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Observations on natural enemies of *Lobesia botrana* (Den. & Schiff.) (Lepidoptera Tortricidae) in Venetian vineyards (*)

Abstract - During the years 1989-1993 a study on the presence and the role of the natural enemies of *L. botrana* Den. & Schiff. in two vineyards of North-Eastern Italy was carried out. More than 30 species of parasitoids and numerous species of predators feeding on juvenile stages were collected. The most widespread species among the parasitoids were *Dicaelotus inflexus* Thomson, *Tranosemella prerogator* L., *Dibrachys affinis* Masi, *Itoplectis alternans* (Gravenhorst), *Pimpla spuria* Gravenhorst, *Campoplex capitator* Aubert, *Colpoclypeus florus* (Walker), *Elasmus steffani* Viggiani and *Phytomyptera nigrina* (Meigen). The predatory activity of insects and arachnids has been noticed particularly on overwintering stages. Even the pathogens (fungi, viruses and microsporidia) seem to be important in controlling the population density of *L. botrana*. Mortality rates due to the complex of natural enemies are variable in different vineyards, generations and years. The influence of pest management on the presence and activity of the beneficial organisms has been evaluated.

Riassunto - *Osservazioni sui nemici naturali di* Lobesia botrana *(Den. & Schiff.) (Lepidoptera Tortricidae) in vigneti veneti.*

Nel corso degli anni 1989-93 in due vigneti veneti sono state eseguite indagini sulla presenza ed il ruolo dei nemici naturali di *Lobesia botrana* Den. & Schiff.. Sono state identificate piú di 30 specie di parassitoidi ed una decina di predatori. Le specie piú abbondanti ed efficaci tra i parassitoidi sono risultate essere gli Icneumonidi *Dicaelotus inflexus*, *Tranosemella prerogator*, *Itoplectis alternans*, *Campoplex capitator*, *Pimpla spuria*, i Calcidoidei *Dibrachys affinis*, *Colpoclypeus florus* ed *Elasmus steffani* ed il Dittero Ta-

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chinide *Phytomyptera nigrina*. L'attività dei predatori è stata rilevata soprattutto nel corso della stagione invernale. Anche i patogeni quali funghi Deuteromiceti, virus e protozoi microsporidi sembrano avere una certa importanza come fattori di limitazione delle popolazioni di Tignoletta. I tassi di mortalità imputabili al complesso degli antagonisti naturali sono variabili nei differenti vigneti, anni, generazioni. In uno dei vigneti in esame è stata inoltre valutata l'influenza dei programmi di difesa sull'attività dei nemici naturali.

Key words: *Lobesia botrana*, predators, parasitoids, pathogens.

INTRODUCTION

The population dynamics of *Lobesia botrana* Den. & Schiff. are controlled by the action of abiotic and biotic factors. Although it is difficult to distinguish the role of the one from the others, it can be affirmed that biotic factors represented by predators, parasitoids and pathogens (fungi, protozoa, and viruses) have a significant importance upon biological control.

The presence and relevance of the natural enemies of *L. botrana* has been noted for some time. Starting in the second half of the nineteenth century (Levi, 1873) and successively in the first thirty years of the twentieth century, many Authors from several european countries studied the natural causes of mortality. Later, according to what can be deduced from existing literature, there was a loss of interest in research in this sector. It is only since the sixties that research on the importance of the natural enemies has received a new impulse due to the necessity to revalue the action of the natural enemies of *L. botrana*, which had been greatly damaged by the irrational use of pesticides.

In order to evaluate the role of natural enemies on the population density of *L. botrana*, in some Venetian vineyards an investigation was carried out both in a plain (characterized by a high level of infestation) and in a hilly area (where the presence of *L. botrana* was more limited).

MATERIAL AND METHODS

Research was carried out from 1989 until 1993 in a plain vineyard (Pernumia in the Padua province) with a surface area of about 1,5 hectares, formed by a late maturation cultivar (Raboso), and surrounded by apple, pear and peach orchards. The training system was «Sylvoz» with a grass growing area between the rows. For some years the pest management include two chemical treatments per year (chlorpyriphos-methyl). In the test parcel all insecticide treatments were eliminated.

Since 1990 research has been extended to a vineyard situated in a «Soave» wine area in the province of Verona (Colognola), with a surface area of about 5 hectares, formed of a medium maturation cultivar (Garganega) and surrounded by cherry, pear, plum and apricot orchards. The training system was horizontal with a grass growing area between the rows. Until 1987 *L. botrana* pest management were carried out by a means of two insecticidal treatments on the first and second generation. Successively a single treatment was carried out on the second generation using organophosphates.

In both designated areas the population density of *L. botrana* was evaluated by monitoring the adults' flight with the use of pheromon traps and sampling of the larval stages.

To evaluate the parasitization rate, periodically throughout each generation, samples of larvae and pupae were collected both from the bunches and from strip-traps placed on the vine trunks at the end of the season. The *L. botrana* specimens collected were separated into single test-tubes and reared in conditions similar to natural ones until complete development, awaiting the emergence of eventual parasitoids. The classification was handled by specialists.

The presence of oophagous parasitoids such as *Trichogramma* spp. was monitored by frequent controls in the field and by means of egg placement of *L. botrana* coming from laboratory rearing.

In the vineyards studied, many larvae and pupae of *L. botrana* appeared to be affected by diseases. The specimens found were treated by proper techniques in order to isolate and identify the pathogenetic causes of the diseases. The identification of pathogens was handled by specialists.

RESULTS AND DISCUSSION

Predators

Among the natural enemies of *L. botrana* the predators play an important control role which is not easy to quantify. During our field observations carried out both at the end of winter and in spring, we observed the predatory action of many spiders against juvenile stages of *L. botrana*, particularly the pupae, as reported by many Authors: Catoni (1910, 1914), Stellwaag (1928), Thompson (1964), Zangheri et al. (1987). The most frequently found species were: *Philaeus chrysops* (Poda) and *Salticus* sp. (Salticidae), *Chyrachanthium* sp. (Clubionidae), *Steatoda bipunctata* (L.) (Therididae). The mite *Allothrombium* *fuliginosum* L. (Thrombididae), was very abundant on vine bark and destroyed numerous pupae. The efficency of this mite was previously mentioned by Zangheri et al. (1987).

Many insects also were important predators of the juvenile stages of *L. botrana*, as mentioned by numerous Authors (Silvestri, 1912; Dobrodeev, 1915; Feytaud, 1913, 1917, 1924; Stellwaag, 1928; Causse et al., 1984; Delrio et al., 1987).

In the forementioned vineyards we observed *Forficula auricularia* L. (Dermaptera, Forficulidae) inside the nests of *L. botrana* eating both larvae and pupae. During winter, *Malachius* sp. (Coleoptera, Malachiidae) was very frequently found under the bark of the vine. It is a predator in the larval stage only. The larvae of *Chrysoperla carnea* (Steph.) and *Mallada prasinus* (Burn.) (Neuroptera, Chrysopidae) were collected in the vineyards. Subsequently their predatory activity against the eggs, larvae and pupae of *L. botrana* was verified in the laboratory.

First generation larvae of *L. botrana* were seen to have been completely empted by *Xanthandrus comtus* (Harr.) (Diptera Syrphidae) as previously observed by Lyon (1968) and Belcari & Raspi (1989).

In order to study the activity of the predators (particularly of the spiders) on overwintering pupae, monthly collections were made during the winter on the strip traps placed on the vine bark in autumn. The count of destroyed pupae showed that the predator activity diminished from the beginning of the winter onwards and started up again in spring.

Parasitoids

In both the Venetian vineyards we noticed a rich fauna of parasitoids (over 30 species) composed of Hymenoptera Ichneumonidae in particular and, to a lesser degree, of Braconidae and Chalcidoidaea. Few Diptera Tachinidae were also noticed.

