OBSERVATIONS ON ACAROFAUNA IN FOUR APPLE ORCHARDS OF CENTRAL GREECE. II. GREEN COVER AND HEDGES AS POTENTIAL SOURCES OF PHYTOSEIID MITES (ACARI: PHYTOSEIIDAE).

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GREEN COVER, HEDGES, PHYTOSEIIDS, ECOLOGICAL REFUGE, APPLE ORCHARD

SUMMARY: This paper presents the role of weeds and hedges as "ecological refuges and sources" of the most abundant and most economically important phytoseiid spacies *Euseius finlandicus, Typhlodromus pyri* and *Amblyseius andersoni*, on apple in Central Greece. The survey was carried out in four orchards in Zagora and Anilio (Prefecture Magnisia), in Farma (Prefecture Trikala) and in Agia (Prefecture Larisa) on a selection of plants which had been made prior to the systematic monitoring of the acarofauna. The population dynamics of *E. finlandicus, T. pyri* and *A. andersoni* were studied. *E. finlandicus* and *T. pyri* were observed on the hedge plants *Rubus fruticosus, Rubus* sp., *Castanea sativa, Juglans regia, Cornus sanguinea, Prunus avium* and *Sambucus nigra* while *A. andersoni* was found mainly on herbaceous plants. This survey explains that weeds and hedges may form "natural ecological refuges and potential sources" for populations of phytoseiid species when conditions are favourable for their supposed flow between those source plants and the protected crop.

PIANTE SPONTAEE SIEPI PHYTOSEIIDAE RIFUGI ECOLOGICI FRUTTETI DI MELO

RIASSUNTO: Sí é voluto verificare il ruolo delle piante spontanee e delle siepi come "rifugi ecologici e sorgenti potenziali" per gli acari fitoseidi *Euseius finlandicus, Typhlodromus pyri* e *Amblyseius andersoni* i queli rapresentano il maggior interesse economico della coltura del melo della Grecia Centrale. La sperimentazione é stata condotta in quattro regioni Zagora, Aniglio, Farma ed Aghia della Grecia Centrale. É stata definita la struttura della communitá erbacea ed arborea delle siepi. Le osservazioni sull' acarofauna sono state compiute raccogliendo campioni di foglie delle specie piu diffuse. I predatori *E. finlandicus, T. pyri* e *A. andersoni* risultano i piu difusi. Sono stati osservati importanti popolazioni mentre le loro densitá si diferiscono tra, le piante spontanee e le siepi. I fitoseidi *E. finlandicus* e *T. pyri* sono molto abbontanti sulle piante delle siepi *Rubus*

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fruticosus, *Rubus* sp., *Castanea sativa*, *Juglans regia*, *Cornus sanguinea*, *Prunus avium* e *Sambucus nigra* mentre *A. andersoni* é piu difuso sull' inerbimento. Le indagini evidenziano principal mentre la grande importanza ecologica delle siepi per il mantenimento delle popolazioni di certe specie di fitoseidi per i quali é ipotizzabile un flusso da o per la coltura.

Introduction

Some phytoseiid mites species have been proved to play an important role in the biological control of serious pests of apple-orchards: *Tetranychus urticae* Koch and *Panonychus ulmi* (Koch), especially when their population do not decrease by the use of non selective pesticides (Papaioannou-Souliotis, 1981; Papaioannou-Souliotis *et al.*, 1994; 1997, 1998 1999; Ragusa *et al.*, 1995). The occurrence of phytoseiids on wild and cultivated plants, in contrast to predacious insects (Coccinellidae, Anthocoridae etc.), does not directly depend on prey because of the many alternative food sources they have (pollen, fungi, honeydew and others) (Solomon, 1975; Duso & Sbrissa, 1990; Coiutti, 1993). It is believed that phytoseiids occur on a certain plant when this provides them a food supply rather than because of the predator's preference for the particular plant (Altieri & Letourneau, 1982; McMurtry, 1982).

