

**NATURAL ENEMIES OF SOLITARY BEE POPULATIONS OF
ANTHOPHORINI WITH A SPECIAL REFERENCE TO *ANTHOPHORA
CRINIPES* SM. AND *A. PARIETINA* F. (HYMENOPTERA:
ANTHOPHORIDAE)**

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Natural enemies of the populations of solitary bees of the tribus Anthophorini are: *Insecta* (41 species of 18 families), *Arachnoida* (2 species), *Nematoda* (1 species). Insects are also in the highest numbers parasitoids and predators of the populations *Anthophora crinipes* and *A. parietina*. Eight species are common reducents of both hosts, while each host has its specific enemies. Parasitoid species for which *A. crinipes* and *A. parietina* are new hosts were also recorded.

KEY WORDS: Anthophorini, parasites, parasitoids, hyperparasitoids, cleptoparasitoids, predators, reducents.

INTRODUCTION

Species populations of the tribus Anthophorini have a great number of natural enemies. The ways of bees reduction are different. Their natural enemies can be: parasites, parasitoids, cleptoparasites, and predators. There are no special data on the reducents of the species populations of the tribus Anthophorini. They were dealt with together with other natural enemies of bees (BISCHOF, 1927; FRESE, 1927; SCHMIEDEKNECHT, 1930; OSINČJUK, 1978), or in the papers dealing with the tribus Anthophorini (MOCZAR, 1957; IUGA, 1958), as well as in the papers on the species of Anthophorini (MALIŠEV, 1925; BANASZAK, 1954; MOCZAR, 1961; MUČALICA, 1987, 1990).

With few exceptions, Arthropoda are exclusive reducents of the populations Anthophorini, among which *Insecta* have the primary place, and *Hymenoptera* are

dominant (Table I). In our study of the tribus Anthophorini bees special attention was devoted to natural enemies of populations of the most widespread and most frequent species of *Anthophora*, *A. crinipes* and *A. parietina*.

Table I
Natural enemies of tribe Anthophorini*

Natural enemy	Host
HYMENOPTERA	
CHALCIDOIDEA	
Torymidae	
<i>Monodontomerus areneus</i> Walker	<i>Anthophora</i>
<i>M. dentipes</i> Dalman	<i>Anthophora</i>
<i>M. obscurus</i> Westwod	<i>Anthophora</i>
Pteromalidae	
<i>Habrocytus conopidarum</i> Bouček	<i>Anthophora</i>
Leucospidae	
<i>Leucospis gigas</i> P.	<i>Anthophora</i> , <i>Amegilla</i>
Eulophidae	
<i>Melitobia megachilis</i> Packard	<i>Anthophora</i>
<i>Pediobius willamisoni</i> Girauld	<i>Anthophora</i>
ICHNEUMONOIDEA	
<i>Gasterruption</i> sp.	<i>Anthophora</i>
SAPYGOIDEA	
<i>Sapyga clavicornis</i> L.	<i>Anthophora</i>
CHRYSIDOIDEA	
<i>Chrysis austriaca</i> F.	<i>Anthophora</i>
<i>Ch. ignita</i> L.	<i>Anthophora</i>
<i>Ch. fulgida</i> L.	<i>Anegilla</i>
MUTILLOIDEA	
<i>Mutilla (ronisa) brutia</i> Petagona	<i>Anthophora</i>
VESPOIDEA	
<i>Vespa crabro</i> L.	<i>Anthophora</i>
APOIDEA	
Megachilidae	
<i>Stelis (S.) punctulatissima</i> Kirby (<i>aterrima</i> Pz.)	<i>Anthophora</i>
<i>Coelioxys rufescens</i> Lep	<i>Clisodon</i> , <i>Anthophora</i> , <i>Paramegilla</i>
<i>C. quadridentata</i> L. (<i>conica</i> L.)	<i>Anthophora</i> , <i>Heliophila</i>
<i>Coelioxys alata</i> Först	<i>Clisodon</i>
Anthophoridae	
<i>Ammobates punctatus</i> F.	<i>Heliophila</i>
<i>Melecta armata</i> Pz. (<i>punctata</i> K.)	<i>Anthophora</i> , <i>Habropoda</i>
<i>M. luctuosa</i> Scop.	<i>Anthophora</i> , <i>Amegilla</i>
<i>M. plurinotata</i> Brülle	<i>Anthophora</i>

