Boll. Zool. agr. Bachic.
Ser. II, 29 (1): 81-90

30 giugno 1997

A. ZAHARIEVA-PENTCHEVA, G. TS. GEORGIEV

Parasitoids of the Satin Moth *Stilpnotia salicis* (L.) (Lepidoptera Lymantriidae) in Bulgaria

Abstract - Studies on the parasitoid complex of the satin moth *Stilpnotia salicis* (L.) have been conducted at different locations in Bulgaria during the period 1978-1991. Twenty parasitoid species from the families Braconidae, Ichneumonidae, Chalcididae, Torymidae, Scelionidae, Tachinidae and Sarcophagidae were identified. From these, six parasitoid species - three primary [*Anastatus bifasciatus* (Fonsc.), *Exorista mimula* (Meig.) and *Pseudosarcophaga mamillata* Pandelle], and three hyperparasitoids [*Theronia atalantae* (Poda), *Brachymeria minuta* (L.) and *Brachymeria secundaria* (L.)], were new records for the parasitoid complex of this host. The percentage of host egg parasitism caused by *Telenomus nitidulus* Thoms. varied from 0 to 45.0, with an average of 15.3%. *Apanteles melanoscelus* (Ratz.) and *Meteorus versicolor* (Wesm.) parasitized an average of 14.4% of the early-stage larvae of this pest. Most mortality is caused by *A. melanoscelus*, which, in some cases may parasitize up to 45.5% of the early-stage larvae. Late-stage larvae and pupae of *S. salicis* are attacked by *Pimpla hypochondriaca* (Ratz.), *T. atalantae* (Ichneumonidae), *Brachymeria intermedia* (Nees) and *Pediobius pyrgo* Walker (Chalcididae), *Monodontomerus aereus* Walker (Torymidae), *Carcelia exavata* (Meig.), *Compsilura concinnata* (Meig.), *Exorista larvarum* (L.), *E. mimula* and *Pales pavida* (Meig.) (Tachinidae) and *P. mamillata* (Sarcophagidae). The species of the family Tachinidae are most important in reducing the number of the pest. In *St. salicis* populations in Bulgaria the avarage mortality caused by parasitoid insects was 47.3%, and in some sites it reached 89.1%. Parasitoids play an important role in the regulation of satin moth populations and for the stability of poplar stands.

Riassunto - *Parassitoidi di* Stilpnotia salicis *(Lepidoptera Lymantriidae) in Bulgaria.*

Negli anni 1978-1991 sono state effettuate ricerche sul complesso dei parassitoidi di *Stilpnotia salicis* (L.) in diverse località della Bulgaria. Sono stati identificati 20 parassitoidi, appartenenti alle famiglie Braconidae, Ichneumonidae, Chalcididae, Torymidae, Scelionidae, Tachinidae e Sarcophagidae. Sei specie, di cui tre primarie [*Anastatus bifasciatus* (Fonsc.), *Exorista mimula* (Meig.) and *Pseudosarcophaga mamillata* Pandelle] e tre iperparassitoidi [*Theronia atalantae* (Poda), *Brachymeria minuta* (L.) e *Brachymeria secundaria* (L.)], risultano nuove per il complesso degli agenti di controllo del lepidottero. La parassitizzazione delle uova

prodotte da *Telenomus nitidulus* Thoms. varia da 0 a 45.0, con una media del 15.3%. *Apanteles melanoscelus* (Ratz.) and *Meteorus versicolor* (Wesm.) attaccano in media il 14.4% delle larve di prima età. Le larve di ultima età e le pupe di *S. salicis* sono parassitizzate da *Pimpla hypochondriaca* (Ratz.), *T. atalantae* (Ichneumonidae), *Brachymeria intermedia* (Nees) and *Pediobius pyrgo* Walker (Chalcididae), *Monodontomerus aereus* Walker (Torymidae), *Carcelia exavata* (Meig.), *Compsilura concinnata* (Meig.), *Exorista larvarum* (L.), *E. mimula* e *Pales pavida* (Meig.) (Tachinidae) e *P. mamillata* (Sarcophagidae). Le specie appartenenti alla famiglia dei Tachinidae esercitano il ruolo più importante nel ridurre il numero delle larve del lepidottero. In Bulgaria le popolazioni di *St. salicis* presentano in media una mortalità causata dai parassitoidi pari al 43,7%, ma in alcune situazioni si può raggiungere l'89.1%.

