Available online: www.notulaebotanicae.ro
Print ISSN 0255-965X; Electronic 1842-4309
Not Bot Horti Agrobo, 2014, 42(1):270-274

Parasitoids and Predators of *Ips typographus* (L.) in Unmanaged and Managed Spruce Forests in Natural Park Apuseni, Romania

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Abstract

The last time span, of protected areas of forest ecosystems established raise of a variety of problems regarding frequency and intensity of the attack carried out by the rich pest complex affecting the trees' state of health. The current legislation forbids the application of pests control measures which can affect the biodiversity of these ecosystems. Species belonging to the useful entomofauna may interfere in the decrease of pest populations in these areas. The study of the parasitoid and predator complex has thus become a very topical research field, and these type of studies were carried out in Natural Park Apuseni, Romania. With the aim to identify present parasitoids and predators, 24 spruce logs provided from physiological weakened trees of 20-25 cm diameter and 1 m length were placed in 6 locations, in order to be populated by the spruce bark beetle *Ips typographus* (Linnaeus) as a trophic base of useful insect species. After its infestation the wood material was put in eclectors and analyzed weekly for the spruce bark beetle *Ips typographus*, its parasitoids and predators. After examining collected biological material, 6 parasitoid species were identified which determined a 4.8% parasitization in unmanaged and 2.3% parasitization in managed forests. The best represented Hymenopteran parasitoids were *Roptrocerus xylophagorum* (Ratzeburg) and *Rhopalicus tutela* (Walker). The found Coleopteran predators were from 12 species, which belong to 4 families. The most captures were of the species *Nemosoma elongatum* (Linnaeus), representing 50.3% of the total captured predators and *Rhizophagus cribratus* (Gyllenhaal), representing 9.5% of the captures.

Keywords: insect natural enemies, parasitoids, predators, spruce bark beetle

Introduction

The spruce bark beetle, *Ips typographus* L., is considered to be one of the most destructive scolytid which attacks the spruce in Palaearctic regions (Christiansen and Bakke, 1988). One of the most harmful bark beetles is located in the spruce (*Picea abies* [L.] Karst.) forest stands in Romania (Oltean, 2003), as well as in another spruce species - *Picea orientalis* (L.) Link, *Picea obovata* Ledeb. and *Picea jezoensis* (Sieb. *et* Zucc.) Carr. (Simionescu, 1976). The population fluctuation depends on the presence of suitable brood material in the forest stands and on the good climatic conditions during the swarming (Escherich, 1942; Lobinger, 1994; Schwenke, 1974). In such situations the pest, which is usually capable to infest physiologically week, harmed trees (Lausch *et al*., 2011), is able to largely multiply and to turn to harmful to healthy standing trees (Arsenescu *et al*., 1966), thus becoming a primary pest. A series of factors, such as drought, soil water excess, tree crashes and cracks due to strong wind, wet snow, defoliation, heat strokes, fire, cryptogamic fungus, competition, age, pollution, predispose trees to spruce bark beetle attacks (Christiansen, 1991; Lausch *et al*., 2011; Faccoli and Bernardinelli, 2011, 2014).

Even though spruce bark beetle control strategies have been thoroughly studied in the course of time, the most efficient method to eradicate the pest outbreaks is to apply sanitation felling of infested trees, followed by the transportation of the infested wood outside the forest stands (Feicht, 2004). Anyway, if no immediate measures are taken to stop the spruce bark beetle outbreaks, the effects on the natural and planted forests are catastrophical on wide spread areas (Dengler, 1995; Niemeyer *et al*., 1995; Weslien and Schroeder, 1996). Zoophage species play a special role in the decrease of a pest population. Against this background, a special attention has been lately awarded to the spruce bark beetle parasitoids and predators. Remarkable research in this field was carried out by Krüger and Mills (1990), Hougardy and Grégoire (2001, 2004), Feicht (2004), Hilszczański *et al*. (2007), Marković and Stoianović (2010). This tendency is also justified by the fact that large conifer forest areas from Europe, including Romania in the last 15-20 years, have been included in the