<i>M. funeraria</i> Sm.	<i>Habropoda</i> , <i>Anthophora</i>
<i>Thyreus scutellaris</i> F.	<i>Anthophora</i>
<i>T. ramosus</i> Lep.	<i>Anthophora</i> , <i>Amegilla</i>
<i>T. histrionicus</i> Ill. (<i>najor</i> Mor.)	<i>Anthophora</i> , <i>Amegilla</i>
<i>T. truncatus</i> Pérez	<i>Amegilla</i>
<i>T. affinis</i> Mor.	<i>Amegilla</i>
FORMICOIDEA	
<i>Cataglyphis viaticus</i>	<i>Anthophora</i>
DIPTERA	
Conopidae	
<i>Phyocephala</i> sp.	<i>Anthophora</i>
Bombyliidae	
<i>Antrax</i> sp.	<i>Anthophora</i>
<i>Bombylus</i> sp.	<i>Anthophora</i>
Sarcophagidae	
<i>Miltegramma astracea</i>	<i>Anthophora</i>
NEUROPTERA	
<i>Myrmeleon formicarius</i> L.	<i>Anthophora</i>
COLEOPTERA	
Melöidea	
<i>Melöe (proscarabeus) violaceus</i> March.	<i>Anthophora</i>
<i>M. (Pr.) proscarabeus</i> L.	<i>Anthophora</i>
<i>M. (Melöe) rugosus</i> March.	<i>Anthophora</i>
<i>M. (M) cicaticosus</i> Leach	<i>Anthophora</i>
<i>Hapalus (Sitaris) muralis</i> Först	<i>Anthophora</i>
Cleridae	
<i>Trichodes alveorius</i> F.	<i>Anthophora</i>
<i>T. apiarius</i> L.	<i>Anthophora</i>
ARACHNIDAE	
Araneae	
<i>Araneus diadematus</i> L.	<i>Anthophora</i>
Acarina	
<i>Sphaerogyne vantriosa</i> Labeulbene	<i>Anthophora</i>
NEMATODES	
<i>Mermis</i> sp.	<i>Anthophora</i>

*) The chart was made on the basis of literatura and personal research.

MATERIAL AND METHODS

The research was carried out in the region of Vojvodina and in wider surroundings of Belgrade. Adults of natural enemies were caught at the entrance to the nests of tribus Anthophorini. Individuals were killed with vinegar ether. The determination was made according to tables for individual groups and material was compared with the collections of the Museum of Natural History in Belgrade and "Zemaljski

Muzej" in Sarajevo. The determination of the species in the superfamily Chalcidoidea was carried out by Ljubodrag Mihajlović (Faculty of Forestry in Belgrade), for which I am thankful. Individual stages of development were monitored directly in host nests, found in the cuts of clay - loess, clay buildings, or in the laboratory. Some specimens were obtained by growing from the host nests. The material belongs to the author's private collection.

