

## Research Article

# Review of the genus *Diglyphus* Walker, 1844 (Hymenoptera: Eulophidae) in Iraq

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**Abstract.** *Diglyphus* Walker, 1844 (Hymenoptera: Eulophidae) has previously been recorded in Iraq, with two species registered in the region: *D. isaea* Walker, 1838 and *D. crassinervis* Erdős 1958. During a survey conducted in Basrah Governorate, Southern Iraq, specimens were collected from alfalfa fields (*Medicago sativa* L.) using a sweep net and yellow pan traps in 2022. In this study, two species were identified: *D. isaea* Walker, 1838 and *D. sabulosus* Erdős, 1951. The latter is a new record for the fauna of Iraq. An illustrated key for identifying *Diglyphus* species in Iraq, along with notes on diagnostic characters and photographs are provided. A distribution map of the species in Iraq is also presented.

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## Introduction

Basrah Governorate is one of the most important and fertile agricultural regions in Iraq. It is the third largest city in the country and is located in southern Iraq near the Iran–Iraq border on the coast of the Persian Gulf (Fig 1). The region is famous for growing several crops, with date palms and alfalfa being the most important. Basrah has a semi-arid climate for most of the year and is consistently one of the hottest cities in Iraq. In the summer, temperatures exceed 53 °C in the shade, whilst those in winter range between 28 °C and 11 °C. The average annual rainfall in Basrah is 169 mm (Al-Mayah *et al.*, 2016).

Alfalfa (*Medicago sativa* L.) holds substantial economic value and has played an important role in the survival of humans and animals for thousands of years. Alfalfa is a crucial component in a complex food chain (Chaudhary *et al.*, 2020; Nimaan, 2021). This plant is also known as an ‘insectary’ due to the large populations of beneficial insects that reside within it (Putnam *et al.*, 2001). Alfalfa attracts various natural enemies, with parasitoid wasps from the family Eulophidae (Hymenoptera: Chalcidoidea) being amongst the most important (Lotfalizadeh *et al.*, 2015; Jafarlu *et al.*, 2022; Mansowr *et al.*, 2024). This family is the most diverse group in the superfamily, comprising more than 6000 species across 328 genera in four subfamilies (UCD Community, 2023). However, only a few papers have addressed Iraqi Eulophidae (Al-Azawi, 1967 & 1971; Bouček & Askew, 1968; Swailem *et al.*, 1975; Abdul Rassoul, 1976; Awadallah *et al.*, 1979 a, b; Hassan, 2012; Mansowr *et al.*, 2024). The subfamily Eulophinae Förster, 1856 (Hymenoptera, Eulophidae) is the largest group within this family (UCD Community, 2023).

The genus *Diglyphus* Walker, 1844 (Hymenoptera: Eulophidae), with worldwide distribution, includes 41 known species, 31 of which are found in the Palearctic region (UCD Community, 2023). This genus can be recognised by the following combination of morphological features: a body with metallic tints in most parts (Figs. 2A, 3A); antenna in both sexes with two funiculars and no branches (Figs. 2B,C, 3B,C); clypeus with an entire anterior margin; and a mesoscutellum with two notauli, which are mostly incomplete and faint, or curved to meet the anterior margin of axillae (Fig. 2C). Species of the Genus *Diglyphus* are important primary ectoparasitoids of leaf-mining pests from the family Agromyzidae (Insecta: Diptera) in alfalfa fields (Spencer, 1973; Lotfalizadeh *et al.*, 2015; Jafarlu *et al.*, 2022). Members of this genus are primarily found infesting several economically important crops, including alfalfa, broccoli, cabbage and tomato, where pesticides definitely were not used for insect control (Carvalho *et al.*, 2014). Therefore, they have shown promise as control agents in pest management strategies for common pests on cultivated ornamentals and vegetables (Heinz & Parrella, 1989). Thus far, two species of this genus, *Diglyphus crassinervis* Erdős, 1958 and *D. isaea* Walker, 1838, have been reported in Iraq (Al-Azawi, 1971).

The objectives of this research are to (1) report new records from the Iraqi fauna, (2) introduce an illustrated identification key for the Iraqi species, (3) provide parasitoids that can be evaluated for use in biological control programmes and (4) review the genus *Diglyphus* in Iraq.

