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Taxonomy & Inventories

New parasitoid (Hymenoptera, Chalcidoidea) records of bark beetles (Coleoptera, Curculionidae, Scolytinae) in pine plantations in Bulgaria

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Abstract

Background

In 2020 and 2021, chalcidoid parasitoids (Hymenoptera, Chalcidoidea) of bark beetles in pine (*Pinus* spp.) plantations were studied in Bulgaria. Samples (cuttings of stems and branches) of pine trees infested by bark beetles were collected from seven plantations of *Pinus sylvestris* and *P. nigra* in Bulgaria. From each sampling plot, five cuttings were collected and placed in photoeclectors in laboratory conditions (18-22ºC). Emerged bark beetles and parasitoids were regularly gathered and fixed in ethanol.

New information

Six parasitoid species - *Dinotiscus colon*, *Metacolus azureus*, *M. unifasciatus*, *Rhopalicus quadratus*, *R. tutela* (Chalcidoidea: Pteromalidae) and *Heydenia pretiosa* (Chalcidoidea,

Heydeniidae) were reared from five bark beetle hosts (*Ips acuminatus*, *Pityogenes bistridentatus*, *Pityophthorus pityographus*, *Tomicus piniperda* and *T. minor*). Amongst them, three species (*H. pretiosa*, *M. azureus* and *R. quadratus*) are recorded as new for Bulgarian fauna.

Keywords

bark beetles, parasitoids, Pteromalidae, Heydeniidae, new records, Bulgaria

Introduction

In the 1950s and 1960s, intensive forest planting has been developed under the process of afforestation on degraded and deforested lands in the lower forest belt in Bulgaria. *Pinus nigra* Arn. and *Pinus sylvestris* L. have been the main species used in forest plantations in this region. Increasing the age of plantations in the habitats has led to an increase in moisture deficit, deterioration of the physiological condition of plants and a reduction of their resistance to abiotic and biotic effects (Mirchev et al. 2016). These factors had an adverse effect on forests, especially on the pine monocultures in the lower forest belt (Yangyozov 2010).

In recent decades, forest mortality has increased for many tree species in the countries in the Mediterranean Region due to dry and warm conditions (Allen et al. 2010). In Bulgaria, the tendency for decreasing precipitation during the vegetation period had an adverse effect on forests reducing their resistance to biotic and abiotic factors. This creates a prerequisite for increased development of population density of biotic agents, such as bark beetles or fungal pathogens, especially in pine plantations created outside of their natural range (Yangyozov 2011).

A total of 121 species of bark beetles have been established in Bulgaria and about half of them are associated with pines (*Pinus* spp.) (Doychev 2014). Some of them, mainly representatives of the genera *Ips* and *Tomicus*, appear as destructive pests in pine plantations weakened by various abiotic factors (Mirchev et al. 2016). Their ecology is not well studied, especially with regard to trophic associations with chalcidoid parasitoids (Chalcidoidea, Hymenoptera).

The present study reports new chalcidoid parasitoids of bark beetles for the Bulgarian fauna and information about their impact on host abundance.

Materials and methods

Our studies of parasitoids (Hymenoptera, Chalcidoidea) of bark beetles were conducted during the years 2020-2022 in seven plantations of *Pinus sylvestris* L. and *Pinus nigra* Arn. growing in five localities in Bulgaria. The main characteristics of the studied areas are presented in Table 1.

Table 1.

Main characteristics of the studied areas.

№	Locality	Geographical coordinates	Altitude, m a.s.l.	Tree species	Origin	Age, years	Year of study
1	Golema Rakovitsa	N 42.615944, E 23.784333	651	*Pinus sylvestris*	Plantation	40	2020
2	Krushovitsa	N 42.590466, E 23.657520	697	*Pinus sylvestris*	Plantation	55	2020
3	Mechkovtsi	N 42.556080, E 23.747801	939	*Pinus sylvestris*	Plantation	45	2021-2022
4	Venkovets	N 42.436282, E 23.668128	828	*Pinus sylvestris*	Plantation	50	2022
5	Dolni Pasarel 1	N 42.424683, E 23.616527	831	*Pinus sylvestris*	Plantation	55	2022
6	Dolni Pasarel 2	N 42.437758, E 23.649787	889	*Pinus sylvestris*	Plantation	55	2022
7	Dolni Pasarel 3	N 42.418542, E 23.617609	833	*Pinus nigra*	Plantation	55	2022

Samples (cuttings of stems and branches of approximate length 30-35 cm and diameter 12-30 cm for stems and 5-10 cm for branches) of trees attacked by bark beetles were collected in May-August. In each plantation, five trees were examined and sampled.

