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Associated *Bracon* Fabricius (Hymenoptera: Braconidae) with flower-heads of Asteraceae in Iran

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ABSTRACT. A study was conducted to determine the Braconinae (Hym., Braconidae) parasitoid wasps, associated with Asteraceae in the northwest of Iran during 2013–2015. Ten species were reared from flower-heads of Asteraceae: *Bracon bipartitus* Wesmael, 1838; *B. leptus* Marshall, 1897; *B. luteator* Spinola, 1808; *B. mariae* Dalla Torre, 1898; *B. pectoralis* Wesmael, 1838; *B. subrugosus* Szépligeti, 1901; *B. talyshicus* Tobias, 1976; *B. trucidator* Marshall, 1888; *B. tschitscherini* Kokujev, 1904 and *B. urinator* (Fabricius, 1798), of which one species (i.e., *B. talyshicus*) is recorded for the first time from Iran. We also reared some non-frugivorous Tephritidae feeding on the collected flower-heads that can be possible host of these braconids. General distribution and biological associations for all species that have been collected in this study are compiled.

Key words: Host, distribution, parasitoid, Braconinae, Iran

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INTRODUCTION

Hymenoptera is one of the most diverse insect orders worldwide, with more than 156,365 known species (Aguiar et al., 2013; Yu et al., 2016; Sharkey et al., 2021). The family Braconidae (Hymenoptera: Ichneumonoidea) is the second largest family of Hymenoptera, with more than 21,626 valid species

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belonging to more than 1,106 genera (Yu et al., 2016; Sharkey et al., 2021), described worldwide, that probably is less than 20% of the total diversity worldwide (van Achterberg, 2014). Up to now 26 subfamilies 141 genera and about 900 species were recorded from Iran (Farahani et al., 2016; Abdoli et al., 2019a; Ameri et al., 2020; Zargar et al., 2020; Abdoli et al., 2021a, 2021b; Dolati et al., 2021). Biologically, the vast majority of braconids are primary parasitoids of other insects, especially upon the larval stages of Coleoptera, Diptera, and Lepidoptera (Shaw & Huddleston, 1991; van Achterberg, 1993; Wharton, 1993), some hemimetabolous insects like aphids (Starý, 1970), web spinners (Shaw & Edgerly, 1986) and plant-bugs (Wharton, 1993; Varis & van Achterberg, 2001). The Braconinae of Iran was summarized in the recent checklist (Farahani et al., 2016), which lists 11 genera and 115 species. Rahmani et al. (2017) reported eight new records of this subfamily and increased number of *Bracon* species to 94 in Iran.

The fruit flies of the subfamily Tephritinae (Dipt.: Tephritidae), usually attack the flower heads of wide range of plant taxa including Aquifoliaceae, Scrophulariaceae, Verbenaceae, and mainly of Asteraceae as leaf miners or gall formers (Norrbom, 2010; Uchôa & Niccio, 2010). So far, 132 species of this subfamily is recorded from Iran (Mohammadzade-Namin & Korneyev, 2018). Čapek & Zwolfer (1990) reported 31 species of the braconids within eight subfamilies: Braconinae, Rogadinae, Cheloninae, Microgastrinae, Agathidinae, Macrocentrinae, Helconinae and Alysiinae in association with Asteraceae. The associated parasitoid species of non-frugivorous Tephritidae have been already known in Braconidae, Chalcididae, Diapriidae, Eulophidae, Eurytomidae, Figitidae, and Pteromalidae (Wharton et al., 1998; Sivinski et al., 2000; Ovruski et al., 2004; Gates et al., 2008; Pourhaji et al., 2016, 2020). About 200 species of Braconidae have been obtained from fugivorous and non-frugivorous tephritids throughout the world (Wharton & Yoder, 2014). Among them, there are many species that parasitize non-frugivorous tephritid flies on Asteracease (Edwards et al., 1996; Basheer et al., 2014). Lotfalizadeh and Gharali (2014) listed 12 parasitoids species on *Carthamus tinctorius* L. that infested by non-frugivorous Tephritidae in Iran, of which, three species have belonged to family Braconidae. The objective of this study is to improve our knowledge about the Braconid associated with Asteraceae that may parasitize non-frugivorous tephritid flies (Diptera: Tephritidae).