Oophagous parasitoids (e.g. *Trichogramma* spp.) were never collected, neither from eggs in the wild nor from eggs coming from laboratory rearing and subsequently placed out in the vineyards.

Observations on biology and distribution of parasitoids are reported herewith.

ICHNEUMONIDAE Ichneumoninae *Dicaelotus inflexus* Thomson	BRACONIDAE Cheloninae *Ascogaster quadridentata* Wesmael
Pimplinae *Itoplectis alternans* (Gravenhorst) *I. tunetana* (Schmiedeknecht) *Pimpla spuria* Gravenhorst *P. turionellae* (Linnaeus)	Microgasterinae *Microplitis* sp. TORYMIDAE Monodontomerinae *Monodontomerus* sp.
Campopleginae *Campoplex capitator* Aubert *Tranosemella prerogator* (Linnaeus) *Venturia canescens* (Gravenhorst)	PTEROMALIDAE Pteromalinae *Dibrachys affinis* Masi *D. cavus* (Walker) *Habrocytus* sp.
Phygadeuontinae *Ischnus alternator* (Gravenhorst) *Gelis cinctus* (Linnaeus) *G. areator* (Panzer) *Agrothereutes abbreviator* Fabricius *Theroscopus hemipterus* Fabricius *Bathytrix decipiens* (Gravenhorst) *B. argentatus* (Gravenhorst)	EULOPHIDAE Eulophinae *Colpoclypeus florus* (Walker) *Sympiesis sandanis* (Walker) Tetrastichinae *Eutetrastichus amethystinus* (Ratz.)
Metopiinae *Triclistus albicinctus* (Thomson) *Exochus tibialis* Holmgren	Elachertinae *Elachertus affinis* (Masi)
Tryphoninae *Phytodiaetus* sp.	ELASMIDAE *Elasmus steffani* Viggiani
Cremastinae *Pristomerus vulnerator* (Panzer)	DIPTERA TACHINIDAE *Phytomyptera nigrina* (Meigen)

ICHNEUMONIDAE ICHNEUMONINAE

Dicaelotus inflexus Thomson

Information concerning the genus *Dicaelotus* as a parasitoid of *L. botrana* can be found in literature referring to the species *D. resplendens* Holmgren (Catoni,1910, 1914; Silvestri, 1912; Causse et al., 1984; Pinna et al., 1984; Delrio et al., 1987; Zangheri et al., 1987; Bagnoli, pers. comm.). In fact, a recent study of the specimen previously identified as *D. resplendens* by the above mentioned Authors, demonstrates that they must be attributed to *D. inflexus* only (Diller, Scaramozzino, pers. comm.).

D. inflexus is a primary, solitary, endophagous, pupal parasitoid of *L. botrana*. Other hosts are unknown.

According to Silvestri (1912) it is the last parasitoid to emerge from the overwintering pupae of *L. botrana* in spring.

DISTRIBUTION: France, Italy, Switzerland.

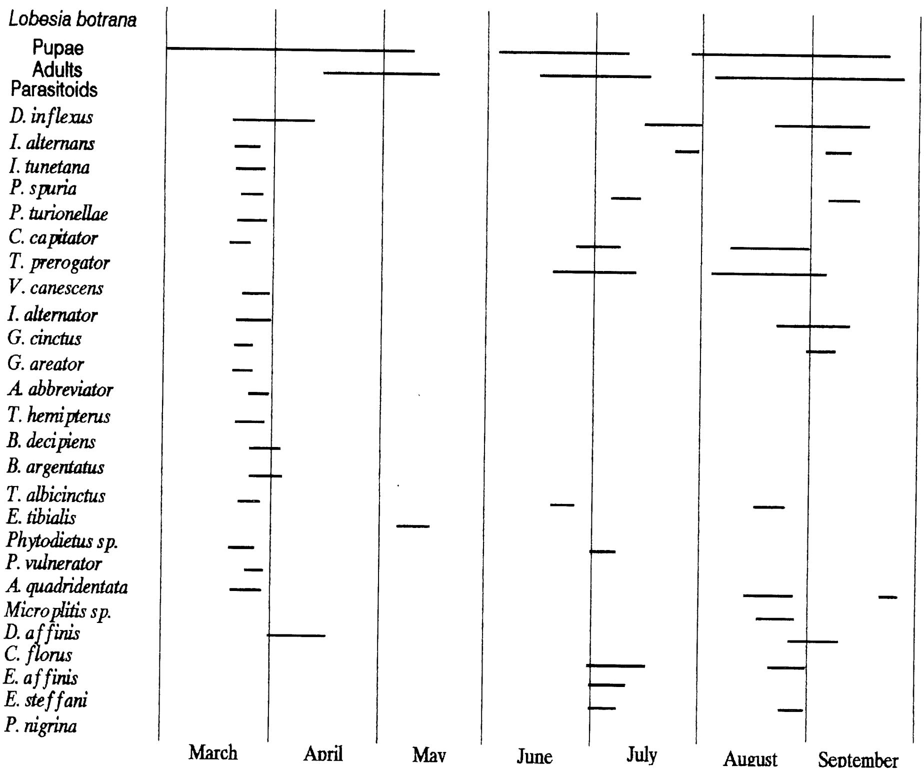

Fig. 1 - Adults flight of parasitoids in comparison to occurrence of pupae and adults of *L. botrana*, Pernumia (Padova).

Samples taken during the winter in the two vineyards showed that the species overwinters as mature larva inside the body of the pupae of *L. botrana*. It is only at the end of the winter that it pupates. *D. inflexus* attacks only the pupae of *L. botrana* but not the still alive and mobile larvae.
FLIGHT PERIODS: from the end of March until the first fortnight of April (from overwintering pupae); throughout the whole July (from first generation pupae); from the end of August to mid September (from second generation pupae) (figs. 1 e 2).

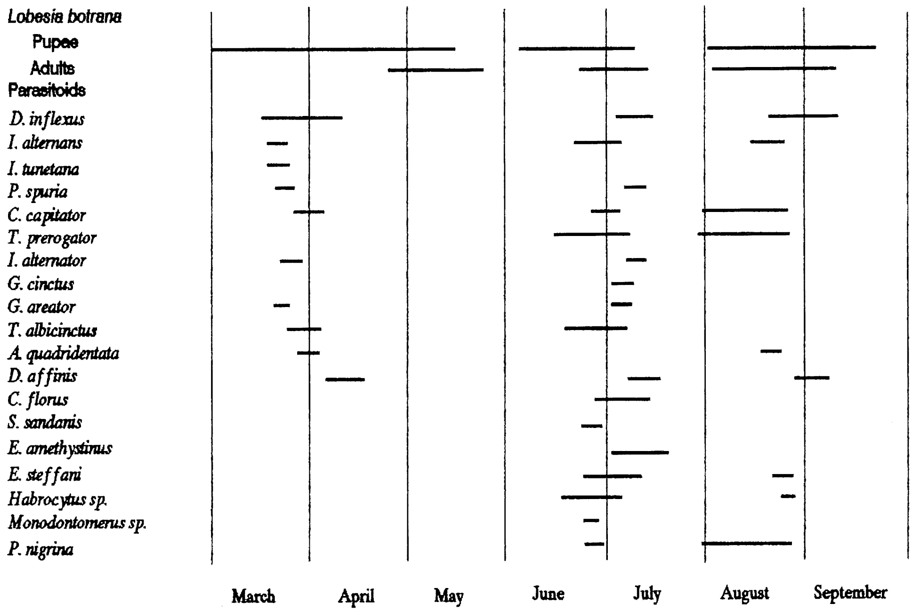

Fig. 2 - Adults flight of parasitoids in comparison to occurrence of pupae and adults of *L. botrana*, Colognola (Verona).

