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Further addition to the braconid fauna of Iran (Hymenoptera: Braconidae)

Neveen S. Gadallah^{1*}, Hassan Ghahari² and Donald L. J. Quicke³

Abstract

Background: The cosmopolitan family Braconidae is one of the largest in the order Hymenoptera. Many of its members are important as biological control agents against more than 120 pest species belonging to four insect orders (Coleoptera, Diptera, Hemiptera, Lepidoptera) that cause economic damage to various agricultural, horticultural, and forestry plants and trees. Due to the lack of regional studies, as well as taxonomic complexities compared with well-studied other western Palaearctic countries, the faunistic knowledge of this family is still largely incomplete.

Results: Based on specimens collected from different localities in Iran, as well as material deposited in different Iranian collections, twenty-five braconid species are recorded for the first time from Iran. Collectively, these belong to ten subfamilies (Alysiinae, Brachistinae, Braconinae, Cheloninae, Euphorinae, Exothecinae, Hormiinae, Ichneutinae, Microgastrinae, and Rogadinae). Two genera, *Pentatermus* Hedqvist (Rogadinae) and *Stenobracon* Szépligeti (Braconinae), are reported in the present study for the first time. Specimens are identified with the help of specialists, as well as using the available keys for each subfamily. A faunistic list comprising the valid species names and the extrazonal distribution are given.

Conclusions: In the present study, a list of 25 species and two genera, *Pentatermus* Hedqvist (Rogadinae) and *Stenobracon* Szépligeti (Braconinae), are newly recorded from Iran, thus raising the total number of this important group as biocontrol agents to reach 1038 species.

Keywords: Braconidae, Subfamilies, New records, Entomological collections

Background

The Braconidae (Hymenoptera: Ichneumonoidea) is one of the most species-rich families in the order Hymenoptera (Quicke and van Achterberg 1990; Wharton 1993; Quicke 2015; Chen and van Achterberg 2019), represented by more than 21,220 described species in more than 1100 genera (Yu et al. 2016). The family is often encountered and almost cosmopolitan (Chen and van Achterberg 2019). Individuals are often black-brown, with reddish markings, though some exhibit striking color and patterns. Braconids are mostly recognized by the following combination of features: vein 2m-cu of fore wing is absent (except in extremely few cases); vein

1RS+M of fore wing is present in almost all members; vein 1r-m of hind wing is present basal to the separation of R1 and RS; and second metasomal tergite is fused with third tergite (secondarily flexible in Aphidiinae) (Sharkey 1993). Many members of the Braconidae have been used as biological control agents against more than 120 pest species belonging to four insect orders (Coleoptera, Diptera, Hemiptera, Lepidoptera) that cause economic damage to various agricultural, horticultural, and forestry plants and trees (Wharton 1993; Austin and Dowton 2000).

Over 40 braconid subfamilies and 114 tribes are currently recognized in the family Braconidae (Chen and van Achterberg 2019). Monophyly of Braconidae is strongly supported in numerous molecular studies (examples are those by van Achterberg 1984; Quicke and

* Correspondence: n_gadallah@hotmail.com

¹Entomology Department, Faculty of Science, Cairo University, Giza, Egypt
Full list of author information is available at the end of the article

van Achterberg 1990; Sharanowski et al. 2011; Li et al. 2016; Quicke et al. 2020).

Faunistic knowledge of the family Braconidae in Iran is largely incomplete due to the paucity of regional studies and, to an extent, greater taxonomic complexity compared with well-studied other western Palearctic countries. Despite these, the Iranian braconid fauna has started to be better investigated, especially over the past 20 years (e.g., Barahoei et al. 2014; Farahani et al. 2016; Beyarslan et al. 2017; Samin et al. 2018a, b; Gadallah et al. 2019). However, Iran is a large country comprising various agro-ecosystems, and therefore, new species are likely to be discovered in future. More than eight hundred species spread over the 30 subfamilies of Braconidae are recognized in Iran to date (Samin et al. 2018a, b; Yu et al. 2016).

Therefore, the aim of the present study is to increase our knowledge about this large and important group of parasitic wasps in Iran.

Here, we record two genera, *Pentatermus* Hedqvist, 1963 (Rogadinae), and *Stenobracon* Szépligeti, 1901 (Braconinae), and 25 species for the first time for the Iranian fauna as a part of ongoing faunistic studies.