Key words: *Stilpnotia salicis*, parasitism, parasitoids, parasitoid complex, hyperparasitoides, host mortality, Bulgaria.

INTRODUCTION

The satin moth *Stilpnotia* salicis (Linnaeus, 1758) is an important pest of poplars (Populus spp.) and willows (Salix spp.) in many regions of the Palearctic zone, and periodically causes extensive damage in Bulgaria (Dirimanov, 1952; Zaharieva, 1982).

The population density of *S. salicis* is regulated by a number of biotic factors among which species of parasitoids are most important. The parasitoid complex of the pest in Europe includes about 70 species from the families Braconidae, Ichneumonidae, Chalcididae, Torymidae, Eupelmidae, Pteromalidae, Trichogrammatidae, Scelionidae, Tachinidae and Sarcophagidae (Mirzoian, 1970; Pisica et al., 1978; Popescu, 1980). The most important among them [*Apanteles melanoscelus* (Ratz.), *Meteorus versicolor* (Wesm.), *Exorista larvarum* (L.) and *Carcelia gnava* (Meig.)] have been introduced into North Amercia for biological control of the satin moth after its discovery in 1920 (Clarke et al., 1976, after Zaharieva, 1982).

Only a few investigations on parasitoids of *S. salicis* have been conducted in Bulgaria (Zaharieva, 1981; Atanasov & Zaharieva, 1984; Georgiev, 1996).

This paper presents observations on the complex of parasitoid species, sime biological features and the regulating role of the parasitoids in *S. salicis* populations in Bulgaria.

MATERIALS AND METHODS

The investigations were conducted between 1978 and 1991 in the following localities in Bulgaria: Burgas, Biala, Dolni Bogrov, Karlovo, Pazardjik, Plovdiv and Samokov (fig. 1).

Studies were performed on two annual generations of *S. salicis* at either location.

A total of 25,644 eggs, and 2,112 larvae and pupae of the host were collected and observed in the laboratory 100 specimens from each life stage were reared individually in petri dishes and test tubes and fed poplar leaves until they pupated. Individual larvae were observed daily. When tachinid and sarcophagid larvae hatched from the host, they were placed in petri dishes with moist, sterile sand to complete their development. At the end of the observation period, a detailed study of either individual host was performed in order to determine the cause of mortality.

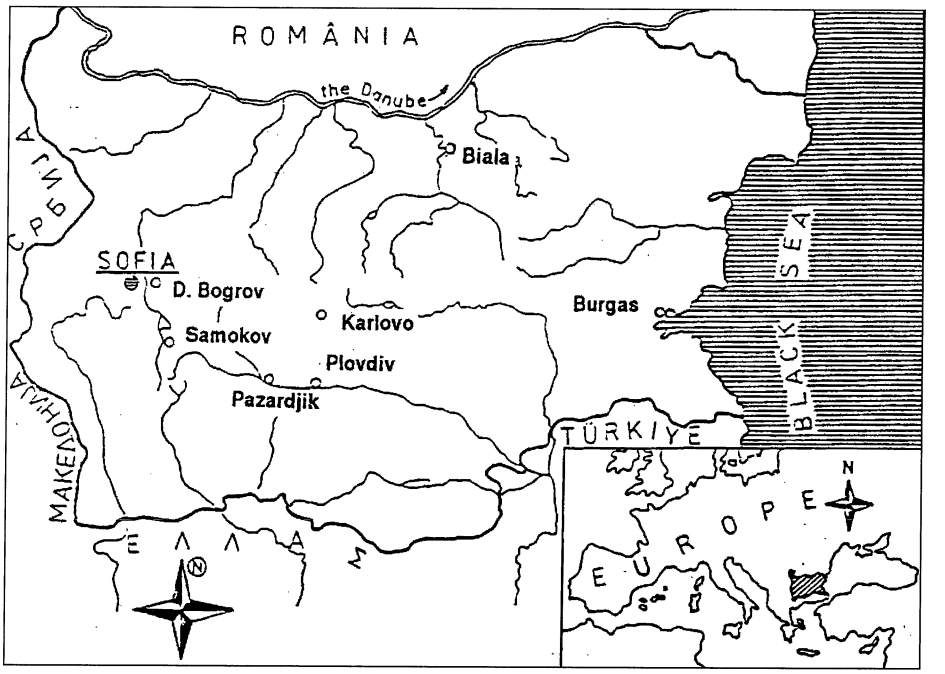

Fig. 1 - Studied localities of *Stilpnotia salicis* (L.) in Bulgaria.

