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I.E. RIGAMONTI, G.C. LOZZIA

Phytoseiid mites (Acari: Phytoseiidae) on apple tree and spontaneous flora under different environmental and cultural conditions in Valtellina (Lombardy, Northern Italy)

Abstract - In the years 1999 and 2000 a research to evaluate the presence of Phytoseiid mites on apple and spontaneous flora under different environmental and cultural conditions was carried out in Valtellina, the main Lombard area for apple cultivations. 18 apple orchards were chosen belonging to three different types: abandoned, in marginal areas and in mono-cultural areas. On the whole 6 species of Phytoseiid mites were found but only three have played an important role: *Amblyseius andersoni* (Chant), *Typhlodromus pyri* Scheuten and *Euseius finlandicus* (Oud.). The presence of Phytoseiid mites on different orchard types is influenced more on the qualitative than quantitative plan. The densities have not shown any notable differences on the cultivation, being approximately 0.5 specimens per dm^2 of the leaf area, and there has been a modest increase on natural vegetation in the abandoned orchards. Phytoseiid mites are always present on apple trees and with permanent populations. On spontaneous flora the situation is variable in relation to the the host species. Phytoseiid mites are much more abundant on cherry, ash and elder trees rather than on apple trees. *A. andersoni* and *T. pyri* are the dominant species on the crop. The former is mostly found on mono-cultural areas while the latter in marginal areas but in uncultivated areas *E. finlandicus* coming from spontaneous flora predominates. *E. finlandicus* is the prevalent species on wild vegetation but in mono-cultural areas *A. andersoni* and *T. pyri* are important too. In the agro-ecosystem there is a double flow of Phytoseiid mites, from and to the cultivation. The critical factor that determines the direction of this move is the volume of the bio-mass. In marginal areas spontaneous essences predominate, with movements towards the apple tree, in mono-cultural areas there is an inverse movement.

Riassunto - *Acari Fitoseidi (Acari: Phytoseiidae) su melo e piante spontanee in differenti situazioni ambientali e gestionali in Valtellina (Lombardia, Italia settentrionale)*

Nel corso del biennio 1999-2000 è stata condotta in Valtellina, la principale area lombarda di coltivazione del melo, una ricerca per valutare la presenza di Fitoseidi su melo e piante spontanee in appezzamenti soggetti a differenti situazioni ambientali e gestionali. Sono stati scelti 18 meleti appartenenti a tre diverse tipo-

logie: abbandonati, in aree marginali e in zone monocolturali. Complessivamente sono state reperite sei specie di Fitoseidi, ma solo tre hanno evidenziato un ruolo importante: *Amblyseius andersoni* (Chant), *Typhlodromus pyri* Scheuten ed *Euseius finlandicus* (Oud.). La presenza di Fitoseidi è influenzata più sul piano qualitativo che quantitativo. Le densità non hanno mostrato differenze sensibili sulla coltura, aggirandosi attorno a 0,5 esemplari per dm^2 di superficie fogliare, e un modesto incremento sulla vegetazione naturale nella tipologia "abbandonati". Su melo sono sempre presenti Fitoseidi e con popolazioni permanenti. Sulla flora spontanea la situazione è variabile in funzione della specie ospite. Solo su ciliegio, frassino e sambuco i Fitoseidi sono sensibilmente più abbondanti che su melo. Sulla coltura dominano *A. andersoni* e *T. pyri*. Il primo prevale nelle zone monocolturali, il secondo nelle aree marginali. Negli incolti si ha però l'affermazione di *E. finlandicus* proveniente dalle piante spontanee. Sulla vegetazione vi è prevalenza di *E. finlandicus*, tranne nelle zone monocolturali, dove è affiancato da *A. andersoni* e *T. pyri*. Nell'agroecosistema si ha un doppio flusso di Fitoseidi, da e verso la coltura. Il fattore critico nel determinare la direzione del trasferimento netto è il volume della biomassa. Nelle aree marginali prevale quella delle essenze spontanee, con spostamenti verso il melo, in quelle monocolturali è più considerevole quella costituita dal melo e si assiste ad un movimento inverso.

Key words: apple, spontaneous flora, Phytoseiidae, cultural condition.

INTRODUCTION

Studies on Phytoseiid mites started in the mid 1900s following the assertion of spider mites as important phytophagous in many orchards as a result of widespread changes in technical practices, and of the use of pesticides above all. The importance of these predators was rapidly ascertained in abandoned and not treated environments (Kuenen, 1947; Collyer, 1953a, b, c; Chant, 1959). At a later stage the role in cultivated orchards was analysed and there was an attempt to increase their diffusion. In Italy this happened at the beginning of the 70's (Ivancich-Gambaro, 1973; 1974) and of the 80's (Ioriatti *et al.*, 1983). For a certain period a particular emphasis was placed on the ability to select strains resistant to pesticides as a means to facilitate the resettlement of Phytoseiid mites in intensive cultures (Strapazzon, 1985; Duso & Sbrissa, 1990). Later on this method started losing interest both because it could delay the passage to integrated production strategies, slowing down the abandoning of traditional active ingredients, and because the development of resistance seems to include a loss of bio-ecological potential (Duso, 1997). As a result of this, there has been a major concentration on the role of the agro-ecosystem, also studying spontaneous flora as a reservoir of predators and the cultural practices which can reduce the impact on Phytoseiid mites making their growth easier as well as the dispersion of the populations (Boller & Remund, 1986, Boller *et al.*, 1988; Lozzia & Rigamonti, 1990; Coiutti, 1993; Lozzia *et al.*, 1996).

The present research aims to verify the diffusion of Phytoseiid mites in orchards

and on spontaneous vegetation in Valtellina (Northern Italy, Province of Sondrio) and how this has been influenced by environmental and management characteristics of the orchards. Three types of apple orchards were chosen: "abandoned", no longer looked after; "marginal", that is, located on the edges of apple orchards near a wooded area and "mono-cultural", completely surrounded by other apple orchards in the middle of highly cultivated areas. The experimental lots were singled out in three areas characterised by a different time of settlement of intensive apple growing and by a decreasing diffusion of the cultivation.

