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The complex of parasitoids of the feeding larvae of *Cydia pomonella* L. (Lep.: Tortricidae)

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By rearing of active caterpillars (in the feeding process) of *Cydia pomonella* L., collected in 1996 from two ecosystems around the city of Iaşi (Romania), 5 hymenopteran species were obtained as primary parasitoids: *Pristomerus vulnerator* PANZ., *Liotryphon crassisetus* THOMS., *L. punctulatus* RATZB. (Ichneumonidae), *Ascogaster quadridentata* WESM. and *Microdus rufipes* NEES (Braconidae). 2 species were recorded as secondary parasitoids: *Perilampus tristis* MAYR (Perilampidae) and *Baryscapus talitzkii* (KOST.) (Eulophidae). *P. vulnerator* is the most important component of this parasitic complex, both by its presence and by the high values of the parasitism ratio (9.2–28.1 % recorded in Iaşi-Şorogari and 3.3–5.5 % in the Iaşi-city). *P. tristis* was obtained from *P. vulnerator*, *A. quadridentata* and *M. rufipes*, with *A. quadridentata* as the preferred host, the highest parasitism ratio, recorded in Iaşi-Şorogari, being of 66.7 %.

Keywords: Apples, codling moth, active larvae, parasitoids, hyperparasitoids.

INTRODUCTION

In apple and pear orchards, the codling moth, *Cydia pomonella* L. (Lep.: Tortricidae) acquires a special economic importance, because the climatic conditions of Romania impose the application of 4–8 phytosanitary treatments in order to maintain the populations under the economic threshold of damage. The level of the attack of such a pest is higher in the intensive orchards where the high number of treatments with insecticides applied destroys, at the same time, most of the useful entomofauna.

It is generally known that the most efficient natural enemies of the codling moth are the oophagous ones, such as some parasitoid species of *Trichogramma* (Hym.: Trichogrammatidae) or some predatory species belonging to certain arthropod orders (Heteroptera, Neuroptera, Acarina, etc). Of special practical importance in increasing the biological control of this pest are the trichograms – as they can be reared at the expense of some laboratory (substitute) host eggs. However, the elaboration of some efficient biological methods for the codling moth's control should also consider the part played by the whole complex of natural enemies of this pest.

Up to now, in Romania 10 parasitoids have been recorded, including 8 ichneumonid species (*Centeterus oprimator* GRAV., *Itoplectis alternans* GRAV., *Liotryphon caudatus* RATZB., *L. crassisetus* THOMS., *L. punctulatus* GRAV., *Pimpla contemplator* MÜLL., *P. turionellae* L., *Pristomerus vulnerator* PANZ.) (PISICĂ, 1983; PISICĂ & DIACONU, 1997) and 2 braconid species (*Ascogaster quadridentata* WESM., *Microdus rufipes* NEES) (PĂTRĂŞCANU, 1968).

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The present paper analyses the parasitoids obtained from the rearing of feeding larvae collected from attacked apples.

MATERIAL AND METHODS

In the summer and autumn of 1996, starting with July 1, attacked apples were collected before the first caterpillars started leaving the feeding place to pupate, until harvesting or until the fruits' physiological falling. The sampling was made in the city of Iași, situated in the northeastern part of Romania, in the Central Moldavian Plateau. One of the sampling sites, Iași-Șorogari, situated on the outskirts of the city, consists of a mixture of fruit bearing and forest trees, created for the consolidation of a slope against landslides. Among the most frequent species are those belonging to *Pinus*, *Malus*, *Pyrus* and *Prunus*. Fruit were also harvested in a private, small orchard, placed inside Iași city limits.

Dissection of the attacked fruit allowed the separation of caterpillars of various ages and their subsequent rearing on a natural diet, in glass or plastic tubes (5–10 cm in diameter and 30–40 cm long) into which the healthy fruit had been previously introduced. Also, into the tubes we introduced 1–2 bands of corrugated cardboard – acting as shelters for the caterpillars leaving the feeding place.