RESULTS

We identified 20 species of parasitoids of the satin moth from populations in Bulgaria - 15 primary and 6 secondary (one species - *Theronia atalantae* (Poda) is a primary as well as a secondary parasitoid) (Tab. 1). Six parasitoids - 3 primary [*Anastatus bifasciatus* (Fonsc.), *Exorista mimula* (Meig.) and *Pseudosarcophaga mamillata* Pandelle] and 3 secondary [*T. atalantae, Brachymeria minuta* (L.) and *Brachymeria secundaria* (L.)] were found on *S. salicis* only in Bulgaria.

Telenomus nitidulus Thoms. and *A. bifasciatus* are egg parasitoids in *S. salicis*, *Apanteles melanoscelus* (Ratz.) and *Meteorus versicolor* (Wesm.) parasitize the early-stage larvae, and the rest of the parasitoids attack the middle and late-stage larvae and pupae of their host.

Table 1 - Parasitoids of Stilpnotia salicis (L.) in Bulgaria.

Family, species	Parasitoid on			Features of parasitism		
	eggs	larvae	pupae	solitary	gregarious	multiple
PRIMARY PARASITOIDS						
Ichneumonidae						
Pimpla hypochondriaca (Retz.)		+	+	+		
Theronia atalantae (Poda)			+	+		
Braconidae						
Apanteles melanoscelus (Ratz.)		+		+		
Meteorus versicolor (Wesm.)		+		+		
Scelionidae						
Telenomus nitidulus Thoms.	+			+		
Chalcididae						
* *Anastatus bifasciatus* (Fonsc.)	+			+		
Brachymeria intermedia (Nees)		+		+		
Pediobius pyrgo Walker			+		+	
Torymidae						
Monodontomerus aereus Walker			+		+	
Tachinidae						
Carcelia exavata (Meig.)		+		+		
Compsilura concinnata (Meig.)		+		+		+
Exorista larvarum (L.)		+		+	+	+
* *Exorista mimula* (Meig.)			+	+		
Pales pavida (Meig.)		+		+		+
Sarcophagidae						
* *Pseudosarcophaga mamillata* Pandelle			+	+	+	
SECONDARY PARASITOIDS						
Ichneumonidae						
**Theronia atalantae* (Poda)			+	+		
Chalcididae						
* *Brachymeria minuta* (L.)			+	+		
* *Brachymeria secundaria* (L.)			+	+		
Pteromalidae						
Dybrachus cavus (Walker)			+		+	
Mesopolobius sp.			+		+	
Phoridae						
Megaselia sp.			+		+	

* Reported in Bulgaria as new for the parasitoid complex of *Stilpnotia salicis* (L.)

B. minuta, B. secundaria, Dybrachus cavus (Walker), *Mesopolobius* sp. and *Megaselia* sp. are secondary parasitoids. *B. secundaria* is a hyperparasitoid of *Pimpla hypochondriaca* (Retz.), and the others hyperparasitize in *P. mamillata* and in the tachinid species.

Most of the species develop as solitary parasitoids in the satin moth, however *Pediobius pyrgo* Walker and *M. aereus* are gregarious primary parasitoids, and *D. cavus, Mesopolobius* sp. and *Megaselia* sp. are gregarious secondary parasitoid species. Among the primary parasitoids *Exorista larvarum* (L.) and *P. mamillata* can be either solitary or gregarious endoparasitoids in larvae and pupae of *S. salicis*. The average number of parasitoid larvae feeding in one host was 1.2 for the former species, and 2.1 for the latter.

Multiple parasitism was observed in *E. larvarum, Compsilura concinnata* (Meig.), and *Pales pavida* (Meig.).