MATERIALS AND METHODS

For every area two apple orchards for each type were chosen in 1999, and only one in the year 2000. The details concerning the lots chosen and their characteristics are found in Table 1. The samples in the apple orchards consisted of a monthly collection of one hundred leaves among those already opened out, chosen at random on about 10 trees from different rows, at different heights and in different light. On arboreal species, which are the best representatives of spontaneous flora in each lot similar collections were carried out in the same way but gathering a variable number of leaves according to their size, so that the total leaf area would remain unchanged as much as possible. In order to compare the data the density of the population was expressed as "number of Phytoseiid mites present in 100 cm^2 of leaf area". In Table 2 the average area of the leaves of the vegetation tested are written down.

Experimental environment

The cultivation of apples is widespread in the central and high parts of Valtellina, with lots mainly located on land facing south, but they are also present at the bottom of the valley facing east / south-east and especially so in the high valley. All the apple orchards are full of weeds. The techniques of cultivation and pest management are the same within an area, since the farmers are members of co-operatives which give indications to its members. The number of treatments, in particular with fungicides, is 15-20 a year; The list of the active ingredients used on the mono-cultural and marginal experimental lots are to be found in Table 3.

The three areas that have been singled out are Ponte in Valtellina, Villa di Tirano and the High Valley. Ponte in Valtellina is the area with the oldest fruit growing tradition, where there have been the greatest changes and improvements and where the territory has now become almost mono-cultural. Only in the higher part of the municipality there is still mixed agricultural land, with permanent meadows, some sown areas and woods, while hedges, rows of trees and uncultivated areas are rare.

Villa di Tirano has a more varied agricultural environment. To the north there is a strip where apple orchards, meadows, vegetable gardens and sown areas are all mixed together. On the other hand the steepest area has been terraced and vineyards grow there. To the south, which is more humid and less sunny, the apple orchards are mixed

Table 1 - Characteristics of the experimental orchards.

Apple orchard	Type	Planting year (year of abandonment)	Area m^2	Bearings	Variety / Stock	Training system
Ponte in Valtellina						
Castellana	Marginal	1993	3410	N - S	Red Chief, Galaxi / M9	Spindel
Madonna 1	Abandoned	(1993)	980	N - S	Stark Delicious	Palmette
Roncale	Abandoned	(1995)	3200	N - S	Golden	Palmette
Roncola	Marginal	1981	1080	N - S	Gold B / M9	Spindel
Madonna 2	Mono-cultural	1994	2400		Hapked / M9	Spindel
Prada	Mono-cultural	1983	850		Gold B / M9, Red Chief / M25	Spindel
Villa di Tirano						
Casello	Abandoned	(1985)	560	N - S	Golden	Palmette
Sant'Antonio	Abandoned	1980 (1998)	1110	N - S	Golden	Palmette
Reola	Marginal	1988	1480		Golden, Stark / M26	Spindel
Villa	Marginal	1978	1430	E - W	Golden, Red Chief / M25	Vase, Spindel
Adda	Mono-cultural	1987	760		Gala / M26, Red Chief / M106	Spindel
Consorzio	Mono-cultural	1997	1560	E - W	Red Chief / M26, Smothee / M9	Spindel
High Valley						
Piazzone 1	Marginal	1996	2300	E - W	Golden B / M26	Spindel
Ponte	Mono-cultural	1985	4220	E - W	Golden / M9, Top Red / M26	Spindel
Piazzone 2	Mono-cultural	1996	2860	E - W	Golden / M26	Spindel
Foppe	Marginal	1970 - 1998	2790	E - W, N - S	Golden / Franco, Stark / M26	Vase, Spindel
Lovero	Abandoned	(1996)	840	E - W	Golden / M26	Vase
Tovo	Abandoned	(1995)	1400	E - W	Golden / M26	Palmette

Table 2 - Average leaf area of the species of vegetation studied.

Plant	average area of a leaf in cm^2	Plant	average area of a leaf in cm^2
Apple	55.3	Grapevine	172.5
Apricot	39.2	Hazelnut	58.1
Ash *	24.3	Hop	117.5
Birch	32.5	Linden	147.8
Bramble	29.9	Locust tree *	22.5
Chestnut	138.9	Oak	67.3
Cherry	56.6	Plum	54.0
Dogwood	39.7	Walnut	134.6
Elder *	60.7	Willow	24.6

* = surface of a simgle leaf.

Table 3 - Active ingredients used in the mono-cultural and marginal experimental orchards.

Ponte in Valtellina		Villa di Tirano		High Valley	
1999	2000	1999	2000	1999	2000
Fungicides	Fungicides	Fungicides	Fungicides	Fungicides	Fungicides
copper hydroxide	copper hydroxide	mancozeb	metiram	mancozeb	mancozeb
mancozeb	metiram	metiram	strobilurine	metiram	dodine
metiram	dodine	dodine	esaconazole	strobilurine	strobilurine
dodine	strobilurine	captane	dichlofluanide	sulphur	sulphur
strobilurine	sulphur	strobilurine		penconazole	penconazole
captane	difenoconazole	difenoconazole		captane	dithianon
sulphur	esaconazole	esaconazole		dithianon	dichlofluanide
difenoconazole	fenbuconazole	dithianon		dichlofluanide	pyrimethanil
esaconazole	dichlofluanide	dichlofluanide		pyrimethanil	
fenbuconazole					
chlortalonil					
dithianon					
dichlofluanide					
Insecticides	Insecticides	Insecticides	Insecticides	Insecticides	Insecticides
mineral oil	mineral oil	mineral oil	mineral oil	mineral oil	mineral oil
oxydemeton methyl	vamidothion	vamidothion	pirimicarb	vamidothion	vamidothion
vamidothion	lufenuron	diflubenzuron	vamidothion	diflubenzuron	diflubenzuron
lufenuron	diazinon	flufenoxuron	diflubenzuron	flufenoxuron	lufenuron
diazinon			flufenoxuron		

together with woods. The areas where the cultivation is intensive are the plains and on the alluvial cones, where, in any case, the presence of meadows, fields and wooded areas, along the bank of the river Adda, are still important.

The High Valley represents the last intensively cultivated area for apple trees and it was assigned for intensive cultivation at a later date than Ponte in Valtellina and Villa di Tirano. It is therefore a "younger" area where the environment is more variable. The cultivated area faces east - south east, which is more humid and less sunny and where the wood with chestnut trees, ash and oak trees goes as far as the cultivated areas. The major concentration of apple orchards is in the lower part while as you go up the valley they are more and more alternated to meadows, grazing land and sown areas.

