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Investigation on Parasitoids of Bark Beetles with New Host Record (*Taphrorychus lenkoranus* Reitter, 1913 (Curculionidae: Scolytinae)) from Northern Forests of Iran

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The present study was carried out to identify parasitoids of bark beetles in the forests of northern Iran, from 2013–2015 (May–August). Four hymenopterans species belonging to 3 families (Eulophidae, Pteromalidae and Braconidae) were identified as *Ecphylus silesiacus* (Ratzeburg, 1848), *Cheiropachus quadrum* (Fabricius, 1787), *Rhaphitelus maculatus* Walker, 1834 and *Entedon ergias* (Ratzeburg, 1844). Among the identified bark beetles species, *T. lenkoranus* Reitter, 1913 was recorded as a new host of *E. silesiacus* for the first time in the world.

Keywords: Bark beetles, forest, Iran, new record, Hymenopterans.

Bark beetles of the subfamily Scolytinae (Coleoptera: Curculionidae) including more than 6,000 described species are found worldwide (Jordal, 2007). Scolytid are small size species that breed in phloem and destroy plant tissues, and some are important pests of forests and fruit orchard that cause considerable damage (Furniss and Carolin, 1977; Kuschel, 1995). Due to the economic and ecological importance of this subfamily, their biological control would be very important. Successful integrated pest management of bark beetles depends on accurate identification of natural enemies, some researchers have suggested that parasitoids have considerable effect on bark beetles population (Schvester, 1957; Moeck and Safranyik, 1984; Lotfalizadeh, 2012).

According to the recent studies, Hymenopterans parasitoids are the most important natural enemies of bark beetles (Mendel and Dagan, 1986; González and Campos, 1990; Zeiri et al., 2011). Parasitoids of bark beetles in the Palearctic region have been widely studied (Nuorteva, 1957; Peck, 1963; Trjapitzin, 1971; Herting, 1973; Zerova, 1978; Yang, 1996; Lotfalizadeh and Khalghani, 2008). Some important studies have been carried out in the world on parasitoids of bark beetles; for instance, Hedqvist (1998) published a book about chalcid and braconid parasitoids of bark beetles in Sweden. Nuorteva (1957) studied parasitoids of bark beetles in Finland. Maksimović (1979) carried out an

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investigation on parasitoids and reported several species such as *Dendrostoter protuberans* (Nees), *Coleoides scolyticida* wesm and *Ecyphalus silesiacus* (Ratz) as important parasitoids of bark beetles in Siberia. Miller (1983) provided a review of conifer bark beetle parasitoids in Europe, but parasitoids of broadleaf-feeding bark beetles were not widely reviewed. Several surveys have been carried out on *Scolytus* species as important vectors of Dutch elm disease (Maksimović, 1979; Mendel, 1986; Schroeder and Lindelow, 1989; Manojlovic et al., 2000). In other study on almond bark beetles species, three new species, *Cheiropachus quadrum*, *Rhaphitelus maculatus* and *Eusandalum merceti,* were reported in Tunisia (Zeiri et al., 2013). Parasitoids of *Phloeotribus scarabaeoides* (Bernard) a destructive pest on olive plantations was studied by several authors (Russo, 1938; González and Campos, 1990).

Although Scolytid species are among the most important pest in forests of northern Iran, only few studies have been published on their natural enemies in this area. Basiri et al. (2013) have reported *Dendrosoter middendorffii* (Ratzeburg, 1848) as a parasitoid of *Scolytus rugulosus* from Northern and Western fruit orchards of Iran. Moreover, Lotfalizadeh (2010) recorded *Coelopencyrtus callidii* (Jansson, 1957) as parasitoid of bark beetles in Northwest of Iran.

Based on the importance of scolytid damage in forest of Iran (Lotfalizadeh, 2010), identification of parasitoids is an important step in the biological control of pests. Therefore, the aim of this study is to identify the parasitoids of bark beetles and their hosts in the forests of Northern Iran.