In spring *D. inflexus* emerges from the overwintering pupae of *L. botrana* 15-20 days before the beginning of flights, very early in comparison to the occurrence of the vulnerable stages of its hosts. Such behaviour could suggest two different hypotheses: the first is that *D. inflexus* may develop in spring on alternative hosts (Catoni, 1910, 1914; Silvestri, 1912; Schwangart, 1918), whereas the second (Silvestri, 1912) is that the fecundated females may lay eggs on the overwintering not yet parasitized pupae.

In order to verify the second hypothesis field experiments were carried out. In early autumn, 30-50 mature larvae were isolated by a gauze on the vines.

These larvae pupated quickly. At the end of the winter the pupae without protection were exposed to a natural parasitization. After a period of two weeks all the pupae were introduced into separate vials and were kept under observation. At the end of their development it appeared that 50% of the total number of the pupae had been parasitized. Adults of *D. inflexus* emerged in the second half of May. These observations show that the species can at least partially develop the spring generation on overwintering pupae of *L. botrana*, without searching for other hosts.

The longevity of *D. inflexus* females during spring was about 58 days. This period is certainly long enough to allow for oviposition on pupae or on mature larvae of the first generation. *D. inflexus* can complete a second generation on *L. botrana* due to such longevity.

On all the three generations, protandry was always observed (fig. 3).

SEX-RATIO: in favour of the females only in the third generation (tab. 3).

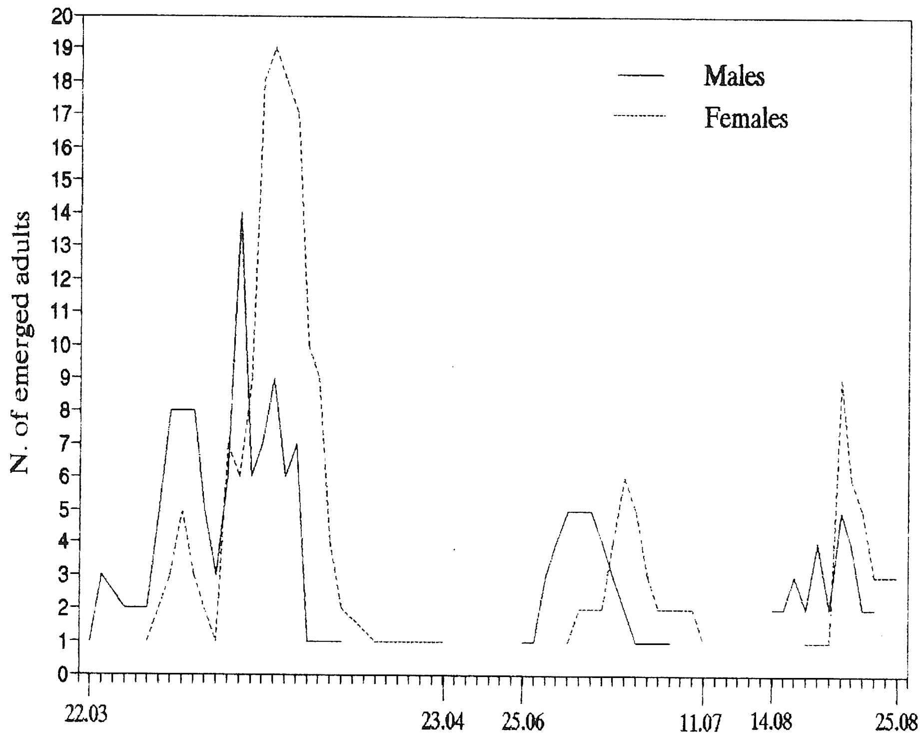

Fig. 3 - Emergence dates of males and females of *D. inflexus* during the three generations of *L. botrana* (1992). One can observe the protandry of the parasitoid.

PARASITIZATION RATES: in both vineyards *D. inflexus* was found to be one of the most important species. Overwintering pupae of *L. botrana* were attacked more (up to 41%) while later, in the spring and summer generations of *L. botrana*, parasitization was considerably reduced (from 1 up to 27%) (tabs. 1-2).

Table 1 - Mortality of juvenile stages of L. botrana *(% on total samples), Pernumia (Padova).*

Years	88-89	89	89	89-90	90	90	90-91	91	91	91-92	92	92	92-93
Generation	III	I	II	III	I	II	III	I	II	III	I	II	III
Samples number	345	115	287	298	102	435	362	101	205	1990	191	1069	5446
L. botrana emerged	35.36	47.83	61	36.91	45	73.1	25.34	41.59	73.65	61.7	57.6	86.6	39.75
Total mortality	64.64	52.17	39	63.09	55	26.9	74.66	58.41	26.35	38.3	42.4	13.4	60.25
Parasitoids	40.57	39.13	30	38.93	40.2	17.23	28.88	38.61	10.73	10.8	10.47	1.22	7.02
Predators	7.4	2.6	1.7	7.39		1.1	25.63		2.45	9.8	4.71	0.93	7.34
Entomopath. fungi	8.11			3.35			7.35			4.3		0.7	16.45
CPV + Microsp.	6.24	9.94	6.5	10.32	13.7	1.07	12	18.6	11.1	11.2	25.13	10.1	23.71
Others	2.32	0.5	0.8	3.1	1.1	1.5	1.07	1.2	2.07	2.2	2.09	0.37	5.73
Ichneumonidae													
D. inflexus	20	13.03	9.4	16.44	6.86	2.76	15.8		0.98	1.6	1.57	0.56	4.28
I. alternans	3.76	2.6	6.62	4.36						0.61			0.33
I. tunetana	0.57												
P. spuria	2.02	1.73		1.69		0.23	1.08			6.03			0.05
P. turionellae	0.3									0.1			
C. capitator	1.46	12.17	3.15	9.4	11.78	0.46							0.02
T. prerogator		8.7	0.35		9.8	4.13		23.76	5.37		5.23	0.19	
V. canescens				1									
I. alternator	0.57			0.33		1.15	5.44		3.41	2.01			0.06
G. cinctus	0.3		0.35	1						0.15			
G. aerator							0.27						0.02
A. abbreviator				0.33									
T. hemipterus	0.57												
B. decipiens	0.86												
B. argentatus	0.29												
T. albicinctus	0.3	0.9	1.4										
E. tibialis							0.3			0.3			0.36
Phytodietus sp.				1				0.99					
P. vulnerator				0.7									
Braconidae													
A. quadridentata	0.3		1.04	1		2.3	1.09					0.28	
Microplitis sp.			0.69										
Chalcidoidea													
D. affinis	8.33		2.3	1.42		2	4				2.1	0.19	0.61
D. cavus	0.97		0.5	0.26		0.3	0.6						
C. florus			2.44		9.8	3.44		9.9					
E. affinis							1.98						
E. steffani					1.96	0.23		1.98			1.57		
Diptera Tachinidae													
P. nigrina			1.76			0.23			0.97				

Table 2 - Mortality of juvenile stages of L. botrana *(% on total samples), Colognola (Verona).*