MATERIAL AND METHODS

This study was carried out in 14 localities (Fig. 1) of East and West-Azarbaijan provinces in the northwest of Iran (from 35°58′ – 39°47′ N to 44°02′ – 48°21′ E) during 2013 to 2015. Infested reproductive organs of 21 species of Asteraceae were widely collected and transferred to the entomology laboratory of Plant Protection Research Department, East-Azarbaijan Agricultural and Natural Resources Research Center. Before incubation, occurrence of other insects on reproductive organs was inspected. Rearing was done in the cylindrical plastic boxes (9 cm diameter and 13 cm Height) at 25±2°C until the adults of flies and/or their parasitoids were emerged. Tephritids were identified using Korneyev & White (1999) and their associated braconids were identified using keys and descriptions provided by Tobias (1986), Beyarslan & Fischer (1990) and Papp (1966, 1968, 1969a, 1969b). Identifications were confirmed or corrected by Dr. K. Samartsev (Zoological Institute of the Russian Academy of Sciences, Saint Petersburg). The general distribution of the recorded *Bracon* species followed Yu et al. (2016). External morphology was illustrated using an Olympus® SZH, equipped with a Canon® A720 digital camera. All specimens are deposited in the insect collection of the Department of Plant Protection, East-Azarbaijan Agricultural and Natural Resources Research and Education Center, Tabriz, and one speciemen of each species in the Zoological Institute of the Russian Academy of Sciences, Saint Petersburg, Russia (ZISP).

No.	Locality
1	Zive
2	Klisa-kandi
3	Kalavans
4	Aland
5	Evougli
6	Aras
7	Kohol
8	Kalaybar
9	Arasbaran 1
10	Arasbaran 2
11	Arpadarasi
12	Ski slop's road
13	Arshad Chamani
14	Shahindezh

Figure 1. Collection localities of associated Braconidae with flower-heads of Asteraceae in the northwest of Iran.

RESULTS

A total of 90 specimens of braconid parasitoids were reared from 21 species of Asteraceae that were infested by 15 species of non-frugivorous tephritids (Table 1). Identified *Bracon* species (Hymenoptera: Braconidae: Braconinae) are listed below.

Bracon bipartitus Wesmael, 1838

Material examined: Iran, East-Azarbaijan, Arpadarasi (38°07′07″N, 46°25′03″E, 1502 m a.s.l.), 15.vii.2014, 1♂, ex *Lactuca serriola*, infested with *Hypenidium robrowskii* (Becker, 1908); West-Azarbaijan, Sardasht (36°28′47″N, 45°19′10″E, 1323 m a.s.l.), 9.viii.2014, 1♂, ex *Echinops* sp. infested with *Tephritomiya lauta* (Loew, 1969), leg.: A.R. Pourhaji.

Distribution in Iran: Kerman, Kermanshah, North Khorasan, Sistan-o Baluchestan (Rahmani et al., 2017) and Khuzestan (Zargar et al., 2020).

General distribution: Palaearctic.

Bracon leptus Marshall, 1897

Material examined: Iran, East-Azarbaijan, Arasbaran (38°53′37″N, 46°48′59″E, 189 m a.s.l.), 7.ix.2014, 2♂♂, 1♀, ex *Causinia* sp., leg.: A.R. Pourhaji.

Distribution in Iran: Hormozgan (Ameri et al., 2014).

General distribution: Palaearctic.

