J Insect Biodivers Syst 03(3), 239–246

ISSN: 2423-8112

OPEN ACCESS

JOURNAL OF
INSECT BIODIVERSITY AND SYSTEMATICS

JIBS

Research Article

http://jibs.modares.ac.ir

http://zoobank.org/References/B137B806-45EF-4595-A175-C71AD4E16865

The first proposal and perspective of Microgastrinae (Hymenoptera, Braconidae) in Iran as a megadiverse group: a major step in the regional studies

Mostafa Ghafouri Moghaddam and Azizollah Mokhtari*

Department of Plant Protection, College of Agriculture, University of Zabol, Zabol, P.O. Box: 98615-538, I. R. Iran.

Received:
27 June, 2017

Accepted:
07 August, 2017

Published:
21 August 2017

Subject Editor:
Ehsan Rakhshani

ABSTRACT. The subfamily Microgastrinae Foerster, 1862 (Hymenoptera, Ichneumonoidea, Braconidae) is a challenging and the most diverse groups of braconids that has significant importance in biological control programs. They are koinobiont endoparasitoids of lepidopteran larvae and generally attack and develop in early instars and exit from the host larvae to pupate. In current paper, the findings of primary taxonomic investigations on these valuable biocontrol agents is presented and for each genus, the general habitus of a represented species is illustrated. Also, the proportion of known hosts for some genera was provided. The purpose of this paper is to provide a preliminary information of the Microgastrinae in Iran to serve as a starting point for future studies on the group and to encourage further study of more species in other regions of Iran, on various aspects of taxonomic, ecological, host associations, conservation, DNA barcoding and bio-control.

Key words: Parasitoids, Braconidae, Microgastrinae, Lepidoptera, Biological control, Cryptic species

Citation: Ghafouri Moghaddam, M. & Mokhtari, A. (2017) The first proposal and perspective of Microgastrinae (Hymenoptera, Braconidae) in Iran as a megadiverse group: a major step in the regional studies. *Journal of Insect Biodiversity and Systematics*, 3 (3), 239–246.

Introduction

Microgastrinae Foerster, 1862 is one of the most important and large group of lepidopteran parasitoids with over 2700 described species worldwide, and ranked as the second most diverse subfamily after Braconinae (Fernández-Triana & Ward, 2017; Yu et al., 2016). Nearly all genera for which the biology is known, are solitary endoparasitoids, but include at least some gregarious species (Quicke, 2015). However, the host association of many gregarious and solitary species were documented from different areas (Gupta & Fernández-Triana, 2014; Fernández-Triana et al., 2014). The actual diversity of Microgastrinae has been estimated between 7,000–46,000 species around the world based on molecular studies in the near future (Rodriguez et al., 2013).

Identification of Microgastrinae is a time-consuming and rather difficult task when using general taxonomic literature, especially if no host records are available.

Corresponding author: Azizollah Mokhtari, E-mail: *mokhtari@uoz.ac.ir*

The problem for identification of this group of parasitoids is exacerbated due to the fact, and also the vast extension of unexplored geographical area. The need for quick and accurate identification of the parasitoid is, however, a common problem as they are frequently encountered in host rearing surveys of Lepidopterous pests.

Recently we handled microgastrine samples which were collected by our researcher's team. Among them, we were able to have a quick look at part on several thousand that hopefully will be prepared soon for more detailed and elaborated studies. Even though, we have barely touched the surface, the diversity of Iranian microgastrine wasps is noteworthy and amazing.

Material and methods

This study is focused on the study of the microgastrines collected in various provinces of Iran. Iran, from the faunistic point of view, is located in the border of Western and Eastern Palaearctic regions with some influences from the Oriental region (Pujade-Villar et al., 2015). All the specimens were captured during 2010–2016 using different sampling techniques including Malaise trap, light trap, yellow and blue pan trap and sweep net in crop and natural ecosystems. Alcohol preserved specimens were processed using Alcohol-Xylene-Amyl acetate (AXA protocol- van Achterberg, 2009) and later triangular card mounted. Morphological terms and general classification are mostly as followed by Mason (1981), Sharkey & Wharton (1997) and Fernández-Triana et al. (2014).