Methods

The material was mainly collected using Malaise traps or by sweep netting from different regions of Iran. Some additional braconid material deposited in different insect collections (some branches of Islamic Azad University) has also been studied. Here, we follow the classification of Yu et al. (2016) and Chen and van Achterberg (2019). Identifications or confirmations of specimens were done with the help of the late J. Papp (Hungarian Natural History Museum: HNHM) and M. Fischer (Naturhistorisches Museum, Wien, Austria: NMW). Resources used to identify the specimens to the subfamily level included van Achterberg (1993), in addition to the available literature and keys, such as Nixon (1945); van Achterberg (1983, 1990, 1991); Quicke (1987); Fischer (1993); Tobias et al. (1995); Belokobylskij (1996, 1998, 2002); Chishti and Quicke (1996); Chen and van Achterberg (1997); Tobias (2001, 2008); Wang et al. (2009); Stigenberg and Ronquist (2011); Peris-Felipo et al. (2014); Fernández-Triana and van Achterberg (2017); and Zhu et al. (2017).

The names of the valid species are listed alphabetically within subfamilies, tribes, and genera, respectively. The extralimital distribution listed for each species newly recorded from Iran is based mainly on Yu et al. (2016) and Fernandez-Triana et al. (2020) (for Microgastrinae), though recent publications are also included to validate some records.

Depositories

HG collection: Hassan Ghahari collection, Iran.

HNHM: Hungarian Natural History Museum, Hungary.

NMW: Naturhistorisches Museum, Wien, Austria.

Results

In this paper, a total of 25 braconid species belonging to 19 genera and ten subfamilies are recorded as new country records: Alysiinae (three species, three genera), Brachistinae (one species), Braconinae (two species, two genera), Cheloninae (five species, two genera), Euphorinae (three species, two genera), Exothecinae (two species, two genera), Hormiinae (one species), Ichneutinae (one species), Microgastrinae (six species, four genera), and Rogadinae (one species).

Order Hymenoptera

Family Braconidae

Subfamily Alysiinae Leach, 1815

Tribe Alysiini Leach, 1815

Genus *Dinotrema* Foerster, 1863

- Dinotrema (Dinotrema) dimidiatum* (Thomson 1895)

Material examined: West Azarbaijan province, Makoo, Mahmoodoghli, 1♀, 11.viii.1996 (NMW).

General distribution: Czech Republic, Denmark, Germany, Hungary, Kazakhstan, Kyrgyzstan, Moldova, Russia, Turkey, Uzbekistan (Yu et al. 2016), Iran (new record).

Genus *Phaenocarpa* Foerster, 1863

- Phaenocarpa (Phaenocarpa) picinervis* (Haliday 1838)

Material examined: Razavi Khorasan province, Dargaz, Sadat, 2♀♂, 15.iv.2005 (NMW).

General distribution: Austria, Bulgaria, Czech Republic, Finland, Germany, Hungary, Ireland, Italy, Kazakhstan, Korea, Mongolia, Netherlands, Norway, Poland, Romania, Russia, Spain, Sweden, Switzerland, Turkey, USA, Ukraine, UK, Uzbekistan (Yu et al. 2016), Iran (new record).

Tribe Dacnusini Foerster, 1863

Genus *Chorebus* Haliday, 1833

- Chorebus (Stiphrocera) varunus* (Nixon 1945)

Material examined: East Azarbaijan province, Osku, Ghandiloo, 1♀, 12.viii.2008 (NMW).

Extralimital distribution: Azerbaijan, Hungary, Kazakhstan, Korea, Poland, Russia, Sweden, Turkey, Ukraine, UK (Yu et al. 2016), Iran (new record).

Subfamily Brachistinae Foerster, 1863

Tribe Brachistini Foerster, 1863

Genus *Eubazus* Nees von Esenbeck, 18124. *Eubazus (Allodorus) semirugosus* (Nees von Esenbeck 1814)

Material examined: Guilan province, Chaboksar, 1♀, 6.vi.2009 (HG collection); Mazandaran province, Tonekabon, Jangal-e 2000, 2♀♀, 26.vii.2013 (HG collection).