Bracon luteator Spinola, 1808

Material examined: Iran, East-Azarbaijan, Arasbaran (38°51′42″N, 46°52′45″E, 1696 m a.s.l.), 7.ix.2014,1♀, ex *Cirsium spectabile*; Ivand (38°21′20″N, 46°07′21″E, 1692 m a.s.l.), 1.viii.2014, 1♀, ex *Echinops* sp.; Kalaybar (38°53′28″N, 46°48′47″E, 1900 m a.s.l.), 7 .ix.2013, 1♀, ex *Cirsium ciliatum,* infested with *Xyphosia milialaria* (Schrank, 1781); Arshad chamani (37°45′04″N, 46°18′51″E, 2847 m a.s.l.), 27.vii.2014, 1♂, ex *Onopordum* sp., infested with *Tephritis postica* (Loew, 1844); Kohol (38°26′01″N, 46°10′22″E, 2282 m a.s.l.), 5.viii.2014, 1♀, ex *Onopordum acanthium,* infested with *T. postica*; Kalaybar (38°53′28″ N, 46°48′47″ E, 1900 m a.s.l.), 7.ix.2013, 1♀, ex *Cirsium vulgare,* infested with *Terellia serratula* (L., 1758); East-Azarbaijan, Kalaybar (38°53′28″N, 46°48′47″E, 1900 m a.s.l.), 7.ix.2013, 1♀, ex *Arctium lappa,* infested with *Tephritomiya lauta* (Loew, 1969); West-Azarbaijan, Evougli (38°44′01″N, 45°14′41″E, 971 m a.s.l.), 4.vii.2014,1♂, ex *Centaurea iberica,* infested with *Urophora* sp.; leg.: A.R. Pourhaji.

Distribution in Iran: Reported from East-Azarbaijan, Chaharmahal-e Bakhtiari, Ilam (Lotfalizadeh & Gharali, 2014) and Khuzestan (Zargar et al., 2020).

General distribution: Palaearctic.

Bracon mariae Dalla Torre, 1898

Material examined: Iran, West-Azarbaijan, Evougli (38°44′01″N, 45°14′41″E, 971 m a.s.l.), 4.vii.2014, 1♂, ex *Centaurea iberica*, infested with *Chaetorellia carthami* Stackelberg, 1929 and *Chaetorellia conjuncta* (Becker, 1913); *Onopordum* sp., infested with *Tephritis postica* (Loew, 1844) and *Urophora* sp., leg.: A.R. Pourhaji.

Distribution in Iran: no specific locality cited (Tobias, 1986)

General distribution: Palaearctic.

Bracon pectoralis Wesmael, 1838

Material examined: Iran, East-Azarbaijan, Aras (38°40′59″N, 45°39′19″E, 1400 m a.s.l.), 29.x.2013, 1♀, ex *Carlina vulgare*, leg.: A.R. Pourhaji.

Distribution in Iran: Hormozgan (Ameri et al., 2015), Guilan, Qazvin (Zargar et al., 2015) and Khuzestan (Zargar et al., 2020).

General distribution: Palaearctic.

Bracon subrugosus Szépligeti, 1901

Material examined: Iran, West-Azarbaijan, Kilisa-kandi (38°50′39″N, 44°25′24″E, 2319 m a.s.l.), 7.vii.2015, 1♂, ex *Cirsium echinus*, infested with *Tephritis cometa* (Loew, 1840), leg.: A.R. Pourhaji.

Distribution in Iran: Khuzestan (Zargar et al., 2020).

General distribution: Palaearctic.

Bracon (*Lucobracon*) *talyshicus* Tobias, 1974 (Figs 2-3)

Material examined: Iran, West-Azarbaijan, Kalavans (38°41′25″N, 44°39′26″E, 2044 m a.s.l.), 17.vii.2014, 2♀♀, ex *Cirsium echinus*. East-Azarbaijan, Azarshar (37°44′07″N, 46°06′55″E, 1875 m a.s.l.), 4.vii.2014, 3♂♂, 1♀, ex *Echinops* sp., infested with *Tephritomiya lauta* (Loew, 1969), leg: A.R. Pourhaji.

Note. This specimens were reared on *Echinops* sp. that was infested by *Tephritomyia lauta* (Loew, 1869) (Dipt.: Tephritidae) and *Cirsium echinus* for the first time. There was not any host record for this parasitoid (Yu et al., 2016).

Distribution in Iran: East Azarbaijan and West Azarbaijan

General distribution: Azerbaijan, Iran (**New record**).