The role of green cover plants in the "hospitality" of natural enemies of the phytophagous mites, in particular the predacious phytoseiids, has been an interesting subject of research over the last years (Fauvel & Cotton, 1981; Solomon 1981; Ragusa & Paoletti, 1985; Boller *et al.*, 1988; Coiutti, 1993; Duso *et al.*, 1993; Lozzia & Rigamonti, 1998). Many phytoseiids colonize a significant number of wild plants, which therefore establish economic importance in the various agroecosystems.

The research carried out in the frame of a Program of the Greek Ministry of Agriculture for the development and application of integrated pest management of mites and insects on apple-orchards, we have been studied on acarofauna, the population dynamics and bioecology of the most important predacious species in three orchards with different agrotechnical methods. The predominant species recorded and studied were *Amblyseius andersoni* (Chant), *Euseius finlandicus* (Oudemans) and *Typhlodromus pyri* Scheuten. High populations of these phytoseiids are maintained even when *T. urticae* and *P. ulmi* are scarce or are not found at all in the orchards (Markoyiannaki-Printziou *et al.*, 1999).

Our investigations on the role of hedges and green cover plants in the apple-orchards as ecological refuges of potential antagonists, started in 1997. Of special interests was the question which plant species are associated regularly with economically important predatory *E. finlandicus*, *T. pyri* and *A. andersoni*. Here we report our preliminary findings and conclusion.

Material and Methods

The survey was carried out from 1997 to 1999, in the apple-orchards in the area of Zagora and Anilio (Prefecture Magnisia), in the Farma area (Prefecture Trikala) and in the Agia area (Prefecture Larisa). A technical description of these orchards has been presented in detail in the first part of this study (Markoyiannaki-Printziou *et al.*, 1999). In order to evaluate the frequency of the predators and their distribution over the apple trees (from the center and periphery), the green cover and hedges, the following samples were taken :

Sampling of apple trees

From the 20 trees randomly selected in all orchards for the two-weekly sampling, 10 trees in peripheral area were taken as *"peripheral"* while the remaining (10), situated in the central part of the orchard were taken as *"central"*. The peripheral and central trees were usually separated by two or three rows of apple trees, depending on the morphology of the orchard. For each sample were put off 10 leaves per tree (taken between the base and half way of the foliage), i.e. 10 x

TABLE 1: The plant species sampled of green cover and hedges of the apple-orchards in Zagora, Anilio, Farma and Agia.

Family	Species	Zagora	Anilio	Farma	Agia
Amaranthaceae	*Amaranthus retroflexus* L.	*	*	*	*
Araliaceae	*Hedera helix* L.	**	**		
Betulaceae	*Alnus* sp.	**	**	**	
Caprifoliaceae	*Sambucus nigra* L.	**			
Chenopodiaceae	*Chenopodium album* L.		*	*	
Compositae	*Chrysanthemum segetum* L.			*	
	Cichorium intybus L.	*		*	
	Lapsana communis L.	*	*	*	
	Matricaria chamomilla L.			*	
	Sonchus arvensis L.		*	*	
	Sonchus oleraceus L.	*	*	*	
	Taraxacum officinale Weber			*	
	Tussilago farfara L.		*		
Convolvulaceae	*Convolvulus arvensis* L.	*			
Cornaceae	*Cornus sanguinea* L.			**	
Corylaceae	*Corylus avellana* L.	**			
Cruciferae	*Capsella bursa-pastoris* (L.)		*	*	
	Sinapis alba L.		*	*	
Cyperaceae	*Cyperus rotundus* L.			*	
Euphorbiaceae	*Euphorbia helioscopia* L.			*	
Fagaceae	*Castanea sativa* Miller		**		
	Fagus sylvatica L.		**		
	Quercus coccifera L.				**
	Quercus sp.	**			
Graminaceae	*Alopecurus* sp.			*	*
	Avena fatua L.			*	*
	Echinochloa sp.			*	*
	Festuca sp.			*	*
	Hordeum murinum L.			*	*
	Sorgum halepense L. Pers.			*	*
Juglandaceae	*Juglans regia* L.	**	**		
Labiatae	*Lamium* sp.	*	*		
	Lamium purpureum L.	*	*		
	Origanum vulgare L.	*	*		
	Salvia pratensis L.	*	*		
Leguminosae	*Cassia tora* L.			*	
	Cercis siliquasrtrum L.			**	
	Lathyrus tuberosus L.			*	
	Trifolium sp.			*	
	Vicia hirsuta (L.) Gray			*	

