pISSN: 0259-9996 – eISSN: 2783-3968

Journal of Entomological Society of Iran

2025, 45 (4), 529–539

Research Article

First record of the genus *Zygota* Förster, 1856 (Hymenoptera: Diapriidae, Belytinae) in Western Asia, with three new records of species from Iran

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Abstract. During our studies on the family Diapriidae, three species of the genus *Zygota* were collected and identified for the first time from Western Asia and the Middle East based on Iranian specimens: *Zygota abdominalis* (Nees, 1834), *Z. nigra* (Thomson, 1859), and *Z. ruficornis* Curtis, 1831. A key to the Iranian species of the genus *Zygota* and diagnostic characters for all newly recorded species are provided along with illustrations. In addition, a worldwide distribution map of the three species is also presented.

Keywords: Belytini, identification key, distribution, Middle East

Article info
Received: 08 May 2025
Accepted: 16 August 2025
Published: 05 October 2025

Subject Editor: Željko Tomanović

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DOI : https://doi.org/10.61186/jesi.45.4.4

Introduction

According to the latest update, the family Diapriidae comprises three subfamilies: Ambositrinae, Belytinae, and Diapriinae. The subfamily Belytinae comprises 54 genera and about 700 described species. Belytinae wasps have a global distribution and are usually found in humid, shaded habitats such as forests, pastures, gardens, and wet meadows (Quadros & Brandão, 2017). Members of Belytinae are parasitoids of the larvae and pupae of Diptera from the families Mycetophilidae and Sciaridae (Yoder, 2007). The tribal taxonomy of the subfamily is extremely poorly developed; however, three tribes have been distinguished up to now: Pantolytini Hellen, 1964, Belytini Förster, 1856, and Cinetini Macek, 1989. The genus *Zygota* Förster, 1856 belongs to the tribe Belytini Förster, 1856 (Macek, 1989; Chemyreva, 2019).

To date, 31 species belonging to 14 genera of wasps in the family Diapriidae have been identified in Iran (Amini *et al*., 2014; Izadizadeh *et al*., 2020, 2021, 2023a, 2023b, 2023c, 2023d, 2024), of which only eight species from two genera (*Belyta* Jurine, 1807 and *Diphora* Foerster, 1856) belong to the tribe Belytini (Izadizadeh *et al*., 2023a, 2023b). Compared to the well-documented Palaearctic fauna (800 species in 90 genera), and exemplified by the extensively studied Russian diversity (153 species in 29 genera), the current records from Iran and the broader Middle East show significant gaps. This region, spanning Western Asia to North Africa, has notably sparse sampling. This contrast underscores the high potential for discovering numerous additional species in the Middle East, including Iran (Gadallah *et al*., 2023; Hübner *et al*., 2024).

The genus *Zygota* comprises 75 described species globally, of which 38 species are known in the Palearctic region (Hübner *et al*., 2024), and 10 species are recorded in Russia (Chemyreva, 2019; Hübner *et al*., 2024). *Zygota* species are distributed worldwide but are more commonly recorded from the Palearctic (38 species) and Nearctic (about 20 species). However, taxonomic revisions and further research on the genus *Zygota* in the Nearctic region are likely to lead to changes in their nomenclatural adjustments (Johnson, 1992; Buhl, 1997, 1998; Macek, 1997; Hübner *et al*., 2024). Despite their wide distribution, the genus remains under-collected and understudied, especially in the Afrotropical and Palearctic regions (Hübner *et al*., 2024).

Taxonomic revisions and regional faunal surveys are ongoing, and new species continue to be discovered and described, often with the aid of modern morphological and molecular techniques (Chemyreva, 2023; Hübner *et al*., 2024). The taxonomic position of all Palaearctic species of the genus *Zygota* has recently been discussed by Hübner *et al*. (2024), and 13 species of *Zygota* sensu Nixon (1957) were transferred to the genus *Pantoclis* Foerster, 1856.

Prior to this study, no species of the genus *Zygota* had been reported from Iran. The present study contributes to the understanding of the genus *Zygota* by reporting new faunistic records from Iran, providing the detailed diagnostic characters, and discussing these findings within the context of Iran's parasitoid wasp biodiversity.