Bracon trucidator Marshall, 1888

Material examined: Iran, West-Azarbaijan, Aland (38°48′45″N, 44°33′58″E,1722 m a.s.l.), 10.vii.2014, 1♀, ex *Onopordum* sp., infested with *Urophora terebrans* (Loew, 1850), East-Azarbaijan, Arasbaran (38°51′42″N, 46°52′45″E, 1696 m a.s.l.), 29.viii.2014, 1♂, 1♀, ex *Cirsium arvensis*, infested with *Chaetorellia* sp., Ski slope's road (37°49′12″N, 46°31′48″E, 2440 m a.s.l.), 1.ix.2014, 1♂, ex *Cirsium* sp., infested with *Terellia nigripalpis* Hendel, 1927, Arshad chamani (37°45′40″N, 46°18′51″E, 2847 m a.s.l.), 27.vi.2014, 1♂, ex *Onopordum acanthium,* infested with *Urophora* sp., Kohol (38°22′3″N, 46°07′42″E, 1729 m a.s.l.), 1.viii.2014, 1♀, ex *Arctium lappa,* infested with *Tephritis bardanae* (Schrank, 1830), leg.: A.R. Pourhaji.

Distribution in Iran: Hormozgan (Ameri et al., 2015), Kerman, Kermanshah and North Khorasan (Rahmani et al., 2017).

General distribution: Palaearctic.

Bracon tschitscherini Kokujev, 1904

Material examined: Iran, West-Azarbaijan, Shahindezh (36°48′39″N, 46°32′46″E, 1614 m a.s.l.), 17.vi.2014, 2♀♀, ex *Echinops* sp., infested with *Tephritomiya lauta* (Loew, 1969), leg: A.R. Pourhaji.

Distribution in Iran: West Azarbaijan province (Ghahari & Fischer, 2011).

General distribution: Palaearctic.

Bracon urinator (Fabricius, 1798)

Material examined: Iran, West-Azarbaijan, Kilisa-Kandi (38°50′39″N, 44°25′24″E, 2319 m a.s.l.), 7.viii.2015, 1♂, ex *Cirsium congestum,* infested with *Tephritomiya lauta* (Loew, 1969); Arasbaran (38°51′42″N, 46°52′45″E, 1696 m a.s.l.), 29.viii.2014, 1♂, ex *Cirsium spectabilis*, leg: A.R. Pourhaji.

Distribution in Iran: No specific locality cited (Beyarslan et al., 2005) and Khuzestan (Zargar et al., 2020).

General distribution: Palaearctic, Afrotropical and Oriental regions.