Table 4 - Phytoseiid mites collected on abandoned apple orchards in the area of Ponte in Valtellina.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Madonna 1 - 1999								
Apple	4 – 4	0.320 (0.16 – 0.54)	59.02	0.00	0.00	29.51	11.48	0.00
Bramble	4 – 2	0.965 (0.00 – 2.19)	87.88	0.00	0.00	12.12	0.00	0.00
Cherry	4 – 4	1.308 (0.81 – 2.14)	4.88	4.88	0.00	90.24	0.00	0.00
Elder	4 – 4	0.915 (0.44 – 1.54)	8.96	11.94	0.00	76.12	2.99	0.00
Roncale - 1999								
Apple	4 – 4	0.135 (0.05 – 0.20)	0.00	17.24	0.00	65.52	17.24	0.00
Oak	4 – 4	0.628 (0.31 – 0.95)	8.70	0.00	0.00	84.78	6.52	0.00
Walnut	4 – 3	0.238 (0.00 – 0.38)	0.00	0.00	0.00	100.00	0.00	0.00
Roncale – 2000								
Apple	5 – 5	1.060 (0.47 – 1.55)	0.00	4.18	0.00	89.73	6.08	0.00
Walnut	5 – 4	0.494 (0.00 – 1.49)	0.00	0.00	0.00	100.00	0.00	0.00

Samples = number of samples; with Phytoseiid = samples with the presence of Phytoseiid mites.
Tp = *T. pyri*; Aa = *A. andersoni*; Ka = *K. aberrans*; Ef = *E. finlandicus*; Pt = *P. talbii*; Pm = *P. macropilis*
The percentages are calculated based on identified specimens.

RESULTS AND DISCUSSION

The data relative to the collection of Phytoseiid mites in each lot is written in the Tables from 4 to 12. On the whole 6 species have been found, *Typhlodromus pyri* Scheuten, *Amblyseius andersoni* (Chant), *Euseius finlandicus* (Oud.), *Paraseiulus talbii* (Athias-Henriot), *Kampimodromus aberrans* (Oud.) and *Phytoseius macropilis* (Banks); however only the first four are present on apple trees. Only the first three play an important role in the agro-ecosystem of apple orchards in Valtellina. Among those left, *P. talbii* is of secondary importance but relatively common and constant both on apple trees and on spontaneous flora, while *K. aberrans* and *P. macropilis* are totally sporadic. As a matter of fact, they were found only on ash, the former on one occasion – in Reola orchard, a marginal lot in the area of Villa di Tirano (Table 8) – and the latter on two occasions – in Casello orchard, an abandoned lot in the Ponte in Valtellina area and in Foppe orchard in the High Valley area (Tables 7 and 8).

Phytoseiid mites are always present on apple trees and with permanent populations. The densities do not show remarkable differences neither in the different types nor in the different areas (Tables 13-14), always being about 0.5 specimens per dm^2 of leaf area. The variation in a single lot, in the two years of observation, is often greater than between the different apple orchards. The values reached are not particularly high but seem to be enough to guarantee the protection from pullulations by phytophagous mites. As a matter of fact it has never been necessary to use acaricides.

Table 5 - Phytoseiid mites collected on marginal apple orchards in the area of Ponte in Valtellina.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Castellana – 1999								
Apple	4 – 4	0.293 (0.18 – 0.47)	87.04	0.00	0.00	5.56	7.41	0.00
Bramble	4 – 2	0.735 (0.00 – 2.43)	75.00	0.00	0.00	0.00	25.00	0.00
Cherry	4 – 4	1.823 (0.52 – 3.65)	15.94	0.00	0.00	84.06	0.00	0.00
Locust tree	4 – 3	0.983 (0.00 – 1.53)	6.45	3.23	0.00	87.10	3.23	0.00
Oak	4 – 3	0.810 (0.00 – 1.37)	39.53	0.00	0.00	60.47	0.00	0.00
Roncola – 1999								
Apple	4 – 4	0.308 (0.13 – 0.42)	92.45	7.55	0.00	0.00	0.00	0.00
Bramble	4 – 1	0.450 (0.00 – 1.80)	0.00	90.48	0.00	0.00	9.52	0.00
Chestnut	4 – 4	0.353 (0.08 – 0.61)	3.33	0.00	0.00	96.67	0.00	0.00
Elder	4 – 4	0.760 (0.06 – 1.35)	0.00	46.55	0.00	53.45	0.00	0.00
Oak	4 – 3	0.133 (0.00 – 0.24)	12.50	25.00	0.00	62.50	0.00	0.00
Willow	4 – 0	0.000 (0.00 – 0.00)						
Roncola – 2000								
Apple	5 – 5	0.542 (0.04 – 1.35)	55.88	44.12	0.00	0.00	0.00	0.00
Ash	5 – 5	1.962 (0.25 – 5.70)	7.92	2.97	0.00	86.14	2.97	0.00
Elder	5 – 4	0.984 (0.00 – 2.06)	14.08	4.23	0.00	81.69	0.00	0.00

Table 6 - Phytoseiids mites collected on mono-cultural apple orchards in the area af Ponte in Valtellina.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Madonna 2 – 1999								
Apple	4 – 4	0.390 (0.27 – 0.51)	13.92	82.28	0.00	0.00	3.80	0.00
Birch	4 – 0	0.000 (0.00 – 0.00)						
Plum	4 – 3	0.390 (0.00 – 0.66)	60.53	13.16	0.00	5.26	21.05	0.00
Prada – 1999								
Apple	4 – 4	0.230 (0.07 – 0.40)	74.42	0.00	0.00	0.00	25.58	0.00
Ash	4 – 4	1.163 (0.15 – 1.71)	18.87	0.00	0.00	56.60	24.53	0.00
Oak	4 – 4	0.418 (0.31 – 0.62)	21.74	34.78	0.00	43.48	0.00	0.00
Prada – 2000								
Apple	5 – 5	0.802 (0.61 – 1.41)	90.05	3.62	0.00	3.62	2.71	0.00
Bramble	5 – 5	1.402 (0.28 – 2.39)	80.39	3.92	0.00	13.73	1.96	0.00
Cherry	5 – 5	3.444 (0.67 – 6.08)	4.17	1.67	0.00	88.33	5.83	0.00