## Materials and methods

Specimens were collected from January to December 2022 using sweep nets and yellow pan traps from alfalfa fields in Basrah governorate, Southern Iraq (30°30'7.23"N, 47°50'30.93"E). They were subsequently placed in 70% ethanol. In the laboratory, the specimens were poured into a Petri dish and examined under a stereomicroscope for wasp collection, using tweezers or a tiny hook under magnification. The method proposed by Noyes (1982) was used to preserve the specimens. Specimens were identified to the genus level using the key by Gibson *et al.* (1997) and Yefremova *et al.* (2007), whilst *Diglyphus* species were identified using the keys by Gordh & Hendrickson (1979), Yefremova *et al.* (2007) and Hansson and Navone (2017). Morphological terminology followed by Gibson *et al.* (1997) and Yoder *et al.* (2010). Specimens were photographed using a Nikon camera mounted on an EZ4 binocular stereomicroscope, and the photos were edited and arranged into plates using Adobe Photoshop® CC software (2015.0.0 Release). All materials are deposited in the insect collection of the Hayk Mirzayans Insect Museum (HMIM) at the Iranian Institute of Plant Protection, Tehran, Iran.

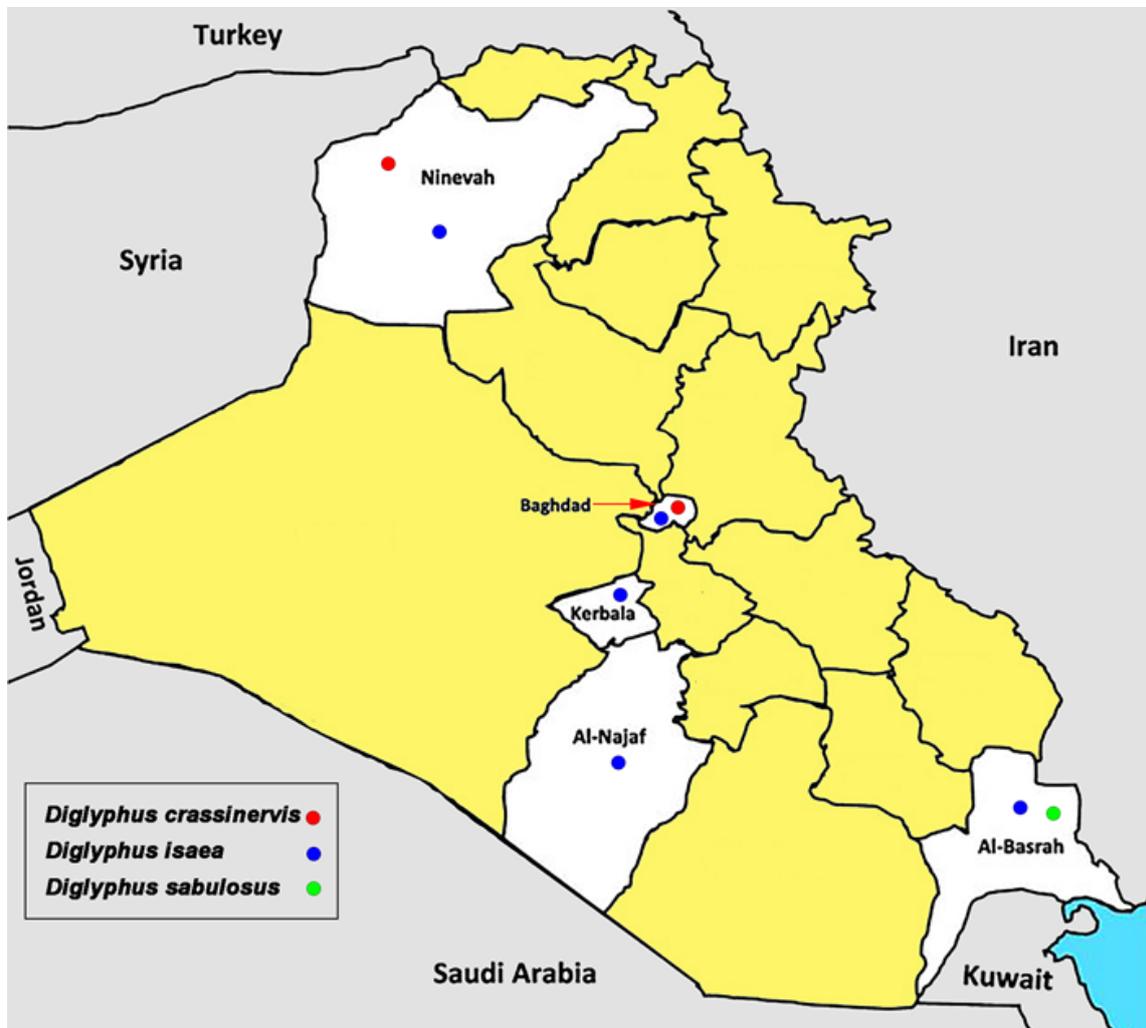


Fig. 1. Distribution map of *Diglyphus* Walker, 1844 species in Iraq and Basrah Governorate

## Results

During this study, 113 specimens were collected from January to December 2022 using sweeping nets. The specimens were identified, and the examination revealed that they belong to two species of the genus *Diglyphus*

Walker, 1844 (Hymenoptera: Eulophidae): *D. isaea* Walker, 1838 and *D. sabulosus* Erdös, 1951. The latter species is a new record for the Iraqi fauna.

### ***Diglyphus crassinervis* Erdös, 1958**

#### **Diagnosis**

Scape completely dark; femora dark and metallic with apical ¼ white; tibiae dark and metallic with apical ¼ white; fore wing speculum with a few scattered setae; males with enlarged veins in the fore wing; male gaster completely dark and metallic (Hansson & Navone, 2017).