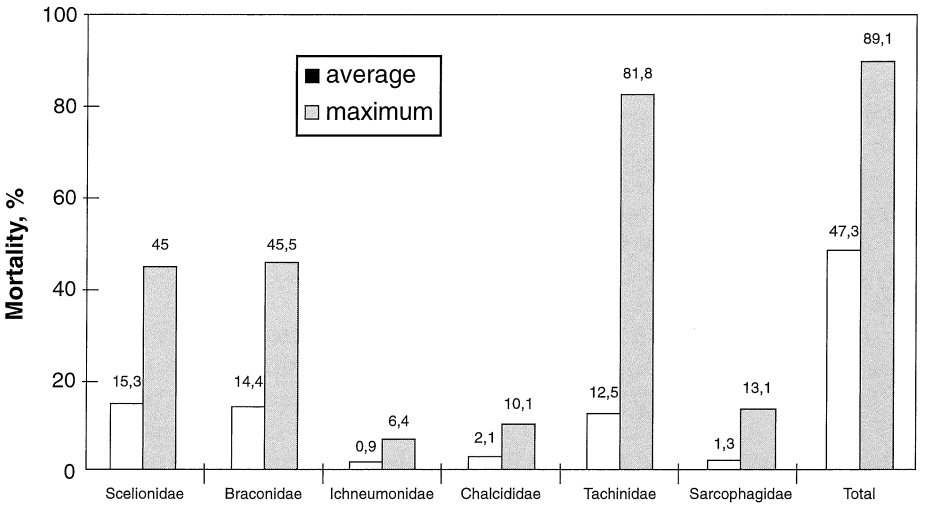

Fig. 2 - Mortality of *Stilpnotia salicis* (L.) caused by parasitoid insects in Bulgaria.

The average mortality of *S. salicis* from all parasitoid species was 47.3%, and the highest mortality observed was 89.1% (Fig. 2). The scelionid *T. nitidulus* destroyed an average of 15.3% of *S. salicis* eggs, while from *A. bifasciatus*, only one specimen was recorded. The maximum mortality caused by egg parasitoids was 45.0 %.
The braconid species parasitized an average of 14.4% of the young (up to third-instar) larvae of *S. salicis*. *A. melanoscelus* was found at all collection sites and destroyed sometimes 2.9-45.5% of the larvae. *M. versicolor*, parasitized an average of 5.9% of the early-stage larvae.

The tachinid parasitoids destroyed an average of 12.5% of the late-stage larvae of *S. salicis,* and in some cases a maximum mortality up to 81.8 % was found. *C. concinnata* and *E. larvarum* were the most effective parasitoids of the late-stage larvae.

The pupal parasitoids of the families Ichneumonidae, Chalcididae and Sarcophagidae caused only 0.9 to 2.1% mortality of satin moth pupae.

T. atalantae, B. minuta L. and *Megaselia* sp. hyperparasitized between 2.5% and 7.5% of the larvae of *P. mamillata.*

DISCUSSION

During our investigations, six parasitoid species were found which are new records for the satin moth.

A. bifasciatus is widely distributed in Europe and North America, where it is a parasite of the eggs of *Malacosoma neustria* L. (Lasiocampidae), *Psylla pruni* Scop., *Psylla pyri* L. (Psylloidea) and some species in the families Pentatomidae and Coreidae (Triapitzin, 1978). In Bulgaria and Greece it parasitizes *Thaumetopoea pityocampa* (Den. & Schiff.) and in Israel *T. wilkinsoni* Tams (Thaumetopoeidae) (Bellin et al., 1990; Halperin, 1990; Tsankov, 1990), however only males were observed. Some females were found in Cyprus (Halperin, 1990) and recently near Marikostinovo/Bulgaria (Tsankov et al., 1996). We recorded only one male of *A. bifasciatus* from eggs of *S. salicis.*

E. mimula was recorded from a wide range of hosts. In Bulgaria, this species was found not only in *S. salicis,* but also in *Mamestra brassicae* L. and *Margaritia sticticalis* L. (Hubenov, 1985).

P. mamillata is known as a predator of larvae and pupae of various species of the genus *Yponomeuta* (Shtakelberg & Nartschuk, 1970). In Bulgaria, the species attacks the larvae in the nests of *Yponomeuta malinellus* Zell., where it destroys between 65.0% and 73.6% of the pest (Trentschev, 1979). Only 2 species from the family Sarcophagidae have been recorded from *S. salicis* populations in Europe: *Sarcophaga affinis* (Fall.) (Pisica et al., 1978) and *Parasarcophaga* sp. (Popescu, 1980). However, *Sarcophaga aldrichi* Parker and *Agria housei* Shewell have been recorded from *S. salicis* in North America (Wagner & Leonard, 1980).

T. atalantae is known as a primary parasitoid of *S. salicis* in Poland and Romania (Snaiderova, 1959; Pisica et al., 1978; Popescu, 1980). In Bulgaria it has been determined to be both a primary parasitoid and also a hyperparasitoid. It was recorded from *P. mamillata. T. atalantae* occurs in many host species as primary or secondary parasitoid (Zerova et al., 1989).