The material was transported to the Forest Research Institute in Sofia where each cutting was kept in a separate photoeclector at room temperature (18-22ºC). The samples were observed weekly for the emergence of adult hosts or parasitoids.

The emerged bark beetles were identified using the keys of Karaman (1971) and Grüne (1979). Parasitoids were identified following Graham (1969), Gibson (2003) and Tselikh (2010).

The biological material was deposited in the entomological collections of the Forest Research Institute and Institute of Biodiversity and Ecosystem Research in Sofia.

Checklist

Dinotiscus colon (Linnaeus, 1758)

Material

a. country: Bulgaria; municipality: Elin Pelin; locality: Krushovitsa; verbatimElevation: 697 m; verbatimLatitude: 42.590466; verbatimLongitude: 23.65752; startDayOfYear: 06/06/2020; endDayOfYear: 23/07/2020; sex: 1 male; establishmentMeans: Rearing from *Ips*

acuminatus; recordedBy: S. Belilov leg. [SB]; occurrenceID: C7ED67B3-F891-54F3-9BB7-B797E14D58CA

Native status: native

Metacolus azureus (Ratzeburg, 1844)

Material

a. country: Bulgaria; municipality: Elin Pelin; locality: Krushovitsa; verbatimElevation: 697 m; verbatimLatitude: 42.590466; verbatimLongitude: 23.65752; startDayOfYear: 06/06/2020; endDayOfYear: 05/08/2020; sex: 4 males, 6 females; establishmentMeans: Rearing from *Ips acuminatus*, *Pityogenes bistridentatus*, *Pityophthorus pityographus*, *Tomicus piniperda*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 54F1A671-E15F-525B-9F25-4CB56D1C60C1

Native status: native

Metacolus unifasciatus (Foerster, 1856)

Materials

a. country: Bulgaria; municipality: Elin Pelin; locality: Krushovitsa; verbatimElevation: 697 m; verbatimLatitude: 42.590466; verbatimLongitude: 23.65752; startDayOfYear: 06/06/2020; endDayOfYear: 05/08/2020; sex: 11 males, 15 females; establishmentMeans: Rearing from *Ips acuminatus*, *Pityogenes bistridentatus*, *Pityophthorus pityographus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 10BEBAA0-9021-59A5-98EB-45A2B0DCEB98

b. country: Bulgaria; municipality: Ihtiman; locality: Mechkovtsi; verbatimElevation: 939 m; verbatimLatitude: 42.55608; verbatimLongitude: 23.747801; startDayOfYear: 29/06/2022; endDayOfYear: 05/07/2022; sex: 2 males, 3 females; establishmentMeans: Rearing from *Ips acuminatus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 899EC99C-99D5-50B7-8790-25FC081F2981

Native status: native

Rhopalicus quadratus (Ratzeburg, 1844)

Materials

a. country: Bulgaria; municipality: Elin Pelin; locality: Golema Rakovitsa; verbatimElevation: 651 m; verbatimLatitude: 42.615944; verbatimLongitude: 23.784333; startDayOfYear: 06/06/2020; endDayOfYear: 02/09/2020; sex: 13 males, 11 females; establishmentMeans: Rearing from *Ips acuminatus*, *Tomicus piniperda*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: CCF09913-6DDD-57E8-9035-635C44EDAE2C

b. country: Bulgaria; municipality: Elin Pelin; locality: Krushovitsa; verbatimElevation: 697 m; verbatimLatitude: 42.590466; verbatimLongitude: 23.65752; startDayOfYear: 06/06/2020; endDayOfYear: 02/08/2020; sex: 46 males, 27 females; establishmentMeans: Rearing from *Ips acuminatus*, *Pityogenes bistridentatus*, *Pityophthorus pityographus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 33D856DE-18EA-50C7-847D-344904C26DD3