Materials and methods

Materials for this study were collected from northern provinces of Iran using Malaise traps (Golestan, Guilan, and Mazandaran provinces). The specimens were extracted from the traps and sorted monthly, transferred to 70% ethyl alcohol, and then stored in a low temperature (- 20 °C) for further studies. For the preparation of samples, the specimens were placed on a piece of absorbing paper for drying. The dried specimens were card-mounted and labelled. Illustrations were done using an Olympus AX70 microscope and Olympus SZX9 stereomicroscope equipped with a BMZ-04-DZ digital imaging system (Behin Pajouhesh Co., Iran). A series of four or five captured images was merged into a single in-focus image using the image-stacking software Combine ZP1.0. Morphological terminology follows Nixon (1957), Masner & García (2002), Quadros & Brandao (2017), Chemyreva & Kolyada (2019), and Hübner *et al*. (2024). A map of the distribution of species is generated using SimpleMappr (Shorthouse, 2010). Specimens are deposited in the insect collection of the Department of Entomology, Tarbiat Modares University, Tehran (TMUC) and the Research Institute of Forests and Rangelands, Tehran (RIFR).

The following abbreviations are used: A1–A15 = antennomeres: segments of the antenna; they are numbered from the scape (A1) to the apical segment (A15), OOL = ocular ocellar line: the shortest distance between the posterior ocellus and the eye, POL = posterior ocellar line: the shortest distance between the posterior ocelli.

Results

Family Diapriidae Haliday, 1833

Subfamily Belytinae Förster, 1856

Genus *Zygota* Förster, 1856

Type species: *Belyta abdominalis* Nees van Esenbeck, designated by Ashmead (1893).

Diagnosis

Body always black; males and females alate; occipital carina with or without occipital pit; fore tibiae modified in some males or bear several stiff setae (Figs 1E, 2B, 3B); submetapleural carina missing or reduced; radial cell long, open at apex in most species (Figs 1D, 2C, 3C); angle between pterostigmal and marginal veins at most 120 degrees; some species with small depression or micro-puncture sculpture on S2 in anterior half; male genitalia short and stout, apex of aedeagus truncate or rounded, digitus large; complete ovipositor always short, at most as long as pygidium. For further details, see Hübner *et al*. (2024).

***Zygota abdominalis* (Nees, 1834)** Fig. 1A

Belyta abdominalis Nees, 1834: 344, male.

Zygota abdominalis: Macek, 1997: 37, neotype male.

Material examined: Golestan Province: Aliabad, Zarringol (36°48′58″ N, 55°02′13″ E, 694 m a.s.l), 14 May 2016 (2♂♂) (TMUC). Loh Forest (37°20′43″ N, 55°40′40″ E, 753 m a.s.l.), 14 May 2016 (2♂♂) (TMUC). Kordkuy, Darazno Forest (36°40′06″ N, 54°08′03″ E, 2179 m a.s.l.), 12 June 2016 (1♂) (TMUC); collector: Samira Farahani. Shast Kola Forest (36°44′10″ N, 54°24′11″ E, 754 m a.s.l.), 11 November 2019 (2♂♂) (RIFR). **Mazandaran Province:** Glandarud (36°26′56″ N, 51°51′20″ E, 1407 m a.s.l.): 23 July 2018 (1♂) (RIFR); 27 August 2018 (10♂♂) (TMUC). Neka Forest (36°30′00″ N, 53°27′14″ E, 828 m a.s.l.): 15 May

2018 (2♂♂) (TMUC); 24 June 2018 (2♂♂) (TMUC); 23 July 2018 (4♂♂) (RIFR); 19 October 2018 (3♂♂) (TMUC). Neka Forest (36°21′43″ N, 53°32′56″ E, 1495 m a.s.l.): 24 July 2018 (51♂♂, 3♀♀) (TMUC); 24 June 2018 (1♂) (RIFR). Kheiroodkenar Forest (36°34′36″ N, 51°34′37″ E, 722 m a.s.l.), 27 August 2018 (1♂) (RIFR). **Guilan Province:** Rezvanshahr (37°31′00″ N, 49°02′07″ E, 199 m a.s.l.), 13 May 2018 (3♂♂) (RIFR). Shafaroud Forest (37°28′18″ N, 48°49′23″ E, 1114 m a.s.l.): 24 June 2018 (17♂♂) (RIFR); 25 August 2018 (21♂♂) (TMUC). Amlash (36°58′31″ N, 50°07′03.1″ E, 1380 m a.s.l.), 24 July 2018 (1♂) (TMUC). Collector: Farzaneh Kazerani.