RESULTS AND DISCUSSION

The research shows that the greatest number of natural enemies of *Anthophora crinipes* and *A. parietina* are Hymenoptera (Table II). Among Chalcidoidea the common parasitoid for both species is *Monodontomerus obscurus* West., which is simultaneously the most numerous and most aggressive parasitoid. It was found in various stages of development in the cells of the nests of both hosts. The number of parasitoid individuals in a nest cell ranged between 6 and 34. Its diapause is in the stage of prepupae (Fig. 1), and the adult leaves the nest cell through a small hole on the lateral wall, in the spring simultaneously with the host. An adult parasitoid was observed during the host diapause, in individual cases. *Monodontomerus dentipes* Dalman was not found in *Anthophora parietina* nests. *Habrocytus conopidarum* (Bouček) is an endo-hyperparasitoid of *Anthophora crinipes*. Up to 30 adult parasitoids leave a dead bee female through the opening on its abdomen (Fig. 2). *H. conopidarum* was recorded also as a hyper-parasitoid of *Megaechile rotundata* F. (MIHAJLOVIĆ, KRUNIĆ, RICHARDS, 1989). *Chrisidoidea* - *Chrisis austriaca* F. is a cleptoparasite of *Anthophora parietina* and *Ch. ignita* L. of *A. crinipes*. They were often found to fly around the host nest, wait for the moment when the female bee leaves the nest, and quickly enter the nest and lay eggs. *Mutilla (Ranista) brutia* Pentagona, known as cleptoparasite of *Anthophora crinipes* was not found during the research. *Vespa crabro* L. is a predator of *Anthophora crinipes*. It often shares habitats with this bee (lofts, stables) where it was found during the research, although it often feeds on plant sap, larvae also feed on insects, among which is the above *Anthophora*, whether in the region of the colony, or on the flowers. *Anthophora* are parasitized by the following genera of Apoidea: *Coelioxys*, *Melecta*, *Thyreus*. *Coelioxys rufescens* Lep. is a cleptoparasite of both species, though in references it is denoted as a cleptoparasite of *Anthophora parietina*. *Coelioxys* egg does not float as that of *Anthophora*, it is fixed at one end to cell cover, so it is readily distinguished from the host's egg. It probably oviposits when the cell is closed, as in *Megaechile*, where a female drills a hole with a sharp end of its abdomen and it oviposits through the hole. Larvae make cocoons in 2-3 layers, and the adults emerge in the spring, together with the host. *C. quadridentata* L. was not found in the nests of

Anthophora parietina. Cleptoparasites of both species are *Melecta armata* Pz. (*punctata* F.) and *M. luctuosa* Scop., although the references mention it only for *Anthophora parietina*. They lay eggs vertically, fixed to the walls of the cells, so that they differ from the host's eggs. Larva makes a cocoon and adults emerge in the spring, together with the host. The research shows that *Thyreus scutellaris* L. is a cleptoparasite of both species, although references mention it only for *Anthophora parietina*. Its diapause is in the stage of prepupa and the adult emerges simultaneously with the host. As opposed to *Coelioxys*, *Melecta* and *Thyreus* are very aggressive in entering the hosts' nests. Often the host fights the cleptoparasite and it is usually obliged to leave the host's nest. However as soon as the host leaves the nest, it enters and lays eggs. The fight also occurs when a bee finds a cleptoparasite in the nest, *Anthophora* can harm it with its jaws. Cleptoparasite activity is continuous throughout the day. The percentage of *Anthophora* parasitized by cleptoparasites is significantly less than by *Monodontomerus*. Formicoidea - *Cataglyphis viaticus* Fabricius is a predator of both *Anthophora* species. This ant is often seen to bite a bee female by its mandibles, when the bee makes a tsi-tsi sound. The fight between an ant and a bee usually ends by bee death. Attracted by nectar, the ant often drags the abdomen of the dead bee. Individual repletes of the genus *Cataglyphis* collect food - nectar.

Table II

Natural enemies of *Anthophora crinipes* Sm. and *A. parietina* F.

Natural enemy	host			
	<i>A. crinipes</i>		<i>A. parietina</i>	
	Personal research	From literature	Personal research	From literature
HYMENOPTERA				
CHALCIDOIDEA				
Torumidae				
<i>Monodontomerus obscurus</i>	+	-	+	-
<i>M. dentipes</i>	-	-	-	+ (4)
Pteromalidae				
<i>Habrocytus conopidarum</i>	+	-	-	-
CHRYSIDOIDEA				
<i>Chrysis austiaca</i>	-	-	+	+ (4)
<i>Ch. ignita</i>	+	+ (12)	-	-
MUTILLOIDEA				
<i>Mutilla (Ronista) brutia</i>	-	+ (12)	-	-