c. country: Bulgaria; municipality: Ihtiman; locality: Mechkovtsi; verbatimElevation: 939 m; verbatimLatitude: 42.55608; verbatimLongitude: 23.747801; startDayOfYear: 18/06/2021; endDayOfYear: 01/07/2021; sex: 5 males; establishmentMeans: Rearing from *Tomicus piniperda*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 8A07ACFC-6FF9-57FA-982D-FA938C3F726F

d. country: Bulgaria; municipality: Sofia, Pancharevo region; locality: Dolni Pasarel; verbatimElevation: 889 m; verbatimLatitude: 42.437758; verbatimLongitude: 23.649787; startDayOfYear: 11/07/2022; endDayOfYear: 21/07/2022; sex: 10 males, 18 females; establishmentMeans: Rearing from *Ips acuminatus*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: DBF82BC2-E5AF-5816-9C8B-74B09D14EB97

e. country: Bulgaria; municipality: Ihtiman; locality: Venkovets; verbatimElevation: 828 m; verbatimLatitude: 42.436282; verbatimLongitude: 23.668128; startDayOfYear: 06/06/2020; endDayOfYear: 01/07/2020; sex: 5 males, 7 females; establishmentMeans: Rearing from *Ips acuminatus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 2F261A1F-BFE9-5010-84EA-71D08C3C11A4

Native status: native

Rhopalicus tutela (Walker, 1836)

Materials

a. country: Bulgaria; municipality: Elin Pelin; locality: Golema Rakovitsa; verbatimElevation: 651 m; verbatimLatitude: 42.615944; verbatimLongitude: 23.784333; startDayOfYear: 11/07/2022; endDayOfYear: 01/08/2022; sex: 3 males, 1 female; establishmentMeans: Rearing from *Tomicus piniperda*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: DA9884E5-C355-527C-B4F8-B23A190DC204

b. country: Bulgaria; municipality: Sofia, Pancharevo region; locality: Dolni Pasarel; verbatimElevation: 833 m; verbatimLatitude: 42.418542; verbatimLongitude: 23.617609; sex: 3 males, 3 females; establishmentMeans: Rearing from *Ips acuminatus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 6F8E5C68-164A-563E-8A71-EF2AFD81ECCB

Native status: native

Heydenia pretiosa (Förster, 1856)

Materials

a. country: Bulgaria; municipality: Elin Pelin; locality: Krushovitsa; verbatimElevation: 697 m; verbatimLatitude: 42.590466; verbatimLongitude: 23.65752; startDayOfYear: 06/06/2020; endDayOfYear: 31/07/2020; sex: 2 males, 18 females; establishmentMeans: Rearing from *Ips acuminatus*, *Pityogenes bistridentatus*, *Pityophthorus pityographus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 92C41B55-3328-50C3-997D-14A77D564FDF

b. country: Bulgaria; municipality: Elin Pelin; locality: Golema Rakovitsa; verbatimElevation: 651 m; verbatimLatitude: 42.615944; verbatimLongitude: 23.784333; startDayOfYear: 06/06/2020; endDayOfYear: 31/07/2020; sex: 1 female; establishmentMeans: Rearing from *Tomicus piniperda*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 32F813A2-A298-563E-B2F5-25FCA7EF9A43

c. country: Bulgaria; municipality: Ihtiman; locality: Venkovets; verbatimElevation: 828 m; verbatimLatitude: 42.436282; verbatimLongitude: 23.668128; startDayOfYear:

11/07/2022; endDayOfYear: 21/07/2022; sex: 1 male, 1 female; establishmentMeans: Rearing from *Ips acuminatus*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 9A29ABAA-EE82-59E5-B617-7465E323CA9D

d. country: Bulgaria; municipality: Sofia, Pancharevo region; locality: Dolni Pasarel; verbatimElevation: 831 m; verbatimLatitude: 42.424683; verbatimLongitude: 23.616527; startDayOfYear: 11/07/2022; endDayOfYear: 01/08/2022; sex: 2 males, 2 females; establishmentMeans: Rearing from *Ips acuminatus*, *Tomicus minor*; recordedBy: S. Belilov leg. [SB]; occurrenceID: 35FB0428-21CA-5C9A-B4E5-EFF0E84F07E2

