IDF

International Dragonfly Fund- Report

A Journal of the International Dragonfly Fund

Yaser Bakhshi

published 11.07.2025

No. 192

ISSN 1435-3393

The International Dragonfly Fund (IDF) is a scientific society founded in 1996 for the improvement of odonatological knowledge and the protection of species.
Internet: http://www.dragonflyfund.org/

This series intends to publish studies promoted by IDF and to facilitate cost-efficient and rapid dissemination of faunistic data.

Editorial Work:	Martin Schorr, Holger Hunger, Reinhard Jödicke, Milen Marinov, Rory Dow
Layout:	Martin Schorr
IDF-home page:	Holger Hunger
Printing:	Colour Connection GmbH, Frankfurt
Impressum:	Publisher: International Dragonfly Fund e.V., Schulstr. 7B, 54314 Zerf, Germany. E-mail: oestlap@online.de
Responsible editor:	Martin Schorr
Cover picture:	*Libellula depressa*, female
Photographer:	Yaser Bakhshi

New data on the Odonata fauna in northwestern Iran – provinces Zanjan and Qazvin

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Abstract

New data on the Odonata fauna of the provinces of Zanjan and Qazvin in north-western Iran are presented. These data are based on adult specimens of dragonflies and damselflies collected from various sites. The study investigates the species distribution and faunal composition of Odonata in the study area. In total, 14 species of Anisoptera and 9 species of Zygoptera were recorded, including the first documentation of 17 species in Zanjan and 15 species in Qazvin. Photographs of the collected odonates are included, along with comments on their diagnostic characteristics and distribution. Additionally, a case of abnormality in the male caudal appendages of *Ischnura pumilio* is reported, possibly attributable to either a genetic defect or environmental factors.

Key words: damselflies, dragonflies, fauna, *Ischnura pumilio*, possible impact of pesticides, structural anomaly, teratology

Introduction

The Odonata fauna of Iran has been the subject of several faunistic and taxonomic studies, primarily conducted in recent years. Iran is home to approximately 100 species of Odonata, most of which belong to the Palearctic region, with seven species endemic to the country (Schneider et al., 2018). It is one of the best-studied countries in Western Asia concerning its Odonata fauna. Schneider et al. (2018) provided the most recent comprehensive checklist of Iranian Odonata. However, new records and even a new species (*Aeshna vercanica* Schneider, Schneider, Schneider, Vierstraete & Dumont, 2015) have recently been identified in the country. Certain areas of Iran remain underexplored or entirely unexplored in terms of their odonate fauna.

Two such areas are the Zanjan and Qazvin provinces in the northwest part of Iran. Prior to this study, only nine species had been recorded from Qazvin Province, and, surprisingly, no species had been reported from Zanjan Province. The main aim of this study is to determine the faunal composition of Odonata in these two provinces. Additionally, a case of abnormality in the male caudal appendages of *Ischnura pumilio* is reported here for the first time.

Material and methods

Study area

Zanjan and Qazvin provinces together cover an area of approximately 37,341 km² in Iran. Qazvin (or Ghazvin) Province, with an area of 15,568 km², borders Zanjan Province to the

Figure 1: Maps illustrating the locations of Zanjan and Qazvin provinces in Iran, as well as the sites from which odonates have been recorded in the present study (round symbols) and in previous studies (square symbols).

west (Shourmij, 2012). The northern region of Qazvin experiences significantly cold winters and temperate summers, while the southern region has mild winters and warm summers (Kouhi and Asadi Oskouei, 2024). Zanjan Province encompasses a total area of 21,773 km² and features a highland climate, characterized by cold, snowy weather in the mountains and a temperate climate in the plains, particularly during winter. In contrast, summers are considerably warm (Raziei, 2017). The geographic locations of the two provinces are illustrated in Figure 1. There are various habitats in the study area, including riverbanks, streams, brooks, lakes, agricultural fields, and dam reservoirs, which provide suitable environments for different odonate species. All photographs of the collection sites (figs. 2-4) were taken during field trips in August 2023.

In order to conduct a comprehensive investigation of the Odonata fauna in the study area, 30 study sites were surveyed; however, odonates were found and/or collected at only 22 of these sites (Fig. 1). The remaining eight sites consisted of streams, brooks, and similar bodies of water that previously contained water but have recently experienced significant reductions or complete drainage, likely due to climate change, over-extraction, and inadequate water management.

Localities

Loc. 1: a stream near Taham Dam, vegetation included scattered grass patches, bushes and fruit orchards, 36°48'00.1"N, 48°36'22.2"E, alt. 2100 m.

Loc. 2: a river lined with tall reeds (*Phragmites* sp.), near Chavarzaq, Darram, 37°01'44.0"N, 48°44'53.9"E, alt. 440 m.