The examination of external morphology of specimens were done using a Nikon® SMZ645 stereomicroscope (Nikon® Inc., Japan) with 2X lenses. All of the photos were taken with a Canon® EOS 700D (Canon® Inc., Japan), and a simple light source with SMD (**S**urface **M**ounted **D**evice) halogen lamp as manual. The camera was mounted on a Hund® Stereomicroscope (Wetzlar Inc., Germany) to allow for taking multiple images. Multiple images (a series more than 12) through the focal plane were taken of a structure and these were merged to produce a single in-focus image. For the pictures taken with the Canon® camera, the Zerene Stacker™ version 1.04 software was used. Finally, plates for the illustrations were prepared using Adobe® Photoshop CS6. All specimens are deposited in the Department of Plant Protection, University of Zabol, Zabol, Iran (**DPPZ**).

Results

Our primary results showed that only 53 species in 9 genera with 30 host associations correctly have been recorded from Iran that contain correct information including host and state the depository of species (unpublished data and needs to be further investigation) and other reported genera and species need more re-examination because of earlier mis-identification and lack of species repository, which means that their work is unverifiable and that only shows the scarceness of studies. This will surely increase those numbers even more. In first step, we separated more than five genera (*Apanteles* Foerster, 1862, *Choeras* Mason, 1981, *Cotesia* Cameron, 1891, *Diolcogaster* Ashmead, 1900, *Glyptapanteles* Ashmead, 1904, *Iconella* Mason, 1981, *Microgaster* Latreille, 1804 and *Microplitis* Foerster, 1862) (Fig. 1). They include more than fifty species, which were collected among the samples from many provinces in Eastern, central and Western parts of Iran. The most diverse genera were *Apanteles, Cotesia* and *Microplitis*. Some specimens clearly represent the new taxa -or at least a new taxon records we comprehend it now.