Table 7 - Phytoseiids mites collected on abandoned apple orchards in the area of Villa di Tirano.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Sant'Antonio – 1999								
Apple	4 – 4	0.518 (0.33 – 0.85)	39.81	37.96	0.00	11.11	11.11	0.00
Ash	4 – 4	1.728 (1.23 – 2.29)	4.35	39.13	0.00	56.52	0.00	0.00
Willow	4 – 0	0.000 (0.00 – 0.00)						
Casello – 1999								
Apple	4 – 4	0.578 (0.27 – 0.98)	0.00	25.86	0.00	74.14	0.00	0.00
Apricot	4 – 2	0.233 (0.00 – 0.58)	0.00	11.11	0.00	88.89	0.00	0.00
Ash	4 – 4	0.908 (0.81 – 1.12)	6.98	67.44	0.00	25.58	0.00	0.00
Cherry	4 – 4	2.298 (1.65 – 3.88)	15.63	9.38	0.00	73.44	1.56	0.00
Elder	4 – 4	1.258 (0.80 – 1.70)	1.08	0.00	0.00	97.85	1.08	0.00
Walnut	4 – 2	0.250 (0.00 – 0.69)	5.00	0.00	0.00	95.00	0.00	0.00
Casello - 2000								
Apple	5 – 5	1.204 (0.27 – 1.84)	6.62	5.63	0.00	67.88	19.87	0.00
Ash	5 – 5	1.210 (0.43 – 2.11)	6.90	54.02	0.00	31.03	2.30	5.75
Elder	5 – 5	2.030 (0.13 – 4.62)	6.30	3.94	0.00	89.76	0.00	0.00

The qualitative composition of the populations, on the other hand, differs greatly between the types while it is not influenced greatly by the geographic location (Tables 13 and 14). In mono-cultural area a co-dominance of *A. andersoni* and *T. pyri* can be found while other species can be completely ignored. In apple orchards of this kind in particular, there are populations greatly dominated by one species, which in four cases it is the first one and in the others two it is the second. Furthermore, on the lots sampled both years, the dominating species is always constant, which indicates that a remarkable stability has already been reached (Tables 6, 9 and 12). This data agrees with what has already been seen in the past both in Valtellina (Duso & Sbrissa, 1990) and in the rest of Northern Italy (Duvernay, 1985; Ioriatti & Mattedi, 1988; Strapazzon & Rensi, 1989) and in a large part of Europe (Collyer, 1956; Bohm, 1960; Boczek, 1964; Karg, 1970; Rambier, 1974; Gruys, 1980; Genini *et al.*, 1983; Garcia-Mari *et al.*, 1989; Espinha *et al.*, 1995; Galli *et al.*, 1995). In all these areas *T. pyri* and *A. andersoni* are the two species that adapt themselves better to the perturbations brought about by cultural practices on apple trees.

In marginal areas the picture is rather different. In all the lots we note that only *T. pyri* asserts itself while *A. andersoni* is a secondary presence and sometimes even completely absent (Tables 5, 8 and 11). The other two species still have a negligeable role.

Table 8 - Phytoseiid mites collected on marginal apple orchards in the area of Villa di Tirano.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Villa – 1999								
Apple	3 – 3	0.490 (0.38 – 0.58)	95.77	4.23	0.00	0.00	0.00	0.00
Bramble	3 – 0	0.000 (0.00 – 0.00)						
Cherry	3 – 3	0.797 (0.59 – 1.21)	10.00	0.00	0.00	83.33	6.67	0.00
Oak	3 – 1	0.023 (0.00 – 0.07)	100.00	0.00	0.00	0.00	0.00	0.00
Walnut	3 – 3	0.253 (0.21 – 0.32)	0.00	0.00	0.00	100.00	0.00	0.00
Reola – 1999								
Apple	4 – 4	0.523 (0.23 – 0.72)	66.00	34.00	0.00	0.00	0.00	0.00
Ash	4 – 3	0.658 (0.00 – 1.05)	6.25	31.25	9.38	53.13	0.00	0.00
Birch	4 – 0	0.000 (0.00 – 0.00)						
Chestnut	4 – 4	0.350 (0.09 – 0.69)	0.00	0.00	0.00	100.00	0.00	0.00
Abandoned grapevine	4 – 3	0.245 (0.00 – 0.46)	45.00	0.00	0.00	55.00	0.00	0.00
Hazelnut	4 – 0	0.000 (0.00 – 0.00)						
Linden	4 – 0	0.000 (0.00 – 0.00)						
Reola – 2000								
Apple	5 – 4	0.454 (0.00 – 0.67)	78.95	8.77	0.00	12.28	0.00	0.00
Ash	5 – 4	1.162 (0.00 – 2.80)	10.81	0.00	0.00	89.19	0.00	0.00
Abandoned grapevine	5 – 5	0.324 (0.21 – 0.52)	23.08	30.77	0.00	38.46	7.69	0.00

In abandoned apple orchards the situation is further changed. Here there is a notable increase of the populations of *E. finlandicus*, which tends to become the most important species, together with a fall in *T. pyri* and *A. andersoni* and a moderate increase in *P. talbii*, which remains of secondary importance, though. In the single lots many species are present at the same time, often all four and only rarely one of them takes on an absolute dominant role (Tables 4, 7 and 10). This variation, recorded on different occasions in Europe (Duso & Sbrissa, 1990; Tuovinen & Rokx, 1991; Coiutti, 1993; Kabicek, 1997), is surely due to the fact that *E. finlandicus* is the most common and most numerous Phytoseiid mite in the whole of Europe on spontaneous tree vegetation, especially if the leaf is hairless (Chant, 1959; Coiutti, 1993).