The caterpillars were recorded and grouped – depending on the tube diameter and their age (appraised by the length of their body, i.e. below 1 cm, between 1–1.5 cm and over 1.5 cm), 15–30 individuals in a tube. Usually, the young caterpillars were resupplied with fresh fruit – once or even twice – up to their complete development.

The rearing of caterpillars and maintenance of the corrugated cardboard shelters up to the appearance of *C. pomonella* adults or of parasitoids took place in a room where the temperature and air's relative humidity were similar to the normal ones. The caterpillars already parasitized at the moment of fruit dissection were isolated and observed until the apparition of the respective adult parasitoids.

The dynamics of the apparition of *C. pomonella* and parasitoid adults from the collected material was monitored on a daily basis, while the host's natural flight was recorded by means of traps with Atra-POM synthetic sexual pheromones.

RESULTS AND DISCUSSION

Out of the 794 active feeding *C. pomonella* caterpillars collected in 1996 we obtained 5 species of primary parasitoids belonging to the Hymenoptera. Among them 3 species belong to the Ichneumonidae and 2 species to the Braconidae.

Also, 2 species of secondary parasitoids belonging to Perilampidae and Eulophidae (Chalcidoidea), have been recorded.

The parasitoid species as well as the parasitoid-host relationships are listed in Tab.1.

Fam. ICHNEUMONIDAE

1. *Liotryphon crassisetus* THOMS. is a larval, solitary, ectoparasitoid species, known from this host in the European region of the former USSR (MIARTZEVA *et al.*, 1988). We obtained 2 ♂♂ on 30.07.1996 from the sample taken on 15.07.1996, and 1 ♂ on 18.08.1996, from the sample taken on 7.08.1996 in Iași-Șorogari.

The female deposits one egg inside the attacked fruit, near a caterpillar, which previously has been paralysed. The egg is 1.85–2 mm long, 0.2–0.3 in diameter, it

Tab. 1. Parasitoid – host relationships.

No.	Parasitoid	Host
	ICHNEUMONIDAE	
1.	*Liotryphon crassisetus* THOMS.	*Cydia pomonella* L.
2.	*L. punctulatus* RATZB.	*Cydia pomonella* L.
3.	*Pristomerus vulnerator* PANZ.	*Cydia pomonella* L.
	BRACONIDAE	
4.	*Ascogaster quadridentata* WESM.	*Cydia pomonella* L.
5.	*Microdus rufipes* NEES	*Cydia pomonella* L.
	PERILAMPIDAE	
6.	*Perilampus tristis* MAYR	*Pristomerus vulnerator* PANZ. *Ascogaster quadridentata* WESM. *Microdus rufipes* NEES
	EULOPHIDAE	
7.	*Baryscapus talitzkii* KOST.	*Liotryphon crassisetus* THOMS.

is slightly curved, transparent in the beginning and turning opaque with time. The larval development is short – approximately 5 days, at an average temperature of 20–22 °C, a period in which it molts two times. However, about 20–23 days are necessary from the stage of mature larva up to the adult's apparition.

L. crassisetus is a species obtained from several Lepidoptera and also from some Coleoptera species (AUBERT, 1969; BABIDORICH & SHAROV, 1986; FITTON *et al.*, 1988; TALITZKI & KUSLITZKI, 1990).

The host-parasitoid relationship is new for Romania.

2. *Liotryphon punctulatus* RATZB. is similar to the previous species *L. crassisetus* in several biological, ecological, behavioural and distributional aspects. We obtained 6 ♂♂ on 15–20.07.1996 from the sample taken on 5.07.1996, and 3 ♀♀, 2 ♂♂ on 16–30.08.1996 from the sample taken on 7.08.1996 in Iași-Șorogari.

It is known as a parasitoid of several Lepidoptera and Coleoptera species, *C. pomonella* included (AUBERT, 1969; BABIDORICH & SHAROV, 1986; FITTON *et al.*, 1988; MIARTZEVA *et al.*, 1988; TALITZKI & KUSLITZKI, 1990).