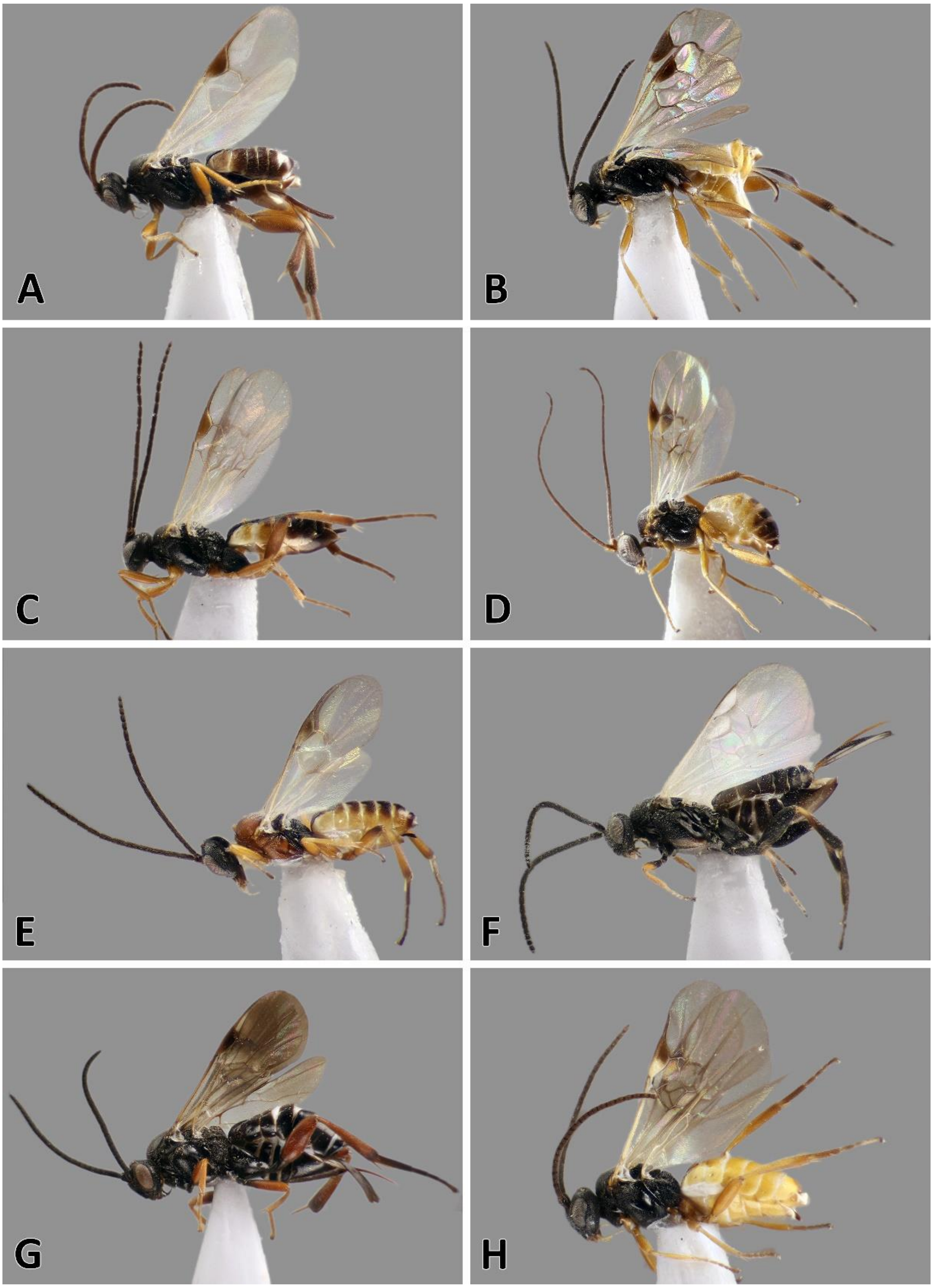

Figure 1. The genera common Iranian microgastrine. **A.** *Apanteles* Foerster, 1862; **B.** *Choeras* Mason, 1981; **C.** *Cotesia* Cameron, 1891; **D.** *Diolcogaster* Ashmead, 1900; **E.** *Glyptapanteles* Ashmead, 1904; **F.** *Iconella* Mason, 1981; **G.** *Microgaster* Latreille, 1804; **H.** *Microplitis* Foerster, 1862 (housed at the **DPPZ**).

As a rule, the majority of the specimens were similar to common Microgastrinae (some *Apanteles, Glyptapanteles,* most and all of *Cotesia, Choeras* and *Diolcogaster* species). But we likewise discovered quite a few species of very large number of microgastrine fauna comprising of several genera (some *Apanteles*, *Iconella* and *Microgaster*) although many specimens still have to be studied. Among the reported genera in Iran, the genus *Cotesia* (41%) had the highest number of documented records concerning host associations followed by *Apanteles* (15%), *Dolichogenidea* (15%) and *Glyptapanteles* (4%) (Fig. 2). Data in table 1 showing that recorded taxa were found in different altitudes (ranging 2–2150) from 19 provinces of Iran, and reflects the great diversity of this group at any altitude, habitat, climate and flora but very few and scattered studies have comparatively been done. Generally, a great number of microgastrines have been found in northern and northwestern parts of Iran and major parts of the country in Eastern, southern and central areas are yet remained unexplored. The results from the current study present that the Microgastrinae might be much more diverse than anticipated in Iran, indeed. The provided information in this study should be supplemented by further investigation, as well as an updated complete catalogue of the recorded species elsewhere. Although some explanations and assumptions are certainly expected, but all of the outputs provided here are rather conservative. It clearly shows the significance of revisionary and works on the recorded information about Microgastrinae of Iran.