General distribution: Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, China, Czech Republic, Finland, France, Georgia, Germany, Hungary, Italy, Latvia, Moldova, Mongolia, Netherland, Norway, Poland, Romania, Russia, Slovakia, Sweden, Switzerland, Turkey, UK (Yu et al. 2016), Iran (new record).

Subfamily Braconinae Nees von Esenbeck, 1811

Tribe Braconini Nees von Esenbeck, 1811

Genus *Atanycolus* Foerster, 18635. *Atanycolus fulviceps* (Kriechbaumer 1898)

Material examined: West Azarbaijan province, Ourmiah, Seroo Road, 1♀, 14.vii.1999 (HNHM).

General distribution: Former Czechoslovakia, Germany, Hungary, Turkey, Ukraine.

Genus *Stenobracon* Szépligeti, 19016. *Stenobracon nicevillei* (Bingham 1901)

Material examined: Sistan & Baluchestan province, Bahu Kalat, Gando Protected Area, 1♀, 3.v.2012 (HNHM).

General distribution: Bangladesh, China, India, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam (Chishti and Quicke 1996; Yu et al. 2016), Iran (new record).

Subfamily Cheloninae Foerster, 1863

Tribe Chelonini Foerster, 1863

Genus *Chelonus* Panzer, 18047. *Chelonus latrunculus* Marshall, 1885

Material examined: East Azarbaijan province, Arasbaran forest, 1♀, 2.vii.2004 (NMW); Semnan province, Shahrud, Jangal-e Abr, 2♂♂, 7.iv.2011 (NMW).

General distribution: Armenia, Azerbaijan, Czech Republic, Finland, Germany, Hungary, Italy, Moldova, Poland, Russia, Slovakia, Sweden, Switzerland, Tajikistan, Turkey, Ukraine, UK (Yu et al. 2016), Iran (new record).

8. *Chelonus retusus* (Nees von Esenbeck 1816)

Material examined: Golestan province, Minudasht, Bazgir, 1♀, 3.vii.2002 (NMW).

General distribution: Armenia, Azerbaijan, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Italy, Moldova, Mongolia, Montenegro, Romania, Russia, Serbia, Slovakia, Sweden, Switzerland (Yu et al. 2016), Iran (new record).

9. *Chelonus subarcuatus* (Tobias 1986)

Material examined: Razavi Khorasan province, Torghabeh, Cheshmeh-Asal, 1♂, 23.viii.2009 (HG collection); Semnan province, Shahrud, Jangal-e Abr, 1♀, 7.iv.2011 (HG collection).

General distribution: Armenia, Bulgaria, Hungary, Kazakhstan, Moldova, Spain, Turkey, Turkmenistan, Uzbekistan (Yu et al. 2016), Iran (new record).

Tribe Phanerotomini Baker, 1926

Genus *Phanerotoma* Wesmael, 183810. *Phanerotoma (Bracotritoma) atra* Šnoflák, 1951

Material examined: Mazandaran province, Ramsar, Dalkhani forest, 2♀♀, 17.v.2011 (HNHM).

General distribution: Armenia, Austria, Azerbaijan, former Czechoslovakia, France, Greece, Hungary, Macedonia, Moldova, Russia, Serbia, Spain, Switzerland, Turkey (Yu et al. 2016), Iran (new record).

11. *Phanerotoma (Phanerotoma) dentata* (Panzer 1805)

Material examined: Hamadan province, Malayer, 3♀♀, 21.vii.2007 (HG collection), ex *Cydia pomonella* (Linnaeus 1758) (Lepidoptera: Tortricidae) on *Malus* sp. (Rosaceae).

Extralimital distribution: Algeria, Argentina, Armenia, Austria, Azerbaijan, Belgium, Canary Islands, Croatia, Egypt, Finland, France, Germany, Greece, Hungary, Italy, Kazakhstan, Kenya, Korea, Latvia, Lithuania, Moldova, Netherlands, Norway, Poland, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, UK, Uzbekistan, former Yugoslavia (Yu et al. 2016), Iran (new record).

Subfamily Euphorinae Foerster, 1863

Genus *Centistes* Haliday, 183512. *Centistes (Ancyclocentrus) nasutus* (Wesmael 1838)

Material examined: Mazandaran province, Savadkuh, Shourmast, 2♂♂, 12.v.2007 (NMW).