#### **Distribution**

This species is generally distributed in the Palaearctic region, including Europe, the Middle East and the People's Republic of China (UCD Community, 2023). It has also been reported from Yemen in the Afrotropical region (Yefremova *et al.*, 2007).

#### **Hosts**

This wasp is an ectoparasitoid of larvae of leaf miners belonging to the Agromyzidae family (Insecta: Diptera) (UCD Community, 2023).

### ***Diglyphus isaea* Walker, 1838 (Fig. 2)**

[*Cirrospilus*] *Cirrospilus lycophron* Walker, 1838; *C. medidas* Walker, 1838; *Entedon gracilis* Goureau, 1851; *Diglyphus bisannulatus* Förster, 1861; *D. ornatus* Förster, 1861; *D. clavicornis* Walker, 1872

#### **Material examined**

IRAQ - Basrah governorate • 21 ♀♀, 9 ♂♂ (HMIM), Hartha; 30°36'23" N, 47°42'59" E; sweeping nets on alfalfa; Z. F. Mansowr leg. • 10 ♀♀, 4 ♂♂ (HMIM), Tanoma; 30°32'20"N, 47°50'48" E; 13.x.2021; collected with sweeping nets on alfalfa; Z. F. Mansowr leg. • 15 ♀♀, 8 ♂♂ (HMIM), Abo Al-Khaseeb; 30°27'36" N, 47°53'35" E; with yellow pan trap.

#### **Diagnosis**

Body with dark metallic green colour (Fig. 2A). Head wider than long in frontal view (Fig. 2B), with compound eyes dark red. Antennal toruli situated well above the lower level of the eye margin (Fig. 2B). Antenna with two funiculars, measuring 0.44 mm; Scape completely dark; Pedicel more than twice as long as wide and slightly shorter than first funicular. Clava slightly more than 1.2 times as long as the two funiculars (Fig. 2B). Pronotum and mesoscutum covered with white setae. Mesoscutellum green to golden green, occasionally reddish (Fig. 2C). Legs with femora dark and metallic with apical ¼–½ white; fore tibia with anterior surface white and posterior surface dark and metallic or dark brown. Mid and hind tibiae dark and metallic with apical ¼ white. Males frequently have a pale median part of the tibiae, but males with predominantly dark tibiae, as in females also occur. Fore wing speculum with dense setation (Fig. 2A).

#### **Distribution**

This species is found throughout the Holarctic region and has also been recorded from Brazil, India, New Zealand, Pakistan and South Africa (UCD Community, 2023).

#### **Hosts**

Many species of Agromyzidae and also Lyonetidae; Tephritidae (Zhu *et al.*, 2000).