The condition of the colonisation on each of the seventeen species of vegetation sampled is extremely constant (Tables 4-12). In eleven cases the Phytoseiid mites were always present, in seven of these with populations generally stable (chestnut, cherry, ash, elder, dogwood, plum tree and grapevine) and in the four other cases the settlement was almost always not permanent (apricot, hop, walnut and oak). On three

Table 9 - Phytoseiid mites collected on mono-cultural apple orchards in the area of Villa di Tirano.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Consorzio – 1999								
Apple	4 – 4	0.380 (0.18 – 0.61)	12.50	84.72	0.00	2.78	0.00	0.00
Birch	1 – 0	0.000						
Elder	1 – 1	0.450	22.22	66.67	0.00	11.11	0.00	0.00
Hop	1 – 1	0.740	11.11	0.00	0.00	88.89	0.00	0.00
Adda – 1999								
Apple	4 – 4	0.323 (0.22 – 0.40)	6.06	90.91	0.00	3.03	0.00	0.00
Birch	4 – 0	0.000 (0.00 – 0.00)						
Elder	3 – 3	0.563 (0.34 – 0.71)	19.35	80.65	0.00	0.00	0.00	0.00
Hop	4 – 2	0.178 (0.00 – 0.37)	5.56	94.44	0.00	0.00	0.00	0.00
Locust tree	4 – 0	0.000 (0.00 – 0.00)						
Walnut	4 – 3	0.185 (0.00 – 0.49)	0.00	52.94	0.00	47.06	0.00	0.00
Adda – 2000								
Apple	5 – 5	0.600 (0.07 – 1.07)	0.00	100.00	0.00	0.00	0.00	0.00
Elder	5 – 5	0.294 (0.15 – 0.61)	13.51	62.16	0.00	24.32	0.00	0.00
Hop	5 – 3	0.308 (0.00 – 0.60)	7.14	92.86	0.00	0.00	0.00	0.00

Table 10 - Phytoseiid mites collected on abandoned apple orchards in the area of the High Valley.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Lovero – 1999								
Apple	4 – 4	0.403 (0.09 – 0.76)	17.20	64.52	0.00	5.38	12.90	0.00
Cherry	4 – 3	0.933 (0.00 – 1.87)	34.38	50.00	0.00	15.63	0.00	0.00
Dogwood	4 – 4	0.570 (0.30 – 0.78)	29.63	18.52	0.00	51.85	0.00	0.00
Elder	4 – 4	0.308 (0.09 – 0.55)	30.00	40.00	0.00	30.00	0.00	0.00
Hazelnut	4 – 0	0.000 (0.00 – 0.00)						
Tovo – 1999								
Apple	4 – 4	0.335 (0.22 – 0.45)	3.28	95.08	0.00	0.00	1.64	0.00
Walnut	4 – 2	0.123 (0.00 – 0.27)	35.29	64.71	0.00	0.00	0.00	0.00
Tovo – 2000								
Apple	5 – 5	0.674 (0.01 – 1.34)	5.39	91.62	0.00	2.99	0.00	0.00
Walnut	5 – 4	0.092 (0.00 – 0.21)	6.25	43.75	0.00	50.00	0.00	0.00

Table 11 - Phytoseiid mites collected on marginal apple orchards in the area of the High Valley.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Piazzone 1 – 1999								
Apple	4 – 4	0.500 (0.40 – 0.58)	71.70	22.64	0.00	0.00	5.66	0.00
Ash	4 – 4	0.475 (0.33 – 0.73)	33.33	16.67	0.00	38.89	11.11	0.00
Elder	4 – 4	0.160 (0.04 – 0.34)	20.00	6.67	0.00	53.33	20.00	0.00
Locust tree	4 – 0	0.000 (0.00 – 0.00)						
Foppe – 1999								
Apple	4 – 4	0.408 (0.18 – 0.78)	85.42	10.42	0.00	4.17	0.00	0.00
Ash	4 – 4	0.818 (0.62 – 0.91)	13.16	7.89	0.00	78.95	0.00	0.00
Birch	4 – 0	0.000 (0.00 – 0.00)						
Cherry	4 – 4	0.950 (0.59 – 1.76)	4.17	0.00	0.00	95.83	0.00	0.00
Chestnut	4 – 4	0.380 (0.28 – 0.60)	2.86	11.43	0.00	85.71	0.00	0.00
Willow	4 – 0	0.000 (0.00 – 0.00)						
Foppe – 2000								
Apple	5 – 5	0.550 (0.16 – 0.94)	54.86	36.81	0.00	2.78	5.56	0.00
Ash	5 – 4	0.496 (0.00 – 1.31)	2.50	2.50	0.00	80.00	0.00	15.00
Cherry	5 – 5	0.894 (0.07 – 2.58)	0.00	2.56	0.00	97.44	0.00	0.00

species, on the contrary, Phytoseiid mites have never been found (birch, willow and linden). Of the other three, the bramble is comparable to the first group, with an almost constant presence but unstable of Phytoseiid mites found on five lots out of six. The other two essences (hazelnut and locust tree) are comparable to the last group. Their colonisation, which is not permanent, has been seen in one case out of three and in one case out of four respectively. This picture confirms what has already been seen in Piedmont (Lozzia & Rigamonti, 1990), with the exception of hazelnut, on which there are high populations of *K. aberrans* in particular in Italy (Lozzia & Rigamonti, 1990; Duso & Sbrissa, 1990; Coiutti, 1993) and of other species in Europe (Tuovinen & Rokx, 1991; Kabicek, 1997). The greater densities have been found on cherry and ash, followed by elder and bramble where they are more abundant than on apple trees. As far as the the plants present in all three orchard types are concerned, the populations seem more consistant, even if not much, in abandoned apple orchards and very similar in the other areas (Table 15).

On each essence, usually, there is one very dominant species, except on ash, oak, elder and grapevine, where there are much more mixed populations, with different Phytoseiid mites co-dominating. Almost always the supremacy belongs to *E. finlan-*

Table 12 - Phytoseiid mites collected on mono-cultural apple orchards in the area of the High Valley.