Loc. 3: Dastjerdeh, Vanisar, Ghezel Ozan River, vegetation included bulrush (*Typha* sp.), tamarisk (*Tamarix* sp.) and scattered small bushes, 36°53'00.1"N, 48°55'45.9"E, alt. 360 m.

Loc. 4: Zanjan City, Zanjanrood River, with reeds on the riverbank 36°40'40.4"N 48°26'17.5"E alt. 1600 m.

Loc. 5: Shiveh, Golabiar Dam with significantly reduced water, covered by cottonthistle (*Onopordum* sp.) and short spiny bushes, 36°19'49.4"N, 48°22'14.0"E, alt. 1700 m.

Loc. 6: a shallow stream near Qazekhlou to Buroon road, 35°54'14.4"N, 48°20'23.1"E, alt. 1600 m.

Loc. 7: Garmab road, a shallow stream with brackish water lined with tall reeds and scattered shrubs of tamarisk, 35°51'29.1"N, 48°14'41.8"E, alt. 1500 m.

Loc. 8: Choruke Sofla, Zanjanrood River, 37°07'23.4"N, 47°53'04.1"E, alt. 1100 m.

Fig. 2 (Page 4). Photos of collection sites 1-8, a. a small stream near Taham Dam, Zanjan Province (Loc. 1); b. Chavarzaq, Zanjan Province (Loc. 2); c. Ghezel Ozan River, Vanisar, Zanjan Province (Loc. 3); d. Zanjanrood River near Zanjan city, Zanjan Province (Loc. 4); e. Shiveh, Golabiar Dam, Zanjan Province (Loc. 5); f. Qazekhlou to Buroon road, Zanjan Province (Loc. 6); g. Garmab road, Zanjan Province (Loc. 7); h. Choruke Sofla, Zanjanrood River, Zanjan Province (Loc. 8).

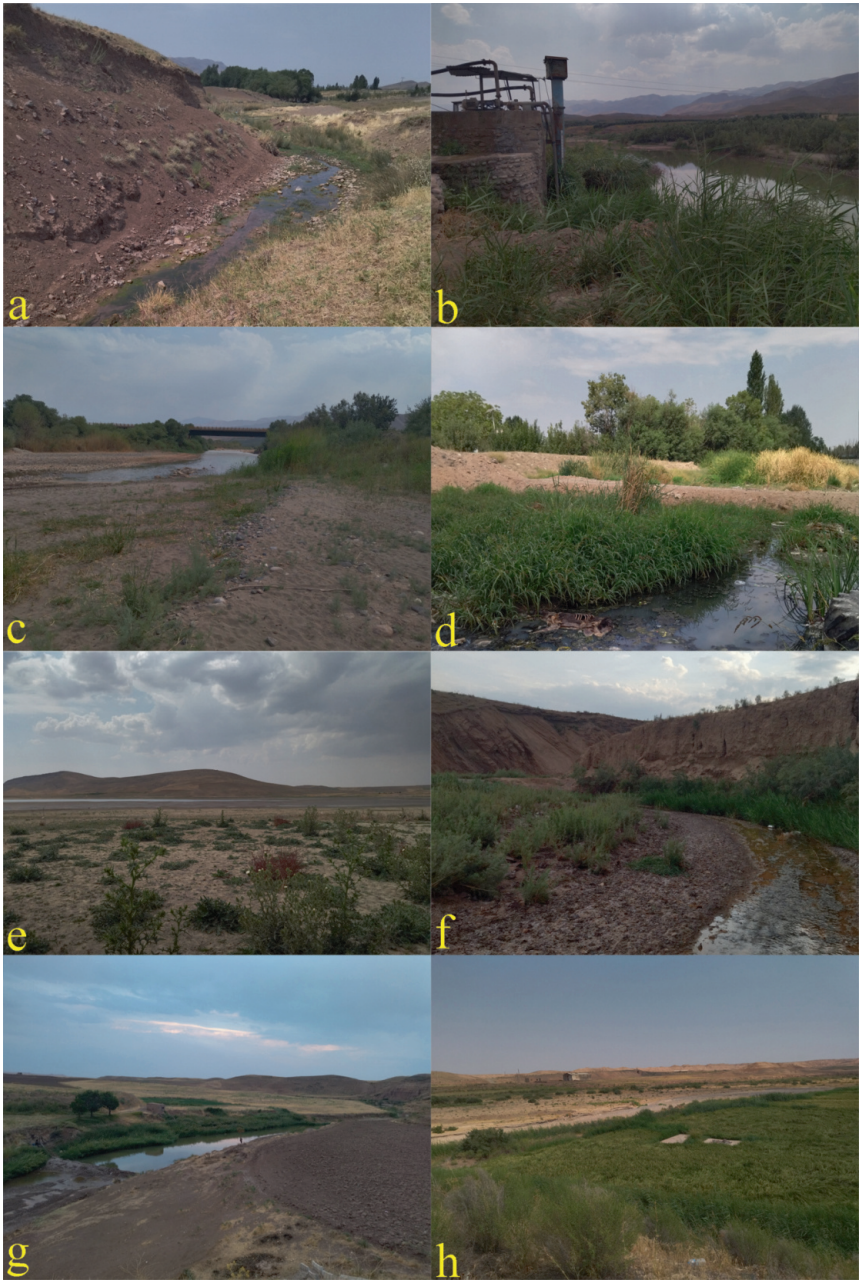

Figure 2. Captions see page 3.