Liliaceae	*Veratrum album* L.		*	*	
Malvaceae	*Malva neglecta* Wallr.		*	*	
Moraceae	*Ficus carica* L.	**		**	
	Morus alba L.			**	
Oxalidaceae	*Oxalis corniculata* L.			*	
Papaveraceae	*Papaver rhoeas* L.			*	
Plantaginaceae	*Plantago* sp.			*	
	Plantago media L.	*		*	
Platanaceae	*Platanus orientalis* L.				**
Polypodiaceae	*Pteridium aquilinum* Kuhn	* **	*, **		
Polygonaceae	*Rumex* spp	*	*	*	
	Rumex crispus L.		*	*	
Portulacaceae	*Portulaca oleracea* L.			*	
Ranunculaceae	*Ranunculus* sp.			*	
Rosaceae	*Cydonia oblonga* Miller			**	
	Prunus avium L.		**		
	Prunus domestica L. ssp. *insititia* L. Schneider			**	
	Rubus fruticosus L.	**		**	
	Rubus sp.	**		**	
Solanaceae	*Solanum nigrum* L.			*	
Scrophulariaceae	*Veronica persica* Poir.		*		
Urticaceae	*Urtica dioica* L.	*	*	*	

* green cover, ** hedge

10 = 100 leaves per case, viz. 200 leaves in total. Care was taken that all trees were approximately at the same age and vegetative growth.

Sampling of the green cover in the orchard

In 1997 the green cover in each orchard was mapped and, because of the large botanical composition (TABLE 1), samples were checked for which plant species host predatory and phytophagous mites. Therefore in 1998 and 1999 those plants (TABLE 2) were sampled every two weeks, as were the trees. The leave samples were taken exclusively from plants growing under the 20 marked trees in an area the size of the top of each tree, viz. 200 leaves each time from the total of various plants. From plants with composed leaves only one leaf was taken.

Sampling of the hedges (perennial shrubs, forestal and cultivated plants)

Comparable observations were made as well on the perennial shrubs, the forestal and cultivated plants of which the natural fences of each experimental orchard are composed (TABLE 2). For each sample 200 leaves in total were taken from the twigs (10-15 cm length) of the various plants that were cut and taken to the laboratory.

All samples were put in paper bags immediately after sampling and kept in small portable refrigerators for transfer to the laboratory. The mobile forms of the phytophagous mites were counted directly under stereo-microscope, while the predators and other species were cleared in NESBITT's solution and mounted in HOYER's liquid for identification to species under phase-contrast microscope.

TABLE 2: Presence of Phytoseiid and Tetranychid mites on plants of green cover and hedges of the apple-orchards in Zagora, Anilio and Farma.