General distribution: Belgium, Finland, France, Georgia, Germany, Hungary, Italy, Kazakhstan, Montenegro, Netherland, Poland, Russia, Sweden, Switzerland, Ukraine, UK (Yu et al. 2016), Iran (new record).

13. *Centistes (Ancylocentrus) subsulcatus* (Thomson 1895)

Material examined: East Azarbaijan province, Azarshahr, Nadiloo, 1♀, 11.vii.2001 (NMW).

General distribution: Azerbaijan, Belgium, Finland, Hungary, Russia, Serbia, Sweden, Switzerland, UK (Yu et al. 2016), Iran (new record).

Genus *Meteorus* Haliday, 1835

14. *Meteorus obfuscatus* (Nees von Esenbeck 1811)

Material examined: Ardabil province, Namin, Garm-Cheshmeh, 1♀, 15.v.2003 (HNHM).

General distribution: Belgium, Finland, France, Germany, Hungary, Italy, Japan, Montenegro, Norway, Poland, Romania, Russia, Slovakia, Sweden, Switzerland, UK (Yu et al. 2016), Iran (new record).

Subfamily Exothecinae Foerster, 1863

Tribe Exothecini Foerster, 1863

Genus *Colastes* Haliday, 1833

15. *Colastes (Colastes) pubicornis* (Thomson 1892)

Material examined: Kordestan province, Saghez, Ghader-Abad, 1♀, 10.vii.2006 (NMW).

General distribution: Bulgaria, China, Finland, Germany, Hungary, Japan, Korea, Lithuania, Russia, Sweden, Ukraine (Yu et al. 2016), Iran (new record).

Genus *Xenarcha* Foerster, 1863

16. *Xenarcha laticarpus* (Thomson 1892)

Material examined: East Azarbaijan province, Kaleybar, Khomarloo, 1♀, 2.vii.2004 (HNHM).

General distribution: Austria, Azerbaijan, Finland, Georgia, Germany, Lithuania, Russia, Sweden (Yu et al. 2016), Iran (new record).

Subfamily Hormiinae Foerster, 1863

Tribe Lysitermini Tobias, 1968

Genus *Chremylus* Haliday, 1833

17. *Chremylus elaphus* Haliday, 1833

Material examined: West Azarbaijan province, Ourmiah, Zeynaloo, 3♀♀, 14.v.1996 (NMW), ex *Archips xylosteana* (Linnaeus 1758) (Lepidoptera: Tortricidae) on *Prunus* sp. (Rosaceae).

General distribution: Argentina, Austria, Azores, Belgium, Canary Islands, Czech Republic, Finland, France, Georgia, Germany, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Netherlands, New Zealand,

Poland, Russia, Sweden, Switzerland, USA, Ukraine, UK (Yu et al. 2016), Iran (new record).

Subfamily Ichneutinae Foerster, 1863

Genus *Pseudichneutes* Belokobylskij, 1996

18. *Pseudichneutes levis* (Wesmael 1835)

Material examined: Northern Khorasan province, Shirvan, Loojley, 1♀, 12.iv.2002 (HNHM).

General distribution: Belgium, Finland, France, Germany, Hungary, Italy, Kazakhstan, Netherlands, Poland, Russia, Sweden, Turkey, Ukraine, UK (Yu et al. 2016), Iran (new record).

Subfamily Microgastrinae Foerster, 1863

Genus *Cotesia* Cameron, 1891

19. *Cotesia acuminata* (Reinhard 1880)

Material examined: West Azarbaijan province, Khoy, 2♀♀, 2.vii.2004 (HNHM). ex *Melitaea didyma* (Esper 1778) (Lepidoptera: Nymphalidae) on *Helianthus* sp. (Asteraceae).

General distribution: Armenia, Austria, China, Czech Republic, Finland, France, Georgia, Germany, Hungary, Israel, Romania, Russia, Slovakia, Spain, Sweden, Tajikistan, Ukraine, Uzbekistan (Fernandez-Triana et al. 2020), Iran (new record).