In Romania, it has previously been obtained from *Cydia molesta* BUSCK., *C. strobilella* L. (Lep.: Tortricidae) and *Biorrhiza pallida* OLIV. (Hym.: Cynipidae) (PISICĂ & DIACONU,1997).

3. *Pristomerus vulnerator* PANZ. was obtained from all collected samples. Out of the caterpillars collected from Iași-Șorogari, 98 individuals were destroyed by the parasitoid – 35 of which (22 ♀♀, 13 ♂♂) emerged between 25.07– 16.08.1996, 45 individuals (23 ♀♀, 22 ♂♂) – between 11.05–15.06.1997 while, from the remaining 18 individuals secondary parasitoids have been obtained. From the samples collected from Iași-city, 4 ♀♀ and 3 ♂♂ hatched between 11–22.05.1997.

P. vulnerator behaves like a solitary endoparasitoid of the *C. pomonella* larvae. The female deposits one egg in the body of young caterpillars, prior to their entering the fruit, while the neonate larva remains in latent state until the parasitized caterpillars leave the attacked fruit and build the shelter for pupa formation (COUTIN, 1974) .

After their complete development, the parasitoid larvae leave the caterpillars' bodies and weave, inside the host's shelter, a hard, elongated cocoon with various

degrees of pigmentation, inside which ontogenetic development continues up to the adult stage.

The parasitoid's mature larvae leave the host's body when the latter reaches a cephalic capsule width of 1.16–1.56 mm, predominantly of 1.47 mm (45.8 %), followed by those of 1.19 mm (only one individual left the host at a cephalic capsule width of 1.56 mm).

This species has been obtained from a large spectrum of hosts, most of them belonging to Lepidoptera – but also from some dipterans (GEIER, 1957; AUBERT, 1969; MEDVEDEV, 1981; BABIDORICH & SHAROV, 1986; MIARTZEVA *et al.*, 1988; ZEROVA *et al.* 1989; TALITZKI & KUSLITZKI, 1990).

In Romania, it has been previously obtained from *Cydia molesta* BUSCK. (PĂTRĂȘCANU, 1968), *Hedya dimidioalba* RETZ. (Tortricidae) (PISICĂ & DIACONU, 1997) and *Aporia crataegi* L. (Pieridae) (VARVARA, 1972).

Fam. BRACONIDAE

4. *Ascogaster quadridentata* WESM. Out of the caterpillars collected from Iași-Șorogari, 57 individuals were destroyed by the parasitoid – 11 of which (5 ♀♀ and 6 ♂♂) emerged between 19.07–15.08.1996, 21 individuals (10 ♀♀, 11 ♂♂) between 21.05–18.06.1997 while, from the remaining 25, we obtained secondary parasitoids. From the samples taken from the Iași-city on 25.07.1996, 1 ♂ hatched on 22.05.1997.

This is a solitary, ovo-larval endoparasitoid. The female deposits the eggs in the host's egg's vitellus and, 2–3 days later, the neonate larva enters the host's embryo, without destroying it (COUTIN, 1974). After the feeding period, the parasitized caterpillar leaves the attacked fruit and builds a rudimentary shelter. The mature parasitoid larva leaves the host's body and weaves a thin, white, parchment-like cocoon, in which it develops into a pupa and later into an adult.

Leaving of the host-caterpillars occurs when the width of their cephalic capsules reaches 0.90–1.40 mm, predominantly 1.08 mm (73.1 %).

A. quadridentata is frequently obtained from different lepidopteran species, especially from Tortricidae, while *C. pomonella* is one of the most common hosts (GEIER, 1957; PĂTRĂȘCANU, 1968; EVENHUIS, 1974; EVENHUIS & VLUG, 1983; BABIDORICH & SHAROV, 1986; TOBIAS *et al.*, 1986; MIARTZEVA *et al.*, 1988; ZEROVA *et al.* 1989; TALITZKI & KUSLITZKI, 1990).