Comparative diagnosis

The male of *Zygota abdominalis* (Nees, 1834) closely resembles *Z. villosa* Macek, 1997 but differs as follows: propodeal plicae parallel posteriorly (vs. divergent in *Z. villosa*); pronotal shoulders distinct (*vs.* indistinct in *Z. villosa*) (Macek, 1997). Body length (male): 3.1–3.5 mm; forewing length: 2.3–2.5 mm; antennae length 2.8–3 mm; Head width in dorsal view 1.35× its length (Fig. 1B); POL 0.85× OOL; A1 1.25× length of A3 (Fig. 1F); flagellomeres cylindrical; A3 with a shallow emargination on the basal third; penultimate antennal segment 2.6–3.0× longer than wide (Fig. 1F); fore tibia simple, lacking a row of thick setae (Fig. 1E); anterior pit of scutellum semicircular (Fig. 1C); radial cell elongated; marginal vein 0.6–0.7× the distance between itself and the basal vein (Fig. 1D); petiole with longitudinal carinae; its dorsal length 1.25× of width; sternite of second metasomal segment with small micro-puncture depression in its anterior part.

Coloration: head, thorax, and petiole black (Figs 1A, B, C); abdomen brown (Fig. 1A); legs brownish-yellow; A1 and A2 pale brown, remaining segments brown (Fig. 1F); tegula and wing veins brown (Fig. 1D).

Distribution (Fig. 4): Western Palearctic Region: Czech Republic, Germany, Poland (Macek, 1997), Russia (European part) (Hübner *et al*., 2024), Iran (**new record –** Guilan, Mazandaran, and Golestan Provinces).

Biology: Unknown.

***Zygota nigra* (Thomson, 1859)** Fig. 2A

Belyta nigra Thomson, 1859: 175, female.

Aclista lanceolata Kieffer, 1909. Synonymized by Macek (1997).

Material examined: Mazandaran Province: Neka Forest (36°21′43″ N, 53°32′56″ E, 1495 m a.s.l.): 24 July 2018 (3♂♂) (TMUC); 24 June 2018 (2♂♂) (RIFR). Collector: Farzaneh Kazerani.

Comparative diagnosis

Male of *Zygota nigra* (Thomson, 1859) closely resembles *Z. parallela* (Thomson, 1859) but differs as follows: fore tibiae without modification (vs. slightly modified in *Z. parallela*), and basal third of F1 not emarginate (vs. emarginate in *Z. parallela*) (Macek, 1997). Body length (male): 3.6–3.9 mm; forewing length: 3.3–3.5 mm; antennae length 3.8–3.9 mm; head width 1.3× its length; POL 0.75× OOL; A1 equal to or slightly shorter than A3 (1:1.1; Fig. 2B); all flagellomeres cylindrical; A3 with a shallow depression on the basal fifth (Fig. 2B); penultimate antennal segment 3.8–4.0× longer than wide; fore tibia simple, bearing a row of thick setae (Fig. 2D); anterior pit of scutellum semicircular; radial cell elongated (Fig. 2C); marginal vein 0.6–0.8× the distance between itself and the basal vein (Fig. 2C); petiole with longitudinal carinae; dorsal length 1.3× its width. S2 without depression and micro-puncture in its anterior part.

Coloration: body dark brown to black (Fig. 2A); antenna and wing veins yellowish-brown (Figs 2B, C); mandibles, tegula, and legs brownish-yellow (Figs 2A, D).

Distribution (Fig. 4): Western Palearctic Region: Czech Republic, Slovakia, Germany, Sweden, Algeria, Russia (European part) (Macek, 1997; Chemyreva, 2019), and Iran (**new record –** Mazandaran Province).

Biology: Unknown.