Loc. 9: Qeytour, Fileh Khasseh, Fileh Khasseh Dam with almost completely drained water due to severe drought conditions, 37°03'48.2"N, 48°03'54.6"E, alt. 1300 m.

Loc. 10: Armaghankhaneh, a small pool created by a brook covered with reeds, near Qender Qalou village, 37°08'23.9"N, 48°18'18.6"E, alt. 1900 m.

Loc. 11: Armaghankhaneh, Dash Bulaq, Dash Bulaq Dam with extremely reduced water storage and some aquatic plants, 37°06'15.7"N, 48°15'23.2"E, alt. 1900 m.

Loc. 12: Zanjan to Dandi road, near Mehtar, Mehtarchai River lined with reeds and bulrush (*Typha* sp.), 36°37'44.8"N, 48°19'50.8"E, alt. 1700 m.

Loc. 13: Zanjan to Dandi road, Baktash, Ghezel Ozan River, with a wide floodplain, 36°30'53.6"N, 47°49'22.0"E, alt. 1300 m.

Loc. 14: Mahneshan, Sari Aghol, Ghezel Ozan River, 36°49'01.7"N, 47°37'59.5"E, alt. 1200 m.

Loc. 15: Moqul Abad, Arana waterfall, a small waterfall created by a brook covered with short grass, reeds and orchard trees, 36°22'01.6"N, 49°15'15.6"E, alt. 1900 m.

Loc. 16: Ziyaran, upstream of Ziyaran Dam, a large river lined on one side by orchard trees such as walnut (*Juglans regia*), mulberry (*Morus* sp.), oriental plane (*Platanus orientalis*), apple (*Malus* sp.), etc., 36°06'33.4"N, 50°31'17.9"E, alt. 1500 m.

Loc. 17: Qazvin County, Alamut-e Gharbi District, Rajaei Dasht village, Shahrood River, 36°27'21.1"N, 50°16'57.2"E, alt. 900 m.

Loc. 18: Alamut, Ovan Lake, a small alpine lake with aquatic plants like coontail (*Ceratophyllum* sp.) and pondweed (*Potamogeton* sp.), and a dense reed belt, under protection by the Iranian Department of Environment, 36°28'57.9"N, 50°26'43.1"E, alt. 1800 m.

Loc. 19: Takestan County, Ziaabad District, Kaneshkin, a small stream near Kaneshkin Dam, 36°13'38.2"N, 49°33'27.8"E, alt. 1600 m.

Loc. 20: Takestan County, Ziaabad District, a shallow stream lined with reeds and grass near Hesar village, 35°48'39.0"N, 49°24'36.8"E, alt. 1500 m.

Fig. 3 (Page 6). Photos of collection sites 9-16, a. Qeytour, Fileh Khasseh Dam, Zanjan Province (Loc. 9); b. Qender Qalou village, Zanjan Province (Loc. 10); c. Armaghankhaneh, Dash Bulaq Dam, Zanjan Province (Loc. 11); d. Mehtar, Mehtarchai River, Zanjan Province (Loc. 12); e. Baktash, Ghezel Ozan River, Zanjan Province (Loc. 13); f. Mahneshan, Ghezel Ozan River, Zanjan Province (Loc. 14); g. Moqul Abad, Arana with a seasonal waterfall. In warm seasons the waterfall disappears because of reduced water flow, a situation to be seen in the photo. Loc. 15); h. Ziyaran, Ziyaran River with a small cascade, Qazvin Province (Loc. 16).

Fig. 4 (Page 7). Photos of collection sites 17-22, a. Qazvin County, Alamut-e Gharbi, Shahrood River, Qazvin Province (Loc. 17); b. Alamut, Ovan Lake, Qazvin Province (Loc. 18); c. Ziaabad, Kaneshkin River, Qazvin Province (Loc. 19); d. Ziaabad, Hesar village, Qazvin Province (Loc. 20); e. Alamut-e Sharqi, Shahrood River, Qazvin Province (Loc. 21); f. Rudbar-e Shahrestan, Sugah village, Qazvin Province (Loc. 22).