5. *Microdus rufipes* NEES. Out of the caterpillars collected from Iași-Șorogari, 33 individuals were destroyed by the parasitoid – 3 of them (2 ♀♀, 1 ♂) hatched between 6–15.08.1996, 23 individuals (15 ♀♀, 8 ♂♂) – between 16.05–29.06. 1997 while, from the remaining 7 we obtained secondary parasitoids. In the sample taken from Iași-city on 16.07.1996, 8 individuals were recorded – 3 of them (1 ♀, 2 ♂♂) emerged between 16–23.08.1996 and 5 (4 ♀♀, 1 ♂) between 16–29.06.1997.

Many of the aspects referring to the biology and ecology of this species are similar to those of the above-discussed *A. quadridentata*. Leaving of the hosts' bodies took place when the caterpillars' cephalic capsule attained a width of 1.19–1.47 mm, predominantly of 1.22 mm (64.3 %).

Microdus rufipes is a polyphagous species, known from several Lepidoptera species, most of them belonging to the Tortricidae (GEIER, 1957; PĂTRĂȘCANU, 1968; BABIDORICH, & SHAROV, 1986; TOBIAS *et al.*, 1986; MIARTZEVA *et al.*, 1988; ZEROVA *et al.* 1989; TALITZKI & KUSLITZKI, 1990).

Fam. PERILAMPIDAE

6. *Perilampus tristis* MAYR was obtained only from Iași-Șorogari, as a larval, solitary and secondary parasitoid of the 3 species of larval endoparasitoids – *Pristomerus vulnerator* PANZ., *Ascogaster quadridentata* WESM. and *Microdus rufipes* NEES.

From *P. vulnerator*, 18 individuals were recorded, out of which 7 (4 ♀♀, 3 ♂♂) emerged between 5–21.08.1996, and 11 (6 ♀♀, 5 ♂♂) between 16.05–12.06.1997. From *A. quadridentata* 25 individuals were recorded, out of which 8 (4 ♀♀, 4 ♂♂) emerged between 1–8.08.1996, and 17 (9 ♀♀, 8 ♂♂) between 1–20.06.1997. From *M. rufipes* 7 individuals (4 ♀♀, 3 ♂♂) were recorded between 24.06–3.07.1997.

Perilampids develop by hypermetamorphosis. The female deposits the eggs on the surface on the plant's organs (leaves, fruits, branches) and, from them, a larva (known as planidium) hatches. It has a high mobility and it is actively looking for caterpillars at the feeding place or at the place of pupation. It can develop as a primary ectoparasitoid on the caterpillars. If a primary parasitoid larva is present in the caterpillar's body, the planidium larva enters the caterpillar's and then, the primary parasitoid larva's bodies. It remains there in latency, until the primary parasitoid reaches the stage of mature larva. In this stage, the planidium larva leaves the host's body, molts and evolves into a typical hymenopteran larva, which develops as a larval ectoparasitoid (GIBSON, 1993).

In this species, the planidium larva becomes a larval ectoparasitoid of the three primary parasitoids after they weave their cocoons.

Special mention should be made of the fact that some *P. tristis* females deposited their eggs inside the cocoons they hatched from, on the host's unconsumed remains, new planidium larvae thus resulting.

The species is known as a secondary parasitoid on some ichneumonid and braconid species, including *P. vulnerator*, *A. quadridentata* and *M. rufipes* (GEIER, 1957; ZEROVA, 1989; BOGENSCHÜTZ, 1991).

The species and the entire host-parasitoid relationships are new for the Romanian fauna.

Fam. EULOPHIDAE

7. *Baryscapus talitzkii* KOST. is a larval, gregarious endoparasitoid obtained from *Liotryphon crassisetae* THOMS. On 10.08.1996, 5 ♀♀ and 14 ♂♂ were obtained from an ichneumonid larva, collected on 15.07.1996 from Iași-Șorogari.