20. *Cotesia melitaearum* (Wilkinson 1937)

Material examined: Mazandaran province, Tonekabon, Jangal-e 2000, 4♀♀, 2♂, 11.v.2003 (HG collection). ex *Lymantria dispar* (Linnaeus 1758) (Lepidoptera: Erebidae) on *Ulmus* sp. (Ulmaceae).

General distribution: Armenia, Azerbaijan, China, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Kazakhstan, Korea, Moldova, Poland, Romania, Russia, Slovakia, Spain, Sweden, Turkey, UK, Uzbekistan (Fernandez-Triana et al. 2020), Iran (new record).

21. *Cotesia pieridis* (Bouché 1834)

Material examined: Lorestan province, Kuhdasht, Hahi-Morad, 2♀♀, 6.vi.2009 (HNHM), ex *Malacosoma neustria* (Linnaeus 1758) (Lepidoptera: Lasiocampidae) on *Poplar* sp. (Salicaceae).

General distribution: Armenia, Azerbaijan, China, Georgia, Germany, Hungary, Israel, Kazakhstan, Lithuania, Moldova, Mongolia, Romania, Russia, Slovakia, Tajikistan, Turkey, Uzbekistan (Fernandez-Triana et al. 2020), Iran (new record).

Genus *Dolichogenidea* Viereck, 1811

22. *Dolichogenidea imperator* (Wilkinson 1939)

Material examined: West Azarbaijan province Ourmiah, Seroo Road, 2♀♀, 6.v.2003 (HNHM), ex *Plutella xylostella* (Linnaeus 1758) (Lepidoptera: Plutellidae) on *Brassica oleracea* L. (Brassicaceae).

General distribution: Armenia, Austria, Azerbaijan, Czech Republic, Germany, Hungary, Italy, Kazakhstan, Lithuania, Moldova, Netherland, Romania, Russia, Switzerland, Turkmenistan, Tajikistan, UK, Uzbekistan (Fernandez-Triana et al. 2020), Iran (new record).

Genus *Iconella* Mason, 1981

23. *Iconella lacteoides* (Nixon 1965)

Material examined: Isfahan province, Isfahan, Borkhar, 3♀♀, 16.v.2000 (HNHM), ex *Homoeosoma nebulella* Denis & Schiffermüller, 1775 (Lepidoptera: Pyralidae) on *Helianthus* sp. (Asteraceae).

General distribution: Armenia, Azerbaijan, Germany, Greece, Hungary, Italy, Kazakhstan, Mongolia, Poland, Russia, Slovakia, Sweden, Turkey, Turkmenistan,

Ukraine, Uzbekistan (Fernandez-Triana et al. 2020), Iran (new record).

Genus *Microplitis* Foerster, 1863

24. *Microplitis tadhicus* Telenga, 1949

Material examined: Northern Khorasan province, Raz, Abdollah-Abad, 1♀, 6.v.2006 (HG collection); Kerman province, Jiroft, Jalal-Abad, 1♀, 10.ix.2008 (HG collection).

General distribution: Afghanistan, Azerbaijan, China, France, Hungary, Kazakhstan, Korea, Russia, Tajikistan, Turkmenistan, Uzbekistan (Fernandez-Triana et al. 2020), Iran (new record).

Subfamily Rogadinae Foerster, 1863

Genus *Pentatermus* Hedqvist, 1963

25. *Pentatermus striatus* (Szépligeti 1908)

Material examined: Ardabil province, Germi, Anjirloo, 1♀, 11.viii.2005 (HNHM).