perimeters of protected areas. Such is the case of the Apuseni Mountains forests. Under these circumstances, various approaches in the national or natural park management occurred, in some perimeters, like those under strict or complete protection, numerous activities were forbidden, respectively allowed but with many restrictions, including that of pest control. These changes require management solutions in the case of the appearance of spruce bark beetle outbreaks, without affecting the environment, especially the biodiversity. In the Natural Park Apuseni the wooden vegetation is dominant and it covers approximately 75% of its total surface. The wooden species are mainly represented by spruce (70%), beech (27%), fir (2%). Other conifer species, like the scots pine and the larch or deciduous trees like the ash, oak, sycamore maple, birch and the elm, can be found among the dominant species. The spruce form pure forest stands or mingle with the beech and the fir making up valuable forest stands.

In study areas the spruce bark beetle *Ips typographus* L. have 2 flights on the growing season, spring flight in Mai-June and summer flight in July-August. Overwintering is mainly in adult stage, under the bark of infested spruce in summer.

In this study, we hypothesize that is difference of abundance of *Ips typographus* parasitoids and predators between unmanaged and managed spruce forests, it amid the fact that in managed forests a lot of branches and tops of trees remain in the forest after the cuttings and are populated by bark beetles. The aim of the study was to identify the parasitoid and predator species of the spruce bark beetle, *Ips typographus* L., and to determine their abundance in the spruce forests, unmanaged or managed, in the Natural Park Apuseni, in endemic conditions.

Materials and methods

For the identification of the useful entomofauna, in the Natural Park Apuseni, 6 spruce forest stand plots have been selected in the natural park, 3 in unmanaged forest stands from the areas Şesul Gârzii, Pârâul Ursului, Tomnatec and 3 in managed forest stands from the areas Cheile Ordâncuşii, Groapa de la Barsa and Călineasa (Tab. 1).

Tab. 1. Experimental sites description in Natural Park Apuseni

Plot name	Elevation (m)	Type of management	Number of sampled logs
Şesul Gârzii	1100	Unmanaged	4
Pârâul Ursului	1150	Unmanaged	4
Tomnatec	1150	Unmanaged	4
Cheile Ordâncuşii	1000	Managed	4
Groapa de la Barsa	1100	Managed	4
Călineasa	1150	Managed	4

The selection of experimental plots in 2012, for parasitoid and predator study, was made according to the *Ips typographus* captures registered by the pheromone traps on the 24 surfaces placed in protected area and monitored in 2011, choosing the spruce forests where the largest captures occurred. Thus, before the start of the bark beetle flight, in April, in each plot, on 4 different places, spruce log samples have been placed in order to be populated by bark beetles. The logs have been taking from the same physiological weakened spruce tree. The logs were of 20-25 cm diameter and 1 m length. They were placed standing. At the middle of June the log samples have been introduced into the eclectors and hung on in the northern exposure buildings in the localities Casa de Piatră, Padiş and Doda Pilii (Fig. 1).

Fig. 1. Eclectors for insect captures

The thus made up eclectors were checked weekly until the middle of September. The insects harvested from each eclector were placed in plastic containers, numbered and dated. The samples were transported and analyzed in the Forest Entomology laboratory of the Faculty for Horticulture and Forestry Timişoara, with a view to determine insect species composition and their abundance. Also, the parasitoid percentage in unmanaged and managed forests was calculated following formula: hatched spruce bark beetles + hatched parasitoids = potential beetles number; parasitism percentage = parasitoids number x 100 / potential beetles number.

The significance of differences between unmanaged and managed spruce forests, in Natural Park Apuseni, in the number of *Ips typographus* emerged beetles and in the number of its natural enemies was determined using one-way analysis of variance.