The species was described in the Republic of Moldavia, having been obtained from a tortricid larva on an apple tree (KOSTJUKOV, 1978) and revised by LA SALLE (1986) and GRAHAM (1991), who mentions that this species was obtained in France by P. DU MERLE, from *Scambus colobatus* GRAV. or *S. elegans* WOLDST. larvae

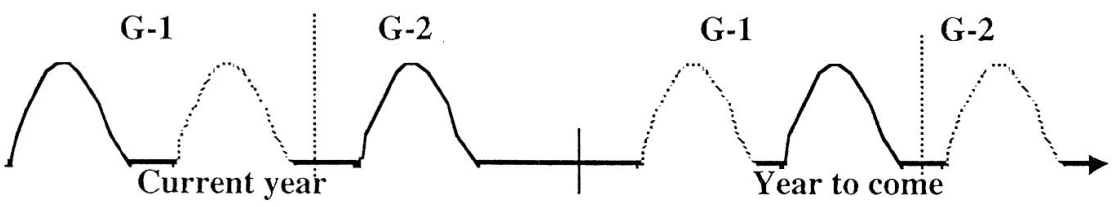

Fig. 1. Scheme of *Cydia pomonella*'s biological cycle under the normal climatic conditions of Iași.

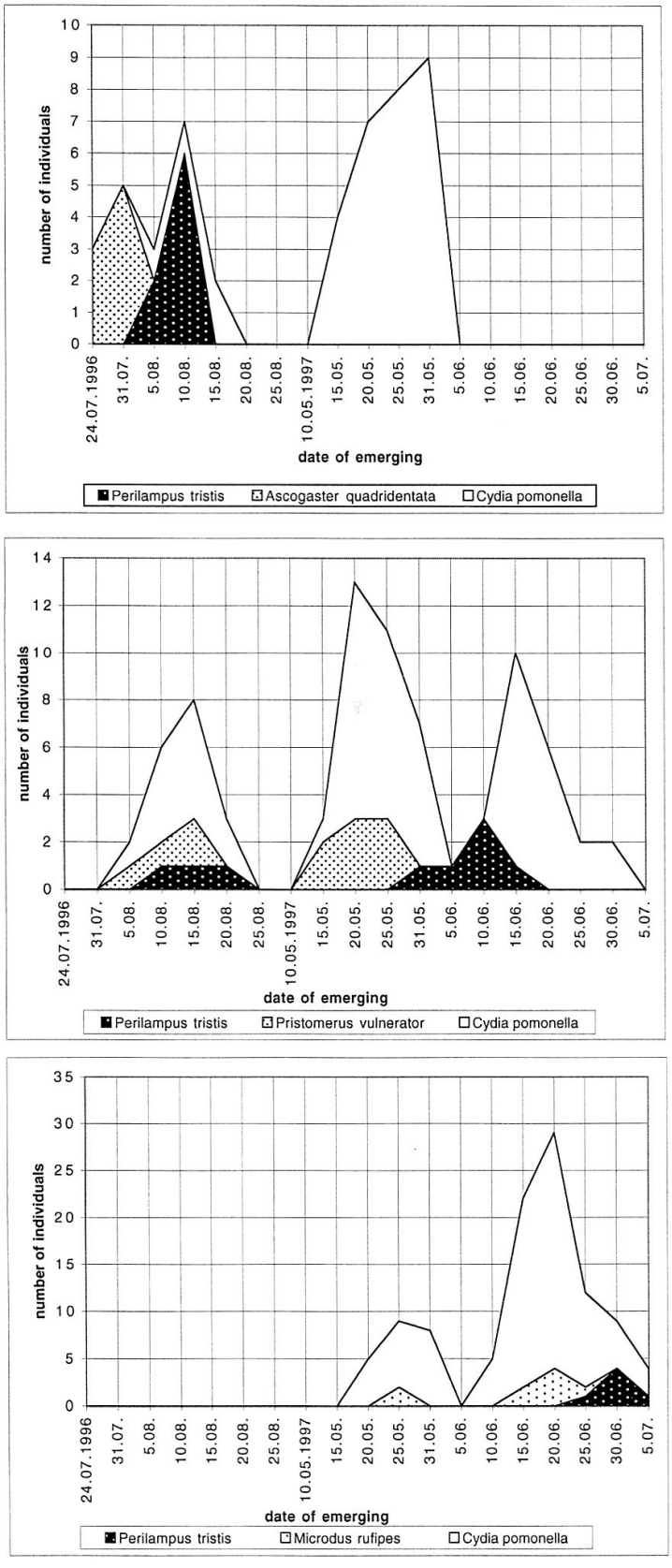

Fig. 2. Dynamics of the appearance of *Perilampus tristis* adults.– a (above): out of *Ascogaster quadridentata* obtained from *C. pomonella* collected on 5.07.1996 - Iași-Șorogari. – b (middle): out of *Pristomerus vulnerator* obtained from *C. pomonella* collected on 15.07.1996 - Iași-Șorogari. – c (below): out of *Microdus rufipes* obtained from *C. pomonella* collected on 7.08.1996 - Iași-Șorogari.

(Hym.: Ichneumonidae). Although the individuals recorded by us are slightly different, especially regarding the antenna's colour and the size of the body, we consider them as belonging to this species.

The species is new for the Romanian fauna, and the host-parasitoid relationship is new to science.

The dynamics of C. pomonella and parasitoid adults apparition

Under the climatic conditions of Iași, characterized by an average annual temperature of 9.6 °C, the biological cycle of the codling moth shows an interesting peculiarity (DIACONU *et al.*, 1997). Thus, analysis of the hibernating caterpillars (Fig. 1) reveals a curve with two flight peaks, clearly separated in time (G-1). From the adults belonging to the first flight peak results the flight of the following generation (G-2) of the same year and, from this one, the second flight peak of G–1 of the next year. From the adults of the second flight peak of G-1, results the first flight peak of G-1 of the next year.