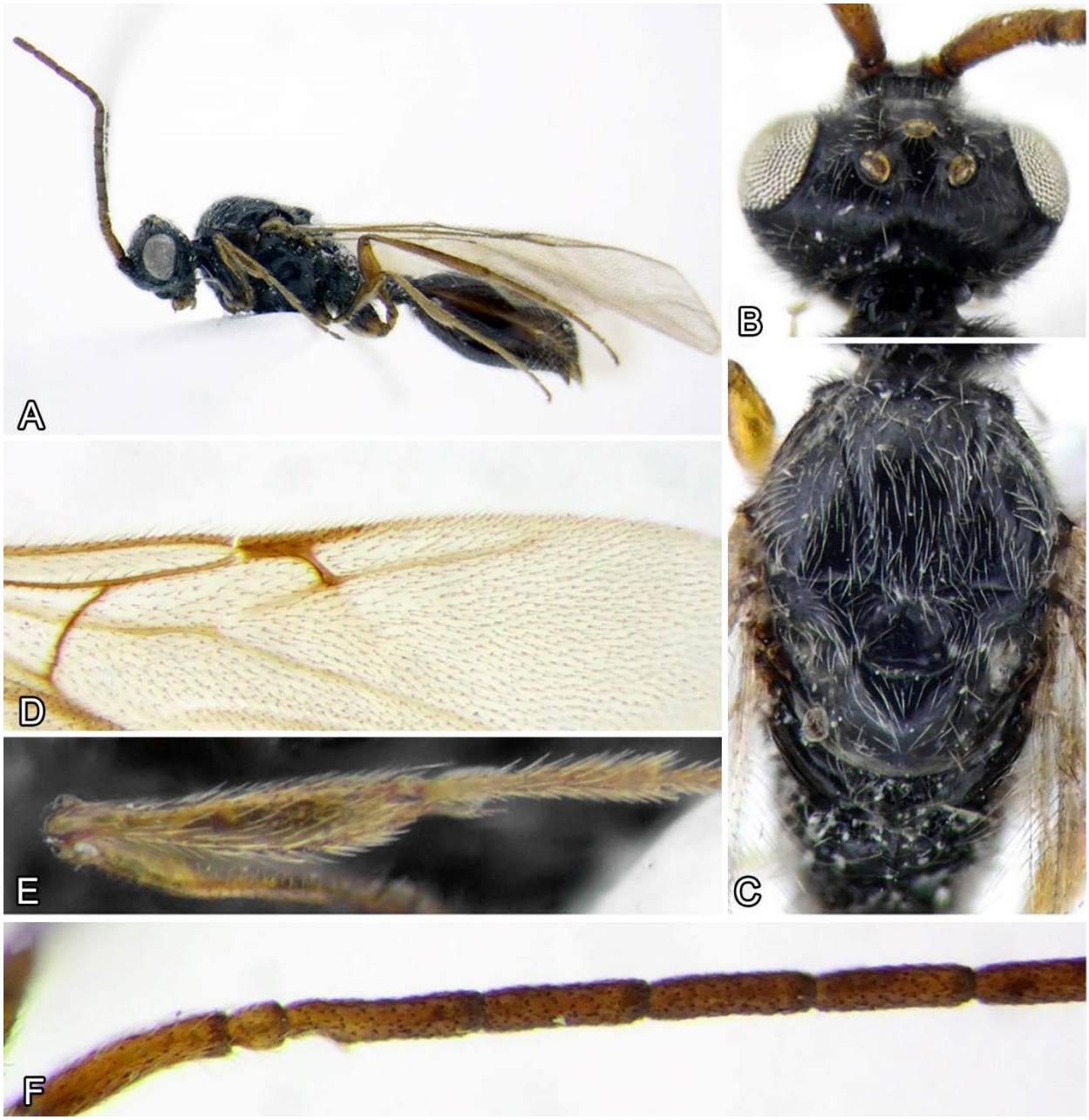

Fig. 1: *Zygota abdominalis* (Nees, 1834), male. **A)** General habitus, lateral view; **B)** Head, dorsal view; **C)** Thorax, dorsal view; **D)** Forewing; **E)** Foreleg; **F)** Antenna.

***Zygota ruficornis* (Curtis, 1831)** Fig. 3A

Cinetus ruficornis Curtis, 1831: 380, female.

Aclista dentatipes Kieffer, 1908: 447. Synonymized by Macek (1997).