Natural enemy	host			
	<i>A. crinipes</i>		<i>A. parietina</i>	
	Personal research	From literature	Personal research	From literature
VESPOIDEA				
<i>Vespa crabro</i>	+	-	-	-
APOIDEA				
Megachilidae				
<i>Coelioxys rufescens</i>	+	-	+	+ (4,12,13)
<i>C. quadridentata (conica)</i>	-	-	-	+ (4,12)
Anthophoridae				
<i>Melecta armata (punctata)</i>	+	+ (4)	+	+ (4,5,12)
<i>M. luctuosa</i>	+	-	+	+ (4,5)
<i>Thyreus scutellaris</i>	+	-	+	+ (5,13)
FORMICOIDEA				
<i>Cataglyphis viaticus</i>	+	-	+	-
NEUROPTERA				
<i>Myrmeleon formicarius</i>	+	-	-	-
COLEOPTERA				
Melöidae				
<i>Melöe (Proscarabeus) violaceus</i>	-	-	-	+ (4)
<i>M. (M.) cicatricosus</i>	-	-	-	+ (14)
<i>Hapalus (Sitaris) muralis</i>	-	-	-	+ (4)
Cleridae				
<i>Trichodes apiarius</i>	+	-	+	-
ARACHNIDA				
Aranea				
<i>Araneus diadematus</i>	+	-	-	-
Acarina				
<i>Sphaerogyne ventricosa</i>	-	-	-	+ (4)
NEMATODA				
<i>Mermis</i> sp.	+	-	-	-

The freezing point of some parasitoid and predator species recorded in the order Hymenoptera (Table III) shows that their hibernating stages are adapted to low temperatures, like the host. They do not freeze to death, i.e. ice crystals are not formed in their bodies. These temperatures are very similar to the host's freezing temperature, which indicates the adaptation to the conditions of the reducent. *Anthophora crinipes* enters the diapause as an adult, as opposed to *A. parietina* and other enemies that enter the diapause as pupae.

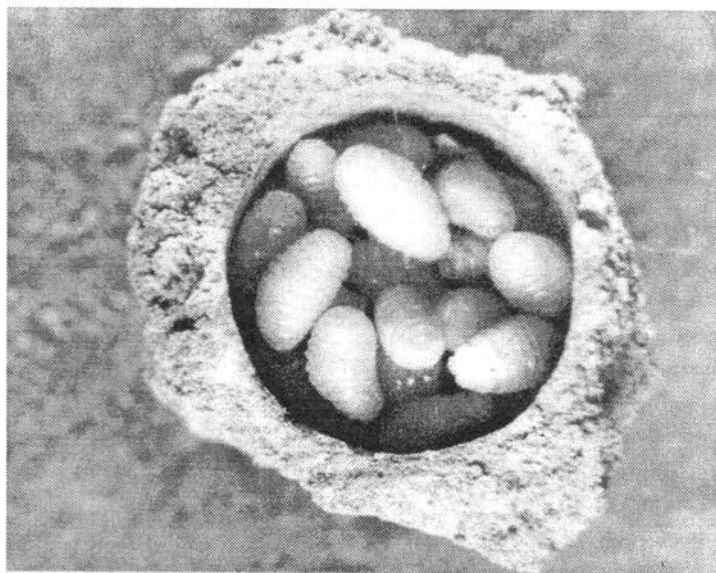


Fig. 1. Cell *Anthophora parietina* F. with prepupae *Monodontomerus obscurus* West. [Original]