The apparition of *C. pomonella* adults resulting from the caterpillars collected in 1996 coincided – to a great extent – with their natural flight, recorded at the Atra-POM traps. At the same time, the evolution of the biological cycle presented in Fig. 1, is confirmed. Thus, from the caterpillars collected on 5.07.1996, resulted the flight curve of the same year G-2 , and also the first flight peak of the G-1 of the following year (Fig. 2a). From the caterpillars collected on 15.07.1996 also resulted the second flight peak of the G-1 of the next year (Fig. 2b). From those collected on 7.08.1996, resulted only the two flight peaks of the G-1 of the following year (of which the second was better represented) (Fig. 2c).

That from a certain sample we obtained adults that formed 2 or 3 flight peaks, is mainly due to the caterpillars' different age at the time of sampling.

By correlating the dynamics of the adult hosts apparition with that of the primary internal and secondary adult parasitoids, we reached the following conclusions:

– the *Pristomerus vulnerator* (Fig. 2b) and *Microdus rufipes* adults (Fig. 2c) appear usually when the maximum of the host's apparition is recorded;

– the apparition of *Ascogaster quadridentata* adults (Fig. 2a) begins a few days before that of the host and ends during the first half of the host's apparition curve;

– the *Perilampus tristis* adults (Fig. 2a,b,c) start to appear towards the end of the flight curve of the primary parasitoids from which they come, and continue to appear after the end of their host's period of apparition.

The contribution of primary parasitoids to the limiting of the host *C. pomonella* populations for each sampling date is presented in Tab. 2.

First and foremost, although the two sampling sites are not far from one another (about 1 km), big differences occur between the levels of partial and total parasitization. Thus, in Iași-Șorogari the percent of parasitization was 22.73– 43.75 %, in the Iași-city the highest value recorded was 16.39 %. A possible explanation might be the higher sensitivity of the parasitoid hymenopterans to the noxious gases in the city.

The most important species of this parasitoid complex are *Pristomerus vulnerator*, *Ascogaster quadridentata* and *Microdus rufipes*. *Pristomerus vulnerator* is the most important, both by its presence and by the higher values of the parasitism ratio.

Tab. 2. Primary parasitoids obtained from the active larvae of *C. pomonella* and their role in the limitation of host populations.

