piercing the chorion and feeding for only a few seconds resulted in the eventual collapse of an egg. Arenas were examined daily and predator development and survival were recorded. Prey eggs consumed were replaced daily by fresh eggs to maintain an ample food supply. Whenever a leaf began to deteriorate (approximately every 3 days), it was replaced with a fresh leaf.

Effect of diets on longevity, consumption and fecundity. Newly-emerged mated females were confined individually on test arenas, along with the food to be tested. Oviposition and survival were recorded daily. Phytoseiid eggs and attacked eggs were removed daily in order to estimate food consumption. 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.

Statistical analysis of data was carried out using analyses of variance and F test.

Assessing of significance was taken at 0.05 and 0.01 level of probability.

Results

Effect of diet on development and survival. Two of five phytoseiid species, *T. swirskii* and *N. californicus* were able to complete development on either egg of *S. littoralis* or *P. operculella* as food. On the opposite, development was not completed for *P. talbii*, *T. balanites* and *T. transvaalensis* (Table 1). The total development period was shorter in *T. swirskii* fed eggs of *P. operculella* (significant at 1 %). On both eggs, *T. swirskii* had a higher percentage of juveniles (85-100%) reaching maturity than *N. californicus* (70-65%) (Table).

Effect of diet on fecundity, consumption and longevity. The preoviposition period was shorter for both phytoseiid mites fed on *P. operculella* eggs than on *S. littoralis* eggs (Table 2). *Typhlodromips swirskii* had significantly longer oviposition period and an adult longevity on both diets (25.0, 29.8 and 19.6, 23.5 days) than *N. californicus* (15.9, 20.9 and 16.1, 20.5 days) for *S. littoralis* and *P. operculella* eggs respectively (Table 2). The female of *T. swirskii* consumed a higher number of *S. littoralis* and *P. operculella* eggs compared to *N. californicus* did (significant at 1% level) (Table 3).

The rate of reproduction of *T. swirskii* on both diets was significantly higher than that of *N. californicus.* The total number of eggs deposited per female *T. swirskii* was 41.8 and 34.8 eggs when fed eggs of *P. operculella* and *S. littoralis* compared to 21.4 and 17.0 eggs for *N. californicus* respectively (Table 3).

Diets	Predator species	No. obs.	Egg	Larva	Protonymph	Deutonymph	Life cycle	%survival
P.operculella	*T. swirskii*	25	35	1.2 ±	1.9 ± 0.1 b	2.3 ± 0.1b	6.6 ± 0.7 c	100 70
	N.californicus	40	22	0.1 b	2.6 ± 0.2 a	3.2 ± 0.1a	8.8 ± 0.4 ab	
	T. balanites	42	1.3 ±	1.3 ±				
	P. talbii	35	0.1 a	0.1 b				
	T.transvaalensis	22	1.4 ±					
			0.1 a					
S. littoralis	*T. swirskii*	25	1.1 ±	1.4 ±	2.7 ± 0.1 a	3.1 ± 0.1 a	8.3 ± 0.5 b	85 65
	N.californicus	40	0.1 b	0.1 b	2.6 ± 0.1 a	2.9 ± 0.1 a	8.9 ± 0.9 a	
	T. balanites	42	1.7 ±	1.7 ±				
	P. talb ii		0.1 a	0.1 a				
	T.transvaalensis							
	F value		2.6*	3.6	5.7**	15.9**	30.9**	
LSD				0.33	0.43	0.29	0.58	

Different letters in a vertical column denote significant difference (F. test: P≤0.01). * Significant, ** highly significant

Table 1: Development time (in days) of five species of Phytoseiidae on eggs of *P.operculella* and *S. littoralis* (Lepidoptera) as food sources at 27°C

DietsPredator	species	No. of replicates	Adult periods				
			Preoviposition	Oviposition	Postoviposition	Adult longevity	Life span
P. operculella	T. swirskii	20	1.4 ± 0.6 c	19.6 ± 2.5 b	2.6 ± 0.5	23.5 ± 0.6 b	30.3 ± 2.4 b
	N. californicus	16	1.7 ± 0.5 bc	16.1 ± 1.8 c	2.7 ± 0.1	20.5 ± 0.3 c	29.1 ± 2.2 b
S. littoralis	*T. swirskii*	25	2.2 ± 0.9 ab	25.0 ± 4.6 a	2.6 ± 0.9	29.8 ± 1.2 a	38.1 ± 3.9 a
	N. californicus	25	2.5 ± 1.1 a	15.9 ± 4.6	2.6 ± 1.1	20.9 ± 1.4	29.9 ± 4.7
		F value	4.94**	16.81**		21.73**	17.03**
		LSD	0.66	2.89		2.43	2.83