Species	Zagora		Ánilio		Farma	
	Phytoseiid mites	**Tetranychid mites**	**Phytoseiid mites**	**Tetranychid mites**	**Phytoseiid mites**	**Tetranychid mites**
Amaranthus retroflexus	E.f., T.p., K.a.	T.u.	E.f., T.p.	T.u.	A.a, E.f., T.p..	T.u.
Alnus sp.	E.f., T.p.		E. f., T. cot., T.p.			
Sambucus nigra	E.f.					
Chenopodium album			T.cot., E.f.		A.a, E.f.	
Chrysanthemum segetum					E.f.	T.u.
Lapsana communis	E.f., P.t.	T.u.	T.cot.	T.u.		
Sonchus arvensis			E.f., P.f.		A.a., P.t.	
Sonchus oleraceuss	E.f., P.t.	T.u.	E.f.	T.u.	A.a.	
Tussilago farfara			T.cot., N.aur.			
Convolvulus arvensis	E.f., T.p., N.aur., A.a.	T.u.			A.a., E.f., T.p.	
Corylus avellana	E.f., T.p., K.a.					
Sinapis arvensis			E.f., T.p.	T.u.	A.a., E.f.	T.u.
Cyperus rotundus					A.a.	
Euphorbia helioscopia						T.u.
Castanea sativa	E.f., T.p.		E.f., T.cot., T.p.			
Fagus sylvatica	E.f.		T.cot., E.f.			
Quercus sp.	E.f.				E.f., T.cot., T. k.	
Juglans regia	E.f., K.a.	T.u.	T.cot., E.f., K.a.		P. m., T.cot.	
Lamium sp.	**E.f., T.p., P. t**		T.cot., T.p.			
Lamium purpureum	E.f., T.p., P. t		T. cot., T.p.			
Salvia pratensis	E.f., K.a.				A.a.	T.u.
Malva neglecta			E.f., N.aur.	T.u.	E.f., A.a., T.p.	T.u.
Ficus carica	E.f., K.a.	T.u.				
Plantago media	E.f.				A.a., E.f., T.p.	
Plantago sp.					A.a., E.f.	
Pteridium aquilinum	E.f., T.p.		E.f., T.cot., T.p., N.aur.			
Rumex sp	E.f.	T.u.	E.f.	T.u.		
Rumex crispus	E.f.		E.f., T.p.			
Cornus sanguinea					A.a, E.f., T.p., P.m.	
Prunus avium			E.f., T.p., T.cot., K.a.			
Rubus fruticosus	E.f., K.a., T.p.	C.ps.	E.f., P.f., K.a.	C.ps.	A.a, E.f., P.m.	
Rubus sp.	E.f., T.p.	C.ps.			A.a, E.f., T.p.	
Solanum nigrum				T.u.	E.f.	T.u.
Veronica persica			E.f., T.p.			
Urtica dioica	E.f., T.p., A.a.	T.u.	E.f., T.cot.	T.u.	A.a., E.f., T.p., T.k.	

E.f=*Euseius finlandicus*, T.p.=*Typhlodromus pyri*, A.a.=*Amblyseius andersoni*, T.cot.=*Typhlodromus cotoneastri*, P.m.=*Phytoseius macropilis*, P.t.=*Paraseiulus talbii*, K.a.=*Kampimodromus aberrans*, N.aur.=*Neoseiulus aurescens*, T.k.=*Typhlodromus kerkirae*, P.f=*Phytoseius finitimus*, T.u.=*Tetranychus urticae*, C.ps.=*Cenopalpus pseudospinosus*

The distribution of the predators over apple trees, green cover and hedges was evaluated and analyzed statistically by STUDENT's "t"-test (LANDI, 1977).

RESULTS AND DISCUSSION

The phytoseiid species that were recorded on the weeds under the trees and in the hedges in the three orchards in Zagora, Anilio and Farma, do not differ appreciably from those found on the apple trees in the respective areas (MARKOYIANNAKI-PRINTZIOU *et al.*, 1999). *E. finlandicus, T. pyri* and *A. andersoni* are again the predominant species. This study, concerning the extent that weeds and hedges may be natural resources of populations of the economically most important species is focused mainly on these three species. Next comes *Typhlodromus cotoneastri* Wainstein, mainly in the Zagora and Anilio area and *Phytoseius macropilis* (Banks) in Farma, while the species *Paraseiulus talbii* (Athias-Henriot), *Kampimodromus aberrans* (Oudemans), *Neoseiulus aurescens* (Athias-Henriot), *Typhlodromus kerkirae* Swirski & Ragusa and *Phytoseius finitimus* (Ribaga) may be considered to occur only sporadically (TABLE 3).

The frequency of the species *E. finlandicus, T. pyri* and *A. andersoni* on green cover and hedges, as observed in the samples over the two years 1998 and 1999, is presented in TABLE 2.