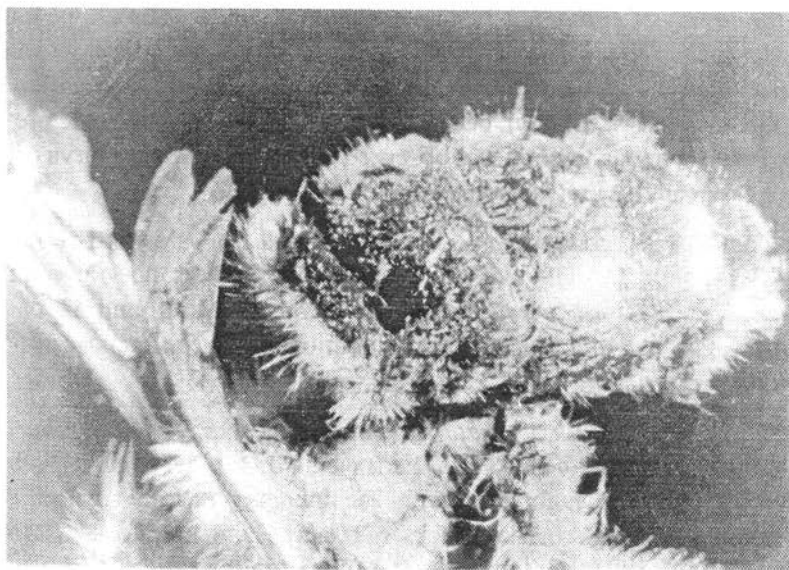


Fig. 2. *Habrocytus conopidarum* Bouček exidit trough the hole on the abdomen of parazited female *Anthophora crinipes* Sm. [Original]

Table III

Freezing temperatures of natural enemies of *Anthophora crinipes* Sm. and *A. parietina* F.

Species	Stage	No. of specimens	Freezing temperature $\bar{x} \pm Se$ (°C)
<i>Monodontomerus obscurus</i>	prepupae	27	- 26.3 ± 0.42
<i>Thyreus scutellaris</i>	prepupae	1	- 24.5 ± 1.49
<i>Anthophora parietina</i>	prepupae	10	- 23.5 ± 1.10
<i>Monodontomerus obscurus</i>	pupae	6	- 22.3 ± 0.01
<i>Anthophora crinipes</i>	pupae	8	- 19.8 ± 1.49
<i>Anthophora parietina</i>	pupae	10	- 23.6 ± 0.46
<i>Anthophora crinipes</i>	adult inactive	12	- 23.6 ± 0.26
<i>Thyreus scutellaris</i>	adult active	4	- 7.1 ± 0.36
<i>Melecta armata (punctata)</i>	adult active	1	- 5.3 ± 0.48
<i>Cataglyphis viaticus</i>	adult active	1	- 11.5 ± 0.28
<i>Anthophora crinipes</i>	adult active	10	- 5.6 ± 0.43
<i>Anthophora parietina</i>	adult active	14	5.7 ± 0.16

In the colony of *Anthophora crinipes* established in loess holes, we found a colony of *Myrmeleon formicarius* L., which occupied the floor of the cavity and *Anthophora* occupied the vertical walls. Coming from the field, loaded with pollen and nectar, due to weak orientation, bee flies to the floor and becomes the prey of *Myrmeleon*. A similar phenomenon was observed in the apiary when a larva of *Eurolone nostras* Forst. caught *Apis mellifera* L.

Coleoptera - *Trichodes apiarus* L. was recorded as a parasitoid of both species, although it is not in the references. According to our findings, it is not frequent, but it is present. We did not observe any *Melöe violaceus* Mard. and *M. cicatricosus* Leach, as well as *Hapalus muralis* Forst., mentioned in the references as parasitoids of *Anthophora parietina*.

Arachnida - *Araneus diadematus* L. is a frequent enemy of *Anthophora crinipes* in its colonies formed in the lofts and sheds where this spider spins its web. Coming from the field, a bee is caught in the web. We did not record any Acarina - *Spharagygne venticosa* Labaulbens that sucks out larvae and prepupae of *Anthophora parietina* (FRIESE, 1923), although we often found in the cells the remnants of prepupa chitin. Some of these cells had an opening on the wall, through which this enemy leaves the cell when there is no more food.

Nematode - *Mermis* sp. were found with *Anthophora crinipes* (Fig. 3), 10-15 days after the individuals were placed in the collections, worms appeared between the segments of the *Anthophora* abdomen. Such a nematode was found during the inspection of the nest in the colony.