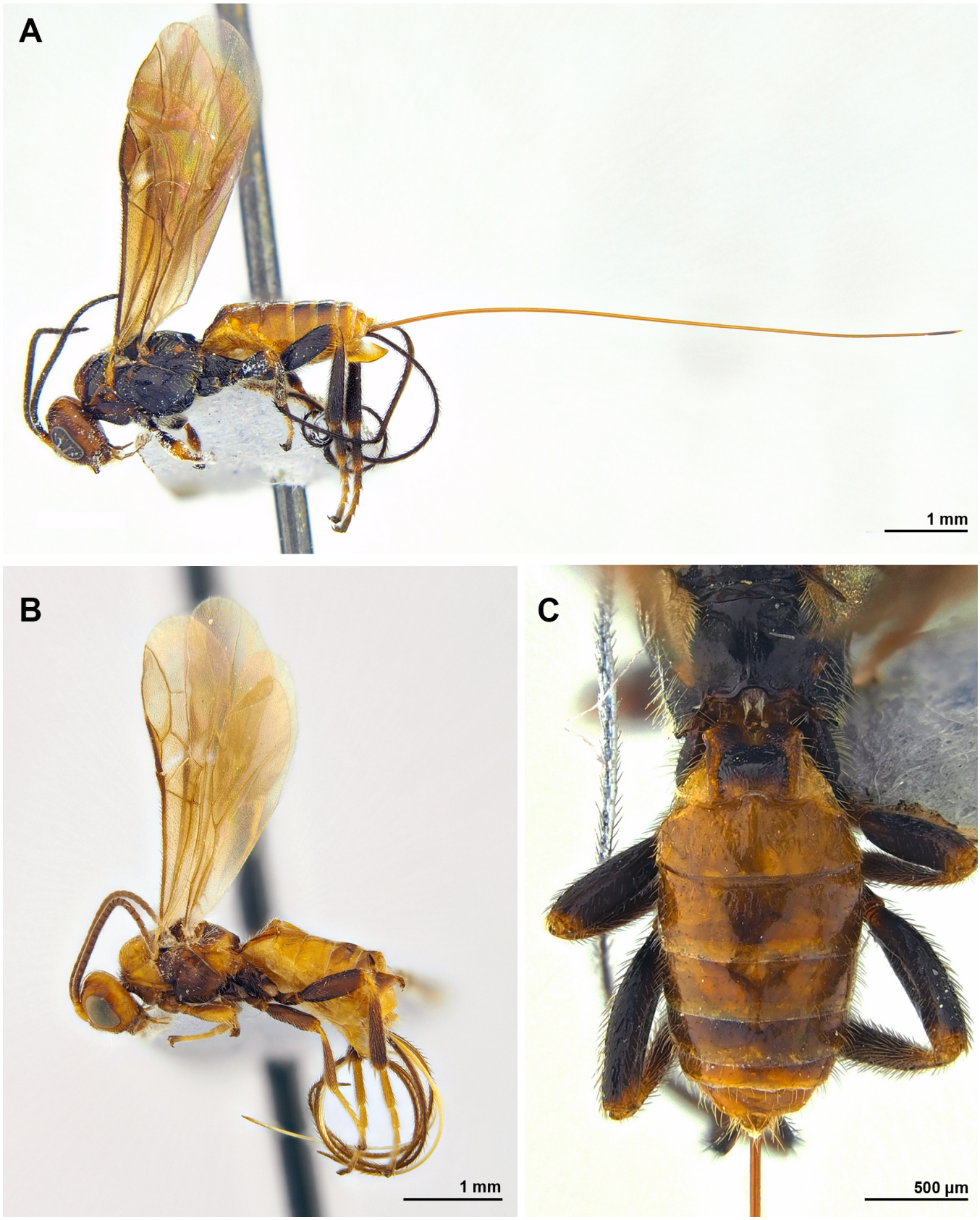

Figure 2. *Bracon talyshicus* Tobias, 1976; **A.** Female in lateral view (darker specimen); **B.** Female in lateral view (lighter specimen); **C.** Propodeum and metasoma in dorsal view.