### ***Diglyphus sabulosus* Erdös, 1951 (Fig. 3)**

#### **Material examined**

IRAQ - Basrah governorate • 15 ♂♂ (HMIM), Hartha; 30°36'23" N, 47°42'59" E; collected with sweeping nets; Z. F. Mansowr leg. • 17 ♂♂ (HMIM), Tanoma; 30°32'20"N, 47°50'48" E; sweeping nets on alfalfa; Z. F. Mansowr leg. • 14 ♂♂ (HMIM), Abo Al-Khaseeb; 30°27'36" N, 47°53'35" E; same data as for preceding.

#### **Diagnosis**

Body with dark metallic green colour (Fig. 3A). Head longer than wide in lateral view, with compound eyes dark red (Figs. 3A, B), and the antennal toruli situated well above the lower level of the eye margin (Fig. 3B). Antenna with scape having an apical ½–¾ dark brown. Pedicel more than twice as long as wide and slightly shorter than

first funicular; Clava slightly more than 1.4 times as long as the two funiculars (Fig. 3B). Fore femur with basal  $\frac{1}{2}$  dark brown and apical  $\frac{1}{2}$  yellowish-white; mid femur with basal  $\frac{1}{2}$ – $\frac{2}{3}$  dark brown and metallic and apical  $\frac{1}{3}$ – $\frac{1}{2}$  yellowish-white. Hind femur with basal  $\frac{2}{3}$  dark brown and metallic and apical  $\frac{1}{3}$  yellowish-white. Fore tibia lightly infuscate, mid tibia yellowish-white and hind tibia yellowish-white with a dark brown ring close to the base. Fore wing speculum bare or with a few scattered setae, more than 2.5 times as long as wide (1.35:0.54) and more than 1.26 times longer than the hind wing length (Fig. 3A).

### Distribution

Czech Republic (Bouček & Askew, 1968), Hungary (Erdős, 1951), Italy, Romania (Bouček & Askew, 1968), Russia, Slovakia (Kalina, 1989), Sweden (Hedqvist, 2003), Turkey (Yefremova *et al.*, 2011), Ukraine (Bouček & Askew, 1968), Iran (Farahbakhsh, 1961; Davatchi & Shojaei, 1989; Jafarlu *et al.*, 2022) and Iraq (new record).

### Host

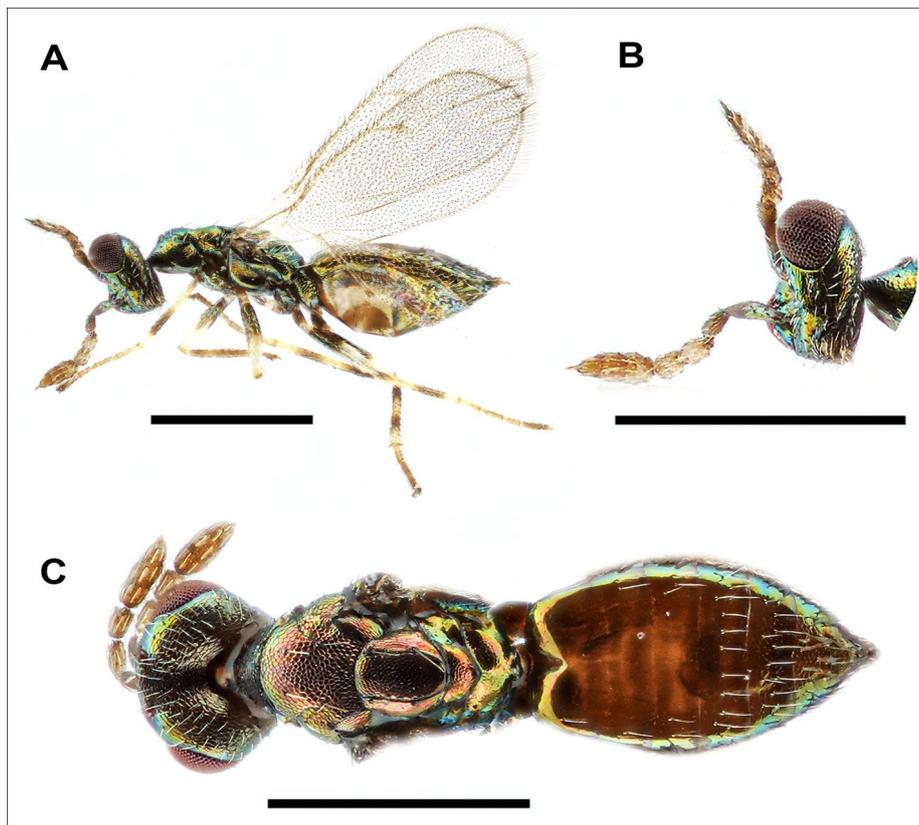
*Liriomyza* (Diptera: Agromyzidae) (Jafarlu *et al.*, 2022).