No.	Locality	Date of collection	No. of collected caterpillars	Primary parasitoids obtained								
						Ichneumonidae				Braconidae		
				No.	%	Total %	cr %	pu %	vu %	Total %	qu %	ru %
1.	Iaşi-Şorogari	5.07.96	160	70	43.8	31.9	-	3.8	28.1	11.9	10.0	1.9
		15.07	154	35	22.7	14.9	1.9	-	13.0	7.8	4.5	3.3
		1.08	75	27	36.0	13.3	-	-	13.3	22.7	12.0	10.7
		7.08	206	62	30.1	12.6	0.5	2.9	9.2	17.5	10.2	7.3
		20.09	26	10	38.5	15.4	-	-	15.4	23.1	15.4	7.7
	TOTAL		621	204	32.9	18.4	0.7	1.9	15.8	14.5	9.2	5.3
2.	Iaşi-city	16.07	61	10	16.4	3.3	-	-	3.3	13.1	-	13.1
		25.07	112	6	5.4	4.5	-	-	4.5	0.9	0.9	-
	TOTAL		173	16	9.3	4.1	-	-	4.1	5.2	0.6	4.6

cr = *Liotryphon crassisetus* THOMS.
pu = *Liotryphon punctulatus* RATZB.
vu = *Pristomerus vulnerator* PANZ.
qu = *Ascogaster quadridentata* WESM.
ru = *Microdus rufipes* NEES

As a secondary parasitoid, *Perilampus tristis* recorded quite high values of the parasitism ratio, for all three hosts obtained from the samples taken from Iaşi-Şorogari. Thus,

– 4 of the 5 samples were taken from *Pristomerus vulnerator* (Fig. 3a), the average value of parasitism recorded being 18.4 %. The highest value (45 %) was recorded with the sample taken on 15.07.1996, when 9 ichneumonid cocoons – from a total number of 20 – were parasitized;

– in the case of *Ascogaster quadridentata* (Fig. 3b), the highest ratio of parasitized individuals (66.7 %) was recorded in the sample taken on 7.08.1996, when 14 of the 21 cocoons were parasitized; the average value recorded, of 43.9 %, shows that this host is preferred by *P. tristis*;

– in the case of *Microdus rufipes* (Fig. 3c), 7 individuals were found in the samples taken on 1. and 7.08.1996, with an average parasitism ratio of 21.2 %, the highest value recorded was 40 % in the sample taken on 7.08.1996.

The absence of this species in the samples taken from Iaşi-city might have the same cause as the low activity of the primary parasitoids – i.e., the presence of noxious gases.

RÉSUMÉ

L'élevage des chenilles actives (nourriteuses) du carpocapse *Cydia pomonella* L., collecteés en 1996 dans deux écosystèmes à Iaşi-Şorogari et Iaşi-ville (Roumanie), a permis d'obtenir 5 espèces d'hyménoptères parasitoïdes primaires: *Pristomerus vulnerator* PANZ., *Liotryphon crassisetus* THOMS., *Liotryphon punctulatus* RATZB. (Ichneumonidae), *Ascogaster quadridentata* WESM. et *Microdus rufipes* NEES (Braconidae) ainsi que deux espèces de parasitoïdes secondaires: *Perilampus tristis* MAYR. (Perilampidae) and *Baryscapus talitzkii* (KOST.) (Eulophidae). *P. vulnerator* est le parasitoïde le plus important tant par sa fréquence que par le taux de parasitisme (9,2–28,1 % à Iaşi-Şorogari et 3.3–5.5 % a Iaşi-ville). En ce qui concerne *P. tristis*, cette espèce a été obtenue à partir de *P. vulnerator*, *A. quadridentata* et *M. rufipes*, l'hôte préféré étant *A. quadridentata* avec un taux parasitaire atteignant jusqu'à 66,7 % à Iaşi–Şorogari.