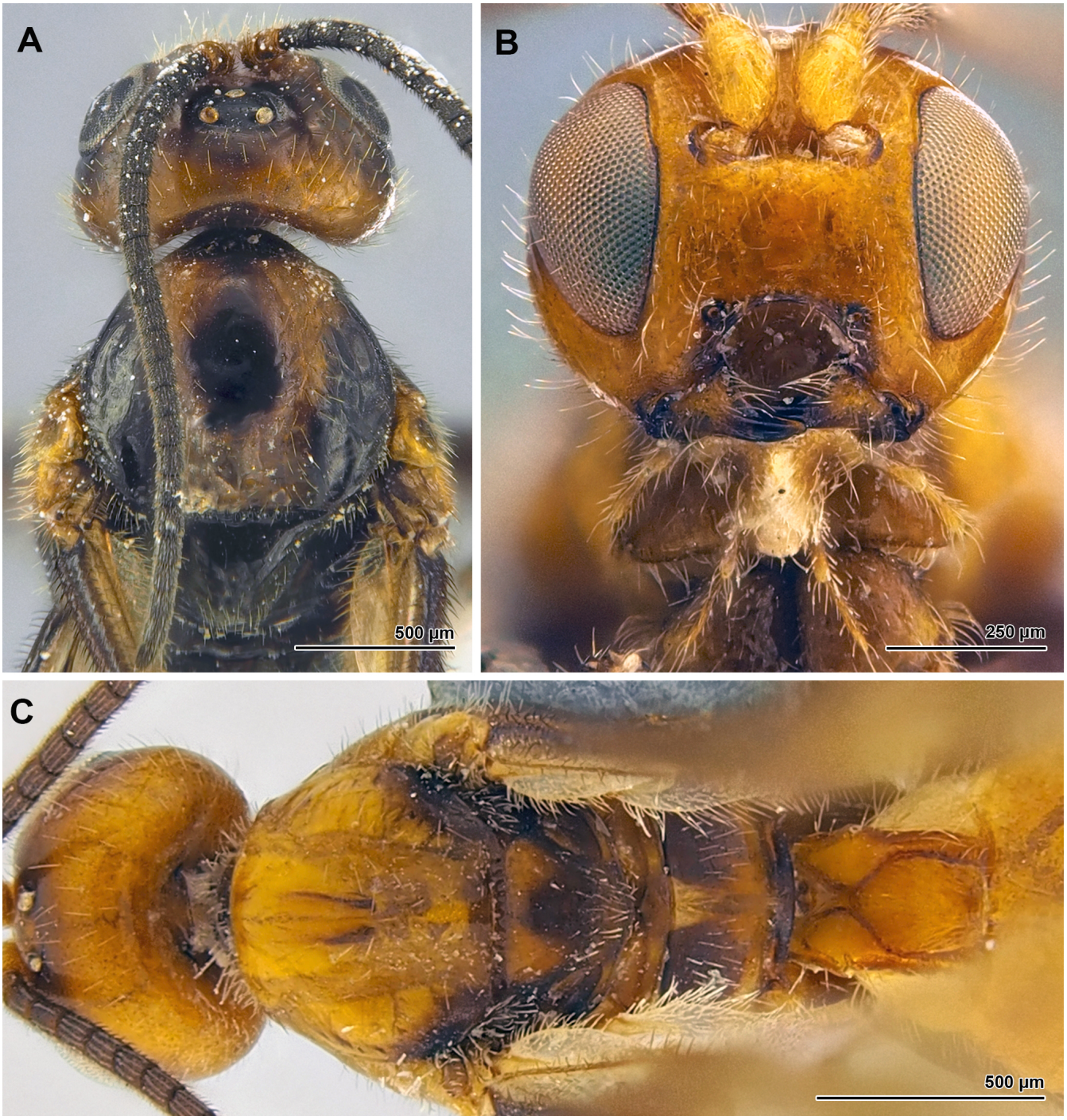

Figure 3. *Bracon talyshicus* Tobias, 1976; **A.** Head and mesosoma in dorsal view; **B.** Head in frontal view; **C.** Head, mesosoma and base of metasoma in dorsal view.

DISCUSSION

In the present study, 10 species of Braconinae were obtained from Asteraceae infested by non-frugivorous Tephritidae. All host-parasitoid-plant associations are new (Table 1). There were not any host and host plant records for these species in the earlier literature (Yu et al., 2016). Redfern et al. (1992) obtained *Bracon* sp. on *Terellia serratulae* (L.) on *Cirisium vulgare* (Savi) in the UK. An unknown *Bracon* species was reared on *Urophora solstitialis* (L.) on *Carduus nutans* L. in Europe (Edwards et al., 1996), while we did not reared any braconids on *Carduus* spp. in our studied area. *Urophora* spp. was obtained with three braconids species (see Table 1).

Table 1. Reared Braconidae on flower-heads of Asteraceae and associated Tephritidae in Iran (* new record).