Aclista norvegica Kieffer, 1912: 20. Synonymized by Macek (1997).

Zygota reticulata Kozlov, 1978: 575, female. Synonymized by Hübner *et al*. (2024)

Material examined: Mazandaran Province: Neka Forest (36°21′43″ N, 53°32′56″ E, 1495 m a.s.l.): 24 June 2018 (8♂♂) (RIFR); 24 July 2018 (14♂♂, 1♀) (TMUC). Neka Forest (36°30′00″ N, 53°27′14″ E, 828 m a.s.l.): 15 May 2018 (1♂) (TMUC); 24 June 2018 (1♂) (RIFR). Glandarud (36°26′56″ N, 51°51′20″ E, 1407 m a.s.l.), 23 July 2018 (1♂) (TMUC). **Golestan Province:** Shast Kola Forest (36°44′10″ N, 54°24′11″ E, 754 m a.s.l.), 25 June 2019 (5♂♂) (TMUC). Collector: Farzaneh Kazerani.

Fig. 2. *Zygota nigra* (Thomson, 1859), male. **A)** General habitus, lateral view; **B)** Basal antennal segments; **C)** Forewing; **D)** Foreleg.

Comparative diagnosis

Male of *Zygota ruficornis* (Curtis, 1831) closely resembles *Z. pubescens* but differs in genital morphology: the digitus bears a spine, projecting at a distinct angle (*vs.* deflected toward the base of digitus in *Z. pubescence*) (Macek, 1997; Hübner *et al*., 2024). Body length (male): 2.6–3.2 mm; forewing length: 2.2–2.8 mm; antennae length 2.6–2.8 mm; head width 1.3× its length; POL 0.75× OOL; A1 slightly longer than A3 (1.1:1; Fig. 3B); flagellomeres cylindrical; A3 with a shallow emargination on the basal 0.4 (Fig. 3B); penultimate antennal segment 2.9–3.3× longer than wide; fore tibia grooved, angulate, and bearing thick setae apically (Fig. 3D); anterior pit of scutellum semicircular; radial cell elongated (Fig. 3C); marginal vein 0.6–0.8× the distance between itself and the basal vein (Fig. 3C); abdominal petiole with longitudinal carinae; dorsal length 1.4× its width; S2 with a small area of micropuncture in anterior half; digitus armed with one long curved spine.

Coloration: head, thorax, and petiole black (Fig. 3A); abdomen brown (Fig. 3A); antenna and tegula brown (Figs 3A, B); mandibles, wing veins, and legs brownish-yellow; fore femur of third leg black (Fig. 3A).

Distribution (Fig. 4**):** Western Palearctic Region: Austria, Czech Republic, France, Germany, Hungary, Ireland, Norway, Poland, Russia (European part), Scotland, Slovenia, U.K. (Nixon, 1957; Macek, 1997; Chemyreva, 2019; Hübner *et al*., 2024), Iran (**new record –** Mazandaran and Golestan Provinces).

Biology: Unknown.

Key to the Identification of *Zygota* Species in Iran (Males)

1. Fore leg modified, bearing long apical setae **(**Fig. 3D**)** ……..***Zygota ruficornis*** (Curtis, 1831)
- Fore leg simple, with or without thick setae **(**Figs 1E**,** 2D**)** ……..2
2. Scape longer than first flagellomere **(**Fig. 1F**)**; 13th antennal segment <3.0× longer than wide; S2 with small micro-puncture depression in its anterior part … ***Zygota abdominalis*** (Nees, 1834)
- Scape equal to or shorter than first flagellomere **(**Fig. 2B**)**; 13th antennal segment >3.5× longer than wide; S2 without depression and micro-puncture in its anterior part … ***Zygota nigra*** (Thomson, 1859)