Years	89-90	90	90	90-91	91	91	91-92	92	92	92-93
Generation	III	I	II	III	I	II	III	I	II	III
Samples number	93	273	134	261	302	277	794	300	207	191
L. botrana emerged	18.28	38.46	53.74	26.82	46.03	68.53	19.4	41	51.2	33,5
Total mortality	81.72	61.54	46.26	73.18	53.97	31.47	80.6	59	48.8	66,5
Parasitoids	30,1	53.83	33.58	51.72	46.03	18.51	50.5	46.3	35.26	30,36
Predators	22.58		0.74	5.75	1	3.24	9.2			7,85
Entomopath. fungi	18.28			6.9		0.69	13.2	5.3	4.35	17,28
CPV + Microsp.	8.6	5.87	9.7	6.51	5.62	8.56	6.9	6.6	8.7	8,40
Others	2.16	1.84	2.24	2.3	1.32	0.47	0.8	0.8	2,61	
Ichneumonidae										
D. inflexus	18.28	0.74	2.25	40.23	22.18	9.95	41.2	19.6	27.05	20,94
I. alternans	1.07		0.74	0.38	3.32		0.38	3	0.48	
I. tunetana			0.74			4.4	0.25	1.7		
P. spuria	2.15			0.38	0.33		0.75	2		5,57
C. capitator		0.74	0.74	2.69	0.33		3.52			
T. prerogator		30,4	20,9		15.56	2.08		17.3	4.83	
I. alternator		0.36		0.38	0.33		1.64			
G. cinctus					0.33					
G. aerator		0.36		1.15			0.12			
T. albicinctus	2.14	0.36		0.38						
Braconidae										
A. quadridentata				1.15		0.47			1.45	2,61
Chalcidoidea										
D. affinis	6			4.63		0.46	2.64		0.97	1,05
D. cavus	0.46			0.35	1					
C. florus		1.46								
S. sandanis		0.73								
E. amethystinus		3.3	1.49		0.33					
E. steffani		11.72			0.33	0.23		1.7		
Habrocytus sp.		3.3			0.66	0.92				
Monodontomeurs sp.						0.33			1	
Diptera Tachinidae										
P. nigrina		0.36	6.72		1				0.48	

Table 3 - Sex-ratio of some species of parasitoids of L. botrana *calculated as percentage of females on the total number of reared specimens.*

Generations	I		II		III	
	Tot. N.	% fem.	Tot. N.	% fem.	Tot. N.	% fem.
D. inflexus	59	30	95	40	519	53
P. spuria					120	68
I. alternans	9	45	19	31.6	26	34.6
C. capitator					61	62
T. prerogator	159	60	68	48.5		
I. alternator					33	54.5
D. afinis					450	80
C. florus	72	64				
E. amethystinus	88	78				
E. steffani	200	72				
Habrocytus sp.	25	77				

Ichneumonidae Pimplinae

Itoplectis alternans (Gravenhorst)

Solitary, polyphagous, larvo-pupal endoparasitoid living on the pupae of many Microlepidoptera. Fitton et al. (1988) mentioned about 30 hosts. Evenhuis and Vlug (1983) mentioned it on apple leafrollers in orchards. It is very rarely found on the pupae of Macrolepidoptera, Coleoptera, Hymenoptera and Diptera (Fitton et al., 1988). Sometimes it lives as a hyperparasitoid (Aubert, 1969). It overwinters as a praepupa. It is reported for *L. botrana* by Catoni (1910, 1914), Silvestri (1912), Dobrodeev (1915), Schwangart (1918), Feytaud (1924), Telenga (1934), Thompson (1945, 1946), Zapryanov & Stoeva (1982), Delrio et al. (1987), Sengonca & Leisse (1988), Pinna et al. (1989) & Forti (1992).
Distribution: throughout Europe, Russia, China, Japan (Aubert, 1969).
Flight periods: at the end of March in the vineyard of Pernumia (from the overwintering pupae); at the end of June-beginning of July (from first generation pupae); first fortnight of September (from second generation pupae). Flight periods were anticipated slightly in the Colognola vineyards (figs. 1-2).
Sex-ratio: always in favour of the males in all the three generations (tab. 3).
Parasitization rates: Not very high in both vineyards (up to 6,5%). The species was more abundant in the Pernumia vineyard (tabs. 1-2).

Itoplectis tunetana (Schmiedeknecht)

Pupal endoparasitoid which mainly develops on Lepidoptera, but also on Hymenoptera and Coleoptera (Aubert, 1969). It has been reported on *L. botrana* by

Zapryanov & Stoeva (1982), Causse et al. (1984), Zangheri et al. (1987), Pinna et al. (1989). Females generally lay female eggs on large hosts and male eggs on small hosts (Aubert, 1969).
DISTRIBUTION: Tunisia, Algeria, France (Corsica included), Switzerland, Turkey, Iran, Hungary (Aubert, 1969) and Italy.

The species is mostly present in the Colognola vineyards on second generation pupae.
FLIGHT PERIODS: end of March (from the overwintering pupae) (fig. 2).
PARASITIZATION RATES: up to a maximum of 4,5% (tab. 1).

Pimpla spuria (Gravenhorst)

This is a polyphagous, solitary endoparasitoid living on the small pupae of many Lepidoptera and Coleoptera (Aubert, 1969; Fitton et al., 1988). It was collected on *L. botrana* by Catoni (1910, 1914), Dobrodeev (1915), Schwangart (1918), Feytaud (1924), Zapryanov & Stoeva (1982), Pinna et al. (1989).

This species can attack both the larval and pupal stages of all the generations of *L. botrana*. It develops two generations and overwinters as praepupa.
DISTRIBUTION: Germany, Italy, France (Corsica included), Finland, Great Britain, Austria, Rumania, Egypt, Canary Islands, Russia, Czechoslovakia and Bulgaria.
FLIGHT PERIODS: last ten days of March (from overwintering pupae); first ten days of July (from first generation pupae); first fortnight of September (from second generation pupae) (figs. 1-2).
SEX-RATIO: in favour of females in the third generation (tab. 3).
PARASITIZATION RATES: not very high (0 - 6%) on the overwintering pupae (winter 1991-1992) (tabs. 1-2).

Pimpla turionellae (Linnaeus)

Polyphagous, solitary, larvo-pupal endoparasitoid.
It can be reared easily in laboratory conditions. It probably overwinters also as an adult (Fitton et al., 1988). It is mentioned as a parasitoid of *L. botrana* by Catoni (1910, 1914), Silvestri (1912), Schwangart (1918), Causse et al. (1984), Delrio et al. (1987), Zangheri et al. (1987).
DISTRIBUTION: Austria, Germany, Sweden, Great Britain, Finland, Dalmatia, Rumania, Russia, Czechoslovakia, France, Balearic Islands, Spain, Algeria, Tunisia, Morocco, Japan. Imported to U.S.A. in 1906 (Aubert, 1969).
FLIGHT PERIODS: adults were reared from the overwintering pupae at the end of March only in Pernumia (PD) (fig.1).
PARASITIZATION RATES: only very few specimens were collected on the overwintering pupae (tab. 1).

Ichneumonidae Campopleginae

Campoplex capitator Aubert

A solitary, larval, endoparasitoid. It was reared from *L. botrana* by Coscolla (1981), and Bagnoli (pers. comm.). Lozzia & Rigamonti (1992) reported *Campoplex* sp.. Others Authors (Catoni, 1910, 1914; Telenga, 1934; Dobrodeev, 1915; Schwangart, 1929; Zapryanov & Stoeva, 1982) mention *C. difformis* Gmel., whereas Schmid (1978) and Baggiolini et al. (1966) report *C. mutabilis* Holmgren.
Distribution: Italy, Spain.
Flight periods: end of March (from overwintering pupae); end of June until beginning of July (from first generation larvae); throughout August (from second generation larvae) (figs. 1-2).
Sex-ratio: In favour of the females for the specimens reared from the overwintering pupae (tab. 3).
Parasitization rates: In the Pernumia vineyard during the years 1989-1990 *C. capitator* appeared to be particularly efficient against first generation larvae (about 12%). It was missing during the two subsequent years and has been substituted by *T. prerogator* belonging to the same family. In the Colognola vineyard important parasitization rates were not recorded (tabs. 1-2).