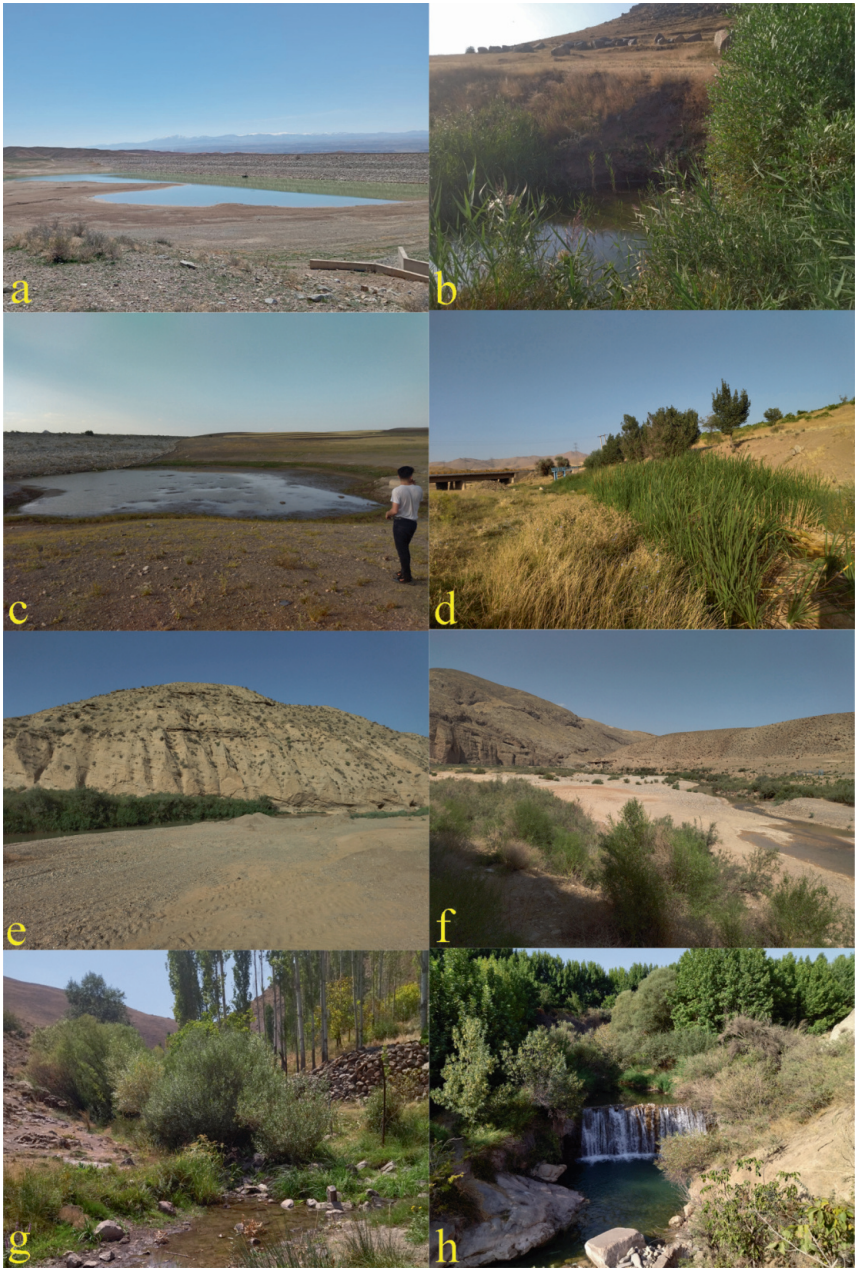

Figure 3. Captions see page 4.

Loc. 21: Qazvin County, Alamut-e Sharqi District, Bahram Abad village, Shahrood River, 36°32'45.2"N, 50°10'21.6"E, alt. 800 m.

Loc. 22: Qazvin County, Rudbar-e Shahrestan, a large river near Sugah village, 36°33'55.9"N 50°14'18.9"E, alt. 1000 m.

Collecting the specimens

Specimens were collected during late summer 2023 and spring 2024 from various aquatic habitats in the Zanjan and Qazvin provinces (Figs. 1-4). Adult dragonflies and damselflies were captured using an aerial net with a mesh size of 1.5 mm and a diameter of 50 cm.

Figure 4. Captions see page 4.

Specimens with distinct diagnostic characteristics were identified in the field with the aid of a magnifier. Captured individuals were released after data recording, except for those used for diagnostic characterization and as voucher specimens. These were examined under a Yaxun AK10 stereomicroscope. Only a minimal number of specimens were collected and preserved in 70% ethanol for potential future analyses. Identification of the collected specimens was conducted based on available taxonomic resources [Kalkman (2006); Dijkstra et al. (2020); Smallshire & Swash (2020)].

Results

In total, 14 species of Anisoptera and 9 species of Zygoptera were recorded in the study area. These 23 species, combined with 5 additional species reported from Qazvin Province in a previous study, indicate that at least 28 odonate species inhabit the study area, which constitutes approximately 28% of the total Odonata fauna of Iran.