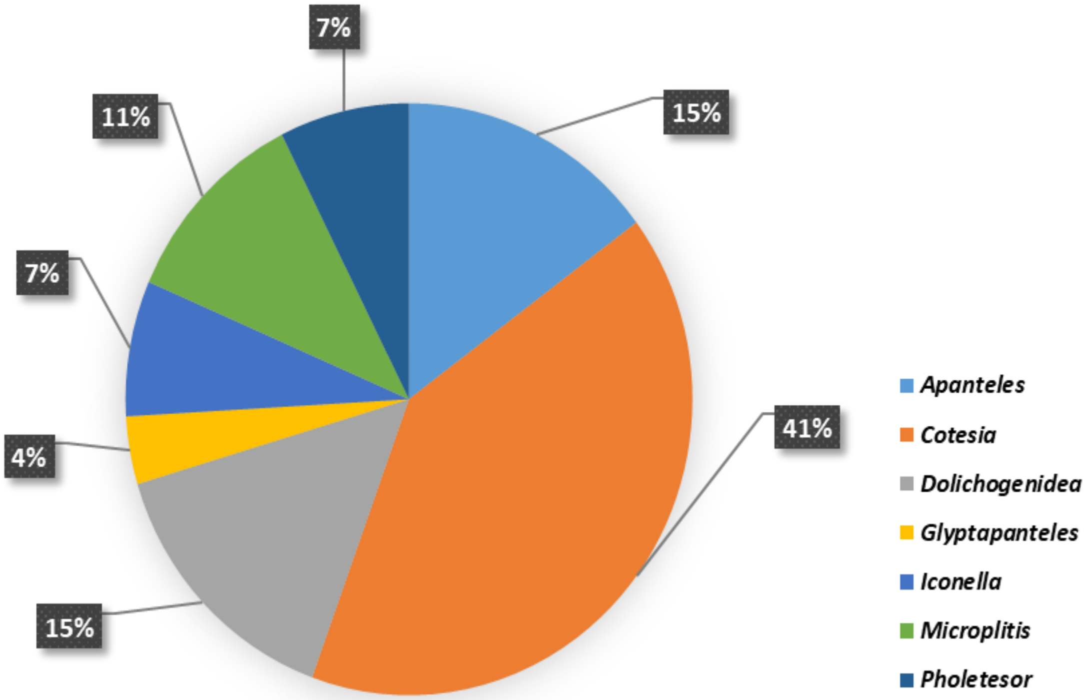

Figure 2. The proportion of known host records some genera of the Microgastrinae (Hymenoptera, Braconidae) in Iran.

Table 1. The recorded genera of Microgastrinae in different provinces of Iran. Name of provinces are sorted based on their altitude (m). Preliminary data based on study done until March 2017

Provinces	Average Altitude (m A.S.L)	Genera
Guilan	2.06	*Apanteles, Cotesia, Dolichogenidea, Glyptapanteles*
Khuzestan	21.38	*Cotesia*
Golestan	36.07	*Cotesia, Pholetesor*
Qom	820.23	*Iconella*
Mazandaran	989.22	*Cotesia*
Sistan-o Baluchestan	1024.27	*Apanteles, Cotesia, Diolcogaster, Dolichogenidea, Iconella*
Semnan	1060.82	*Cotesia*
Khorasan-e Razavi	1146.01	*Microplitis*
Qazvin	1226.82	*Microplitis*
Ardabil	1284.96	*Microplitis*
Tehran	1297.19	*Apanteles, Cotesia, Iconella, Microplitis*
Isfahan	1476.76	*Dolichogenidea, Iconella, Microplitis*
Lorestan	1496.26	*Dolichogenidea*
West Azerbaijan	1882.68	*Cotesia, Diolcogaster, Dolichogenidea, Glyptapanteles*
Alborz	1890.17	*Cotesia, Microplitis, Pholetesor*
East Azerbaijan	1909.78	*Microgaster, Pholetesor*
Fars	1918.98	*Apanteles, Cotesia, Diolcogaster*
Kerman	2009.35	*Dolichogenidea, Iconella*
Markazi	2142.92	*Iconella, Pholetesor*
Not defined	–	*Apanteles, Cotesia, Glyptapanteles, Microgaster, Microplitis*

Discussion

Still, a portion of the species seems to be extremely troublesome in our collections – due to inaccessibility to the type specimens in the various museums throughout of world. Existence of many cryptic species which can not be morphologically seprated, as well as lacking the enough material for comparison make the studies rather complicated. Therefore, we are trying to enhance the collections for more comprehensive studies. There are considerable taxonomic implements that prevents further advances in the knowledge of microgastrine wasp in Iran and in many other regions. Using an integrative taxonomic approach including host association data and DNA barcoding as well as ecological, morphological and geographical data would greatly help in correct identification of Microgastrinae. In this way, the number of known species in Iran, as well as the identity of many cryptic species will be resolved. The genera *Beyarslania* Kocak & Kemal 2009, *Distatrix* Mason, 1981, *Keylimepie* Fernández-Triana, 2016, *Miropotes* Nixon, 1965, *Nyereria* Mason, 1981, *Snellenius* Westwood, 1882, *Venanides* Mason, 1981 and *Wilkinsonellus* Mason, 1981, given that they were reported from neighboring countries. Therefore, they are most likely occurred in southern parts of Iran with similar habitats.