The ten predacious phytoseiids were recorded on 33 out of the 62 plant species, belonging to 32 families (TABLE 1), that make up the total of plants (annuals and perennials) in the orchards, while from the phytophagous mites *T. urticae* was the only species recorded. Among the plants growing in the orchards predators were most numerous on the species *Amaranthus retroflexus, Lamium* sp., *Lamium purpureum, Convolvulus arvensis, Urtica dioica, Rumex crispus, Lapsana communis, Sonchus oleraceus, Malva neglecta* and *Pteridium aquilinum*. In the hedges the species *Rubus fruticosus, Rubus* sp., *Sambucus nigra, Cornus sanguinea, Prunus avium, Juglans regia, Castanea sativa, Quercus* sp., *Pteridium aquilinum* are most important as natural refuges and potential sources of populations of the species *E. finlandicus, T. pyri* and *A. andersoni*. Hardly any phytoseiids were recorded on species of the Graminaceae family. Same observations were made on the apple-orchard in the Agia area. The modern agrotechnical methods were applied and the small number of green cover plants, mainly consisting of species of the Graminaceae family, did not allow the collecting of predators during the three-year period of this survey.

The most abundant species (*E. finlandicus*) was recorded on the largest number of plants of green cover and hedge. It is most numerous on stinging nettle (*Urtica dioica*), amaranth (*Amaranthus retroflexus*), dead nettle (*Lamium purpureum, Lamium* sp.), mallow (*Malva neglecta*), plantain (*Plantago media, Plantago* sp.), field bindweed (*Convolvulus arvensis*), blackberry (*Rubus fruticosus*), oak (*Quercus* sp.), common dogwood (*Cornus sanguinea*), alder (*Alnus* sp.), elderberry (*Sambucus nigra, Sambucus* sp.), chestnut (*Castanea sativa*), walnut (*Juglans regia*) and cherry (*Prunus avium*). On the leaves of hedge plants, like blackberry, chestnut, oak, walnut and cherry, up to 4 individuals per leaf were counted during summer, even on leaves where none *T. urticae* or other mite species were found (Tydeidae, Stigmaeidae and others), while there were large populations of aphids.

Occurrence of such plant species in a crop and in hedges apparently plays an important role in hosting phytoseiids. The rather limited studies that have been made in vineyards, pear orchards and vegetable crops in Switzerland, Italy and Spain respectively (BOLLER *et al.*, 1988; DUSO *et al.*, 1993; ESCUDERO & FERRAGUT, 1999; IRAOLA CALVO *et al.*, 1999) confirm that *Rubus fruticosus* and *Cornus sanguinea* are a potential source of *T. pyri* and *E. finlandicus* populations, as are *Corylus avellana, Sambucus* sp. and elm for *A. andersoni* and *K. aberrans*. *Taraxacum officinalis, Plantago* sp., *Rumex crispus, Rumex* sp. and *Convolvulus arvensis* are an important natural resource of populations of *Neoseiulus californicus* (McGregor), *Neoseiulus barkeri* Hughes and *Euseius stipulatus* Athias-Henriot.

In TABLE 3 the total number of individuals of each predator species hosted on the total of green cover and hedge plants at each experimental orchard is presented and compared to the apple trees in the respective areas. The data collected during this two years survey showed that the colonization by the phytoseiid may depend on the botanic composition of green cover and hedges.

TABLE 3: Total numbers of the phytoseiid species found on apple, green cover and hedges in the apple-orchards in Zagora, Anilio and Farma over the years 1998-1999.