### Primary hosts

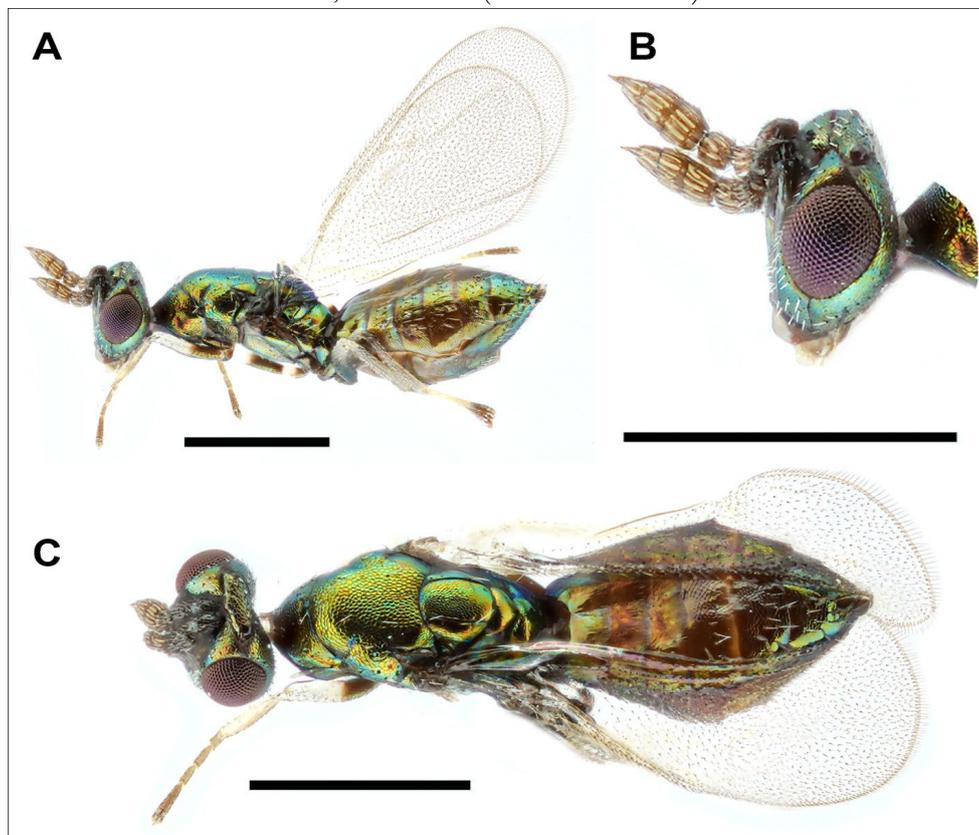
*Diglyphus isaea* is the best-known species among the target parasitoids of leaf-mining Agromyzidae. However, this species has occasionally been reported from leaf-mining Gracillariidae and Nepticulidae (Lepidoptera) (Navone & Vidano, 1983; Schauff *et al.*, 1998; Gonzáles Tirado *et al.*, 1996; Conti *et al.*, 2001; Elekçioğlu & Uygün, 2006) and was found in Iraq by Abdul Rassoul & Al Saffar (2014) in *Liriomyza congesta* and *L. bryoniae* on *Medicago sativa* and *L. sativa* on *Cucurbita sativa* and *Trigonella phoenicum*. Additionally, *L. bryoniae* was found on *Melilotus indicus*.