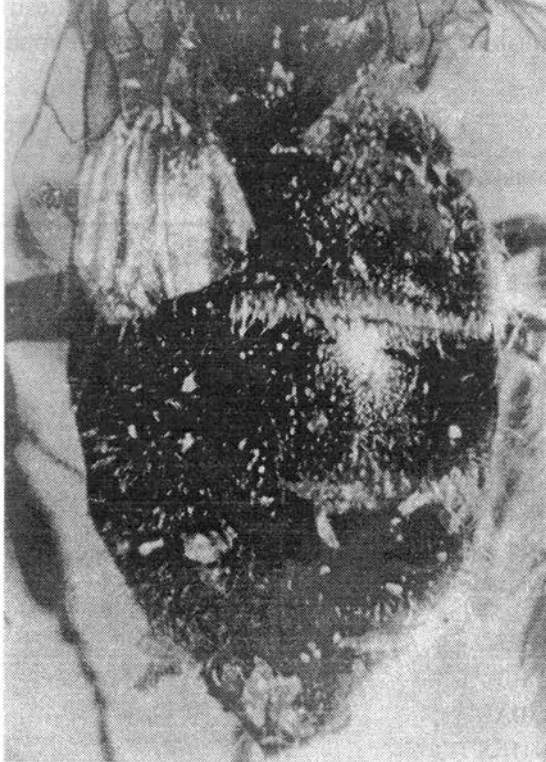


Fig. 3. Worms *Mermis* sp. that parasided female *Anthophora crinipes* Sm. stick out between the abdominal segments of the host. [Original]

Along with the registered natural enemies, some Invertebrata nad Vertebrata can be considered as potential predators of Anthophorini (Table IV). They are predators of many relatives of Anthophorini, so they can be expected to be predators of these bees. Among Hymenoptera, these are: *Monomerius pharaonis* L., *Lasim niger* L., *Paravespula germanica* F., *P. vulgaris* L., *Phylanthus triangulum* F., *Palarus variegatus* F., *Cerceris* sp. Some Asilidae, Syrphidae are potential predators of Anthophorini, but Syrphidae also cause indirect harm by feeding on nectar, and thus cause less food for bees. *Manthis religiosa* L. is also a predator, as well as Arachnida *Thomis alba* L., *Misumena calycina*, *M. tricuspidata* F., *Synaema glo-*

bosum, *Xystricus lateralis* Hahm. which sit on flowers and catch successfully many relatives of Anthophorini. We cannot exclude absolutely the Vertebrata as potential predators: *Bufo*, *Lacertilia*, some Aves. The research of potential predators of Anthophorini is in progress. Humans, by changing the configuration of the ground where the colonies of Anthophorini occur, as well as by destroying the buildings made of clay, contribute to the reduction of Anthophorini populations.

Table IV

Potential natural – enemies of Anthophorini - Invertebrata and Vertebrata

INVERTEBRATA
HYMENOPTERA
FORMICIDAE
<i>Monomerius pharaoneus</i> L.
<i>Lasius niger</i> L.
VESPIDAE
<i>Paravespula germanica</i> F.
<i>P. vulgaris</i> L.
SPHECIDAE
<i>Philanthus (Philanthinus) triangulum</i> F.
<i>Palarus variegatus</i> F. (<i>flavipes</i> F.)
<i>Cerceris</i> sp.
DIPTERA
SYRPHIDAE
ASILIDAE
MANTHOPTERA
<i>Mantis religiosa</i> L.
ARACHNIDA
<i>Thomis alba</i> L.
<i>Misumena calycina</i>
<i>M. tricuspidata</i> F.
<i>Synaema globosum</i> L.
<i>Xystricus lateralis</i> Hahm.
VERTEBRATA
AMPHIBIA - <i>Bufo</i>
REPTILIA - <i>Lacertilia</i>
AVES - <i>Merops apiaster</i> L., <i>Peris apivorus</i> L., <i>Lanius</i> sp.

CONCLUSION

The tribus Anthophorini has a great number of natural enemies: among insects, 41 species of 18 families; 2 species of Arachnida, and 1 species of Nematodes.

Insects, and among them the greatest number of Hymenoptera, are parasitoids, cleptoparasites, predators of the tribus Anthophorini, as well as of the populations *Anthophora crinipes* and *A. parietina*. They have common but also specific natural enemies.

By the research *Monodontomerus obscurus*, *Cataglyphis viaticus*, and *Trichodes apiarius* were recorded as natural enemies of both species.

New natural enemies of *Anthophora crinipes* are: *Habrocytus conopidarum*, *Vespa crabro*, *Coelioxys rufescens*, *Melecta luctuosa*, *Thyreus scutellaris*, *Myrmecoleon formicarius*, *Araneus diadematus*, and *Mermis* sp. Such a great number of new reducents of this species can be explained by the insufficiently researched biology of the species.