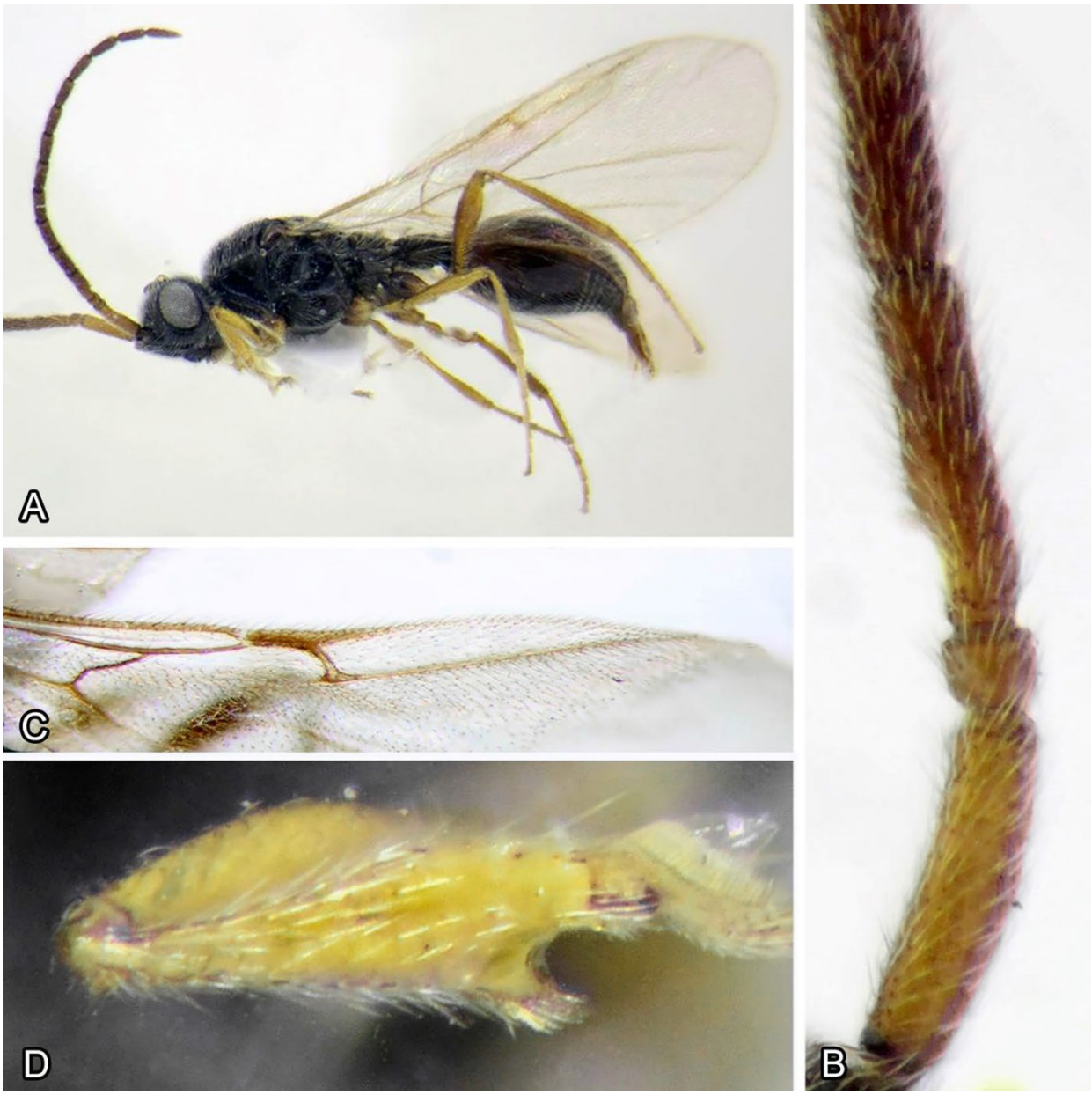

Fig. 3. *Zygota ruficornis* (Curtis, 1831), male. **A)** General habitus, lateral view; **B)** Basal antennal segments; **C)** Forewing; **D)** Foreleg.