Different letters in a vertical column denote significant difference (F. test: P ≤ 0.01) ** Highly significant

Table 2 Average duration (in days) of various adult periods of *T. swirskii* and *N. californicus* at 27°C on eggs of *P. operculella* and *S. littoralis.*

Diets	Predator species	Total no. eggs deposited/ female	Average no. eggs/ day/female during ovipostion period	Total no. eggs consumed/female	Average no.eggs consumed /day/female during ovipostion period
P. operculella	*T. swirskii*	41.8 ± 8.9 a	2.1 ± 0.4 a	73.9 ± 13.4 a	2.5 ± 0.4 a
	N. californicus	21.4 ± 3.9 c	1.1 ± 0.1 bc	55.5 ± 14.1 b	1.9 ± 0.5 b
S. littoralis	T. swirskii	34.8 ± 6.5 b	1.3 ± 0.1 b	78.4 ± 14.7 a	2.2 ± 0.5 ab
	N. californicus	17.0 ± 5.9	0.9 ± 0.2 c	30.8 ± 7.6	1.0 ± 0.2 c
	F value	39.6**	55.2**	39.7**	29.6**
	LSD	5.3	0.2	10.1	0.3

TABLE 3.Consumption rate and fecundity of *T. swirskii* and *N. californicus* on eggs of *S. littoralis* and *P. operculella* at 27°CDifferent letters in a vertical column denote significant difference (F. test: P ≤(ff;0>0.01).** ≩ighly significant.

DISCUSSION

The present study indicated that *T. swirskii* had a higher survival rate when fed on *P. operculella* eggs than on *S. littoralis* eggs (TABLE 1). *T. swirskii* fed on both diets showed prolonged developmental time and low oviposition rates respectively compared to nymphs fed on more favourable food sources like eriophyid mites.

Typhlodromips swirskii feeding on *E. dioscoridis* needed 5.7 days for development and laid 3.1 eggs /day/female (MOMEN & EL-SAWI 1993). According to ABOU-AWAD *et al.* (2000), the period from larva to adult of *T. swirskii* fed on *Aceri ficus* (Cotte) and *Rhyncaphytoptus ficifoliae* Keifer took 8 and 9.3 days and a mean oviposition rate of 1.5 and 1.0 eggs/female/day, this result agrees with our data with *T. swirskii* fed on eggs of *S. littoralis*. Similarly, *T. swirskii* had a high percentage of juveniles (80-100%) reaching maturity when fed on eggs of the moths *Prodenia litura* Fabricius, *Ectomyelois ceratonia* Zeller and *P. citri*, as well as young stages of *B. tabaci* and *Retithrips syriacus* Mayet. (SWIRSKI *et al.* 1967). They noted also that with the exception of *Prodenia* eggs, a marked egg-laying ability with an almost uniform rate were recorded for the above mentioned food. RAGUSA & SWIRSKI (1977) observed that crawlers of armoured scales and honeydew of the coccids and mealybugs serve only as survival food for *T. swirskii*. Recently ABOU EL ELLA (2003) demonstrated that *T. swirskii* successfully developed when fed on nymphs of *T. tabaci* and the total egg production was higher (40.2 eggs) than that of *Cydnoseius zaheri* (Yousef and El-Borolossy) (25.2 eggs). SABELIS (1981) model for estimations of biomass conversion suggests that 60-70% of the ingested prey is utilized in predator egg production.