Iran has almost same climate, fauna and flora with the adjacent countries, and it is expected that many of the microgastrine species in these countries would be identical. Notwithstanding the fact, all the numbers and remarks given here are just preliminary observations of the Iranian microgastrine diversity and are incomplete yet but impressive. We estimated that the real number of species would be substantially higher than current situation when our research has been completed. The significant number of species remained unknown/undescribed in the many provinces of Iran. Further explorations will certainly led to discovery of these species and increase in the faunistic knowledge. At the same way, a gradual growth and strengthen collections in the various museums would initiate the opportunities for future studies.

Critical morphological terminology, cryptic species and overlapping characters make the identification rather complicated. Extensive studies of the literature and borrowing of identified specimens enabled familiarization with the group. Over the time, experience led to confidence, which allowed variations to be recognized and new species were identified. This experience confirmed the need for user to identify diagnostic tools and to expedite the identification process while highlighting the poor taxonomic knowledge of our regional microgastrine fauna. This learning process evolved to be the foundation of this major project. Nonetheless, Whitfield et al. (2018) presented comprehensive current status of understanding of the general biology, taxonomic history, diversity, geographical patterns, host relationships and phylogeny of Microgastrinae as a stimulus and foundation for further study that in the meantime DNA barcoding studies provided the most accurate and fastest way for to analyze the different complexes of this megadiverse group and perhaps the most species-rich subfamily of animals on Earth. Also, they will provide a perfect and flawless genus-level classification in the near future.

This proposal addressed challenges, opportunities and future strategies in the study of this group and the issues of poor microgastrine taxonomy and identification tools for Iran by carrying out a taxonomic revision and by the development of different identification tools. As an introduction to the proposal, this case will look broadly at the Braconidae fauna and then focus on the generic classification and reclassification within the Microgastrinae.

Acknowledgments

MGM would like to thank collectors for aid in collecting specimens using the different techniques. The authors are grateful to the anonymous reviewers for their critical comments which provided us with the opportunity to improve the manuscript.

Conflict of Interests

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

References

Fernández-Triana, J.L., Whitfield, J.B., Rodriguez, J.J., Smith, M.A., Janzen, D.H., Hallwachs, W., Hajibabaei, M., Burns, J.M., Solis, M. A., Brown, J., Cardinal, S., Goulet, H. & Hebert, P.D.N. (2014) Review of *Apanteles* (Hymenoptera: Braconidae, Microgastrinae) from Area de Conservación Guanacaste, northwestern Costa Rica, with keys to all described species from Mesoamerica. *ZooKeys,* 383, 1–565. https://doi.org/10.3897/zookeys.383.6418

Fernández-Triana, J.L. & Ward, D. (2017) *Microgastrinae Wasps of the World.* Available from: http://microgastrinae.myspecies.info/ [accessed on 25thJune 2017].

Gupta, A. & Fernández-Triana, J.L. (2014) Diversity, host association, and cocoon variability of reared Indian Microgastrinae (Hymenoptera: Braconidae) *Zootaxa,* 3800 (1), 001–101. https://doi.org/10.11646/zootaxa.3800.1.1

Mason, W.R.M. (1981) The polyphyletic nature of *Apanteles* Foerster (Hymenoptera: Braconidae): A phylogeny and re-classification of Microgastrinae. *Memoirs of the Entomological Society of Canada,* 115, 1–147. https://doi.org/10.4039/entm113115fv

Pujade-Villar, J., Tavakoli, M., Melika, G. & Ferrer-Suay, M. (2015) *Andricus synophri*

(Hymenoptera: Cynipidae), a new species of oak gallwasp from Iran. *Journal of Insect Biodiversity and Systematics,* 1 (1), 1–10.