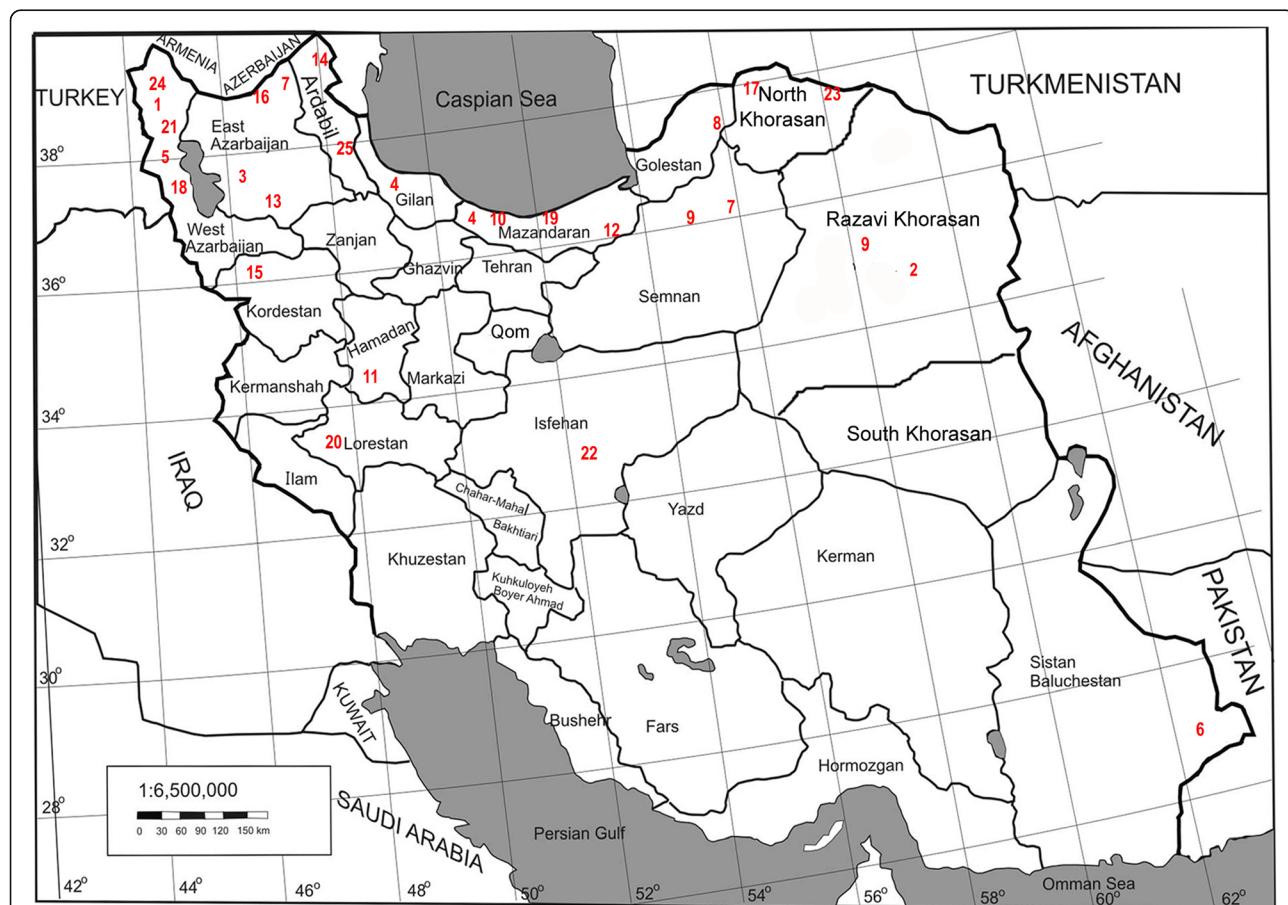
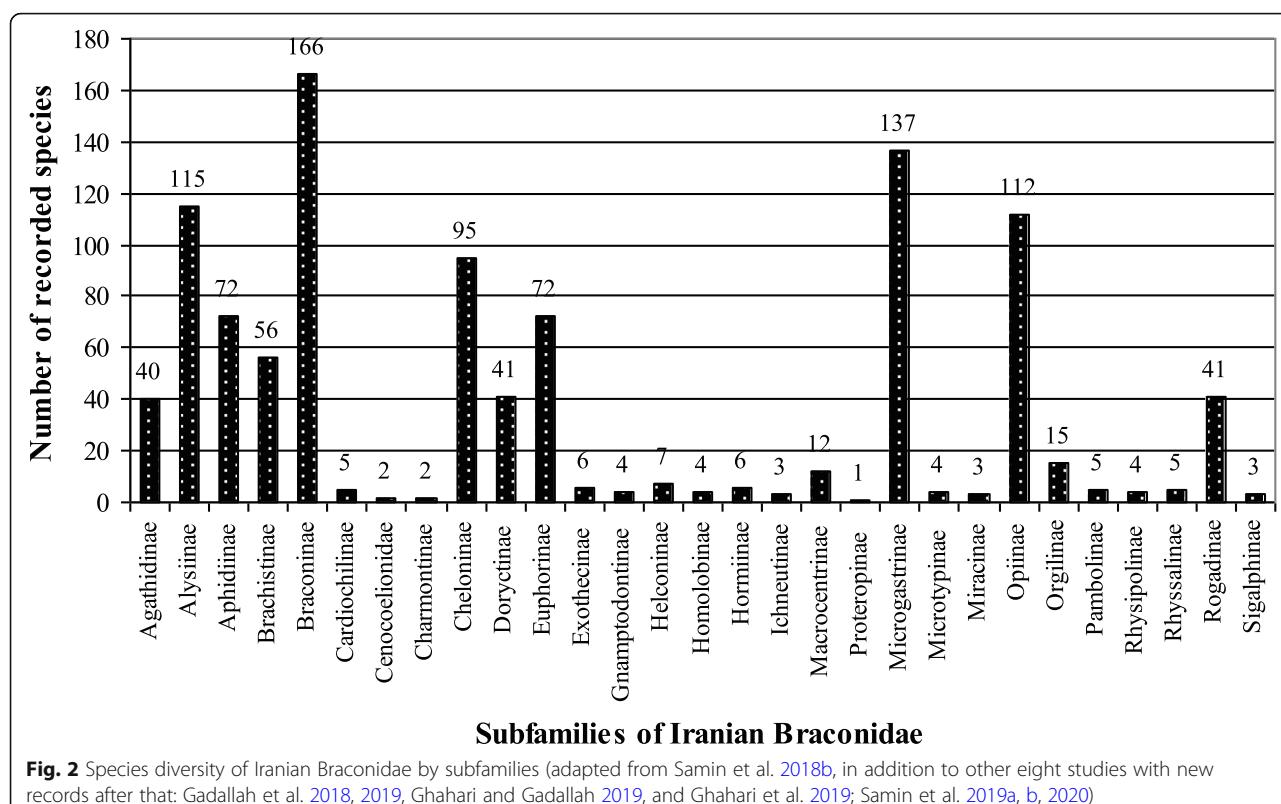