Tranosemella prerogator (Linnaeus)

This species is one of the most common primary, solitary endoparasitoids of the apple Tortricids (Evenhuis and Vlug, 1983). It is first recorded here as a parasitoid of *L. botrana*.
Flight periods: from the second fortnight of June to the first days of July (from first generation larvae); throughout August (from second generation larvae); missing in the third generation (figs. 1-2).
Sex-ratio: in favour of the females in the first generation and in favour of the males in second generation (tab. 3).
Parasitization rates: *T. prerogator* is particularly efficient against the first generation larvae (up to a maximum of 30%) (tabs. 1-2). It is also reared from second generation larvae but with lower parasitization rates. It is always missing on third generation larvae. This species can probably overwinter on alternative hosts.

A rich group of hyperparasitoids is associated with this species. They are the chalcidoids *E. steffani*, *E. amethystinus*, *Habrocytus* sp..

The juvenile stages of *T. prerogator* develop on the larvae of *L. botrana* completely destroying them. The larvae of *T. prerogator* may be parasitized by *E. steffani*, that can be parasitized in turn by *E. amethystinus*. The flights periods of these three species are reported on fig. 4. The emergence of the three parasitoids is sequential in time.

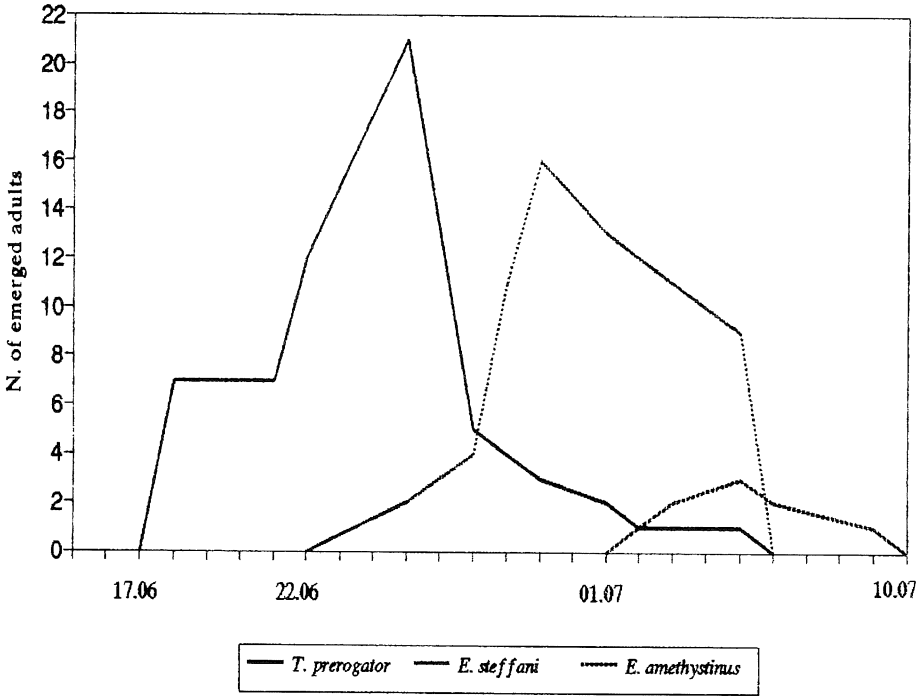

Fig. 4 - Adults flight of *T. prerogator* (primary parasitoid), *E. steffani* (secundary parasitoid) and *E. amethystinus* (tertiary parasitoid), Colognola (Verona), 1990.

Venturia canescens (Gravenhorst)

Common endophagous endoparasitoid of *Anagasta kuheniella* Zell. and other Lepidoptera living on stored products. Egg laying generally takes place on mature larvae. After reaching maturity the parasitoid pupates into a cocoon spun both inside and outside the host's larval skin, but always inside the host's silky cocoon (Frilli, 1965; Viggiani, 1977).

This species is recorded for the first time as a parasitoid of *L. botrana*. Few specimens have been reared from mature larvae of the third generation of *L. botrana* taken from the Pernumia vineyards.

Ichneumonidae Phygadeuontinae

Ischnus alternator (Gravenhorst)

Larvo-pupal parasitoid. The pupae of *L. botrana* parasitized by *I. alternator* are easily recognizable by the internal presence of a fine silky cocoon attached to the walls of the pupal skin.

This species has been reared on *L. botrana* by Catoni (1910, 1914), Feytaud (1913, 1917, 1924), Schwangart (1918), Coscolla (1981), Causse et al. (1984), Zangheri et al.(1987), Pinna et al. (1989) and Lozzia & Rigamonti (1991).
Distribution: Northern and Central Europe (Stellwaag, 1928).
Flight periods: In the Pernumia vineyard the last ten days of March (from overwintering pupae); from the end of August to the beginning of September (from second generation pupae). In the Colognola vineyard at the end of March (from third generation pupae); first ten days of July (from first generation pupae) (figs. 1-2).
Sex-ratio: in favour of the females in the third generation (tab. 3).
Parasitization rates: not very high, reaching the highest levels (about 5%) during the third generation only (tabs. 1-2).

Gelis cinctus (Linnaeus)

This species too is a hyperparasitoid associated with the same above mentioned hosts for *G. areator*. *G. cinctus* was mentioned by Zangheri et al. (1987) for *L. botrana* and by Priore (1975) for *Ostrinia nubilalis* Hb..
Flight periods: end of March (from overwintering pupae); first ten days of July (from first generation pupae) and first ten days of September (from second generation pupae) (figs. 1-2).
Parasitization rates: very low. Only a few specimens were collected (tabs. 1-2).

Gelis areator Panzer

Hyperparasitoid probably associated with *Itoplectis* spp., *Pimpla* spp. and maybe also with *D. inflexus*. This species has been mentioned on *L. botrana* by many Authors: Catoni (1910), Marchal (1906, in Stellwaag, 1928), Silvestri (1912), Dobrodeev (1915), Schwangart (1918), Delassus (1925, in Stellwaag, 1928), Zapryanov & Stoeva (1982), Causse et al. (1984). Pinna et al. (1989) report *Gelis* sp..
Distribution: throughout Europe, Algeria.
Flight periods: end March (from overwintering pupae); first ten days of July (from first generation pupae) (figs. 1-2).
Parasitization rates: very low. Only a few specimens were collected (tabs. 1-2).

Other species of Ichneumonids were found in the two vineyards, generally on the immature stages of the third generation of *L. botrana* with very low parasitization rates (not exceeding 1%).
Agrothereutes abbreviator (Pinna et al., 1989 report *Agrothereutes* sp.; Delrio et al., 1987 report *A. pumilus*).
Theroscopus hemipterus (Catoni, 1910; Schwangart, 1918; Delrio et al., 1987; Zangheri et al., 1987; Bagnoli, pers. comm.).
Bathytrix decipiens (Zangheri et al., 1987).
Bathytrix argentatus (Delrio et al., 1987; Pinna et al., 1989).
Triclistus albicinctus (Luciano et al., 1988 report *Triclistus* sp.; Delrio et al., 1987 report *Triclistus latidiventris* Ths.).
Exochus tibialis (Catoni, 1910, 1914; Schwangart, 1918; Pinna et al., 1989; Lozzia & Rigamonti, 1991).
Phytodiaetus sp. (Telenga, 1934; Luciano et al., 1988 report *Phytodiaetus segmentator* Grav.).
Pristomerus vulnerator (Telenga, 1934; Zapryanov & Stoeva, 1982; Delrio et al., 1987).

Braconidae Cheloninae

Ascogaster quadridentata Waesm.

A solitary endoparasitoid of many Lepidoptera particularly Tortricids. The females lay eggs inside the eggs of the hosts, whose larva develops very slowly without reaching maturity. When the larva of *A. quadridentata* is mature it comes out through the skin of its host and spins a fine silky cocoon inside which it pupates (Frilli, 1968; Viggiani, 1977). It has been reared frequently from *L. botrana* by Schwangart (1918), Telenga (1934), Kisakurek (1972), Zapryanov & Stoeva (1982), Luciano et al. (1988), Bagnoli (pers. comm.).
Distribution: throughout Europe.
Flight periods: end March (from third generation larvae); second half of August - first days of September (from second generation larvae). It has never been reared from larvae of the first generation probably because at the moment of its emergence the eggs of *L. botrana* are not yet available. It can be supposed that newly emerged adults search for other hosts (figs. 1-2).
Parasitization rates: not very high, varying from 0,3 up to 2,6% (tabs. 1-2).