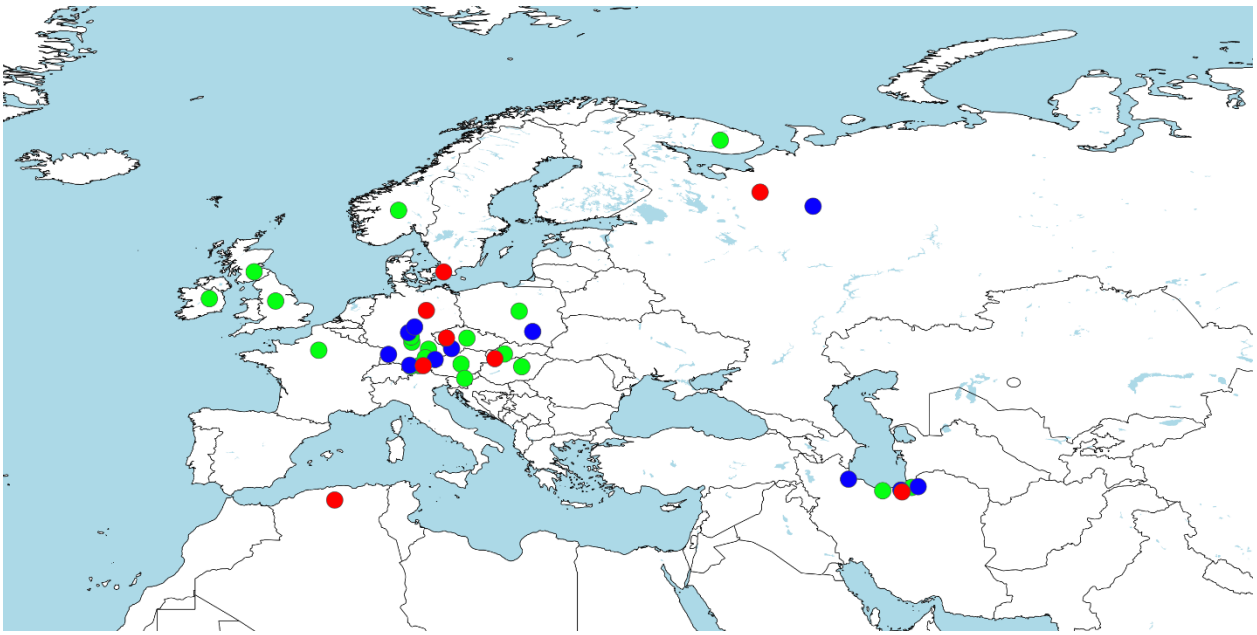

Fig. 4. Distribution map of *Zygota abdominalis* (blue), *Z. nigra* (red), and *Z. ruficornis* (green) in the world.

Discussion

The results of this study added three species of the family Diapriidae to the Iranian fauna. Including the species reported in the present study, the number of Iranian species of Diapriidae increased to 34 species from 15 genera. The species of *Zygota* prefer humid habitats and are more abundant at high latitudes or at significant altitudes in the mountains, which explains the fact that the majority of these wasps were collected from the Hyrcanian Forest in northern Iran at altitudes of more than 750 meters. Only a few males of *Zygota abdominalis* were collected below 750 m in May (199 m and 694 m) or at the end of summer (722 m). Very few female samples (*Z. abdominalis*, 3 females; *Z. ruficornis*, 1 female**)** were collected during this study. Previous studies have also shown that females of *Zygota* species are rare in collections throughout their habitat and are much less likely to be caught in traps than males (Macek, 1997; Hübner *et al*., 2024). This phenomenon is not unique to Diapriidae and has been observed in other parasitoid groups such as Ichneumonidae (Aguiar & Santos, 2010). This disparity likely reflects different flight behaviors or activity patterns during mate-searching for females, potentially increasing their exposure to traps (Skvarla *et al*., 2021).

The primary hosts of the *Zygota* species are unknown, but these wasps are likely endoparasitoids of Diptera (Hübner *et al*., 2024). There are 38 *Zygota* species in the Palaearctic region (Chemyreva, 2019; Hübner *et al*., 2024), but this genus has not yet been recorded from Western Asia and the Middle East (see Gadallah *et al*., 2023). *Zygota ruficornis* has been known as the most common species in Europe (Macek, 1997). However, in this study, the majority of the collected samples were of the species *Z. abdominalis*. Anyway, more studies are needed to clarify the distribution and species diversity of this genus in Iran.