### Key to the Iraqi species of genus *Diglyphus* Walker, 1844 (female and male)

1. Scape white except for apical  $\frac{1}{3}$ – $\frac{1}{2}$  dark brown (Figs 3A, 3B); fore femur with anterior half dark brown (Fig. 3A); fore wing speculum bare or with a few scattered setae (Fig. 3A) ..... ***D. sabulosus* Erdős, 1951**
  - Scape predominantly to completely dark (Figs 2A, 2B); fore femur predominantly dark but if with apical half white then fore wing speculum with dense setation instead of a few scattered setae (Fig. 2A) ..... 2
2. Scape completely dark (Figs 2A, 2B); femora dark and metallic with apical  $\frac{1}{4}$ – $\frac{1}{2}$  white (Fig. 2A); fore wing speculum with dense setation; marginal vein of male not thick but normal (Fig. 2A) ..... ***D. isaea* Walker, 1838**
  - Scape completely dark or with very base pale; femora predominantly dark; fore wing speculum with a few scattered setae; marginal vein of male thick and swollen ..... ***D. crassinervis* Erdős, 1958**



**Fig. 2.** *Diglyphus isaea* Walker, 1838, male: **A.** General habitus, lateral view; **B.** Head and antenna, lateral view; **C.** General habitus, dorsal view. (Scale bar = 0.5 mm).



**Fig. 3.** *Diglyphus sabulosus* Erdős, 1951, male: **A.** General habitus, lateral view; **B.** Head and antenna, lateral view; **C.** General habitus, dorsal view. (Scale bar = 0.5 mm)

Table 1. List of *Diglyphus* species associated with plants

<i>Diglyphus</i> species	Association with plant	Country-Governorate	References
<b><i>D. crassinervis</i> Erdős, 1958</b>	alfalfa ( <i>Medicago sativa</i> L.)	Iran, Azarbaijan Iran, Urmia;	Jafarlu <i>et al.</i> (2022)
	Weeds	Iraq, Baghdad	Abdul Rassoul & Al Saffar (2014)
	different host plant	Iraq, Mosul	Mekhlif and Abdul Rssoul, (2002)
<b><i>D. isaea</i> Walker, 1838</b>	alfalfa ( <i>Medicago sativa</i> L.)	Iraq	Gordh & Hendrickson (1979); Hendrickson & Barth (1979); Drea <i>et al.</i> (1982); Hansson (1987); Askew <i>et al.</i> (2001); Lotfalizadeh <i>et al.</i> (2015)
	Different host plant	Iraq, Mosul	Mekhlif and Abdul Rssoul, (2002)
	alfalfa ( <i>Medicago sativa</i> L.)	Iraq, Baghdad, Iraq, Kerbala Iraq, Basrah Iraq, Nejef	Abdul Rassoul and Al Saffar (2014)
	<i>Cucurbita sativa</i> , <i>Melilotes indicus</i> , <i>Raphanus sativa</i>		
	alfalfa ( <i>Medicago sativa</i> L.)	Iraq, Basrah	Present study
<b><i>D. sabulosus</i> Erdős, 1951</b>	alfalfa ( <i>Medicago sativa</i> L.)	Iran, Azarbaijan, Iran, Khoy, Iran, Miandoab	Jafarlu <i>et al.</i> (2022)
	alfalfa ( <i>Medicago sativa</i> L.)	Iraq, Basrah	Present study

## Discussion

The fauna of eulophid wasps (Hymenoptera: Eulophidae) in Iraq has been rarely studied (Al-Azawi, 1967, 1971; Bouček & Askew, 1968; Swailem *et al.*, 1975; Abdul Rassoul, 1976; Awadallah *et al.*, 1979 a, b; Hassan, 2012; Mansowr *et al.*, 2023, 2024). Therefore, this study aims to provide information regarding this important group in Iraq and enhance the Iraqi fauna with new records. In the present study, the genus *Diglyphus* was identified with two species for the fauna of Basrah Governorate in Iraq. Including the new report for the Iraqi fauna, the number of species of this genus has increased to three, and the recent detection of *D. isaea* in Basrah Governorate represents a highly expanded distribution of this species in the country. The two species are collected from alfalfa fields. Alfalfa is one of the most cultivated plants in Basrah governorate, with a planted area of 237 dunams (5950 km<sup>2</sup>) (Al-Sanaf *et al.*, 2021; Mansowr *et al.*, 2024).