N. californicus is recorded as specialized predator of spider mites (MCMURTRY & CROFT 1997). It was successfully developed on *E. dioscorides*, date palm and castor oil pollens (EL-LATHY & EL-SAWI 1998), as well as *Mononychellus progresivus* Doreste (MESA *et al.* 1990) and *Polyphagotarsonemus latus* (Banks) (CASTAGNOLI & FALCHINI 1993). In the present study, *N. californicus* showed a moderate percentage of juveniles reaching adulthood when fed on both eggs, and had a low rate of oviposition (TABLES 1 & 3). *N. californicus* had a high percentage of juveniles reaching adulthood and showed moderate oviposition rate (0.53 egg /day/female) when fed on crawlers of the California red scale (SWIRSKI *et al.* 1970). On the opposite, the young stages did not reach adulthood when fed on young stages of *B. tabaci* and *R. syriacus*. The same authors observed also that nymphs of *N. californicus* sucking eggs of *S. littoralis* eggs close to hatch. In the present study, *N. californicus* consumed a lower number of both eggs than *T. swirskii* did (TABLE 3). The low number of both eggs attacked may be was attributed to an apparent avoidance reaction by the predator to egg encountered after attacking the first egg. The mortality of *T. balanites*, *T. transvaalensis* and *P. talbii* in the present study, mainly occurred in the protonymphal stage, and none reached the deutonymphal stage. The reason for this probably is eggs of *S. littoralis* and *P. operculella* being unfavorable for these phytoseiids. Negative results with 3 tested phytoseiid predators on developmental, mortality and egg production can be attributed to the following reasons (1) may be due to resistance of egg chorion, (2) it could be caused by the presence of an antifeeding factor in the eggs, (3) may be due to inadequacies of level of certain nutrients of eggs if compared with the high nutritional value of prey immature. Similarly the percentage of nymphs reaching adulthood and the oviposition rate were nil or negligible when *M. occidentalis* Nesbitt fed on eggs of *S. litoralis, P. citri* and *E. ceratoniae*, but eggs of *P.citri* provided enough nutrition for the complete development of *Typhlodromus athiasae* Porath and Swirski (SWIRSKI & DORZIA 1969) . According to PUTMAN (1962), females of *Typhlodromus (Anthoseius) caudiglans* Schuster did not attack eggs of *Grapholita molesta* Busck. RAGUSA & TSOLAKIS (1994), reported that when eggs of stored product moth, *Ephestia kuehniella* Zeller offered to *Amblyseius andersoni* (Chant), the percentage of individuals reaching adulthood was 8% only. MOMEN 1999 reported that the development of *P. talbii, T. balanites* and *T. transvaalensis* was not completed when larvae of each species offered *T. urticae* eggs as food.

CONCLUSION

In evaluating the biological control potential of *T. swirskii,* the results obtained with both eggs of *S. litoralis* and *P. operculella* suggest that *T. swirskii* has potential as biological control agent of both pests, whereas those for *N. californicus* are less encouraging, and both eggs, may be of value for rearing predators in the laboratory. The results we have obtained confirm the ability of *N. californicus* to adapt to different prey and make it a potential candidate for the biological control of eggs, *S. litoralis* and *P. operculella* respectively. On account of its polyphagous nature, *T. swirskii* may well be able to prey on other moth's eggs and its use in the field together with or as an alternative to the more specialized predators, could be extremely convenient. Several food types that are readily accepted for some phytoseiids under laboratory conditions may not be relevant under field conditions (OVERMEER 1985). So, more attention should be given to the other food sources as well as new techniques to detect consumption in the field.

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REFERENCES

ABOU-AWAD B.A., EL- SAWAF B.M. & ABDEL-KHALEK A.A., 2000. — Impact of two eriophoid fig mites, *Aceri ficus* and *Rhyncaphytoptus ficifolia,* as prey on postembryonic development and oviposition rate of the predacious mite *Amblyseius swirskii*.-Acarologia, XI (4): 367-371.

ABOU-AWAD B. A., REDA A. S. & El sawi S. A., 1992. — Effect of artificial and natural diets on the development and reproduction of two phytoseiid mites *Amblyseius gossipi* and *Amblyseius swirskii* (Acari:Phytoseiidae). — Insect Sci. Applic., 13 :441-445.

ABOU-EL ELLA G.M., 2003. — Suitability of the *Thrips tabaci* as prey for three predacious mites of the family Phytoseiidae . — J. Agric. Sci. Mansoura University. (In Press).

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

CASTAGNOLI M. & FALCHINI L., 1993. — Suitability of *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) as prey for *Amblyseius californicus* (McGregor) (Acari: Phytoseiidae) . Redia 76: 273-279.

CHANT D. A. & MCMURTRY J. A., 1994. — A review of the subfamilies Phytoseiinae and Typhlodrominae (Acarina: Phytoseiidae). — Int. J. Acarol., 25: 223-316.

COMPARESE P. & DUSO D., 1995. — Life history and life table parameters of the predatory mite *Typhlodromus talbii* . — Entom. Exp. Appl.,77: 149-157 .

de MORAES G. J., MCMURTRY J. A. & DENMARK H., 1986. — A catalog of the mite family Phytoseiidae. References to taxonomy, synonymy, distribution and habitat. — EMBRAPA, Brasilia, Brazil.

DOSS S.A., LAGNAOUI R. & FAYAD A.N., 1994. — Control of potato tuber moth *Phthorimaea operculella* (Zeller) in potato stores in Egypt. — J. Agric. Sci., Mansoura University, 19 (8): 2759-2768.