Materials and Methods

Sampling was randomly carried out by direct observation. The branches of infested trees were collected from different localities of forest in Guilan, Mazandaran and Golestan provinces in Iran. The exact position of sampling areas are shown in Table 1. Samples were collected from *Carpinus* sp., *Prunus* sp., *Malus* sp. and *Fagus orienta-*

Table 1

Collection site data north forest of Iran

Location	Position		Host plant
Guilan	N 37° 09´ 36˝	E 50° 34´ 28˝	*Prunus* sp.
Guilan	N 37° 09´ 46˝	E 49° 24´ 07˝	*Malus* sp.
Guilan	N 37° 16´ 32˝	E 49° 33´ 49˝	*Prunus* sp.
Golestan	N 36° 53´ 21˝	E 54° 53´ 24˝	*Fagus* sp.
Golestan	N 36° 49´ 95˝	E 54° 41´ 00˝	*Fagus* sp.
Mazandaran	N 36° 29´ 42˝	E 51° 39´49˝	*Prunus* sp.
Mazandaran	N 36° 33´ 36˝	E 51° 36´29˝	*Carpinus* sp.
Mazandaran	N 36° 29´ 26˝	E 51° 39´29˝	*Carpinus* sp.

lis in 2013–2015 from May–August. Collected branches contained larval stages of bark beetles in their galleries. For rearing the beetles, the collected branches were cut off into 50 cm long pieces and put in the rearing boxes (2*2*1) separately under suitable conditions in insectarium. Moisture was 70% temperature at 25 °C and the photoperiod was 16 h light/8 h dark. After 10–15 days, adults of hymenoptera emerged and were collected daily, counted and put into vials containing 90% ethanol and then mounted for morphological identifications. Bark beetles were collected under the bark of trees and counted. All specimens were identified by authors based on relevant keys such as Hedqvist (1998), Farahani and Talebi (2012) and Pfeffer (1995). Species were confirmed by specialists such as Dr. Michail Mandelshtam (Centre for Bioinformatics and Genome Research, Saint-Petersburg State Forest Technical University – Russia), Dr. Gary Gibson (Associate professor, Canadian National Collection of Insects (CNC), Dr. Hossein Lotfalizadeh (Head of East-Azarbaijan Research Center for Agriculture and Natural Resources Tabriz) and Dr. Samira Frahani (Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran). Photographs were taken by Dino-lite AM-423 X attached to binocular Olympus SZ11. Identified samples were labeled with necessary information and deposited in Zoology Museum, University of Tehran, Iran.

Results and Discussion

In this study, a total of 151 specimens of parasitoids, belonging to four species were reared and identified. These are *E. silesiacus* (Ratzeburg, 1848) (Hym:Braconidae), *C. quadrum* (Fabricius, 1787) (Hym:Peteromalidae), *R. maculatus* Walker, 1834 (Hym:-Peteromalidae) and *E. ergias* (Ratzeburg, 1844) (Hym:Eulophidae). During the rearing of *E. silesiacus,* no adult beetles emerged and during dissecting of the logs, parasitized beetles were observed in larval and pupal stages. In total, two adult beetles were identified as *S. rugulosus* (Muller, 1818) and *T. lenkoranus* Reitter, 1913 (Table 2). *E. silesiacus* was counted as 85 specimens and is the most abundant species among other parasitoids (Table 2) that was first recorded by Aubert (1966) from Iran. Maksimović (1979) stated that it is one of the most important parasitoids of bark beetles found on *Ulmus* such as *Scolytus multistriatus* and *S. scolytus* species. This species can be distinguished from

Table 2

Number of reared hymenoptera species

Species	Number of parasitoids emerged	Number of branches in 50 cm long	Host bark beetle
Cheiropachus quadrum	26	3	*Scolytus rugulosus*
Ecphylus silesiacus	85	2	*Taphrorychus lenkoranus*
Entedon ergias	12	1	*Scolytus rugulosus*
Rhaphitelus maculatus	28	2	*Scolytus rugulosus*