Quicke, D.L.J. (2015) *The Braconid and Ichneumonid Parasitoid Wasps: Biology, Systematics, Evolution and Ecology,* Willey-Blackwell, 704 pp.

Rodriguez, J.J., Fernández-Triana, J.L., Smith, M.A., Janzen, D.H., Hallwachs, W., Erwin, T. L. & Whitfield, J.B. (2013) Extrapolations from field studies and known faunas converge on dramatically increased estimates of global microgastrine parasitoid wasp species richness (Hymenoptera: Braconidae). *Insect Conservation and Diversity*, 6, 530–6. https://doi.org/10.1111/icad.12003

Sharkey, M.J. & Wharton, R.A. (1997) Morphology and terminology. In: Wharton, R.A., Marsh, P.M. & Sharkey, M.J. (eds.) *Manual of the New World genera of the family Braconidae (Hymenoptera).* Special Publication No. 1, International Society of Hymenopterists, Washington, D.C., pp. 19–63.

van Achterberg, C. (2009) Can Townes type Malaise traps be improved? Some recent developments. *Entomologische Berichten Amsterdam*, 69 (4), 129–135.

Whitfield, J.B., Austin, A. & Fernández-Triana J.L. (2018) Systematics, Biology, and Evolution of Microgastrine Parasitoid Wasps. *Annual Review of Entomology,* 63 (1), in press. https://doi.org/10.1146/annurev-ento-020117-043405

Yu, D.S.K., van Achterberg, C. & Horstmann, K. (2016) *Taxapad 2016, Ichneumonoidea 2015.* Database on flash-drive. www.taxapad.com, Nepean, Ontario, Canada.

اولین طرح پیشنهادی و دورنمای زنبورهای پارازیتویید زیرخانواده Microgastrinae (Hymenoptera, Braconidae) در ایران به عنوان یک گروه با تنوع گونه‌ای بسیار بالا: یک گام بزرگ در مطالعات منطقه‌ای

مصطفی غفوری‌مقدم و عزیزاله مختاری*[*]

گروه گیاهپزشکی، دانشکده کشاورزی، دانشگاه زابل، ایران، صندوق پستی: ۹۸۶۱۵-۵۳۸
[*] پست الکترونیکی نویسنده مسئول مکاتبه: *mokhtari@uoz.ac.ir*

تاریخ دریافت: ۰۶ تیر ۱۳۹۶، تاریخ پذیرش: ۱۶ مرداد ۱۳۹۶، تاریخ انتشار: ۳۰ مرداد ۱۳۹۶

چکیده: زنبورهای زیرخانواده Microgastrinae Foerster, 1862 (Hymenoptera, Ichneumonoidea, Braconidae) یکی از چالش‌برانگیزترین و متنوع‌ترین گروه‌های زنبورهای خانواده براکونیده هستند و اهمیت قابل توجهی در برنامه‌های کنترل بیولوژیک دارند. این گروه پارازیتویید داخلی و کویینوبیونت لارو بال‌پولکیان می‌باشند و به طور کلی در مراحل اولیه سنین لاروی، میزبان را پارازیت و در نهایت از شفیره میزبان خارج می‌شوند. در مطالعه حاضر نتایج بررسی‌های اولیه تاکسونومیک روی این عوامل بیوکنترل ارزشمند ارایه و عکس حشرات کامل جنس‌ها نشان داده شد. همچنین درصد میزبان‌های شناخته شده برای برخی از جنس‌ها ارایه شده است. هدف از این مقاله آماده کردن اطلاعات اولیه درباره زیرخانواده Microgastrinae در ایران به عنوان نقطه شروع برای مطالعات آینده و تشویق به مطالعه بیشتر گونه‌ها در دیگر نواحی مختلف ایران از نظر تاکسونومیک، اکولوژیک، روابط میزبانی، حفاظت، بارکدینگ DNA و کنترل بیولوژیک می‌باشد.

واژگان کلیدی: پارازیتویید، براکونیده، میکروگاسترینه، بال‌پولکیان، کنترل بیولوژیک، گونه‌های مخفی