ZAGORA

	1998			1999		
	Apple-trees	**Green cover**	**Hedge**	**Apple-trees**	**Green cover**	**Hedge**
E. finlandicus	1705	213	100	970	208	73
T. pyri	540	606	142	161	182	50
T. cotoneastri	32	0	0	45	0	0
P. talbii	21	2	0	20	0	0
K. aberrans	8	1	6	5	0	0
A. andersoni	5	2	0	3	0	4
N. aurescens	0	1	0	0	0	0

ANILIO

	1998			1999		
	Apple-trees	**Green cover**	**Hedge**	**Apple-trees**	**Green cover**	**Hedge**
E. finlandicus	297	41	554	302	65	1422
T. cotoneastri	154	9	55	32	15	22
T. pyri	44	84	10	96	81	129
K. aberrans	0	0	0	0	0	13
P. finitimus	0	0	0	0	0	13
N. aurescens	0	0	0	0	3	0

FARMA

	1998			1999		
	Apple-trees	**Green cover**	**Hedge**	**Apple-trees**	**Green cover**	**Hedge**
A. andersoni	1197	115	37	180	175	10
E. finlandicus	17	23	167	131	31	134
T. pyri	32	11	2	29	26	35
P. macropilis	45	0	31	25	0	10
P. talbii	6	0	1	0	0	0
T. cotoneastri	2	0	0	0	0	0
T. kerkirae	1	0	7	0	0	0
N. aurescens	0	0	1	0	0	0

In the orchard in Zagora the frequency of the dominant species *E. finlandicus* (Markoyiannaki-Printziou *et al.*, 1999), is lower in the hedge than on the trees and green cover (Table 3). The 100 and 73 individuals that were collected in 1998 and 1999 respectively are rather due to the presence of few *Sambucus nigra, Rubus fruticosus* and *Quercus* sp. plants and less to *Corylus avellana* and *Ficus carica* that are the main hedge plants; the high frequency of this species on the weeds is mainly due to *Amaranthus retroflexus, Urtica dioica, Convolvulus arvensis, Plantago* sp., *Plantago media, Rumex crispus, Rumex* sp., *Pteridium aquilinum* that hosted most individuals. In the area of Anilio where the hedge is composed of *Castanea sativa, Juglans regia, Prunus avium, Rubus* sp. and *Pteridium aquilinum*, the occurrence of *E. finlandicus* is rather notable (554 and 1422 individuals in 1998 and 1999 respectively) in comparison to apple trees (297 and 302 mites) and green cover (41 and 65 mites), as all hedge trees hosted this species in considerable numbers. The high frequency of this species in the hedge of the Farma orchard (Table 3) is due mainly to *Rubus fruticosus, Rubus* sp. and *Cornus sanguinea* which hosted the largest number of individuals. The high frequency of *E. finlandicus* on wild, forestal and cultivated plants, especially when growing on a rather high altitude, is confirmed also by previous studies (Ragusa *et al.*, 1995; Markoyiannaki-Printziou *et al.*, 1999).

T. pyri, the second important predator in the orchards in Zagora and Anilio (Markoyiannaki-Printziou *et al.* 1999), showed a higher frequency on weeds and apple trees than in the hedges (Table 3). This prompts the authors for further investigations on the behaviour of the predators in the choice of their host plants. Comparable observations have been made also for *A. andersoni*, the predominant species in Farma (Table 3). The numbers collected on the weeds are almost the same as those on apples especially in 1999, 175 and 180 individuals respectively, while the species occurs in the hedge in rather low numbers.

Records from the literature state that certain plants like hazelnut, walnut and blackberry not only host phytoseiid species but that several of them can develop high densities on those plants. Walter & O'Dowd (1992) showed that the morphology of the leaves may play an important role in the indication of colonization of phytoseiids on wild plants. On the other hand it is already known that certain phytoseiid species distinctly show preference for definite plant species like for instance *K. aberrans* for hazelnut (Collyer, 1956; Chant, 1959; Ragusa, 1974; Duso *et al.*, 1993), *E. finlandicus* for plants with glabrous leaves (Collyer, 1956; Chant, 1959) and several species of the genus *Phytoseius* for pubescent plants (Collyer, 1956; Nicotina, 1992; Walter & O'Dowd, 1992; Walter, 1992; Couitti, 1993; Papaioannou-Souliotis *et al.*, 1999).