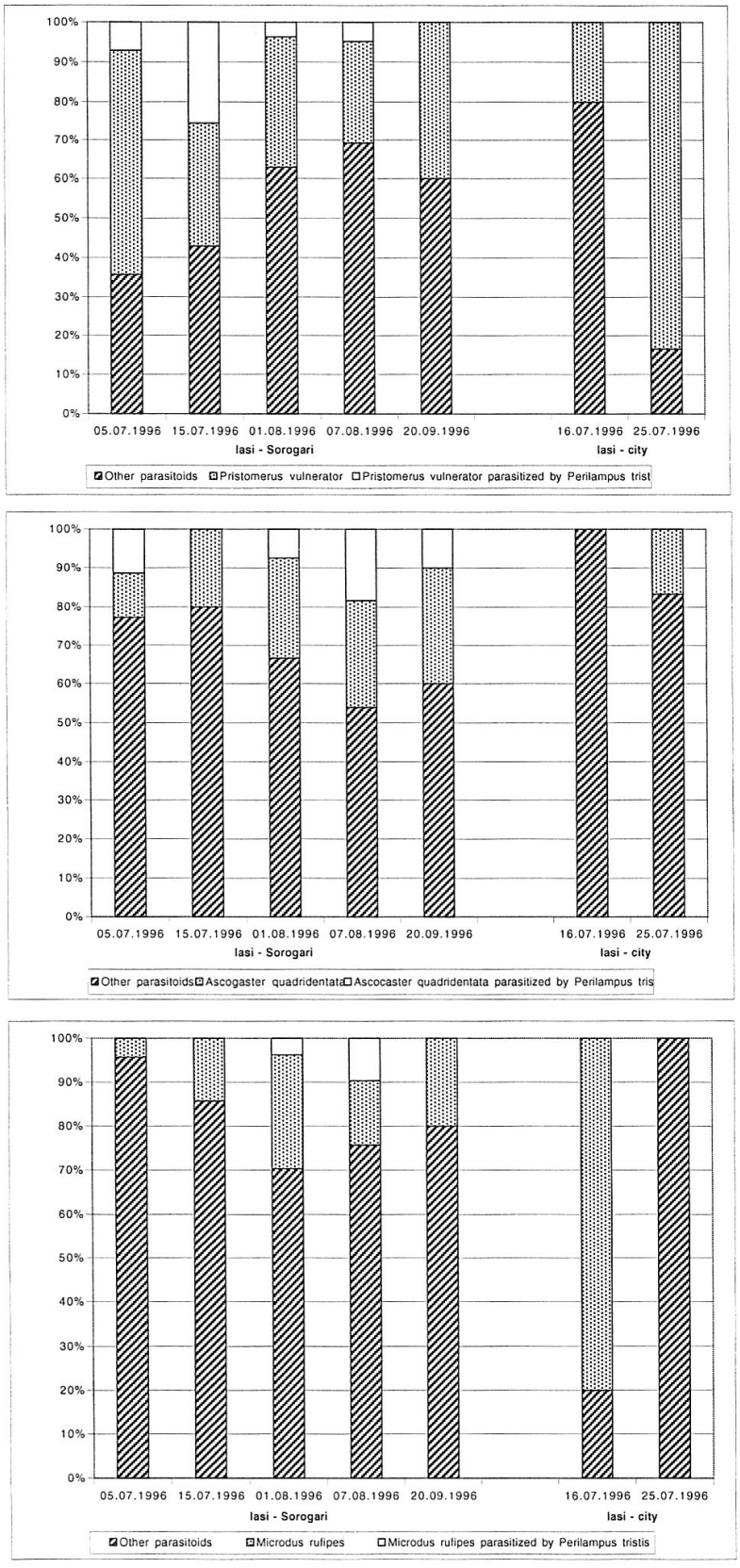

Fig. 3. *Perilampus tristis.*– a (above)*:* from *Pristomerus vulnerator* within the parasitoid complex of the codling moth - Iaşi - 1996. – b (middle): from *Ascogaster quadridentata* within the parasitoid complex of the codling moth - Iaşi - 1996. – c (below): from *Microdus rufipes* within the parasitoid complex of the codling moth - Iaşi - 1996.

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