This study was conducted in the northern slopes of the Alborz Mountains (Golestan, Guilan, and Mazandaran provinces), a region representing 10% of the Caucasus biodiversity hotspot as a globally significant area renowned for its exceptional biological diversity in temperate forests (Noroozi *et al*., 2019; Japoshvili & Ljubomirov, 2023). The Hyrcanian forests within this hotspot are recognized as a center of species richness in Iran, as demonstrated by prior research on other Hymenoptera groups such as Chrysidoidea (Barahoei *et al*., 2022), Chalcidoidea (Rahmani *et al*., 2022; Shojaey *et al*., 2025), and Proctotrupidae (Izadizadeh *et al*., 2022). Accordingly, more than 90 % of the species of Iranian Diapriidae have been reported from Hyrcanian forests (Izadizadeh *et al*., 2020, 2021, 2023a, 2023b, 2023c, 2023d, 2024).

Author's Contributions

Mohammad Izadizadeh: sorting, identification of the specimens, photographs, draft preparation; **Ali Asghar Talebi:** visualization, conceptualization, supervision, draft preparation, review and editing**; Vasilisa G. Chemyreva:**

contribution in identification of the specimens, review of the manuscript; **Samira Farahani:** collecting of specimens, review of the manuscript; **Farzaneh Kazerani:** collecting of specimens, review of the manuscript; **Ali Ameri:** review of the manuscript; **All authors** approved the final version of the manuscript.

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Funding

This research was financially supported by Tarbiat Modares University, Tehran, Iran (M. Izadizadeh and A.A. Talebi), the Research Institute of Forests and Rangelands, Tehran, Iran (S.Farahani and F.Kazerani), and the Russian state research project No. 125012901042-9 (V. G. Chemyreva).

Data Availability Statement

The specimens collected are deposited in the insect collection of the Department of Entomology, Tarbiat Modares University, Tehran (TMUC), and the Research Institute of Forests and Rangelands, Tehran (RIFR), and are available from the curator, upon request.

Acknowledgments

We would like to thank the Department of Entomology, Tarbiat Modares University, Tehran, Iran, and the Research Institute of Forests and Rangelands, Tehran, Iran, for providing laboratory facilities, specimen curation resources, and technical assistance essential to this research. We cordially thank the anonymous reviewers for their critical review and constructive comments, which significantly helped the improvement of the manuscript.

Ethics Approval

Insects were used in this study. All applicable international, national, and institutional guidelines for the care and use of animals were followed. This article does not contain any studies with human participants performed by any of the authors.

Conflict of Interest

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

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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Citation: Izadizadeh, M., Talebi, A. A., Chemyreva, V. G., Farahani, S., Kazerani, F. & Ameri, A. (2025) First record of the genus *Zygota* Förster, 1856 (Hymenoptera: Diapriidae, Belytinae) in Western Asia, with three new records of species from Iran. *J. Entomol. Soc. Iran*, 45 (4), 529–539.

DOI : https://doi.org/10.61186/jesi.45.4.4

URL: https://jesi.areeo.ac.ir/article_131275.html

pISSN: 0259-9996 – eISSN: 2783-3968

Journal of Entomological Society of Iran

2025, 45 (4), 529–539

Research Article

نخستین گزارش جنس *Zygota* Förster, 1856 (Hymenoptera: Diapriidae) در غرب آسیا، همراه با گزارش جدید سه گونه از ایران

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چکیده: در طی این پژوهش‌در مورد خانواده Diapriidae ، سه گونه از جنس *Zygota* برای نخستین بار در غرب آسیا بر اساس نمونه‌های جمع‌آوری شده از ایران شناسایی شدند: *Zygota abdominalis* (Nees, 1834)، *Z. nigra* (Thomson, 1859) و *Z. ruficornis* Curtis, 1831 . در این مقاله، کلید شناسایی گونه‌های ایرانی جنس *Zygota* و ویژگی‌های تشخیصی آنها، همراه با تصاویر مرتبط ارائه شده است. علاوه بر این، نقشه پراکندگی جهانی این سه گونه نیز تهیه شده است.

کلمات کلیدی: Belytini، کلید شناسایی، پراکندگی، خاورمیانه

اطلاعات مقاله

دریافت: ۱۴۰۴/۰۲/۱۸

پذیرش: ۱۴۰۴/۰۴/۲۵

انتشار: ۱۴۰۴/۰۷/۱۲

دبیر تخصصی: زلکو تومانوویچ

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DOI : https://doi.org/10.61186/jesi.45.4.4