Recorded species

Zygoptera

Lestidae

Sympecma Burmeister, 1839

Sympecma fusca (Vander Linden, 1820) (Fig. 5)

Material examined: **Loc. 10**: 1♀ , 17.VIII.2023; **Loc. 18**: 2♂♂ & 1♀ , 25.VIII.2023; **Loc. 20**: 1♀ , 25.IV.2024.

Fig. 5. *Sympecma fusca*, a) lateral view of male, b) dorsal view of male caudal appendages.

Comments: The specimens were observed flying or perching on plants with coloration that matched their body color (Fig. 6a), providing effective visual camouflage against predators such as birds. This species is primarily distributed in northern and northwestern Iran and was not abundant in the study area.

With respect to the long maturation and hibernation of the species (in Europe), the following annectodal observations are added: The specimen found in April was immature, while those collected in summer were mature. However, an immature male, which was not captured, was also observed in the summer.

Calopterygidae

Calopteryx Leach, 1815

Calopteryx splendens splendens (Harris, 1780) morph intermedia (Fig. 6)

Loc. 21: 1♀ , 1♂ , 27.VIII.2023

Fig. 6. *Calopteryx splendens splendens* morph intermedia, male in lateral view.

Comments: *Calopteryx splendens splendens* morph intermedia can be distinguished from *Calopteryx s. orientalis* found in northern Iran by the size, position, and shape of the male's dark wing spot. In *C. s. splendens*, this spot is large and oval, occupying almost two-thirds of the distal part of the wing (Fig. 6), whereas in the other subspecies, the wing spot is distinctly smaller (see Dumont et al. 2025). The intermedia morph of *C. s. splendens* is the most common. The distribution of *C. s. orientalis* is limited to the southern fringe of the Caspian Sea and the Kopet Dag mountain range, Dumont et al. (2025) provided figures of two males of *C. s. orientalis* from the border zone between Iran and Azerbaijan. *Calopteryx splendens* is widespread in Iran, with a distribution range extending from the northwest to the southeast of the country. In the present study, this damselfly was found on the banks of Shahrood River, an area characterized by dense riparian vegetation primarily composed of reeds and trees. Specimens were collected only at this location, which may indicate its scarcity in the study area.

Platycnemididae

Platycnemis Burmeister, 1839

Platycnemis dealbata Selys, 1863 (Fig. 7)

Loc. 2: 1♂ , 11.VIII.2023; **Loc. 6**: 1♂ & 1♀ , 14.VIII.2023, 1♂ & 1♀ , 12.IV.2024; **Loc. 13**: 2♂♂ , 20.VIII.2023, 1♂ , 18.IV.2024; **Loc. 21**: 1♂ , 28.VIII.2023, 1♀ , 26.IV.2024.

Comments: *Platycnemis dealbata* can be distinguished from its congeneric species in Iran, *P. kervillei*, by its unnotched upper terminal appendage in males (Fig. 7b). *P. dealbata* is

primarily found in mountainous regions and occurs across nearly all parts of Iran. Although the species is widespread, it was rarely encountered in the present study area.

Fig. 7. *Platycnemis dealbata*, a) lateral view of male, b) lateral view of male caudal appendages.

Coenagrionidae

Enallagma Charpentier, 1840

Enallagma cyathigerum (Charpentier, 1840) (Fig. 8)

Loc. 11: 3♂♂ & 1♀, 18.VIII.2023; **Loc. 18**: 1♂, 25.VIII.2023.

Fig. 8. *Enallagma cyathigerum cyathigerum*, a) lateral view of male, b) lateral view of male caudal appendages.

Comments: A stalked, rounded spot on the second segment of the abdomen and the absence of a short black line on the median lateral suture of the thorax (Fig. 8a) make *Enallagma cyathigerum* easily distinguishable from other damselflies of similar size and coloration. The distribution of *Enallagma c. cyathigerum* in Iran is limited to the northern and northwestern regions, and it has been collected in both Qazvin and Zanjan provinces. In contrast, the other subspecies, *Enallagma c. risi*, occurs in the southern and eastern parts of Iran. The two subspecies can be distinguished by examining the male terminal appendages (Fig. 8b). For further details, see Schneider et al. (2018). Regarding the proposed change in taxonomic status from "*risi*" to *Enallagma cyathigerum rotundatum* Bartenef, 1929, refer to Kosterin (2023). However, since the name *risi* is still commonly used in the majority of works on the dragonfly fauna of Iran, or discussed comparatively with *E. c. cyathigerum*, the term risi is retained here to avoid confusion for the reader.

Erythromma Charpentier 1840

Erythromma viridulum (Charpentier, 1840) (Fig. 9)

Loc. 18: 1♂ , 25.VIII.2023.