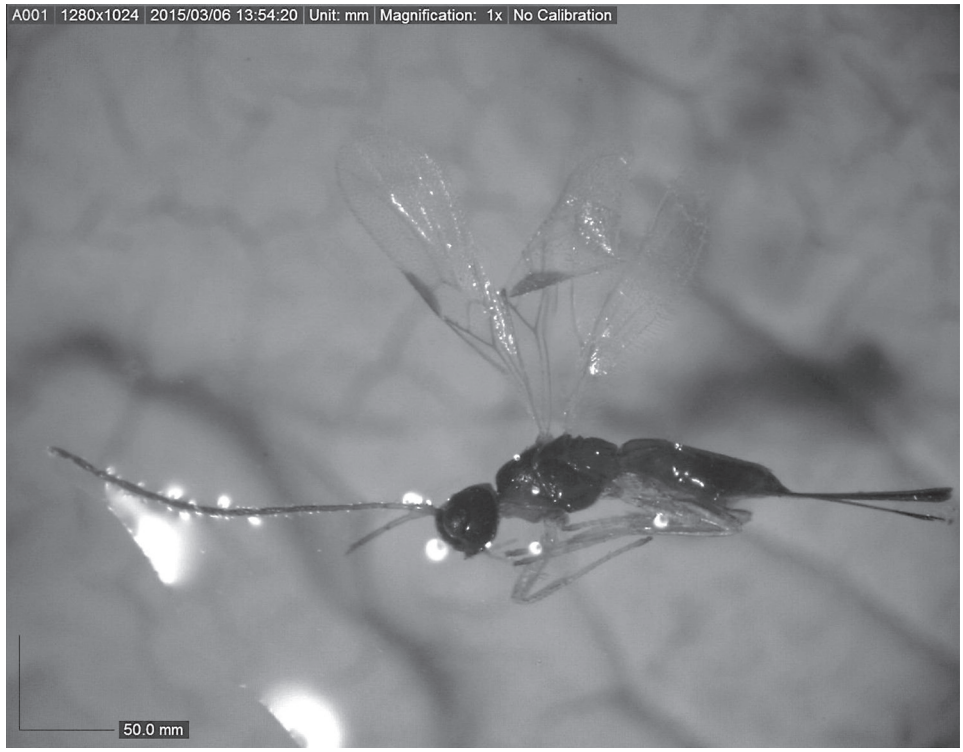

Fig. 1. *Ecphylus silesiacus* (Female)

closely related species like *E. caudatus* by the following morphological characters: body color is dark brown to black; absence of Cu vein in forewing, developed costal vein in hind wing and closed basal cell; ovipositor as long as the abdomen (Farahani et al., 2014) (Fig. 1). In recent studies, several hosts were recorded for *E. silesiacus* such as *Dryocoetes villosus* (Fabricius, 1792), *Orthomicus laricis* (Fabricius, 1792), *Ipstypo graphus* (Linnaeous, 1758), *Ptelobious vitatus* (Fabricius, 1787), and *Trypodendron domesticum* (Linnaeous, 1758), but in this study, a new host called *T. lenkoranus* was identified for the first time. *T. lenkoranus* is an important pest in the forests of northern Iran. This species was collected for the first time by Amini et al. (2013) from Guilan province. The most important morphological characters of *T. lenkoranus* are as follows: Body length is 1.8–2.3 mm, cylindrical, dark brown, covered by long hairs. The frons in male were covered with short and sporadic hairs; female with topknot hair in the middle with projections Pronotum cylindrical, longer in width Pronotom with projections anteriorly and dotted posteriorly; elytra covered with large striated punctures. The back slope of elytra in female was concave and in male, it was more or less flattened with a shining circular surface and small punctures; length of elytra was 1.65–1.75 mm (Pfeffer, 1995) (Fig. 2).

The second identified parasitoid, *C. quadrum* is a common parasitoid of bark beetles and other xylophages (Lotfalizadeh, 2012). It has remarkable morphological char-

acters including: two transverse marking on forewings; thickened fore and hind femur, hind tibia and a row of spines in dorsal and easily recognize by the combination of a large propleura, enlarged fore femora and maculate forewings (Mitroiu et al., 2011) (Fig. 3).