Bracon species	Host plants	Associated Tephritidae	References
B. bipartitus Wesmeal, 1838	*Lactuca serriola* L. *Echinops* sp.	*Hypenidium robrowskii* (Becker, 1908) *Tephritomiya lauta* (Loew, 1969)	Present study
B. brevicornis (Wesmael, 1838)	*Carthamus tinctorius* L.	*Acanthiophilus helianthi* (Rossi, 1794) *Chaetorellia carthami* Stackelberg, 1929 *Terellia luteola* Wiedemann, 1830 *Urophora mauritanica* (Macquart, 1851)	Lotfalizadeh & Gharali (2014)
B. leptus Marshall, 1897	*Cousinia* sp.	not found	Present study
B. luteator Spinola, 1808	*Cirsium spectabile* DC. *Echinops* sp. *Cirsium ciliatum* (Murray) *Onopordum* sp. *Centaurea iberica* Trevir & Spreng *Onopordum acanthium* L. *Cirsium vulgare* (Savi) Ten. *Arctium lappa* L.	not found not found *Xyphosia mililaria* (Schrank, 1781) *Tephritis postica* (Loew, 1844) *Urophora* sp. *Chaetorellia carthami* Stackelberg, 1929 *Chaetorellia conjuncta* (Becker, 1913) *Tephritis postica* (Loew, 1844) *Terellia serratula* (L., 1758) *Tephritomiya lauta* (Loew, 1969)	Present study
	Carthamus tinctorius L.	*Acanthiophilus helianthi* (Rossi, 1794) *Chaetorellia carthami*, Stackelberg, 1929 *Terellia luteola* Wiedemann, 1830 *Urophora mauritanica* (Macquart, 1851)	Lotfalizadeh & Gharali (2014)
		Some Tephritidae	Falcoj et al. (1993)
	Centaurea spp. *Oirsium* spp. *Carduus* spp.	*Urophora solstitialis* (L., 1758)	Beyarsalan et al. (2005); Tobias (1986)
B. mariae Dalla Torrer, 1898	*Echinops* sp. *Cirsium ciliatum* (Murray) *Onopordum* sp. *Centaurea iberica* Trevir & Spreng	not found not found *Tephritis postica* (Loew, 1844) *Urophora* sp. *Chaetorellia carthami* Stackelberg, 1929 *Chaetorellia conjuncta* (Becker, 1913)	Present study
B. pectoralis Wesmael, 1838	*Carlina vulgaris* L.	not found	Present study
B. subrugosus Szepligeti, 1901	*Cirsium echinus* (M.Bieb.) Hand.-Mazz	*Tephritis cometa* (Loew, 1840)	Present study
	Angelica sylvestris L. *Daucus carota* L. *Peucedanum arenarium* L. *Pimpinella saxifraga* L.	*Chaetostomella cylindrica* (Robineau-Desvoidy, 1830) *Noeeta pupillata* (Fallén, 1814) *Tephritis leontodontis* (De Geer, 1776) *Terellia serratulae* (L., 1758) *Urophora solstitialis* (L., 1785) *Urophora cardui* (L., 1758) *Urophora quadrifasciata* (Meigen, 1826)	Beyarslan (2014)
B. talyshicus Tobias, 1976*	*Cirsium echinus* (M.Bieb.) Hand.-Mazz *Echinops* sp.	not found *Tephritomiya lauta* (Loew, 1969)	Present study
B. trucidator Marshall, 1888	*Cirsium arvensis* (L.) Scop. *Cirsium* sp. *Onopordum acanthium* L. *Arctium lappa* L. *Onopordum* sp.	*Chaetorellia* sp. *Terellia nigripalpis* Hendel, 1927 *Urophora* sp. *Tephritis bardanae* (Schrank, 1830) *Urophora terebrans* (Loew, 1850)	Present study

Table 1. Continued.

B. trucidator Marshall, 1888	*Carduus nutans* L.	*Myopites inulaedyssenteriae* Blot, 1827 *Urophora solstitialis* (L., 1758)	Beyarslan (2014)
B. tschitscherini Kokujev, 1904	*Echinops* sp.	*Tephritomiya lauta* (Loew, 1969)	Present study
B. urinator (Fabricius, 1798)	*Cirsium spectabile* DC. *Cirsium congestum* Fisch. & C.A.Mey.	not found *Tephritomiya lauta* (Loew, 1969)	Present study
	Cirsium sp. *Echinop* sp. *Prangos* sp. *Carduus* sp. *Scorzonera* sp. *Centaurea* sp. *Tragopogon* sp.	*Tephritis pulchar* (Loew, 1844)	Zikic et al. (2012)