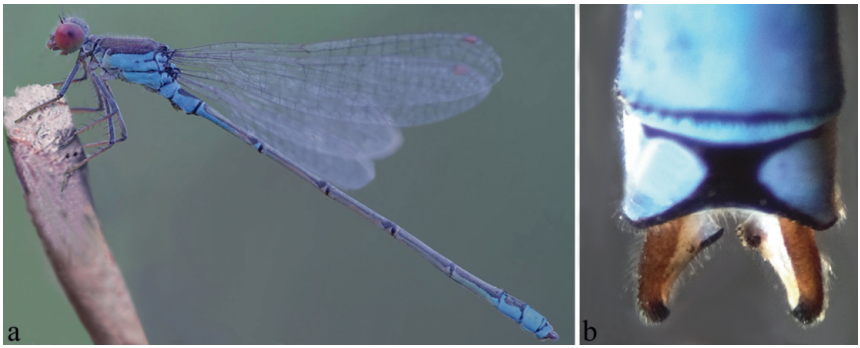

Fig. 9. *Erythromma viridulum*, a) lateral view of male b) dorsal view of male caudal appendages.

Comments: *E. viridulum* is the only red-eyed blue damselfly found in Iran. Its distribution extends from the northern to the southern regions of the country. Globally, this species is primarily distributed across Europe, whereas its southeastern range limit is in southern Iran. Tandem formations and egg-laying females were observed on the floating vegetation of Ovan Lake.

Ischnura Charpentier, 1840

Ischnura elegans (Vander Linden, 1820) (Fig. 10)

Loc. 4: 1♂ & 1♀ , 12.VIII.2023, 1♂ & 1♀ , 10.IV.2024; **Loc. 5**: 1♂ & 1♀ , 13.VIII.2023, 1♂ , 11.IV.2024; **Loc. 7**: 2♂♂ , 14.VIII.2023, 1♂ , 12.IV.2024; **Loc. 8**: 2♂♂ & 2♀♀ , 15.VIII.2023, 1♀ , 13.IV.2024; **Loc. 11**: 2♂♂ , 18.VIII.2023; **Loc. 17**: 1♂ , 17.VIII.2023,

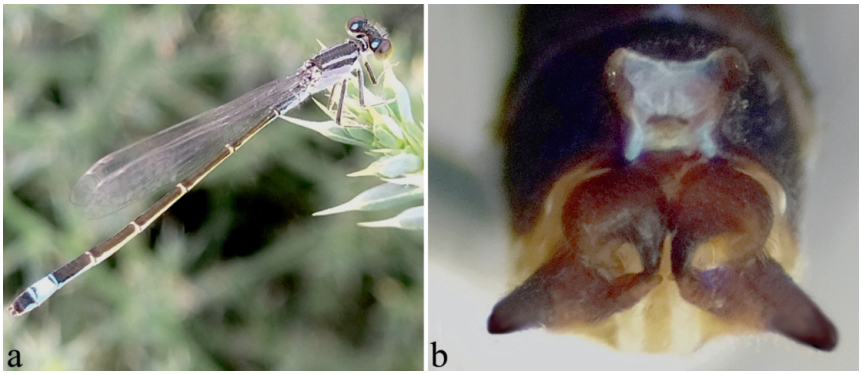

Fig. 10. *Ischnura elegans*, a) lateral view of female, b) posterior view of male caudal appendages.

2 ♂♂, 22.IV.2024; **Loc. 18**: 1 ♂ & 1 ♀, 25.VIII.2023; **Loc. 20**: 2 ♂♂ & 2 ♀♀, 27.VIII.2023, 1 ♀, 25.IV.2024; **Loc. 21**: 1♂ & 1♀, 28.VIII.2023, 2♂♂, 26.IV.2024.

Comments: Although two subspecies - *elegans* and *ebneri* - of *Ischnura elegans* have been reported from Iran by some authors, the characteristics used to distinguish them are weak. Consequently, the taxonomic status of these subspecies remains uncertain (Schneider et al., 2018). In the present study, all collected specimens are treated as *Ischnura elegans* without subspecific distinction. This species is one of the most widespread in Iran and can be found in nearly all habitat types, except for desert regions. This broad distribution may be attributed to its high ecological tolerance, particularly with respect to temperature extremes.

Ischnura fountaineae Morton, 1905 (Fig. 11)

Loc. 9: 2♂♂ & 2♀♀, 16.VIII.2023, 1♂, 14.IV.2024; **Loc. 14**: 2♂♂ & 1♀, 21.VIII.2023, 2♂♂, 19.IV.2024.

Fig. 11. *Ischnura fountaineae*, a) dorsal view of male, b) posterior view of male caudal appendages.

Comments: This species was not abundant in the study area, as it was found in only two localities. In Iran, it occurs primarily in the southern regions of the country. Its presence in habitats characterized by high temperatures and elevated salinity, such as those in Khuzestan Province (Bakhshi and Sadeghi, 2014), suggests that *I. fountaineae* is capable of tolerating both high temperatures and high salinity levels.