Plant	Samples – with Phytoseiids	Avg. mites/dm^2 (min. – max.)	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Ponte – 1999								
Apple	4 – 4	0.340 (0.26 – 0.43)	81.82	0.00	0.00	18.18	0.00	0.00
Bramble	4 – 1	0.200 (0.00 – 0.80)	100.00	0.00	0.00	0.00	0.00	0.00
Elder	4 – 3	0.533 (0.00 – 1.41)	60.00	5.71	0.00	0.00	34.29	0.00
Locust tree	4 – 0	0.000 (0.00 – 0.00)						
Plum	4 – 4	0.563 (0.34 – 1.19)	71.11	0.00	0.00	17.78	11.11	0.00
Piazzone 2 – 1999								
Apple	4 – 4	0.653 (0.47 – 0.98)	16.13	80.65	0.00	0.00	3.23	0.00
Cultivated grapevine	4 – 3	0.255 (0.00 – 0.39)	35.71	42.86	0.00	0.00	21.43	0.00
Hazelnut	4 – 1	0.035 (0.00 – 0.14)	0.00	33.33	0.00	66.67	0.00	0.00
Walnut	4 – 3	0.228 (0.00 – 0.37)	10.71	14.29	0.00	75.00	0.00	0.00
Piazzone 2 – 2000								
Apple	5 – 5	1.238 (0.27 – 1.73)	9.03	90.97	0.00	0.00	0.00	0.00
Cultivated grapevine	5 – 5	0.250 (0.10 – 0.34)	74.19	19.35	0.00	0.00	6.45	0.00
Walnut	5 – 3	0.318 (0.00 – 0.64)	5.41	5.41	0.00	89.19	0.00	0.00

Table 13 - Collection of Phytoseiid mites per type of cultivation in the three geographical areas.

Type	Species – samples – with Phytoseiids	Avg mites/dm^2 - N° of mites	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Ponte in Valtellina								
Apple – abandoned	1 – 13 – 13	0.505 – 395	10.20	4.53	0.00	77.34	7.93	0.00
Apple – marginal	1 – 13 – 13	0.381 – 282	70.78	26.34	0.00	1.23	1.65	0.00
Apple – monocultural	1 – 13 – 13	0.474 – 359	70.55	21.28	0.00	2.33	5.83	0.00
Flora - abandoned	5 – 25 – 21	0.758 – 278	15.47	3.77	0.00	78.87	1.89	0.00
Flora - marginal	8 – 46 – 33	0.817 – 459	12.73	12.50	0.00	72.95	1.82	0.00
Flora - monocultural	6 – 26 – 21	1.136 – 291	29.47	5.96	0.00	54.39	10.18	0.00
Villa di Tirano								
Apple – abandoned	1 – 13 – 13	0.766 – 575	11.98	16.73	0.00	57.60	13.69	0.00
Apple – marginal	1 – 12 – 11	0.489 – 320	78.60	16.49	0.00	4.91	0.00	0.00
Apple – monocultural	1 – 13 – 13	0.434 – 321	4.66	93.91	0.00	1.43	0.00	0.00
Flora - abandoned	6 – 38 – 30	1.101 – 591	6.20	21.62	0.00	70.49	0.75	0.94
Flora - marginal	10 – 46 – 26	0.318 – 286	11.42	7.09	1.18	78.74	1.57	0.00
Flora - monocultural	5 – 32 – 18	0.272 – 180	10.56	63.35	0.00	26.09	0.00	0.00
High Valley								
Apple – abandoned	1 – 13 – 13	0.471 – 356	8.41	84.42	0.00	3.12	4.05	0.00
Apple – marginal	1 – 13 – 13	0.486 – 363	68.50	25.14	0.00	2.31	4.05	0.00
Apple – monocultural	1 – 13 – 13	0.744 – 574	22.00	74.40	0.00	2.80	0.80	0.00
Flora - abandoned	5 – 25 – 17	0.337 – 129	28.57	41.96	0.00	29.46	0.00	0.00
Flora - marginal	7 – 42 – 29	0.417 – 245	8.13	6.22	0.00	80.38	2.39	2.87
Flora - monocultural	7 – 38 – 23	0.265 – 240	46.23	10.55	0.00	32.16	11.06	0.00

Species = number of collected plant species; samples = number of samples; with Phytoseiid = samples with the presence of Phytoseiid mites.

Table 14 - Collection of Phytoseiid mites per type of cultivation.

Type	Species – samples – with Phytoseiids	Avg mites/dm^2 - N° of mites	% Tp	% Aa	% Ka	% Ef	% Pt	% Pm
Apple – abandoned	1 – 39 – 39	0.581 – 1326	10.50	31.25	0.00	48.83	9.42	0.00
Apple – marginal	1 – 38 – 37	0.452 – 965	72.43	22.65	0.00	2.86	2.06	0.00
Apple – monocultural	1 – 39 – 39	0.551 – 1254	32.53	63.01	0.00	2.32	2.14	0.00
Flora - abandoned	10 – 88 – 68	0.785 – 998	11.66	18.92	0.00	67.88	0.99	0.55
Flora - marginal	13 – 134 – 88	0.514 – 990	11.30	9.52	0.33	76.30	1.88	0.66
Flora - monocultural	12 – 96 – 62	0.477 – 711	29.92	21.71	0.00	40.47	7.91	0.00

dicus, as it happens on spontaneous flora in Europe (Lozzia & Rigamonti, 1990; Tuovinen & Rokx, 1991) (Table 15). The hop, the plum tree and the bramble are different. On the first *A. andersoni* predominates which takes on a relevant role also on elder, cherry, ash, walnut and bramble. On the other two *T. pyri* is on top which is also abundant on oak, elder and dogwood (Table 15). This is a rather anomalous situation, because these two Phytoseiid species are usually not very conspicuous on spontaneous plants in Europe, even if *T. pyri* has been noted as an important member of Phytoseiid populations on bramble and abandoned grapevine in Piedmont (Lozzia & Rigamonti, 1990); on bramble as well as on dogwood and hazelnut, *Lonicera xylosteum* and *Prunus spinosa* in Switzerland (Boller *et al.*, 1988) and always on bramble as well as on a lesser scale on *Prunus spinosa* in Denmark (Hansen & Johnson, 1986). The importance of these two Phytoseiid mites should probably be associated with the almost total absence of *K. aberrans* at the same time, which in Italy is usually abundant about as much as *E. finlandicus*, in particular on species with hairy leaves as the hazelnut, fig and *Broussonetia papirifera* as well as on hackberry (Lozzia & Rigamonti, 1990; Coiutti, 1993).