The genus *Diglyphus* has been reported from all agrosystems (Table 1), and the species *D. isaea* has been collected from 20 families of plants (UCD Community, 2023), including alfalfa (Lotfalizadeh *et al.*, 2015; Jafarlu *et al.*, 2022). Alfalfa is attacked by several species of leaf miners in the dipterous families Agromyzidae and Tephritidae, as well as the lepidopterous families Gracillariidae, Lyonetiidae and Nepticulidae. The association of wasps with alfalfa fields occurs because the wasp is an ectoparasitoid of these pests. Therefore, the wasps can reduce the damage and economic losses caused by these pests in agrosystems and may be used for biological control programmes (Jafarlu *et al.*, 2022). In this study, the most frequent species among the identified species is *D. isaea*, and both species were found from February to May in three locations in Basrah Governorate. During this period, the climate in the sampled area is characterised by average temperatures ranging from 20 °C to 25 °C and variable relative humidity. This finding is consistent with Kassem *et al.* (2009), who recorded the highest average numbers of the parasitoid *D. isaea* in April in all greenhouses. Various insects respond to abiotic factors, such as temperature, humidity, thermal effects, light and food, in different ways. These abiotic factors not only affect the behaviour of insects but also their distribution and physiological mechanisms (Karl *et al.*, 2011; Khaliq *et al.*, 2014).

According to Kocmánková *et al.* (2009), insects are poikilothermic organisms; thus, the temperature is probably the most important environmental factor affecting their behavior, development, distribution and reproduction.

The highest species number of bee and wasp species in April could be impacted by flower colour, the number of flowers and environmental conditions (Wratten *et al.*, 2012; Nursal, 2014). Winfree *et al.* (2008) also reported that the presence of flowers affects the density stability of populations and enhances insect diversity.

This present study shows that the two species were found in only three stations: Hartha, Shatt-Al Aarab and Abo Al-Khaseeb. These wasps were not found in the Zubair station. The differences between the studied stations may be due to various reasons. According to Wilson & Fox (2021), the number, abundance and distribution of insects may depend on several factors that respond to multiple stresses, such as differences in the natural topography of

the areas, organismal interactions, habitat and climate change. No one community has the same biodiversity as another, even if both have the same characteristics, such as topography, vegetation and weather (Kim, 2017). Moreover, geographical distance influences the community dissimilarity of insects (Perillo *et al.*, 2017). The neighbouring farms and the edge of cultures are equally important in preserving the biological diversity of insects in agroecosystems (Schoener *et al.*, 2016; Perillo *et al.*, 2017). All these factors indicate notable differences in insect prevalence and their distribution.

### Author's Contributions

**Zainab F. Mansowr:** conceptualization, Specimens collect, methodology, formal analysis, investigation, draft preparation and funding acquisition. **Majid Jafarlu:** identification, final review and edit. **Hossein Lotfalizadeh** confirmed the diagnosis supervision, visualization and project administration.

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### Data Availability Statement

The specimens examined in this study are deposited in the insect collection of the Hayk Mirzayans Insect Museum (HMIM), Iranian Institute of Plant Protection, Tehran, Iran and are available by the curator upon request.

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### 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 the author.

### Conflict of Interest

No conflict of interest.

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## مرور جنس *Diglyphus* Walker, 1844 (Hymenoptera: Eulophidae) در عراق

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**چکیده:** جنس *Diglyphus* Walker, 1844 (Hymenoptera: Eulophidae) با دو گونه شامل *Diglyphus sabulosus* Erdős, 1951 و *D. isaea* Walker, 1838 پیش از این از عراق گزارش شده است. در طی تحقیقی که در استان بصره واقع در جنوب عراق صورت گرفت، در سال ۲۰۲۲ با استفاده از تور حشره‌گیری و تله لگنی زرد نمونه‌هایی از مزارع یونجه (*Medicago sativa* L.) جمع‌آوری شدند. در نتیجه، دو گونه شامل *D. isaea* Walker, 1838 و *D. sabulosus* Erdős, 1951 شناسایی شدند که گونه اخیر یک گزارش جدید برای فون عراق است. یک کلید شناسایی مصور برای شناسایی گونه‌های *Diglyphus* در عراق همراه با مشخصات مورفولوژیکی مورد کاربرد در شناسایی گونه‌ها و تصاویر مربوطه فراهم شدند. همچنین، نقشه پراکنش گونه‌ها در عراق ارائه شد.

### تاریخچه مقاله

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