Braconidae Microgasterinae

Microplitis sp.

Found only in the Pernumia vineyard in 1989 on second generation larvae. Schwangart (1918), Catoni (1910), and Ruscka & Fulmek (in Stellwaag, 1928) report *M.*

tuberculifera Wesm.. Baggiolini et al. (1966) report *M. brachycerus* Thoms.; Coscolla (1981) reports *Microplitis* sp..

Torymidae Monodontomerinae

Monodontomerus sp.

It can behave both as a primary and secondary parasitoid (Viggiani, 1977). According to Stellwaag (1928) it lives as an endoparasitoid in Lepidoptera pupae and as an ectoparasitoid in Diptera Tachinid pupae. Silvestri (1912) mentions *M. obsoletus* on overwintering pupae of *L. botrana.*
Parasitization rates: very low (0,3-1%). A few specimens were collected in the Colognola vineyard only on pupae of the first generation (tab. 2).

Pteromalidae Pteromalinae

Dibrachys affinis Masi

A primary, gregarious endoparasitoid or hyperparasitoid on the larvae and pupae of Lepidoptera and Diptera (Thompson, 1958; Grahm, 1969; Viggiani, 1977). During the summer it develops in 23 days. It is common on the overwintering pupae of *L. botrana* (Catoni, 1910, 1914; Silvestri, 1912; Schwangart, 1918; Voukassovitch, 1922, 1924b; Coscolla, 1981; Causse et al., 1984; Delrio et al., 1987; Zangheri et al., 1987; Pinna et al., 1989; Bagnoli, pers. comm.). It is possible to obtain up to 14 specimens (average 6) from each pupa.
Distribution: Italy, France, Spain, Austria, Great Britain, Algeria (Grahm, 1969).
Flight periods: first fortnight of April (from overwintering pupae); second ten days of July (from first generation pupae); end August – first days of September (from second generation pupae) (figs. 1-2).
Sex-ratio: in favour of the females in the third generation (Tab. 3).
Parasitization rates: varying in the two vineyards and during the different generations (tabs. 1-2). The highest mortality rates were noticed on overwintering pupae. Although *D. affinis* is the last parasitoid to emerge in spring it always emerges earlier than the first appearance of the vulnerable hosts of the first generation of *L. botrana*. Similarly , as observed on *D. inflexus*, it seems that *D. affinis* may continue to develop by parasitizing the unparasitized overwintering pupae. This hypothesis has been verified through experiments carried out in natural conditions by placing the pupae of *L. botrana* and adult females of *D. affinis* together in a cage. Over 50% of the *L.botrana* pupae were parasitized. The length of juvenile development varies from 48 to 62 days in spring. The parasitoid could continue developing other generations on the juvenile stages of the first generation of *L. botrana*, without searching for other alternative host.

Dibrachys cavus (Walker)

A polyphagous, gregarious, larvo-pupal endoparasitoid, frequently mentioned as a secondary parasitoid on pupae of Ichneumonids, Braconids and Chalcidoids parasitoids of Lepidoptera and Coleoptera. *D. cavus* can also be a primary parasitoid of larvae. It has also been reared from pupae of Diptera Tachinidae (Grahm, 1969). It has been reported on *L. botrana* by Catoni (1910), Silvestri (1912), Jordan, (1916), Schwangart (1918), Coscolla (1981), Zapryanov & Stoeva (1982), Causse et al. (1984), Delrio et al. (1987), Pinna et al. (1989), Bagnoli (pers. comm.). *D. cavus* often behaves as a secondary pseudoendophagous parasitoid: the females lay eggs outside the body of the larvae of the primary parasitoid, but inside the body of the pupa of *L. botrana* (Silvestri, 1912; Viggiani, 1977).

As we have observed in both vineyards, *D. cavus* parasitizes the juvenile stages of *I. alternator* and *T. prerogator*.

DISTRIBUTION: throughout Europe; also present in Canada, U.S.A., China, Korea, Northern Africa, Uruguay (Graham, 1969).

FLIGHT PERIODS: first ten days of April (from overwintering pupae), end of June beginning of July (from first generation pupae) (figs. 1-2).

PARASITIZATION RATES: very low (not over 1%) (tabs. 1-2).

Habrocytus sp.

This is one of the hyperparasitoids associated with *T. prerogator*. It was reared from the larvae of *L. botrana* of the first and second generation in the Colognola vineyard only.

Catoni (1910, 1914) and Schwangart (1918) mention two species: *H. punctiger* Thoms. and *H.acutigena* Thoms. as hyperparasitoids of *L. botrana*.

FLIGHT PERIODS: beginning of July (from second generation larvae) (fig. 2).

SEX-RATIO: in favour of the females in the first generation (Tab. 3).

PARASITIZATION RATES: reaching a maximum of 3% (tab. 2).

EULOPHIDAE EULOPHINAE

Colpoclypeus florus Wlk.

A gregarious, larval ectoparasitoid living on many species of Lepidoptera particularly Tortricids (leafrollers) (Lucchese, 1945, Janssen, 1958; Bouceck & Askew, 1968; Panizza-Dalla Montà & Ivancich-Gambaro, 1973; Gruys & Vaal, 1984; Van Veen et al., 1985; Dijkstra, 1986). It was reported on *L. botrana* by Dalla Montà (1984), Zangheri et al. (1987) & Luciano et al. (1988). It overwinters as mature larva and can develop up to a maximum of 8 generations per year.

DISTRIBUTION: all eastern palearctic regions.

It has been reared in both vineyards from the larvae of the first and second generation of *L. botrana*.
FLIGHT PERIODS: first fortnight of July (from first generation larvae); end of August-first ten days of September (from second generation larvae) (figs. 1-2).
SEX-RATIO: in favour of the females in the first generation (tab. 3).
PARASITIZATION RATES: up to a maximum of about 10 during the first generation. From 1,5 up to 3% in the second generation (tabs. 1-2).

Sympiesis sandanis (Walker)

An ectoparasitoid of the larvae and pupae of Lepidoptera Gracillaridae and Tortricidae (Boucek & Askew, 1968).

It was first recorded as a parasitoid of *L. botrana*. Only a few specimen were collected on first generation *L.botrana* larvae in the Colognola vineyard (tab. 2).

EULOPHIDAE TETRASTICHINAE

Eutetrasthychus amethystinus Ratzeburg

Generally a solitary, primary endoparasitoid of the larvae and pupae of Lepidoptera (leafminers) or a hyperparasitoid on many species of Hymenoptera Chalcidoids (Domenichini, 1966). Silvestri (1910) reared it from *Elasmus flabellatus* (Fonscolombe) on *Prays oleae* Bernardi. Adults emerge in April-May and many generations develop continously until October-November (Viggiani, 1963).
DISTRIBUTION: Great Britain, Italy, Germany, Switzerland, Austria, Czhechoslovakia, Hungary, Moldavia (Domenichini, 1966).

The species was recorded for the first time as a hyparparasitoid of *L. botrana*. It was reared from the pupae of *E. steffani* (parasitoid of *T. prerogator*) only in the Colognola vineyard. *E. amethistinus* is therefore a tertiary parasitoid of *L. botrana*.
FLIGHT PERIODS: first 20 days of July (from first generation larvae); between the end of August and the beginning of September (from second generation larvae) (fig. 1).
SEX-RATIO: in favour of the females in the first generation (tab. 3).
PARASITIZATION RATES: rather low (from 0,3 up to 3,3) (table 1).