In marginal areas the spontaneous vegetation is made up of wooded strips of variable width, even if there are meadows, sown areas and other tree cultivations and in particular grapevine. The main essences are therefore those typical for forest (birch, chestnut, cherry, ash, oak, locust tree, bramble, elder) and normally their bio-mass is relevant with respect to that of the surrounding apple orchards. The presence of plants within cultivated areas and on the borders of the roads can be completely ignored. In these conditions *E. finlandicus* clearly predominates, representing 70-80% of the total followed by *T. pyri* and *A. andersoni* with about 10% each, while the remaining three species constitute the last 3% (Tables 13 and 14). The vegetation on abandoned orchards is mainly made up of species used in the construction of lines, as invasive or as secondary fruit trees which are always present in small numbers in apple orchards (cherry, ash, walnut, elder). The consistency is variable depending on whether it is in a marginal or mono-cultural area, naturally being greater in the first case. Here, too, the most important Phytoseiid mite is *E. finlandicus* which makes up just over two thirds of the total population, slightly less than in the preceeding case. The presence of *T. pyri* and *A. andersoni* is higher and reaches about 30% in total, while *K. aberrans* completely disappears (Tables 13 and 14).

In mono-cultural areas there are only a few arboreal plants along the borders of

Table 15 - Collection of Phytoseiid mites on spontaneous flora.

Plant	Samples (abnd. / marg. / mono.)	Avg. mites/dm^2 (abnd. / marg. / mono.)	% Tp (abnd. / marg. / mono.)	% Aa (abnd. / marg. / mono.)	% Ka (abnd. / marg. / mono.)	% Ef (abnd. / marg. / mono.)	% Pt (abnd. / marg. / mono.)	% Pm (abnd. / marg. / mono.)
Apricot	1 1/0/0	0.233 0.233 / - / -	0.00 0.00 / - / -	11.11 11.11 / - / -	0.00 0.00 / - / -	88.89 88.89 / - / -	0.00 0.00 / - / -	0.00 0.00 / - / -
Ash	10 3/6/1	1.058 1.282 / 0.929 / 1.163	9.37 6.03 / 9.90 / 18.87	22.16 51.76 / 6.60 / 0.00	0.54 0.00 / 0.99 / 0.00	62.34 38.69 / 78.88 / 56.60	3.60 1.01 / 1.65 / 24.53	1.98 2.51 / 1.98 / 0.00
Birch	5 0/2/3	0.000 - / 0.000 / 0.000						
Bramble	6 1/3/2	0.625 0.965 / 0.395 / 0.801	68.91 87.88 / 20.69 / 82.46	17.65 0.00 / 65.52 / 3.51	0.00 0.00 / 0.00 / 0.00	9.24 12.12 / 0.00 / 12.28	4.20 0.00 / 13.79 / 1.75	0.00 0.00 / 0.00 / 0.00
Chestnut	3 0/3/0	0.361 - / 0.361 / -	1.85 - / 1.85 / -	3.70 - / 3.70 / -	0.00 - / 0.00 / -	94.44 - / 94.44 / -	0.00 - / 0.00 / -	0.00 - / 0.00 / -
Cherry	8 3/4/1	1.556 1.513 / 1.116 / 3.444	10.26 16.79 / 9.26 / 4.17	6.44 17.52 / 0.62 / 1.67	0.00 0.00 / 0.00 / 0.00	80.91 64.96 / 88.89 / 88.83	2.39 0.73 / 1.23 / 5.83	0.00 0.00 / 0.00 / 0.00
Dogwood	1 1/0/0	0.570 0.570 / - / -	29.63 29.63 / - / -	18.52 18.52 / - / -	0.00 0.00 / - / -	51.85 51.85 / - / -	0.00 0.00 / - / -	0.00 0.00 / - / -
Elder	11 4/3/4	0.750 1.128 / 0.635 / 0.460	12.08 6.84 / 9.03 / 30.36	19.18 6.84 / 21.53 / 50.00	0.00 0.00 / 0.00 / 0.00	65.54 85.34 / 67.36 / 8.93	3.20 0.98 / 2.08 / 10.71	0.00 0.00 / 0.00 / 0.00
Grapevine (abandoned)	2 0/2/0	0.285 - / 0.285 / -	32.61 - / 32.61 / -	17.39 - / 17.39 / -	0.00 - / 0.00 / -	45.65 - / 45.65 / -	4.35 - / 4.35 / -	0.00 - / 0.00 / -
Grapevine (cultivated)	2 0/0/2	0.253 - / - / 0.253	62.22 - / - / 62.22	26.67 - / - / 26.67	0.00 - / - / 0.00	0.00 - / - / 0.00	11.11 - / - / 11.11	0.00 - / - / 0.00
Hazelnut	3 1/1/1	0.012 0.000 / 0.000 / 0.035	0.00 - / - / 0.00	33.33 - / - / 33.33	0.00 - / - / 0.00	66.67 - / - / 66.67	0.00 - / - / 0.00	0.00 - / - / 0.00
Hop	3 0/0/3	0.409 - / - / 0.409	8.00 - / - / 8.00	60.00 - / - / 60.00	0.00 - / - / 0.00	32.00 - / - / 32.00	0.00 - / - / 0.00	0.00 - / - / 0.00
Linden	1 0/1/0	0.000 - / 0.000 / -						
Locust tree	4 0/2/2	0.246 - / 0.491 / 0.000	6.45 - / 6.45 / -	3.23 - / 3.23 / -	0.00 - / 0.00 / -	87.10 - / 87.10 / -	3.23 - / 3.23 / -	0.00 - / 0.00 / -
Oak	5 1/3/1	0.402 0.628 / 0.322 / 0.418	23.14 8.70 / 36.54 / 21.74	8.26 0.00 / 3.85 / 34.78	0.00 0.00 / 0.00 / 0.00	66.12 84.78 / 56.62 / 43.48	2.48 6.52 / 0.00 / 0.00	0.00 0.00 / 0.00 / 0.00
Plum	2 0/0/2	0.476 - / - / 0.476	66.27 - / - / 66.27	6.02 - / - / 6.02	0.00 - / - / 0.00	12.05 - / - / 12.05	15.66 - / - / 15.66	0.00 - / - / 0.00
Walnut	9 5/1/3	0.242 0.239 / 0.253 / 0.244	5.04 5.96 / 0.00 / 5.05	15.11 11.92 / 0.00 / 24.24	0.00 0.00 / 0.00 / 0.00	79.86 82.12 / 100.00 / 70.71	0.00 0.00 / 0.00 / 0.00	0.00 0.00 / 0.00 / 0.00
Willow	3 1/2/0	0.000 0.000 / 0.000 / -						