Ischnura intermedia Dumont, 1974 (Fig. 12)

Loc. 6: 1♂ & 1♀, 14.VIII.2023; **Loc. 21**: 1♂, 29.VIII.2023

Fig. 12. *Ischnura intermedia*, a) lateral view of male b) posterior view of male caudal appendages.

Comments: *Ischnura intermedia*, commonly known as the Persian Bluetail, was previously recorded only in central and western Iran. The present records from northwestern Iran indicate that its distribution within the country is broader than previously believed. These findings are significant, because *I. intermedia* is considered a damselfly with a limited range both in Iran and in other countries. It is classified as Near Threatened on a global scale (Smallshire & Swash, 2020) and as Endangered in Europe (De Knijf et al., 2024).

Ischnura pumilio (Charpentier, 1825) (Fig. 13)

Loc. 1: 4♂♂ & 1♀, 10.VIII.2023; **Loc. 2**: 1♂ & 1♀, 11.VIII.2023; **Loc. 4**: 2♂♂ & 1♀, 12.VIII.2023; 1♂ & 1♀, 10.IV.2024; **Loc. 12**: 2♂♂ & 2♀♀, 19.VIII.2023; 2♂♂, 17.IV.2024; **Loc. 15**: 1♂ & 1♀, 22.VIII.2023, 1♀, 20.IV.2024; **Loc. 21**: 4♂♂ & 2♀♀, 28.VIII.2023.

Fig. 13. *Ischnura pumilio*, a) lateral view of male b) posterior view of male caudal appendages.

Comments: This species occurs throughout Iran; therefore, it was anticipated that it would be collected in the present study. Several individuals were observed, suggesting that the populations in the study area may be in good condition.

In a typical male *I. pumilio*, the two inferior appendages are positioned ventrally, slightly curved, and nearly aligned with the axis of the abdomen. These appendages are significantly longer than the two superior appendages, which are elongated triangles featuring a dorsal median concavity (Dumont, 1974).

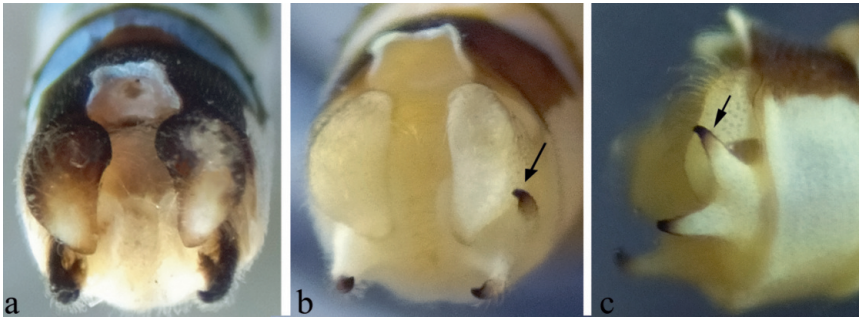

Fig. 14. Caudal appendages of *I. pumilio* male specimens collected from location 1 in Zanjan Province. (a) a normal specimen with two inferior appendages in posterior view, (b) and (c) the abnormal specimen with an extra inferior appendage in posterior and lateral views respectively. Arrows indicate the extra right appendage.

During the identification of the male specimens of *I. pumilio* collected in the present study, one teneral specimen was observed exhibiting an unusual morphology of the terminal appendages. Specifically, it possessed three inferior branches (Fig. 14). The additional inferior appendage is identical in size, color, and shape to the normal right inferior appendage, but it is positioned above it. Both these right appendages originate from the same point, creating a forked appearance in lateral view (Fig. 14c). The left side exhibits the typical number of superior and inferior appendages.

Anisoptera

Aeshnidae

Anax Leach, 1815

Anax imperator (Leach, 1815) (Fig. 15)

Loc. 1: 1 ♂ observed, 1 ♀ collected, 10.VIII.2023.

Fig. 15. *Anax imperator*, dorsal view of female.

Comments: *Anax imperator* is one of the largest dragonfly species in Iran. Males can be distinguished from other *Anax* species in the region by their short, square lower appendages, while females lack tubercles on their occiput. This species is widespread throughout Iran, inhabiting mainly areas with standing water and slow-flowing rivers. In the present study, individuals were observed patrolling over a slow-flowing stream.

Anax parthenope Selys, 1839

Loc. 18: 1 ♂ observed, 10.VIII.2023

Comments: Distinct blue markings and a yellow basal ring on the second abdominal segment, along with the brown sides of the thorax, can be used to identify this species in the field. This large dragonfly is widespread in Iran and can be found throughout the country. *Anax parthenope* is sometimes observed in large swarms (Ikemeyer et al., 2015). However, during the present study, only one male was seen flying over Ovan Lake.