In our investigations, *B. minuta* was determined to be a hyperparasitoid of *P. mamillata* and some tachinid species. *B. minuta* was reported by Popescu (1980) as a primary parasitoid of *S. salicis*, but after Triapitzin (1978) the species is connected only with representatives of Tachinidae and Sarcophagidae.

B. secundaria was recorded from cocoons of *P. hypochondriaca*, and *Megaselia*

sp. from pupae of *P. mamillata* for the first time. However, colonies of *Megaselia hesperia* Borgmeier have been found on satin moth larvae and pupae, often in association with other parasitoids, but their trophic status is unclear (Wagner & Leonard, 1980).

The rest of the primary and secondary parasitoids was reported for *S. salicis* by other authors in Europe (Diadetschko, 1959; Snaiderova, 1959; Mirzoian, 1970; Pisica et al., 1978; Popescu, 1980).

The mortality of *S. salicis* caused by parasitoids in various regions of Bulgaria varied from 5.9-89%, and the average for the country was 47.3%. These values are close to those that have been reported by other authors (Snaiderova, 1959; Popescu, 1980). In Bulgaria, *T. nitidulus* destroyed up to a maximum of 45.0% of the pest eggs, while in other countries, levels of parasitism were sometimes near 100.0% (Nef, 1976). In Bulgaria, the low percentage of egg parasitism was possibly due to the fact, that during the years of investigation, very few outbreaks of *S. salicis* occurred, and the populations declined fast, thus the parasitoids failed to multiply.

Parasitoids destroyed a significant portion of eggs, larvae and pupae of *S. salicis*, they are probably important to maintain the pest populations on relatively low level of density.

Most of the parasitoid species become adults after emergence of *S. salicis* (Georgiev, 1996). *A. melanoscelus* and *M. versicolor* attack the early-stage larvae of the pest The rest of the species emerges simultaneously or some are flying even 1.5 months later than the host. At that time the larvae of the second generation of *S. salicis* are hatching. When the population density of *S. salicis* is high and some pest control is needed, it is advisable to spray bacterial insecticides. Therefore the flying adult parasitoids of *S. salicis* will not be adversely affected and can exert an additional impact on the pest and increase the sustainability of poplar stands.

ACKNOWLEDGEMENTS

We are grateful to the specialists listed below for their kind assistance in identifying parasitoids in the following taxonomic groups:

- Dr Z. Hubenov, from the Institute of Zoology at the Bulgarian Academy of Sciences (BAS) (Tachinidae and Sarcophagidae);
- Dr V. Beshovski from Institute of Zoology at BAS (Phoridae);
- Dr J. Kolarov from the Biological Faculty of the University of Sofia ìSt. Kl. Ohridskiî and Dr A. Atanasov from the Institute for Plant Protection - Kostinbrod (Ichneumonidae);
- Dr V. Pelov from the Institute for Plant Protection - Kostinbrod (Chalcididae, Pteromalidae and Torymidae).

We also thank Dr. M. McManus, USDA-Forest Service, Center for Forest Health Research, Hamden (USA) and Dr. G. Schmidt, University of Hannover (Germany), for their critical reading of the manuscript and correction of the English version.

REFERENCES

ATANASOV A., ZAHARIEVA A., 1984 - Study of certain biotic factors and the effect of nuclear-polyhedral virus (Kurganski strain) in reducing the density of *Stilpnotia salicis* L. (Lepidoptera, Orgydae) - In: Problems of biological fighting with pests in agriculture and forestry, vol. 3, Sofia, Publ. of BAS: 221-230 (in Bulgarian).

BELLIN S., SCHMIDT G.H., DOUMA-PETRIDOU E., 1990 - Structure, ooparasitoid spectrum and rate of parasitism of egg-batches of *Thaumetopoea pityocampa* (Den. & Schiff.) (Lep., Thaumetopoeidae) in Greece. - J. appl. Ent. 110: 113-120.

DIADETSCHKO N. P., 1959 - Intraareal movement of parasites in fighting the satin moth (*Stilpnotia salicis* L.). - Scientific works of the Ukrainian research institute for plant protection 8: 205-209 (in Russian).

DIRIMANOV D., 1952 - Studies on the biology of the satin moth on the poplar (*Stilpnotia salicis* L.). - Scientific works of HAI "V. Kolarov": 255-275 (in Bulgarian).