The previously recorded data were mainly concentered on the economically important tephritid species that were reared on safflower fruit flies, *Carthamus tinctorius* L., as a key pest of safflower. Lotfalizadeh & Gharali (2014) reported *Bracon hebetor* Say, *B. brevicornis* (Wesmael) and *B. luteator* Spinola and Basheer et al. (2014) reported *B. luteator* and *B. intercessor* Nees in Iran and Syria, respectively. *Bracon luteator* was a most abundant species in safflower fields in Iran (Lotfalizadeh & Gharali, 2014).

Some species of two other braconids of Opiinae and Alysiinae have also been reported with non-frugivorous Tephritidae, infesting Asteraceae (Wharton & Yoder, 2014), were not found in the present study. So far 115 species of the subfamily Braconinae from Iran (Farahani et al. 2016), of which, 96 species belonging to six subgenera, included in the genus *Bracon* (Zargar et al., 2020). A new record of *B. talyshicus* increases it to 97 species. Within the reported species in this research, *B. talyshicus* and *B. bipartitus*, were reared for the first time on *Echinops* sp. and *Lactuca serriola* (Astraceae) that infested with *Tephritomyia lauta* and *Hypenidium robrowskii* (Dipt.: Tephritidae), respectively. Within reared *Bracon* species on Asteraceae, *B. luteator* and *B. urinator* have a wide range of associated host plants, reared from nine species (Table 1). *Bracon luteator* and *B. trucidator* were found in association with numerous Tephritids (11 and 7 species, respectively – see Table 1). *Bracon luteator* has already been reported on non-frugivorous Tephritidae flies by Lotfalizadeh & Gharali (2014) that confirm this plant-phytophagous-parasitoid relationship. However, most of plant-phytophagous-parasitoid associations are new. For confirmation of host-parasitoid association, further studies with separately rearing of infested larvae or pupa of non-frugivorous Tephritidae can be helpful.

AUTHOR'S CONTRIBUTION

The authors confirm contribution to the paper as follows: A.P.: collecting, rearing and writing of manuscript. H.L.: designing research plane, writing of manuscript. N.K.: identification of host plants. B.G.: identification of fruit flies. A.A.: identification of some *Bracon* species.

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AVAILABILITY OF DATA AND MATERIAL

Not applicable.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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زنبورهای جنس *Bracon* Fabricius (Hymenoptera: Braconidae) مرتبط با طبق گیاهان خانواده Asteraceaeدر ایران

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چکیده: این تحقیق به منظورجمع‌آوری و شناسایی زنبورهای Braconidae مرتبط با گیاهان خانواده Asteraceae در شمال غرب ایران، طی سال‌های ۱۳۹۴-۱۳۹۲ انجام شد. در این تحقیق از این گیاهان، ده گونه زنبور و همچنین تعدادی مگس میوه (Diptera: Tephritidae) پرورش داده شد که میزبان احتمالی این زنبورها در نظر گرفته می‌شوند. این گونه‌ها عبارتند از: *Bracon bipartitus* Wesmael, 1838، *B. leptus* Marshall, 1897، *B. luteator* Spinola, 1808، *B. mariae* Dalla Torre, 1898، *B. pectoralis* Wesmael, 1838، *B. subrugosus* Szépligeti, 1901، *B. talyshicus* Tobias, 1976، *B. trucidator* Marshall, 1888، *B. tschitscherini* Kokujev, 1904 و *B. urinator* (Fabricius, 1798) که از بین آنها گونه *B. talyshicus* گزارش جدید برای فون زنبورهای ایران است. ارتباط احتمالی تمام گیاهان میزبان- مگس‌های میوه-زنبورهای پارازیتویید برای دنیای علم جدید هستند. انتشار جغرافیایی زنبورهای پارازیتویید و ارتباط زیستی بحث شد.

واژگان کلیدی: میزبان، انتشار، پارازیتویید، Braconidae، ایران