Results and discussion

The conducted studies in 2012 revealed that the 24 analyzed samples were parasitoids from 6 Hymenopteran species which, systematically, belong to two families Braconidae and Pteromalidae. The total number of collected specimens was of 375 individuals - 245 from unmanaged forests located in the preservation area (65.33% of total captures), and 130 from managed forests located in the buffer park area (34.67% of the total parasitoid captures). In the protected Apuseni perimeter, *Roptrocerus xylophagorum* Ratz. and *Rhopalicus tutela* Walk. were the most numerous and the most frequent occurred parasitoids of *Ips typographus* L.. The number of the collected

parasitoids belonging to the species *R. xylophagorum* was 114 individuals, found in 92% of the eclectors from the preservation area, respectively in 83% of the eclectors from the buffer area. The other species - *R. tutela* was detected in 83% of the samples from the preservation area and 42% of the samples from the buffer area. The number of spotted individuals of this species was 111. Both species represent ectoparasitoids of the pest larvae. The parasitoids *R. xylophagorum* and *R. tutela* have frequently been encountered together on spruce trees attacked by *Ips typographus* in unmanaged as well as managed forests, with a relatively uniform distribution on the monitored forest stands areas.

Another larval ectoparasitoid was *Coeloides bostrichorum* Gir. with a number of 76 individuals, signalled in 25% of the analyzed unmanaged forest samples, respectively 17% of the samples from managed forests. The collected individuals of the species *Dendrosoter middendorffi* Ratz. were 49, the species was detected in 33% of the preservation area eclectors, respectively in 58% of the samples from the buffer area. It was the only larval parasitoid signalled in several analyzed samples from the buffer area, but the number of individuls was larger than found in preservation area samples. In small numbers and with a low frequency *Dinotiscus eupterus* Walk. was encountered - in 17% of the preservation area samples and in 12% of the buffer area samples. The species *C. bostrichorum* was encountered grouped in the park perimeter, as well as *Dinotiscus eupterus* Walk. but in a smaller number. *Tomicobia seitneri* Rusch., ectoparasitoid of the imago, was encountered on a single location, in 3 individuals, only in the unmanaged forest.

The parasitization percentage determined for the Hymenopteran parasitoids ranged from 0.1% (*T. seitneri*) to 1.6 % (*R. xylophagorum*) in unmanaged woods and from 0.1% (*D. eupterus*) to 0.8% (*R. tutela*) in managed forests. The total parasitation by 6 parasitoid wasp species was 4.8% in unmanaged forests and 2.3% in managed forests. The results regarding the parasitoid species composition, their

Tab. 2. Parasitoid species of *Ips typographus* L., abundance and parasitization percentage in the Natural Park Apuseni

Species	Unmanaged forests				Managed forests			
	Eclector no.		Parasitoids (no.)	Parasitation (%)	Eclector no.		Parasitoids (no.)	Parasitation (%)
	Total	With parasitoids			Total	With parasitoids		
Hymenoptera: Braconidae								
Coeloides bostrichorum	12	3	52	1.0	12	2	24	0.4
Dendrosoter middendorffi	12	4	26	0.5	12	6	23	0.4
Hymenoptera: Pteromalidae								
Dinotiscus eupterus	12	2	16	0.3	12	1	6	0.1
Rhopalicus tutela	12	10	66	1.3	12	5	45	0.8
Roptrocerus xylophagorum	12	11	82	1.6	12	10	32	0.6
Tomicobia seitneri	12	1	3	0.1	12	-	-	-
Total			245	4.8			130	2.3

abundance and the parasitization percentage in the Natural Park Apuseni are presented in Tab. 2.

The special literature shows that the bark beetle parasitization percentage varies very much. The most parasitization percentages rarely exceed 10%. Eck (1990) indicates a variation ranging from 0.1% to 70%, Marcović and Stoianović (2010) - from 1% to 15%, Feicht (2006) - from 1.2% to 92.2%.