EULOPHIDAE ELACHERTINAE

Elachertus affinis Masi

A gregarious ectoparasitoid of the mature larvae of Lepidoptera Tortricidae (Silvestri, 1912; Colizza, 1927). This species is reported as a hyperparasitoid of *L.*

botrana by Masi (1911), Silvestri (1912), Stellwaag (1928), Coscolla (1981), Delrio et al. (1987); Pinna et al. (1989); Bagnoli (pers. comm.).
DISTRIBUTION: Italy, France, Hungary, Morocco (Bouceck & Askew, 1968), Spain (Coscolla, 1981).
FLIGHT PERIODS: first half of July (from first generation larvae) (fig. 1).
PARASITIZATION RATES: a few specimens were reared in the Pernumia vineyard only from first generation larvae (tab. 1).

ELASMIDAE

Elasmus steffani Viggiani

By studying some specimens of *Elasmus* sp. reared from *L. botrana*, Masi (1907) identified them as *Elasmus flabellatus* (Fonscolombe). Later Silvestri (1912) and Ferrier (1947) redescribed the species as *E. flabellatus*, while Steffan (1962) studied the «typus» of Fonscolombe at the Museum National d'Histoire naturelle de Paris and classified the specimens described by Masi not as *E. flabellatus* but as a new species which he called *E. masi*. More recently Viggiani (1967) changed the name *E. masi* into *E. steffani*.

E. steffani is a parasitoid of the Ichneumonid *T. prerogator* and it is, in turn, parasitized by the Chalcidoid *E. amethistinus*. It is reported by Silvestri (1912), Mercet (1917), Bagnoli (pers. comm.) as *E. flabellatus*.
DISTRIBUTION: Italy, Spain.
FLIGHT PERIODS: end of June-first ten days of July (from first generation larvae); second half of August (from second generation larvae). (figs. 1-2). The females of *E. steffani* emerge 30 days before the males.
SEX-RATIO: in favour of the females in the first generation (tab. 3).
PARASITIZATION RATES: very variable. From 0,23% up to 11,72% correlated to the population density of *T. prerogator* (tabs. 1-2).

DIPTERA TACHINIDAE

Phytomyptera nigrina (Meigen)

Very polyphagous species. It is reported as a parasitoid of Lepidopteran larvae, particularly Tortricids. It is mentioned as a parasitoid of *L. botrana* by Catoni (1910, 1914), Silvestri (1912), Dobrodeev (1915), Feytaud (1924), Laccone (1979), Coscolla (1981), Nuzzaci & Triggiani (1982), Luciano et al. (1988), Bagnoli (pers. comm.). The females lay eggs on the integument of *L. botrana* larvae (Silvestri, 1912; Mellini, 1954). The newly hatched larvae penetrate into the hemocoel feeding on the reserve substances of the host at first and later, when the victim begins to spin its cocoon, also on vital organs. On maturity the parasitoid spins a puparium wrapped by the victims skin.
DISTRIBUTION: Southern and Central Europe.
FLIGHT PERIODS: throughout June (from first generation pupae); throughout August (from second generation pupae) (figs. 1-2).

PARASITIZATION RATES: rather low for the first generation (0,6-1%); higher for the second generation (up to 6,72%) (tabs. 1-2) in the Colognola vineyard.

Pathogens

The population density of *L. botrana* is also regulated by the action of pathogens.

Several species of entomopathogenic fungi and a Cytoplasmic Polyedrosis Virus (CPV) associated with a Protozoa Microsporidia were isolated from the juvenile stages of *L. botrana* collected in both vineyards and during different periods of the year and classified.

Fungi

The importance of fungi as limiting factors of *L. botrana* population density has been noticed, particularly on overwintering pupae, by many Authors: Catoni (1910), Dobrodeev (1915), Paillot (1913, 1917), Voukassovitch (1922), Stellwaag (1928), Deseo et al. (1981), Pinna et al. (1989).

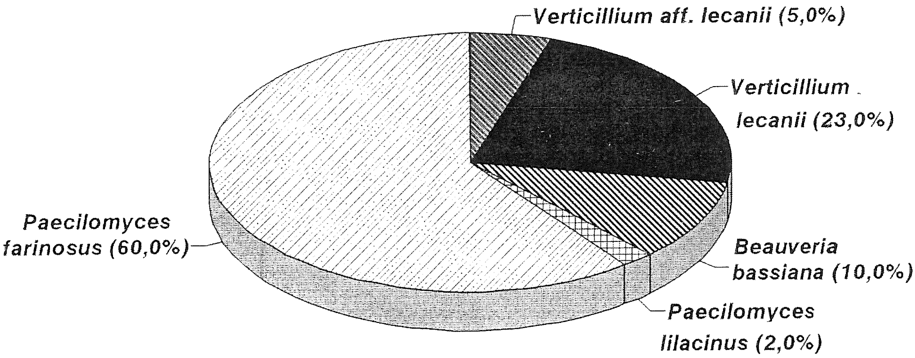

Fig. 5 - Mortality rates of juvenile stages of *L. botrana* caused by different fungi during winter 1991-1992.

The species of fungi noticed in both vineyards are: *Paecilomyces farinosus* (Holm: Fr.) Brown & Smith, *Verticillium lecanii* (Zimm.) Viegas, *Beauveria bassiana* (Balsamo) Vuill., *Verticillium* aff. *lecanii*, *Paecilomyces lilacinus* (Thom.) Samson. The mortality rates caused by these species are represented in fig. 5.

Among these fungi *P. farinosus* plays an important role in the mortality factor.

Cytoplasmic Polyedrosis Virus

The juvenile stages of *L. botrana* collected in both vineyards were found to be contaminated by a CPV. That virus was observed for the first time on *L. botrana* in 1978 by Deseö et al. (1979). The infected larvae look swollen and glossy, slow down their development and die prematurely. Dissected larvae show a white colored mesenteron with greenish masses. The pupae show considerable deformations and a greenish color. Inside they seem half empty with small black-greenish masses. Adults show a swollen and greenish abdomen (Deseö et al., 1980-81).

Protozoa Microsporida

A microsporidian Protozoa, *Pleistophora legeri* (Paillot) has frequently been noticed as being associated with the CPV in the cytoplasm of the mesenteron cells of *L. botrana*. It was observed for the first time on *L. botrana* in France by Paillot (1941) and classified as *Mesnilia legeri*. Later the genus *Mesnilia* changed to *Pleistophora* (Lipa, 1982) and the occurrence of this disease has been noticed in all European vine growing areas (Lipa, 1982; Lipa & Deseö, 1987). The Microsporidia cause a chronical but not mortal disease, which weaken's the insects resistence to other pathogens and adverse environmental conditions. The symptoms of the disease are not specific: the larvae feeding and growing slow down. The pupae show a darker cuticle (Deseö et al., 1980). The synergic action of the two pathogens causes the fast death of the host and consequently an important decrease in the population density of *L. botrana*.

The data concerning the two localities and the different generations of *L. botrana* are discussed separately.

The Pernumia vineyard

THIRD GENERATION (OVERWINTERING GENERATION). Biotic mortality factors noticeably affect the population density of *L. botrana*. Mortality rates varying from 38,5% up to 74,66% were observed. Parasitoids represent the most important cause of mortality. Among these the Ichneumonid *D. inflexus* predominates. During the first three years it showed a parasitization level of 20%, 16.44%, and 15,8%. During the fourth and fifth years the levels of parasitization declined. The parasitization level due to the Pteromalid *D. affinis* was variable during the first three years (8,33%, 1,42% and 4,62%). After which *D. affinis* was missing in the last two. *I. alternans* and *C. capitator* were more efficent against overwintering pupae during the first two years. *I. alternator* was always present and it appeared to be more abundant during the winters of 1990, 1991 and 1991, 1992 (5.44%, 2.01%).