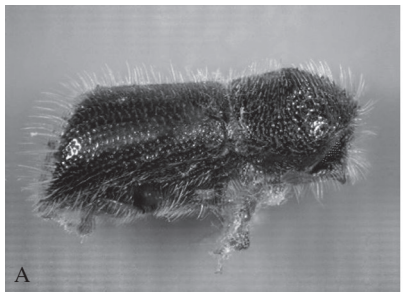

Fig. 2A. *Taphrorychus lenkoranus*. Lateral view (male)

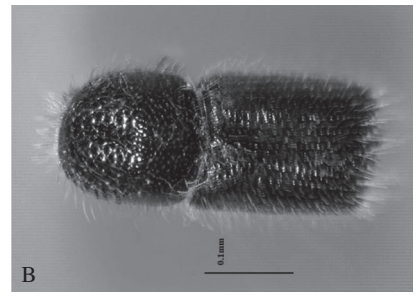

Fig. 2B. *Taphrorychus lenkoranus*. Dorsal view (male)

Fig. 3. *Cheiropachus quadrum* (male)

Lotfalizadeh and Gharali (2008) reported this species on *S. rugulosus* on fruit orchards. This species was recorded from East Azerbaijan, Iran (Lotfalizadeh, 2002).

R. maculatus was first reported from Iran by Radjabi (1989) from Markazi, Zanjan, Hamedan and Esfahan Provinces then Lotfalizadeh (2012) collected it from East Azerbaijan and Davatchi and Chodjai (1968) reported it from Karaj and Ardebil. This species has short club-like antenna and a few erect setae on hind coxa (Fig. 4).

Fig. 4. *Rhaphitelus maculatus* (male)

E. ergias has been reared from *S. rugulosus* from Markazi, Tehran Zanjan province (Davatchi and Chodjai, 1968; Radjabi, 1989). This species is distributed worldwide including Austria, Canada, Germany, Italy, Russia, America, France and Czech Republic. Body size is 1.5–2 mm. Color is black. Head is wide, antennae is short and geniculate, vein is consumptive and the wing is covered by setae (Basiri et al., 2013).

The numbers of parasitoids and their host is given in Table 1. The authors mentioned about the numbers of branches that parasitoids emerged, too (Table 1).

Table 3

List of parasitoid wasps in the family Braconidae that have been reported to attack bark beetles in Palearctic region (Wegensteiner et al., 2015)