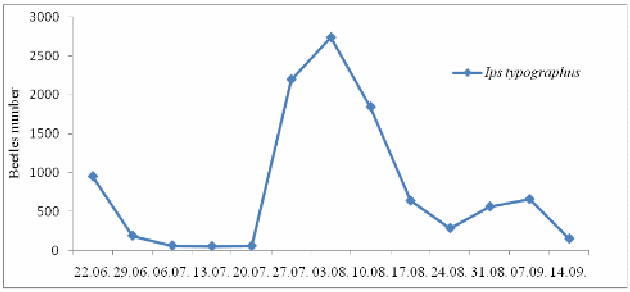
Gutowski and Krzysztofiak (2005) infer the fact that the strict reservations from the preservation area offer more favourable conditions for the development of parasitoids than the managed forests and this is the reason that *Ips typographus* parasitization to be larger in the unmanaged forests as compared to the managed ones. In our study no significant differences were found between unmanaged and managed spruce forests. The parasitoid abundance may be influenced by numerous factors, among which the bark beetle density, the predator density and the existence of alternative feed sources (Feicht, 2004).

The diagram of the parasitoid appearance in correlation with the host species was presented on the Figs. 2a and 2b. As it could be noticed until the 23rd of July the diagram of parasitoid appearance had a more accentuated rising than the diagram of *Ips typographus*. According to the experimental data, 72% of the parasitoids were observed until the moment of the maximum host flight. This fact could be explained by the fact that 5 of the found Hymenopterans are parasites of the last larvae stages and of the host pupae, thus confirming the tight correlation between natural enemies and their hosts, also claimed by Feicht (2004).

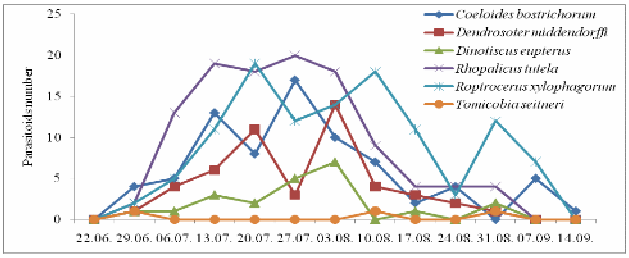
A total number of 10377 individuals of *Ips typographus* L. and 1581 predator individuals (798 in the preservation area samples and 783 in the buffer area samples) were collected (Tab. 3). The number of *Ips typographus* emerged from the single log are comparable in unmanaged and managed forest stands, no statistical differences were found, as previous studies have also reported (Faccoli, 2002). The predators belong to 12 species, 6 species are in Fig. 2c and additional 6 species, which were under 53 individuals each, in logs, was: *Quedius cruentus* Oliv., *Quedius plagiatus* Mannh., *Nudobius lentus* Grav., *Oxypoda acuminata* Steph., *Tachinus elongatus* Gyll., *Epurea laeviuscula* Gyll.. The predator/prey ratio was of 1:6.2 in unmanaged forests and of 1:6.9 in the managed forests area. A very small difference in species composition of predators could be observed between the two investigated areas contrariwise the parasitoids, which presented a higher abundance in the

unmanaged areas as compared with the managed ones. All signalled predator species are from the Order Coleoptera and systematically belong to 4 families: Ostomidae, Monotomidae, Staphylinidae and Nitidulidae.

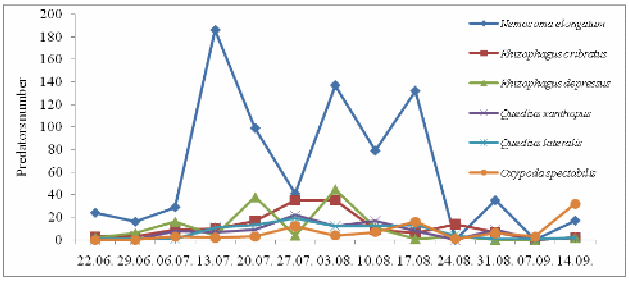
Regarding the abundance of signalled predators foremost the species *Nemosoma elongatum* L. was noticed with a number of 795 individuals, representing total up to 50.3% of the predators. The species was distributed uniformly in the studied area, being signalled in all analyzed eclectors. The next species, from the point of view of captures, was *Rhizophagus cribratus* Gyll. with 150 specimens (representing 9.5% of the predator total),



a)



b)



c)

Fig. 2. Total insects number from the analyzed spruce log samples: a) *Ips typographus*; b) parasitoids; c) predators

followed closely by *R. depressus* F. with 132 individuals (8.3% of the predator total).