Recent studies confirm that *E. finlandicus* especially prefers plants with glabrous to slightly pubescent leaves like ash, walnut, chestnut, blackberry and alder. This may explain also the high density of this species in the hedge in the Anilio orchard, which is composed mainly of chestnut, walnut, cherry and blackberry. *A. andersoni*, although its preference is not cleared, is the most widespread species on herbaceous plants with glabrous leaves (Duso *et al.*, 1993), which is in conformity with observations made in the orchard in Farma. Important data concerning the relation between certain phytoseiid species and leaf types have also been published for grapevine. Varieties characterized by leaves of different types of pubescence, may favor the prevalence of certain species like *A. andersoni, T. pyri* and *P. finitimus* accordingly (Duso, 1992; Nicotina, 1992; Papaioannou-Souliotis *et al.*, 1999).

As far as the distribution is concerned of the total of predators over the central and peripheral trees, over trees and weeds as well as between hedges and peripheral trees close by in the Zagora and Anilio area, where the numbers were rather considerable, data reveal the following. The distribution of the predators between the central and peripheral trees is not statistically significant nor in the Zagora orchard, neither in that of Anilio, while the difference in distribution between weeds and apple trees is statistical significant (Table 4).

Comparison of the averages of the samples from hedges and peripheral trees in the area of Zagora shows a statistically significant difference and phytoseiids on peripheral trees outnumber those on the hedges, while in the area of Anilio occurs the opposite, phytoseiids on hedges outnumber those on the

TABLE 4: Average numbers of phytoseiids collected on the central and peripheral trees, the green cover and hedges of the apple-orchards in Zagora and Anilio.

ZAGORA

	1998	1999
	Means (± S.D.)	Means (± S.D.)
Central trees	121.1 (± 24.2) a*	59.1 (± 19.2) a
Peripheral trees	103.4 (± 24.2) a	61.3 (± 32.6) a

	1998	1999
	Means (± S.D.)	Means (± S.D.)
Apple trees	112.25 (± 25.2) a	60.2 (± 26.1) a
Green cover	40.95 (± 17.7) b	19.5 (± 8.5) b

	1998	1999
	Means (± S.D.)	Means (± S.D.)
Hedge	24.8 (± 5.1) a	12.7 (± 4.6) a
Peripheral trees	103.4 (± 24.2) b	61.3 (± 32.6) b

ANILIO

	1998	1999
	Means (± S.D.)	Means (± S.D.)
Central trees	20.4 (± 8.2) a	20.1 (± 13.4) a
Peripheral trees	29.1 (± 9.7) a	22.9 (± 13.7) a

	1998	1999
	Means (± S.D.)	Means (± S.D.)
Apple trees	24.75 (± 9.8) a	21.5 (± 13.27) a
Green cover	6.7 (± 5.3) b	8.2 (± 9.7) b

	1998	1999
	Means (± S.D.)	Means (± S.D.)
Hedge	61.1 (± 10.8) a	159.9 (± 56.64) a
Peripheral trees	29.1 (± 9.7) b	22.9 (± 13.7) b

* For each column of values those indicated with the same letter do not differ at P= 0.05 after Student's "t" test.

peripheral trees (TABLE 4). This confirms once more that hedges may, better than weeds, play the role of natural resources of phytoseiids, when they are composed of plant species that host these predators.

The above data indicate that the natural immigration of the predatory mites from hedges or forest plants into the peripheral trees of the apple-orchards and thence their dispersal over the central trees, is not a slow process.

Finally, the number of the phytoseiids recorded in total on green cover and hedges, confirming the views of other investigators, indicates that these elements may classify as natural ecological refuges of certain predator species and potential sources for the supply of the crops when conditions are favorable.

Conclusions

Distribution maps of *E. finlandicus, T. pyri* and *A. andersoni* in the three apple-orchards show in general higher predatory mites populations in the border areas facing hedges or forest plants and green cover. The data of the survey positively indicate these two elements "as natural ecological refuges" and potential sources of populations of certain phytoseiid species, especially when conditions are favorable for their supposed flow from and to the culture.

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