Species	Host bark beetle genus
Blacus humilis (Nees, 1811)	*Tomicus*
Blacus koenigi Fischer 1965	*Tomicus*
Bracon hylobii Ratzeburg, 1848	*Polygraphus*
Bracon obscurator Nees, 1811	*Pityogenes*
Bracon palpebrato Ratzeburg 1844	*Tomicus*
Bracon stablis Wesmael 1838	*Hylesinus*
Bracon tenuicornis Wesmael 1838	*Phloeotribus*
Caenopachys caenopachoides (Ruschka, 1925)	*Orthomicu, Pityogenes*
Caenopachys hartigii (Ratzeburg, 1848)	*Pityogenes*
Cenocoelius nigrisoma (Rohwer, 1914)	*Dendroctonus, Ips*
Centistes cuspidatus Haliday, 1835	*Lepersinus*
*Coeloides abdominalis (*Zetterstedt, 1838)	*Ips, Pityogenes*
Coeloides bostrichorum Giraud 1872	*Cryphalus, Ips, Pityogenes, Pityokteines*
Coeloides filiformis Ratzeburg, 1852	*Hylesinus, Lepersinus, Phloeotribus*
C*oeloides melanotus* Wesmael, 1838	*Hylesinus, Lepersinus, Phloeotribus*
Coeloides scolyticida (Ashmead, 1889)	*Lepersinus, Scolytus*
Coeloides sordidator Ratzeburg 1844	*Ips, Scolytus, Tomicus*
Coeloides subconcolor Russo, 1938	*Lepersinus, Phloeotribus*
Coeloides ungularis Thomson, 1892	*Scolytus*
Cosmophorus cembrae Ruschka, 1925	*Cryphalus, Pityogenes*
Cosmophorus klugii Ratzeburg, 1848	*Pityogenes, Ips, Pityokteines*
Cosmophorus regius Niezabitowski, 1910	*Hylurgops, Ips, Orthomicus, Polygraphus, Pityokteines*
Cryptoxilos cracoviensis Muesebeck, 1936	*Cryphalus*
Caenopachys hartigii (Ratzeburg, 1848)	*Ips, Orthomicus, Polygraphus, Pityogenes*
Dendrosoter middendorffii (Ratzeburg, 1848)	*Ips, Orthomicus, Cryphalus, Dendroctonus, Polygraphus, Pityogenes, Pityokteines*
D*endrosotinus ferrugineus* (Nees, 1834)	*Phloeotribus*
Dendrosotinus similes	*Cryphalus*
Doryctes pomarius Reinhard, 1865	*Scolytus*
Ecphylus caudatus Ruschka, 1916	*Cryphalus*
Ecphylus eccoptogastri (Ratzeburg, 1848)	*Phloeotribus, Scolytus*
Ecphylus hylesini (Ratzeburg, 1848).	*Polygraphus, Pityogenes, Pityokteines, Ips, Tomicus*
Ecphylus silesiacus (Ratzeburg, 1848)	*Cryphalus, Scolytus, Phloeotribus, Pityogenes, Pityokteines*

Table 3 (cont.)

Species	Host bark beetle genus
Hecabolus sulcatus Curtis, 1834	*Phloeosinus*
Heterospilus ater Fischer 1960	*Scolytus*
Heterospilus incompletus (Ratzeburg 1844)	*Phloeosinus*
Heterospilus sicanus (Marshall, 1888)	*Cryphalus*
Lysitermus pallidus Foerster, 1862	*Polygraphus*
Meteorus consimilis (Nees 1834).	*Scolytus*
Meteorus obfuscatu (Nees, 1811).	*Scolytus*
Monolexis fuscicornis Forster, 1862	*Phloeotribus*
Ontsira antica (Wollaston, 1858).	*Hylurgops, Orthotomicus, Ips*
Perilitus rutilus (Nees, 1812)	*Pityokteines*
Rhoptrocentrus piceus Marshall 1897	*Phloeotribus*
Ropalophorus clavicornis (Wesmael, 1835)	*Ips*
Spathius brevicaudis (Ratzeburg, 1844)	*Scolytus*
S*pathius curvicaudis* Ratzeburg, 1844	*Scolytus*
Spathius rubidus (Rossi, 1794)	*Scolytus*, *Phloeotribus*

Table 4

List of parasitoid wasps in the family Pteromalidae that have been reported to attack bark beetles in Palearctic region (Wegensteiner et al., 2015)

Parasitoids species	Bark beetle genus
Acrocormus semifaciatus Thomson, 1878	*Scolytus*
Agrilocida ferrierei Steffan, 1964	*Scolytus*
Cerocephala cornigera (Westwood, 1832)	*Scolytus, Phloeotribus, Lepersinus*
Cerocephala eccoptogastri Masi, 1921	*Scolytus, Phloeotribus, Lepersinus, Phloeosinus*
Cheiropachus quadrum (F. 1848)	*Scolytus, Phloeotribus, Lepersinus, Ips*
Cleonymus brevis Boucek, 1972	*Scolytus*
Cleonymus obscurus Walker, 1837	*Scolytus*
Dinotiscus aponius (Walker, 1848)	*Scolytus, Hylesinus, Lepersinus*
Dinotiscus colon (Linnaeus, 1758)	*Scolytus, Ips, Phloeotribus*
Dinotiscus eupterus (Walker, 1836)	*Dendroctonus, Cryphalus, Pityophtoru, Ips, Pityokteines, Pityophtorus, Pityogenes, Polygraphus*
Habritys brevicornis (Ratzeburg, 1844)	*Trypodendron*
Heydenia praetiosa Förster, 1856	*Leperisinus, Ips, Orthotomicus, Phloeosinus, Phloeotribus, Pityogenes, Tomicus, Scolytus, Pityokteines*
Macromesus amphiterus	*Scolytus, Ips, Pityophtorus*
Mesopolobus typographi (Ruschka, 1924)	*Polygraphus, Ips, Pityogenes*

Table 4 (cont.)