It was captured 289 individuals from the Genus Quedius (18.3% of the total predator number) belonging to 4 species, and from the Genus Oxypoda 129 specimens (8.2% of the total predator number) belonging to 2 species. The least individuals were collected from the species *N. lentus* (25 specimens) and *T. elongatus* (20 specimens).

Regarding the predator appearance diagram it was observed a relative overlapping with the appearance of *Ips typographus* beetles. Predators consume the eggs and first larval stages of the host species. Thus, it was noticed that 67% of the predators were captured after the triggering of

Tab. 3. Species of *Ips typographus* L. predators, and their abundance in the Natural Park Apuseni

Date	Unmanaged forests		Managed forests	
	Ips typographus no.	Predators no.	*Ips typographus* no.	Predators no.
22.06.	435	28	516	2
29.06.	101	3	87	24
06.07.	44	44	17	40
13.07.	38	58	15	177
20.07.	17	157	40	57
27.07.	1429	84	766	84
03.08.	1441	154	1295	131
10.08.	763	62	1080	101
17.08.	273	126	365	73
24.08.	70	20	215	13
31.08.	211	52	351	18
07.09.	90	0	568	8
14.09.	35	10	115	55
Total	4947	798	5430	783

the large spruce bark beetle flight and until the decrease in intensity of the flight (Figs. 2a and 2c).

Natural enemies probably play an important role in endemic situations and towards the end of an outbreak, understanding the interactions between bark beetles, antagonists, host plant and control measures will guide silvicultural practice to sustain to increase the regulatory capacities of natural enemies (Wermelinger, 2004).

Except the large spruce bark beetle another bark beetle species were found in the spruce samples collected from the monitored arboreta: *Pityogenes chalcographus* L., *Ips amitinus* Eichh., *Ips acuminatus* Gyll., *Hylurgops glabratus* Zett., *Hylurgops palliatus* Gyll. and *Dryochoetes autographus* Ratz.

Conclusions

In the conifer forest stands from the Natural Park Apuseni, Romania, numerous bark beetles outbreaks were registered, with the dominant species *Ips typographus* followed by *P. chalcographus*. The bark beetle parasitoid complex was represented especially by Hymenopteran parasitoids from the Braconidae and Pteromalidae families. In the studied area 6 parasitoid species were signalled. The most of the captured parasitoids (65.33%) were from unmanaged forest samples versus 34.67% collected from managed forests. The parasitisation percentage of the species *Ips typographus* was of 4.8% in unmanaged forests from the park preservation area and of 2.3% in managed forests from the buffer area, the most significant parasitoid species considered to be *R. xylophagorum* and *R. tutela*. The predator complex was presented by 12 coleopteran species. The species *N. elongatum* and *R. cribratus*, followed by the species from the Genera Quedius and Oxypoda were encountered in the highest abundance. The predator/pray ratio was of 1:6.2 in unmanaged forests and of 1:6.9 in managed ones. In our study no significant differences were found between unmanaged and managed spruce forests by

the point of view of *Ips typographus* emerged beetles, its parasitoids and predators.

Acknowledgment

This study was financed by the project "Postdoctoral School in Agriculture and Veterinary Medicine", POSDRU/89/1.5/S/6237, co-financed by the European Social Fund, through Sectorial Operational Programme for Human Resources Development 2007-2013. We thank to Prof. dr. dr.h.c. Karl Fritz Lauer (University of Applied Sciences Weihenstephan-Triesdorf/Freising), Mr. Adrian Mircu (Forest Research and Management Institute Timişoara) and to administration of Natural Park Apuseni for technical support and general permission.

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