Fig. 1 Distributional data of newly recorded species in different provinces of Iran (numbers refer to species in the text)

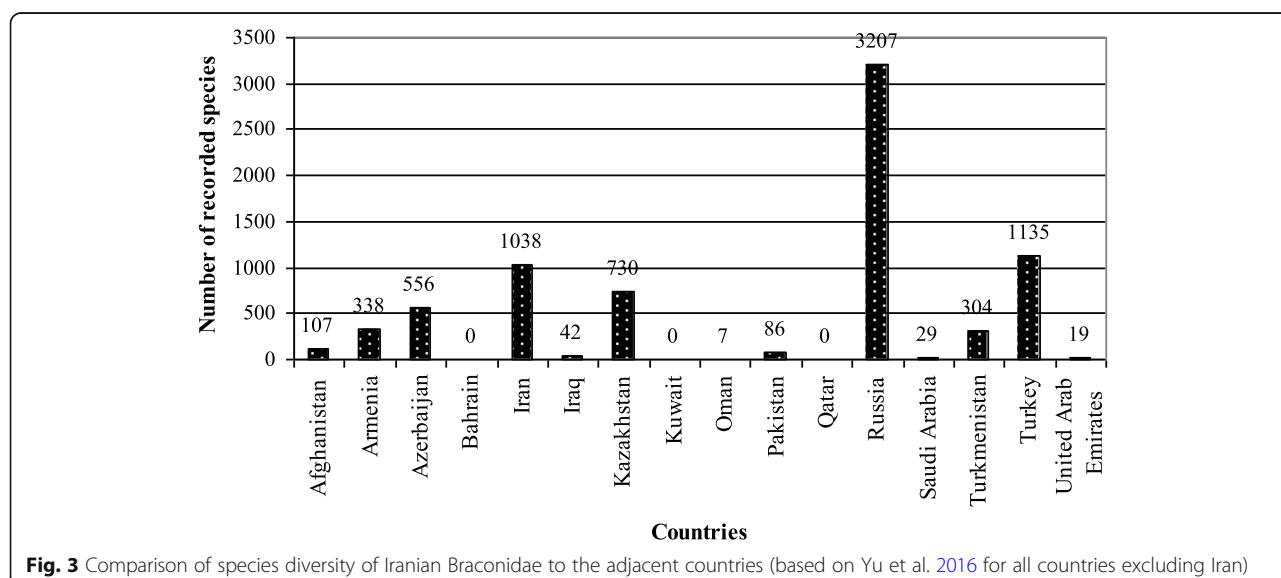


General distribution: China, India, Indonesia, Japan, Madagascar, Malaysia, Niger, Nigeria, Oman, Somalia, South Africa, Vietnam (Yu et al. 2016), Iran (new record).