El-badry E. A., 1968. — Biological studies on *Amblyseius aleyrodis* a predator of the cotton whitefly. — Entomophaga 13 :323-329.

EL-BAGOURY M.E. & MOMEN F.M., 1989. — *Typhlodromus balanites* (Acarina: Phytoseiidae) as a predator of the gall mite *Eriophyes dioscoridis* (Acarina, Eriophyidae). — Ann. Agric. Sci. Moshtohor, 27(4): 2513-2520.

EL-LAITHY A.Y. & EL-SAWI S.A., 1998. — Biology and life table parameters of the predatory mite *Neoseiulus californicus* fed on different diet. — J .Plant Diseases & Protection, 105(5): 532-537.

KLERK M. L. de & RAMAKERS, P. M. J., 1986. — Monitoring population Densities of the phytoseiid predator *Amblyseius cucumeris* and its prey after large scale introductions to control *Thrips tabaci* on sweet pepper. — Med. Fac. Landbouww. Rijksuniv. Gent., 51: 1045-1048.

KAMBUROV S. S., 1971. — Feeding, development and reproduction of *Amblyseius largoensis* on various food substances. — J. Econ. Entomol., 64: 643-648.

LAGNAOUI A. & LAGNAOUI A., 1997. — An integrated pest management strategy for controlling potato tuber moth in Egypt. — CIP circul (Peru), 22(3): 6-7.

LINDQUIST L.L., 1983. — Some thoughts on the potential for use of mites in biological control, including a modified concept of " parasitoids",pp: 12-20. — In: M. A.Hoy, G. L. Cunningham & L. Knutson [eds.], Biological control of pests by mites. Div. Agric. Nat. Res. Publ. 3304. University of California, Berkeley, USA.

MCMURTRY J.A., 1982. — The use of phytoseiids for biological control: progress and future prospects, pp.23-48. In: M.A. Hoy [eds.], Recent advances in Knowledge of the Phytoseiidae. Div. Agric. Sci. Spec. Publ. 3284. University of California, Berkeley, USA.

MCMURTRY J. A., BADII M. & H., JOHNSON H. G., 1984. — The broad mite, *Polyphagotarsonemus latus*, as a potential prey for phytoseiid mites in Californi. — Entomophaga 29: 83-86.

MCMURTRY J.A., & CROFT B.A., 1997. — Life styles of phytoseiid mites and their roles in biological control. — Annu. Rev. Entomol. 42: 291-321.

MCMURTRY J. A., HUFFAKER C. B. & VAN DE VRIE M. 1970. — Ecology of tetranychid mites and their natural enemies: a review. 1. Tetranychid enemies: their biological characters and the impact of spray practices. Hilgardia 40: 331-390.

MCMURTRY J. A. & JOHNSON H. G., 1966. — An ecological study of the spider mite *Oligonychus punicae* (Hirst) and its natural enemies. — Hilgardia 37: 363-402.

MESA N.C., BRAUN A.R. & BELOTTI A.C., 1990. — Comparison of *Mononychellus progresivus* and *Tetranychus urticae* as prey for five species of phytoseiid mites. — Exp. Appl. Acarol.,9: 159-168.

Metwally A.M., Abou el-naga M.M., Taha H.A. & Hoda F.M., 1984. — Studies on feeding, reproduction and development of *Amblyseius swirskii* (A.H.) (Acarina :Phytoseiidae). — Agric. Res. Rev., 62: 323-326.

MOMEN F. M. 1995. — Feeding, development and reproduction of *Amblyseius barkeri* (Acarina: Phytoseiidae) on various kinds of food substances. — Acarologia 36: 101-105.

MOMEN F. M. 1999. — Feeding behaviour of some phytoseiid predators on two Spotted spider mite eggs (Acari: Phytoseiidae: Tetranychidae). — Phytophaga IX: 85-92.

MOMEN F.M. & El sawi S.A., 1993. — Biology and feeding behaviour of the predatory mite, *Amblyseius swirskii* (Acari: Phytoseiidae).-Acarologia, 34 :199-204.

MOMEN F.M. & HUSSEIN H., 1999.-Relationschips between food substance, developmental success and reproduction in *Typhlodromus transvaalensis* (Acari: Phytoseiidae).-Acarologia, 40: 107-111.