Many other species were reared from a few collected samples (table 1); however some of these, that behave as hyperparasitoids (as *Gelis* sp., *Bathytrix* spp., *D. cavus*), play an important role in the natural balance.

Predator activity was more significant during the third year, in particular, whereas during the other years it was less so.

Pathogenic fungi are efficient only against overwintering pupae and particularly during the first, the third and the last year.

The efficiency of CPV and Protozoa also seems to be important against the overwintering pupae (6% - 23,7%).

First generation. The mortality rates caused by biotic factors are equal to about 50% (tab. 1). During the first three years the parasitoids were responsible for a mortality rate of 40%, while subsequently their activity was reduced (10.5%). During the first generation the larval parasitoids, *C. capitator* and *T. prerogator*, were dominant, while the larvo-pupal parasitoids, *D. inflexus* and *I. alternans*, were less important. Among the Chalcidoids, the occurrence of *C. florus* (10%) and *E. steffani* (hyperparsitoid of *T. prerogator*) was noticeable. Hymenopteran Braconids and Dipteran Tachinids were missing.

It is difficult to quantify the importance of predators. Therefore the data shown in the tab. 1 are only indicative.

It has been possible to evaluate the incidence of CPV and Microsporidia (from 1 to 25%) in constant increase between the years 1989 and 1992.

Second generation. Mortality rates recorded for this generation result as being the lowest (tab. 1). It is interesting to observe the progressive reduction of mortality caused by parasitoids over the four years. During the first three years a decrease of *D. inflexus* and at the same time an increase of *T. prerogator* were noticed. This tendency underwent a reversal during the course of the third year. The Braconid *A. quadridentatus* and the Chalcidoids *D. affinis* and *C. florus* showed low parasitization rates. The Tachinid *P. nigrina* was present during the second generation only.

Although not very numerous, predators were active throughout the 4 years.

The role of CPV and Microsporidia (from 6.5% to 11%) is moderately important.

The Colognola vineyard

The highest mortality rates were observed during the third generation in this vineyard also, the lowest during the second, while those relative to the first generation are to be found in an intermediate position (tab. 2).

Third generation (overwintering generation). The predominant role was held by parasitoids (with a percentage of parasitization reaching 51%), the most important being *D. inflexus*. Other Ichneumonids were present with a variable rate of parasitization. A moderate role is held by Chalcidid *D. affinis* (from 1 to 6%). The efficency of predators, fungi and CPV with Microsporidia varied through the years but was more consistent during the first year.

FIRST GENERATION. The mortality rates due to *D. inflexus* were noticeably lower with respect to those found during the third generation. On the other hand the presence of other Hymenoptera was noted (*T. prerogator* and other Chalcidoids associated with it). Other species of parasitoids were found to be of little relevance with regard to the population control measures of *L. botrana*. Few specimens of Diptera Tachinidae were collected on larvae of this generation, contrary to what was noted at the Pernumia vineyard.

With regard to CPV and Microsporidia the percentage of parasitization resulted as being constant through the years (around 6%).

SECOND GENERATION. Among the larvo-pupal parasitoids *D. inflexus* still remained predominant. *P. nigrina* was predominant among the larval parasitoids and only during the first year.

With regard to other biotic mortality factors the action of control brought about by CPV associated with Microsporidia remained constant over the years, while that due to predators and fungi varied.

Influence of treatments on natural enemies

Observations carried out on the three generations of *L. botrana* in the Colognola vineyard during the years 1991-1992 highlighted the varying incidence of treatments on the activity of the entomophagous species. The vineyard was divided into two parcels: the first was treated by means of methylparathion (MP) (over the last five years 2 treatments per year, on the first and second generations) and the second has been treated by means of *Bacillus thuringiensis* Berliner (BT) (2 treatments against the second generation). In the area treated by means of MP, the parasitization levels were noticeably lower than those in the area treated by means of BT (tab. 4).

The biotic factors which were most influenced by the treatments were the parasitoids, while the pathogens were affected far less.

An analysis of the data reported in table 3 shows that the decrease in parasitization levels is correlated to the use of methylparathion. The side effect of MP consists in a quantitative and qualitative variation of the composition of the auxiliary fauna. In all the generations, the mortality rates of the juvenile stages of *L. botrana* due to parasitoids and predators noticed in the BT parcel, were higher than those noticed in the MP parcel. On the other hand, the total mortality in the third generation was nearly equal in the two parcels (66,5% and 56%) because it included the action of pathogens, which are not influenced by chemical treatments. The results of these first observations show that the use of a biological insecticide, such as BT, allows *L. botrana* to be efficaciously controlled thus the auxiliary fauna is protected.

Table 4 - Mortality of juvenile stages of L. botrana *in vineyards treated by means of* B. thuringiensis *(BT) and methyl-parathion (MP), Colognola (Verona), 1992.*

Generations	I		II		III	
Insecticides	BT	MP	BT	MP	BT	MP
Samples number	300	153	207	187	191	191
L. botrana emerged	41	70	51.2	76	33.5	44
Total mortality	59	30	48.8	24	66.5	56
Parasitoids	46.3	21.5	35.26	11.74	30.4	18.3
Predators					7.8	4.7
Entomopath. fungi	5.3	3.9	4.35	3.2	17.3	24
CPV + Microsp	6.6	4.6	8.7	7.46	8.4	7.3
Others	0.8		0.49	1.6	2.6	1.7
Ichneumonidae						
D. inflexus	19.6	11.11	27.05	8.55	21	15.2
I. alternans	3		0.48			
I. tunetana	1.7	0.64				1
P. spuria	1	1.95			5.7	
T. prerogator	17.3	6.52	4.83			
Braconidae						
A. quadridentata			1.45	1.07	2.7	
Chalcidoidea						
D. affinis						2.1
E. steffani	1.7					
Monodontomerus sp.	1	0.64				
Diptera Tachinidae						
P. nigrina		0.64	0.48	2.14		

CONCLUSIONS

Research carried out has shown that biotic mortality factors regulate the population density of *L. botrana* to a great extent at times. The mortality of the juvenile stages is influenced by the predominant activity of parasitoids, added to which are other factors such as predators and pathogens. Although the role of predators is generally difficult to quantify, it seems to be of minor importance compared to that of other natural enemies. It was possible to observe a considerable activity of insects and arachnids on the overwintering stages. Among the pathogens, fungi are above all active on overwintering pupae while viruses and microsporidia are active on the juvenile stages of all the generations.

Among the parasitoids found (more than 30 species) there was seen to be a certain variability both with regard to the numbers of the species and the rates of parasitization. On the other hand there does not appear to be any relationship between the population density of *L. botrana* and the rates of parasitization. The most widespread species were *D. inflexus*, *D. affinis*, *T.*

prerogator and *C. capitator*. Other species were present with low parasitization rates. In any case they contributed to lowering the population density of *L. botrana*. Together with primary parasitoids, the presence of hyperparasitoids was noticed. According to literature, the highest mortality rates were to be found on overwintering pupae, while the lowest were observed on the juvenile stages of the second generation.

The observations carried out in the two localities during different years show that every wine-growing area forms a complex ecosystem with its own shape and dynamics, where the relationship between the phytophagous insect and its natural enemies is in continuous evolution.

It has also been noticed that, over the years, a decrease in the activity of the parasitoids corresponds to an increase in that of other natural enemies in particular fungi and CPV capable of controlling the population density of *L. botrana*. The use of insecticides seems to have had a great influence on this delicate and complex balance. In fact, in the vineyards where only biological methods were used (e.g. BT), the percentage of parasitization is considerably higher. The presence of natural enemies, although not decisive for the biological control of *L. botrana* in the short term, neverthless carries out an important action which must be defended and increased through the use of biological and integrated control methods.

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