Native status: native

Analysis

Six parasitoid species from two chalcidoid families were found to emerge from the tree samples: *Dinotiscus colon* Linnaeus, 1758, *Metacolus azureus* Ratzeburg, 1844, *Metacolus unifasciatus* Foerster, 1856, *Rhopalicus quadratus* (Ratzeburg, 1844), *Rhopalicus tutela* (Walker, 1836) (Chalcidoidea, Pteromalidae) and *Heydenia pretiosa* Förster, 1856 (Chalcidoidea, Heydeniidae) (Table 2).

Table 2.

Number and relative abundance of different species in the parasitoid complex.

Species	**Host**	**Locality**	**Date of collection**	**E mergence period**	**Parasitoid number**			**Relative share**, %
					♀♀	♂♂	**Σ**	
Dinotiscus colon	*I. acuminatus*	Krushovitsa	05.06.2020	06.06.-23.07.2020	1	0	1	0.4
**Heydenia pretiosa*	*I. acuminatus*	Krushovitsa	05.06.2020	06.06.-31.07.2020	11	1	12	12.6
		D. Pasarel 1	11.07.2022	11.07.-01.08.2022	1	0	1	
		Venkovets	11.07.2022	11-21.07.2022	1	1	2	
	P. bistridentatus	Krushovitsa	05.06.2020	06.06.-31.07.2020	5	1	6	
	T. piniperda, *T. minor*	G. Rakovitsa	05.06.2020	06.06.-31.07.2020	1	0	1	
	I. acuminatus, *P. bistridentatus*, *P. pityographus*	Krushovitsa	05.06.2020	06.06.-02.08.2020	2	0	2	
	T. minor	D. Pasarel 1	11.07.2022	11-21.07.2022	1	0	1	
		D. Pasarel 3	11.07.2022	11.07.-01.08.2022	1	2	3	
**Metacolus azureus*	*I. acuminatus*	Krushovitsa	05.06.2020	06.06.-05.08.2020	1	0	1	4.5
	P. bistridentatus	Krushovitsa	05.06.2020	06.06.-23.07.2020	3	0	3	

Species	**Host**	**Locality**	**Date of collection**	**E mergence period**	**Parasitoid number**			**Relative share**, %
					♀♀	♂♂	**Σ**	
	I. acuminatus, *P. bistridentatus*, *P. pityographus*	Krushovitsa	05.06.2020	06.06.-05.08.2020	2	3	5	
	T. piniperda, *T. minor*	Krushovitsa	05.06.2020	06.06.-05.08.2020	0	1	1	
Metacolus unifasciatus	*I. acuminatus*	Krushovitsa	05.06.2020	06.06.-05.08.2020	6	4	10	14.0
		Mechkovtsi		29.06.-05.07.2022	3	2	5	
	P. bistridentatus	Krushovitsa	05.06.2020	06.06.-23.07.2020	7	5	12	
	P. bistridentatus, *P. pityographus*	Krushovitsa	05.06.2020	06.06.-02.08.2020	0	1	1	
	I. acuminatus, *P. bistridentatus*, *P. pityographus*	Krushovitsa	05.06.2020	06.06.-02.08.2020	2	1	3	
**Rhopalicus quadratus*	*Ips acuminatus*	G. Rakovitsa	05.06.2020	06.06.-02.09.2020	5	2	7	64.0
		Krushovitsa	05.06.2020	06.06.-05.08.2020	14	15	29	
		D. Pasarel 1	11.07.2022	11.07.-01.08.2022	2	0	2	
		D. Pasarel 2	11.07.2022	11-21.07.2022	9	5	14	
		Venkovets	11.07.2022	11-21.07.2022	7	5	12	
	P. bistridentatus	Krushovitsa	05.06.2020	06.06.-23.07.2020	10	29	39	
	I. acuminatus, *P. bistridentatus*, *P. pityographus*	Krushovitsa	05.06.2020	06.06.-02.08.2020	3	1	4	
	T. piniperda, *T. minor*	G. Rakovitsa	05.06.2020	06.06.-01.07.2020	6	11	17	
	T. piniperda, *T. minor*	Krushovitsa	05.06.2020	06.06.-05.08.2020	0	1	1	
	T. minor	Mechkovtsi	16.06.2021	18.06.-01.07.2021	2	0	2	
		D. Pasarel 1	11.07.2022	11-21.07.2022	7	5	12	
	T. minor, *T. piniperda*	Mechkovtsi	16.06.2021	18.06.-01.07.2021	3	0	3	
Rhopalicus tutela	*T. piniperda*, *T. minor*	G. Rakovitsa	05.06.2020	06.06.-01.07.2020	1	3	4	4.5
	I. acuminatus	D. Pasarel 1	11.07.2022	11.07.-01.08.2022	0	1	1	
	I. acuminatus	D. Pasarel 2	11.07.2022	11-21.07.2022	3	2	5	
Total					**120**	**102**	**222**	**100.0**