MONETTI L.N. & CROFT B.A., 1997. — *Neoseiulus californicus* (McGregor) and *Neoseiulus fallacies* (Garman): larval responses to prey and humidity, nymphal feeding drive and nymphal predation on phytoseiid eggs. — Exp. Appl. Acarol., 21: 225-234

MUMA M.H., 1971. — Food habits of Phytoseiidae (Acarina: Mesostigmata) including common species on Florida citrus. — Fla. Entom., 54: 21-34.

OVERMEER W. P. G., 1985. — Alternative prey and other food resources.-pp. 131-139. In W. Helle & M. W. SABELIS(eds.), spider mites. Their biology, natural enemies and control, vol. 1B. Elsevier, Amsterdam, The Netherland.

PUTMAN W.L., 1962. — Life history and behaviour of the predacious mite *Typhlodromus (T.) caudiglans* Schuster (Acarina: Phytoseiidae) in Ontario, with notes on the prey of related species. — Can. Entomol.,94: 163-177.

RAGUSA S. & SWIRSKI E., 1975. — Feeding habits, development and oviposition of the predacious mite *Amblyseius swirskii* Athias-Henriot (Acarina: Phytoseiidae) on some pollen of various weeds. — Israel J. Agric. Res., 10: 93 -103.

RAGUSA S. & SWIRSKI E., 1977. — Feeding habits, post embryonic and adult survival, mating, virility and fecundity of the predacious mite *Amblyseius swirskii* (Acarina: Phytoseiidae) on some coccids and mealy bugs. — Entomophaga,22 :383- .

RAGUSA S. & TSOLAKIS H., 1994. — Influence of different kinds of food substances on the postembryonic development and oviposition rate of *Amblyseius andersoni* (Chant) (Parasitiformes, Phytoseiidae). — Proc. 2 nd Symp. EURAAC, Krynia (Poland) 1992: 411-419.

RAVENSBERG W. J. & ALTENA K., 1987. — Recent developments in the control of thrips in sweet pepper and cucumber, pp. 160-164. In West Palaearctic Regional Section Bull. 1987.

SABELIS M. W., 1981. — Biological control of two spotted spider mites using Phytoseiid predators. Part 1: Modeling thr predator prey interaction at the Individual level. — Agric Res. Rep. (Versl. Landbouwk. Onderz.),910 : 1-242.

SAITO Y. & MORI H., 1981. — Parameters related to potential rate of population increase of three predacious mites in Japan (Acarina: Phytoseiidae). — Appl. Entoml. Zool., 16: 45-47.

SCHAUSBERGER P. 1998. — Survival, development and fecundity in *Euseius finlandicus*, *Typhlodromus pyri* and *Kampimodromus aberrans* (Acari, Phytoseiidae) feeding on the San José scale *Quadraspidiotus perniciosus* (Coccina, Diaspididae). — J. Appl. Ent., 122 :53-63.

SHETA H.M.A., 1998. — The role of certain biotic factors and storage arrangement on the population fluctuation of the potato tuber moth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechidae) in the storage. — M.Sc. Thesis, Fac. Of Agric, Cairo University.

SWIRSKI E., AMITAI S. & DORZIA N., 1967. — Laboratory studies on the Feeding, Development and reproduction of the predacious mites *Amblyseius rubini* Swirski and Amitai and *Amblyseius swirski* Athias Henriot (Acarina: Phytoseiidae) on various kinds of food substances. — Isr. J. agric. Res., 17: 101-119.

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

SWIRSKI E. & DORZIA N., 1968. — Studies on the feeding, development and oviposition of the predacious mite *Amblyseius limonicus* Garman and McGregor (Acarina: Phytoseiidae) on various kinds of food substances. — Isr. J. Agric. Res., 18 :71-75.

SWIRSKI E. & DORZIA N., 1969. — Laboratory studies on the feeding, Development and fecundity of the predacious mite *Typhlodromus occidentalis* Nesbitt (Acari: Phytoseiidae) on various kinds of food substances. — J. Agric. Res. 19: 143-145.

TAKAFUJI A. & CHANT D.A., 1976. — Comparative studies of two species of predacious phytoseiid mites (Acarina: Phytoseiidae),with special reference to their responses to the density of their prey. — Res. Popul. Ecol., 17: 255-310.

YOUSEF A. A. & EL-HALAWANY E. A., 1982. — Effect of prey species on the biology of *Amblyseius gossipi* El badry (Acari: Mesostigmata: Phytoseiidae). — Acarologia 23: 113-117.

ZAHER M.A., EL-BOROLOSSY M.A. & ALI F.S., 2001. — Morphological and biological studies on *Typhlodromus talbii* Athias-Henriot (Gamasida: Phytoseiidae). — Insect Sci. Applic., 21: 43-53.