GEORGIEV G., 1996 - Bioecological features of parasitoids on the adult larvae and pupae of the satin moth (*Stilpnotia salicis* L., Lepidoptera: Lymantriidae) in Bulgaria. - Forest science 3 (in press) (in Bulgarian).

HALPERIN J., 1990 - Natural enemies of *Thaumetopoea* spp. (Lep. Thaumetopoeidae) in Israel. - J. appl. Ent. 109: 425-435.

HUBENOV Z., 1985 - Review of the hosts of species from family Tachinidae (Diptera), spread in Bulgaria. - Acta Zool. Bulg. 27: 27-35 (in Bulgarian).

MIRZOIAN S. A., 1970 - On parasites of the satin moth (*Leucoma salicis* L., Lepidoptera, Orgydae) in Armenia. - Biological journal of Armenia, vol. 23, 3: 66-74 (in Russian).

NEF L., 1976 - Etude ecologique de *Telenomus nitidulus*, parasite des oeufs de *Stilpnotia (Leucoma) salicis*. - J. Plant Dis. Prot. 83 (1/2/3): 109-119.

PISICA C., LACATUSU M., TUDOR C., TEODORESCU I., NASTASE I., 1978 - Les entomophages du defoliateur *Stilpnotia salicis* L. (Lepidoptera, Lymantriidae) en Europe et Romanie. - Trav. Mus. hist. natur. Gr. Antipa 19: 279-301.

POPESCU T., 1980 - Fluturele alb al plopului *Stilpnotia (Leucoma) salicis* L Bucuresti, Editura Ceres, 262.

SCHNAIDEROVA J., 1959 - Z. Baden nad biolka wierzbowka (*Leucoma salicis* L.). - Prace Inst. Lesn. Warszawa 189: 19-62.

SHTAKELBERG A.A., NARTSCHUK E.P., 1970 - Classifierbook of insects of the European part of the USSR. Vol. V, Second part. Leningrad, Nauka, 943 (in Russian).

TRENCHEV G., 1979 - Investigation on the biology of *Pseudosarcophaga mamillata* Pandelle (Diptera, Sarcophagidae). - Scientific works of HAI "V. Kolarov", vol. 24 (3): 161-164 (in Bulgarian).

TRIAPITZIN V. A., 1978 - Classifierbook of insects of the European part of the USSR. Vol. III, Second part. Leningrad, Nauka, 757 (in Russian).

TSANKOV G., 1990 - Egg parasitoids of the pine processionary moth, *Thaumetopoea pityocampa* (Den. & Schiff.) (Lep., Thaumetopoeidae) in Bulgaria: Species, importance, biology and behaviour. - J. appl. Ent. 110: 7-13.

TSANKOV G., SCHMIDT G.H., MIRCHEV P., 1996 - Parasitism of egg-batches of the pine processionary moth *Thaumetopoea pityocampa* (Den. & Schiff.) (Lep., Thaumetopoeidae) in various regions of Bulgaria. - J. appl. Ent. 120: 93-105.

WAGNER T., LEONARD D., 1980 - Mortality factors of satin moth, *Leucoma salicis* (Lepidoptera, Lymantridae) in aspen forests in Maine. - Entomophaga 25 (1): 7-16.

ZAHARIEVA A., 1981 - Study on the species composition and the role of parasites by the satin moth (*Stilpnotia salicis* L.) in our country. - Scientific works of HIF vol. 27: 107-113 (in Bulgarian).

ZAHARIEVA A., 1982 - Studies on the biology of the satin moth (*Stilpnotia salicis* L., Lymantridae) and measures for fighting it. - Ph.D.Thesis, Univ. of Forestry of Sofia, 202 (in Bulgarian).

ZEROVA M. D., MELIKA ZH. G., TOLKANIC V. I., KOTLENKO A, G., 1989 - Annotated list of insects parasitizing leaf rollers which damage apples in the South-West of the European part of the USSR. - Information bulletin EPS IOBS 28: 7-69 (in Russian).

DR. ANELIA ZAHARIEVA-PENTCHEVA - University of Forestry, Blv. Kliment Ohridski 10, Sofia 1756, Bulgaria.

DR. GEORGI TS. GEORGIEV - Forest Research Institute, Blv. Kliment Ohridski 132, Sofia 1756, Bulgaria.

Accepted 10 January 1997.