The parasitoids emerged from five species of bark beetles (Coleoptera, Curculionidae, Scolytinae): *Ips acuminatus* (Gyllenhal, 1827), *Pityogenes bistridentatus* (Eichhoff, 1878),

Pityophthorus pityographus (Ratzeburg, 1837), *Tomicus piniperda* (Linnaeus, 1758) and *Tomicus minor* (Hartig, 1834).

In this study, three species (*H. pretiosa*, *M. azureus* and *R. quadratus*) were newly recorded for the Bulgarian fauna.

During the study period, *R. quadratus* (64.0%) was the most abundant species in the total number of the emerged parasitoids, followed by *M. unifasciatus* (14.0%), *H. pretiosa* (12.6%), *Metacolus azureus* (4.5%) and *Rhopalicus tutela* (4.5%), whereas *Dinotiscus colon* was represented by 0.4%.

The parasitism varied widely in individual species and groups of bark beetles and in different localities: in *I. acuminatus* from 47.8% (Krushovitsa loc.) to 90.5% (Dolni Pasarel loc.); in *T. piniperda* and *T. minor* from 2.1-2.8% (Mechkovtsi loc.) to 91.7% (Rakovitsa loc.); in *P. bistridentatus* and *P. pityographus* from 7.7 to 89.6% (Krushovitsa) (Table 3). It should be emphasised that, in individual cases, both more than one host and more than one parasitoid were isolated from the photoeclector samples.

Table 3.

Parasitism of bark beetles in studied localities.

Locality	**Year**	**Parasitoid species**	**Bark beetle host**	**Parasitism**, %
Golema Rakovitsa	2020	*Rhopalicus quadratus*	*Ips acuminatus*	53.8
		Heydenia pretiosa, *Rhopalicus quadratus*, *Rhopalicus tutela*	*Tomicus piniperda*, *Tomicus minor*	91.7
Krushovitsa	2020	*Dinotiscus colon*, *Heydenia pretiosa*, *Metacolus azureus*, *Metacolus unifasciatus*, *Rhopalicus quadratus*	*Ips acuminatus*	47.8
		Heydenia pretiosa, *Metacolus azureus* , *Metacolus unifasciatus*, *Rhopalicus quadratus*	*Ips acuminatus*, *Pityogenes bistridentatus*, *Pityophthorus pityographus*	58.3
		Heydenia pretiosa, *Metacolus azureus* , *Metacolus unifasciatus*, *Rhopalicus quadratus*	*Pityogenes bistridentatus*	89.6
		Metacolus unifasciatus	*Pityogenes bistridentatus*, *Pityophthorus pityographus*	7.7
		Metacolus azureus, *Rhopalicus quadratus*	*Tomicus piniperda*, *Tomicus minor*	14.3
Mechkovtsi	2020	*Rhopalicus quadratus*	*Tomicus piniperda*	2.8
		Rhopalicus quadratus	*Tomicus piniperda*, *Tomicus minor*	2.1
	2021	*Metacolus unifasciatus*	*Ips acuminatus*	71.4
Venkovets	2021	*Heydenia pretiosa*, *Rhopalicus quadratus*	*Ips acuminatus*	66.7
Dolni Pasarel 1	2021	*Heydenia pretiosa*, *Rhopalicus quadratus*, *Rhopalicus tutela*	*Ips acuminatus*	66.7