Parasitoids species	Bark beetle genus
Metacolus azureus (Ratzeburg, 1844)	*Ips, Orthomicus, Pityogenes*
Metacolus unifasciatus Förster, 1856	*Tomicus, Orthomicus, Phloeosinus*
Perniphora robusta Ruschka, 1923	*Trypodendron, Ips*
Platygerrhus affinis (Walker, 1836)	*Ips*
Platygerrhus dolosus (Walker, 1836)	*Scolytus*
Platygerrhus ductilis (Walker, 1836)	*Scolytus*
Platygerrhus maculatus Erdös, 1957	*Scolytus*
Pteromalus abieticola Ratzeburg, 1848	*Pityogenes*
Pteromalus brunnicans Ratzeburg 1848	*Scolytus*
Rhaphitelus ladenbergii (Ratzeburg, 1844)	*Scolytus*
*Rhaphitelus macul*atus Walker, 1834	*Scolytus*
Rhopalicus guttatus (Ratzeburg, 1844)	*Tomicus*
Rhopalicus quadratus (Ratzeburg, 1844)	*Tomicus, Phloeosinus, Ips, Pityogenes*
Rhopalicus tutela (Walker, 1836)	*Dendroctonus, Ips, Pityogenes, Tomicus, Scolytus, Polygraphus*
Roptrocerus brevicornis Thomson 1878	*Ips, Pityogenes, Tomicus*
Roptrocerus mirus (Walker, 1834)	*Ips, Tomicus, Polygraphus, Pityogenes*
Roptrocerus xylophagorum Ratzeburg, 1844	*Dendroctonus, Cryphalus, Orthotomicus, Ips*
Tomicobia acuminati Hedqvist, 1959	*Ips*
Tomicobia pityophthori (Boucek, 1955)	*Ips, Pityogenes, Pityophtorus*
Tomicobia seitneri (Ruschka, 1924)	*Ips*
Trigonoderus princeps Westwood, 1832	*Ips*

Conclusion

Bark beetles are among the most important forest pests of Iran (Amini et al., 2013) and Hymenopterous parasitoids are likely the most effective natural enemies in their biological control (Russo, 1938; Mendel and Dagan, 1986; González and Campos, 1990; Zeiri et al., 2011). In this study, four parasitoid species of bark beetles were identified as *E. silesiacus* (Ratzeburg, 1848), *C. quadrum* (Fabricius, 1787), *R. maculatus* Walker, 1834 and *E. ergias* (Ratzeburg, 1844). Two hosts were identified and *T. lenkoranus* was recorded for the first time as a new host for *E. silesiacus*. During the rearing of *E. silesiacus,* no bark beetles emerged. Results of this study showed that *E. silesiacus* parasites are all bark beetles in larval and pupal stage and were the most abundant parasitoid. Recent studies showed that *E. silesiacus* has an important role in reducing the population level of bark beetle (Stojanovic and Markovic, 2007). Finally according to recent studies and result of this present study there are nearly more than 100 species which parasite bark beetles. The list of parasitoids and their host in Palearctic region is mentioned in below

tables (Basiri et al., 2013; Wegensteiner et al., 2015) (Table 3 and Table 4). Among these parasitoids of bark beetles, the most abundant species are belong to Pteromalidae family and nearly 50 species are in Braconidae family. The result in present study is in line with the results of other studies. Nevertheless, due to the high diversity of bark beetles and effective role of parasitoids in controlling them, there is need for further studies of parasitoids in forest.

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