Abnd. = abandoned; marg. = marginal; mono. = mono-cultural

the roads (birch, walnut, locust tree, elder), or infesting ones or fruit trees within the lot (hop, bramble, plum tree). The bio-mass is negligeable though, with relation to that of cultivation. Here there are three species present: *E. finlandicus*, *T. pyri* and *A. andersoni* in decreasing order together with some specimen of *P. talbii* (Tables 13 and 14). The distribution of Phytoseiid mites on the natural flora of each type is constant in the three geographical areas with the exception of a greater presence of *A. andersoni* in the mono-cultural area of Villa di Tirano and in the abandoned areas of the High Valley, in the first case to the detriment of *T. pyri* and in the second of *E. finlandicus* (Table 13).

The picture that emerges is not very different to what has already been cited in literature. *A. andersoni* and *T. pyri* dominate on apple trees while on natural essences *E. finlandicus* dominates. The sub-division in types has given the opportunity to highlight some interesting variations. In abandoned fruit orchards there is a substantial increase of *E. finlandicus* which quickly becomes preponderant, probably as a result of its greater competitiveness, at least with regards to *T. pyri*, due to its greater size and speed and to a better distribution on the leaf (Chant, 1959). This change is proof again of the consistent passage of predators through the spontaneous essences and it is also very quick in marginal areas, concluding in a couple of years. In fact, only in the apple orchard Sant'Antonio, which was abandoned in 1998, you can still find the classic composition of cultivated fruit orchards (Table 7). The situation is different, though, when the abandoned orchards are located in mono-cultural areas. Here, as in the case of Tovo and Lovero orchards (Table 10), after five years there is still the predominance of *A. andersoni*, particularly evident in the first apple orchard, where the presence of arboreal plants is down to a few walnut trees. The smallest consistency of refuges made by this flora not only is not enough to allow the colonisation of the lot, but it even allows the settlement of an inverse flow from the apple tree to the spontaneous essences. This situation, as seen above, leads to the increase of *A. andersoni* and *T. pyri* which can take over also when they are present on plant species normally more in favour of *E. finlandicus*, as the cherry tree, walnut and elder. Paradoxically, for this reason, the lots out of production in a mono-cultural area can take on a more important role than of those located in marginal areas, since the abandoning of pest management techniques can lead to an increase of the populations of Phytoseiid mites which are more interesting for the cultivation. The importance of these lots cannot be overestimated though, since uncultivated areas resist for a short time as they are continually cleared and made ready for a new cultivation.

A clear difference was also found on apple trees between mono-cultural and marginal areas. In the first there is a dominance of *A. andersoni* in four apple orchards against the two which favour *T. pyri* (Tables 6, 9 and 12) which is the only dominant species in the second ones (Tables 5, 8 and 11). The assertion of *A. andersoni* in the more "difficult" mono-cultural territories depends on the fact that many active ingredients are less toxic for this species (Duso, 1997) and it is also capable of developing resistent strains more easily. It is possible that in marginal sectors the flow of preda-

tors from natural vegetation contributes to the lowering of the pressure of selection. In these conditions *T. pyri*, even if there is no greater movement, as it is in the same number of *A. andersoni*, can take over thanks to its greater competitiveness on apple trees. This is more evident in fresher areas and thanks to the better performance of *T. pyri* in containing Spider mites, *Panonychus ulmi* (Koch) in particular, as it is able to survive in presence of low densities of the phytophagous mites, which on the other hand can lead to the decline of *A. andersoni* populations (Genini *et al.*,1983; Johnsen & Hansen, 1986; Blommers & Overmeer, 1986 Strapazzon & Rensi, 1989). *E. finlandicus*, albeit more competitive and abundant on arboreal plants, is very sensitive to pesticides and is rapidly eliminated (Dabrowski, 1969; Solomon, 1982)

CONCLUSIONS

The presence of Phytoseiid mites on apple trees and on spontaneous plants adjacent to cultivated orchards does not depend on the geographic location of apple orchards while the type of lots and their cultural state has more influence on the qualitative than quantitative plan. The densities have not shown any great differences in the cultivation, being around 0.5 samples per dm^2 of leaf area. There is only a moderate increase in the "abandoned" lots on spontaneous essences distributed in all the three types taken into consideration. Populations of predators are always present on apple trees and they are permanent. Instead, in spontaneous vegetation there are species without predators as birch and willow, and others that are always colonised and with permanent populations such as the chestnut, cherry, ash and elder, and lastly some have a sporadic presence (hazelnut, locust tree) and/or temporary (walnut, bramble). Only in few cases (cherry, ash and elder) the Phytoseiid mites are remarkably more abundant than on apple trees.

The picture of the specific distribution is deeply diversified. *A. andersoni* and *T. pyri* dominate on apple trees. The first one prevails in mono-cultural areas, maybe thanks to its lesser sensitivity to pesticides; the second one prevails in marginal areas where, thanks to the flow from the surrounding flora, manages to compensate this disadvantage. However, when the cultivation is abandoned *E. finlandicus* coming from spontaneous plants asserts itself, which appears to be more competitive than the preceeding species as there is no pressure due to the pest management practices. There is a clear prevalence of *E. finlandicus* on the vegetation in the areas next to the apple orchards, except in mono-cultural areas where it is found together with *A. andersoni* and *T. pyri*. In this case there is an inverse movement from the apple tree to the other plants. In the agro-ecosystem there is therefore a double flow to and from the cultivation. The critical factor in determining the direction of the move is the volume of the bio-mass. In marginal areas the bio-mass of natural essences predominates, with moves towards the apple tree, while in mono-cultural areas the most considerable biomass is the one made by the apple tree and we can see an inverse movement.

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DR. IVO ERCOLE RIGAMONTI, PROF. GIUSEPPE CARLO LOZZIA - Istituto di Entomologia agraria. Università degli Studi di Milano, Via Celoria 2, I-20133 Milano (Italy).
E-mail: ivo.rigamonti@unimi.it, giuseppe.lozzia@unimi.it

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