Locality	Year	Parasitoid species	Bark beetle host	Parasitism, %
		Heydenia pretiosa, *Rhopalicus quadratus*	*Tomicus minor*	37.1
Dolni Pasarel 2	2021	*Rhopalicus quadratus*, *Rhopalicus tutela*	*Ips acuminatus*	90.5
Dolni Pasarel 3	2021	*Heydenia pretiosa*	*Tomicus minor*	18.8

Discussion

The chalcidoids found in this study are well known as parasitoids of bark beetles: *Dinotiscus colon* was previously reared from *Ips acuminatus*, *Tomicus minor* and *T. piniperda*; *Heydenia pretiosa* – from *I. acuminatus*, *I. typographus*, *T. minor*, *Orthotomicus erosus* (Wollaston, 1857) and *Pityokteines vorontzowi* (Jakobson, 1895); *Metacolus azureus* – from *I. acuminatus*, *O. erosus*, *Pityogenes conjunctus* (Reitter, 1887), *Pityogenes chalcographus* (Linnaeus, 1761), *T. minor* and *T. piniperda* (Kenis et al. 2004, Wegensteiner et al. 2015); *Metacolus unifasciatus* – from *I. acuminatus*, *I. typographus*, *O. erosus*, *T. minor* and *T. piniperda* (Kenis et al. 2004, Wegensteiner et al. 2015); *Rhopalicus quadratus* – from *I. acuminatus*, *Ips amitinus* (Eichhoff, 1871), *P. chalcographus*, *Pityokteines curvidens* (Germar, 1824), *Polygraphus poligraphus* (Linnaeus, 1758), *T. minor* and *T. piniperda* (Kenis et al. 2004, Wegensteiner et al. 2015); *Rhopalicus tutela* – from *Dendroctonus micans* (Kugelann, 1794), *I. acuminatus*, *I. amitinus*, *Ips duplicatus* (Sahlberg, 1836), *Ips sexdentatus* (Börner, 1776), *I. typographus*, *P. chalcographus*, *P. curvidens*, *P. poligraphus*, *T. minor* and *T. piniperda* (Kenis et al. 2004, Wegensteiner et al. 2015).

Three chalcidoid species (*Heydenia pretiosa*, *Metacolus azureus* and *Rhopalicus quadratus*) were reported as new for the Bulgarian fauna. One of them, *H. pretiosa*, was recently elevated from Pteromalidae to family rank (Heydeniidae) by Burks et al. (2022).

As concerns the remaining parasitoid species, *Dinotiscus colon* has been previously recorded from Bulgaria as a parasitoid of *Scolytus amygdali* Guerin, 1847, *Scolytus mali* (Bechstein, 1805) and *Scolytus rugulosus* (Muller, 1818) (Thompson 1954). In addition, another species from the genus, *Dinotiscus eupterus* Walker, 1836, was established as a parasitoid of *Ips typographus* (Linnaeus, 1758) in Bulgaria (Georgiev and Stojanova 2006).

Metacolus unifasciatus has been previously recorded from Bulgaria as a parasitoid of *Ovalisia* (*Palmar*) *festiva* (Linnaeus, 1767) (Coleoptera, Buprestidae) (Ruseva et al. 2020).

Rhopalicus tutela was first recorded for the Bulgarian fauna by Vidal (1993) and was reported again later as a parasitoid of *I. typographus* by Georgiev and Stojanova (2006).

It can be concluded that the species composition and the population dynamics of chalcidoid parasitoids of bark beetles in pine stands in Bulgaria have not been studied sufficiently in the past. In this study, high levels of host mortalities were registered, but

more field observations are necessary to evaluate the actual impact of these natural enemies on the pest populations.

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