Discussion

Our findings revealed that 25 species are new Iranian records which are distributed across 14 provinces, most in

northern areas (Fig. 1). The fauna of Iranian Braconidae is progressed rather fast (Modarres Awal 1997 and 2012: 16 and 50 species of Aphidiidae + 51 and 64 species of Braconidae, respectively; Fallahzadeh and Saghaei 2010: 202 species; Farahani et al. 2016: 780 species; Yu et al. 2016: 804 species; Samin et al. 2018a, b: 835 and 861 species, respectively; as well as several catalogs which were established during 2013–2019. Together with the



25 new records dealt with in the present study, raise the total number of Iranian Braconidae to reach 1038 species. Among the 30 subfamilies that have been recorded from Iran to date, the Braconinae is the most diverse with 166 recorded species (Fig. 2). Comparison of the Iranian fauna to those of the adjacent countries indicates that Braconidae of Iran has the highest diversity after Russia (with 3207 species) and Turkey (with 1135 species) (Fig. 3); however, these results are biased towards the more sampled regions in some countries and less or without any sampling in some others. Since Iran is a large country with variable ecosystems, more faunistic surveys in different regions will result to new findings (new species, new country records, new distributional data, and parasitoid-host relationships).

Although the Iranian fauna of Braconidae has been studied rather well and cataloged by several authors (see above references), however, the reported species were collected by Malaise traps or sweep netting, so the hosts of most Iranian braconids remain unknown. In this investigation, parasitoid-host relationships have been determined for only seven species (*Phanerotoma dentata* (Cheloninae), *Chremylus elaphus* (Hormiinae), *Cotesia acuminata*, *Cotesia melitaearum*, *Cotesia pieridis*, *Dolichogenidea imperator*, and *Iconella lacteoides* (Microgastrinae)) (28% of the total number of species reported herein) and all the newly recorded hosts belong to the Lepidoptera (families Erebidae, Lasiocampidae, Nymphalidae, Plutellidae, Pyralidae, and Tortricidae). Host determination for the parasitoids is the first step in classical and applied biological control programs (DeBach and Rosen 1991; Bellows et al. 1999).

Conclusion

In the present study, a list of 25 species belonging to ten subfamilies (Alysiinae, Brachistinae, Braconinae, Cheloninae, Euphorinae, Exothecinae, Hormiinae, Ichneutinae, Microgastrinae, and Rogadinae), as well as two genera, *Pentatermus* Hedqvist, 1963 (Rogadinae), and *Stenobracon* Szépligeti, 1901 (Braconinae), are newly recorded from Iran. The study is based on specimens collected from different localities in Iran, in addition to material deposited in Iranian collections. A faunistic list comprising the valid species names arranged alphabetically within genera, tribes, and subfamilies is provided, as well as extrazonal distribution of species.

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Authors' contributions

NG was the major contributor in writing the manuscript and suggesting the suitable keys for identifying the species. HG collected some of the newly recorded species, examining species in the different Iranian collection, and editing the manuscript. DQ revised and corrected the manuscript taxonomically and linguistically. All authors read and approved the final manuscript.

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Availability of data and materials

All the mentioned specimens are deposited in the different Iranian collections (some branches of Islamic Azad University), and Natural History Museums of Vienna and Budapest are available. All data are available in the article.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Entomology Department, Faculty of Science, Cairo University, Giza, Egypt.

²Department of Plant Protection, Yadegar-e-Imam Khomeini (RAH) Shahre Rey Branch, Islamic Azad University, Tehran, Iran. ³Integrative Ecology Laboratory, Department of Biology, Faculty of Science, Chulalongkorn University, Phayathai Road, Pathumwan, Bangkok 10330, Thailand.

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