The reference data were confirmed, i.e. that *Melecta armata* is the reducent of populations of both species. For *Anthophora crinipes* - it is *Crysis ignita*, and for *A. parietina* - it is *Chrysis austriaca*, *Coelioxys rufescens*, *Melecta luticosa* and *Thyreus scutellaris*.

It was not confirmed that natural enemies of *Anthophora crinipes* is *Mutilla brutia* Petagna, and for *A. parietina* - *Monodontomerus dentipes* Dalman, *Coelioxys quadridentata* L., *Melöe cicatricosus* Leach., *M. violaceus* March., *Hapalus muralis* Forst., *Sphaerogyne venticosa* Laboulbene.

Some Hymenoptera natural enemies of *Anthophora crinipes* and *A. parietina* are phylogenetically and morphologically similar to the host, because they belong to the same family (*Melecta*, *Thyreus*).

The reaction of the host to the presence of natural enemies is very active. Fights between the parasitoid and the host are very frequent, and the host is mainly the winner.

The measurement of freezing temperature of parasitoids of the order Hymenoptera shows that their hibernating stages are adapted to survive low temperatures, i.e. they do not freeze to death. These temperatures are very similar to freezing temperatures of the host's hibernating stages, which indicates the adaptation to environmental conditions.

Mortality was not assessed from the aspect of the host of natural enemies. However it can be concluded that the most important reducent of the populations of *Anthophora crinipes* and *A. parietina* is the parasitoid *Monomontomerus obscurus*.

Some Invertebrata and Vertebrata, whose research is in progress, can be considered as potential reducents of the populations of the tribus *Anthophorini*, and among them we can also include the humans.

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ПРИРОДНИ НЕПРИЈАТЕЉИ ПОПУЛАЦИЈА ПЧЕЛА ТРИБУСА
ANTHOPHORINI СА ПОСЕБНИМ ОСВРТОМ НА ВРСТЕ *ANTHOPHORA*
CRINIPES SM И *A. PARIETINA* F. (HYMENOPTERA: ANTHOPHORIDAE)

З. МУЧАЛИЦА

ИЗВОД

Природни непријатељи популација солитарних пчела трибуса Anthophorini (Таб. I) су: инсекти (41 врста из 18 фамилија, претежно Hymenoptera), Arachnida две и Nematoda једна врста. Инсекти, односно Hymenoptera су такође у највећем броју паразитоиди, клептопаразити и предатори популација *Anthophora crinipes* и *A. parietina*. Оне имају заједничке али и специфичне природне непријатеље (Таб. II).

Природни непријатељи заједнички за обе врсте су: *Monodontomerus obscurus*, *Cataglyphus viaticus* и *Trichodes apiarius*. За *Anthophora crinipes* природни непријатељи редуценти популација су *Habrocytus conopidarium*, *Vespa crabro*, *Coelioxys rufescens*, *Melecta luctuosa*, *Thyreus scutellaris*, *Murmeleon formicarius*, *Araneus diadematus* и *Mermis* sp.

Потврђени су подаци да су редуценти популација за обе врсте *Melecta armata*, а за *Anthophora crinipes* то је *Chrysis ignita*, а код *A. parietina* то су: *Chrysis austiaca*, *Coelioxys rufescens*, *Melecta luctuosa*, *Thyreus scutellaris*.

Нису потврђени наводи из литературе да је редуцент популација *Mutilla brutia* код *Anthophora crinipes*, нити за *A. parietina* врсте *Monodontomerus dentipes*, *Coelioxys quadridentatus*, *Meloe cicatricosus*, *M. violaceus*, *Hapalus muralis*, *Sphaerogone venticosa*.

Температуре мржњења презимљујућих стадијума домаћина и природних непријатеља су врло сличне (Таб. III).

Реакција домаћина на присуство природног непријатеља у гнезду је врло активно. Највећи редуцент популација за обе врсте је *Monodontomerus obscurus*.

Неке Инвертебрата и Вертебрата можемо сматрати као потенцијалне природне непријатеље популација трибуса Anthophorini (Таб. IV).

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