Gomphidae

Onychogomphus Selys, 1854

Onychogomphus lefebvrii (Rambur, 1842) (Fig. 16)

Loc. 14: 1 pair in copula observed, 1♂ collected, 21.VIII.2023.

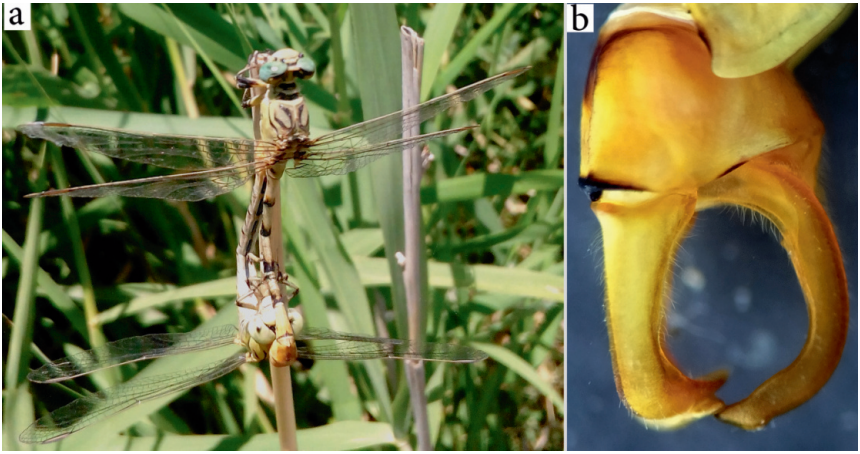

Fig. 16. *Onychogomphus lefebvrii*, a) male and female in heart position during mating, b) lateral view of male caudal appendages.

Comments: *Onychogomphus lefebvrii* (Fig. 16a) closely resembles *O. forcipatus albotibialis* in size and body coloration; however, it can be distinguished by the absence of an apical tubercle on the lower branch of the male terminal appendage (Fig. 16b), which is present in *O. forcipatus albotibialis* (Dijkstra et al., 2020). Previous records of *O. lefebvrii* in Iran are limited to the western, southern, and eastern regions of the country (Schneider et al., 2018). This report extends the known range of this species to northwestern Iran, indicating a broader distribution across the country.

Libellulidae

Orthetrum Newman, 1833

Orthetrum coerulescens anceps (Schneider, 1845) (Fig. 17)

Loc. 9: 2♂♂ & 1♀, 16.VIII.2023, 1♂ & 1♀, 14.IV.2024; **Loc. 13**: 1♀, 20.VIII.2023, 1♂ seen, 18.IV.2024; **Loc. 18**: 2♂♂, 25.VIII.2023; **Loc. 19**: 1♂, 26.VIII.2023.

Comments: *Orthetrum coerulescens* is a small species within the genus *Orthetrum*. The subspecies *Orthetrum c. anceps* is common and widespread in Iran. This taxon has been observed in various types of habitats throughout the study area.

Orthetrum brunneum (Fonscolombe, 1837) (Fig. 18)

Loc. 1: 2♂♂, 10.VIII.2023; **Loc. 4**: 2♂♂, 10.IV.2024; **Loc. 13**: 1♂, 20.VIII.2023; **Loc. 14**: 1♂, 21.VIII.2023, 1♀, 19.IV.2024; **Loc. 15**: 1♂, 22.VIII.2023, 1♂, 20.IV.2024; **Loc. 19**: 1♀, 26.VIII.2023.

Comments: A prominent hook on the hamule of the male (Fig. 18b) and an expanded eighth abdominal segment of the female make it easy to distinguish this species from other congeners. The specimens were mostly found on stones or low branches and bushes while resting.

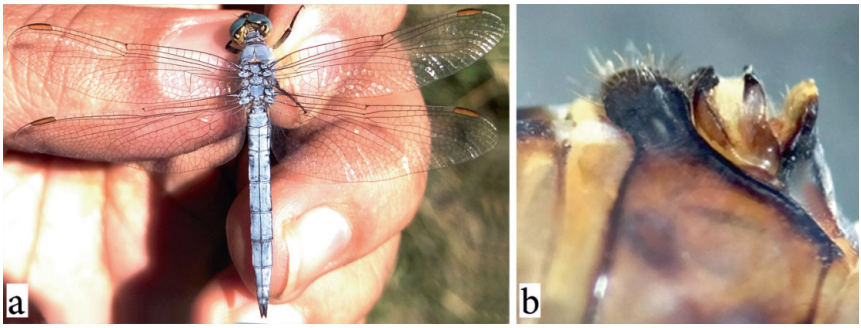

Fig. 17. ***Orthetrum coerulescens anceps*****, a) dorsal view of male b) lateral view of male secondary genitalia.**

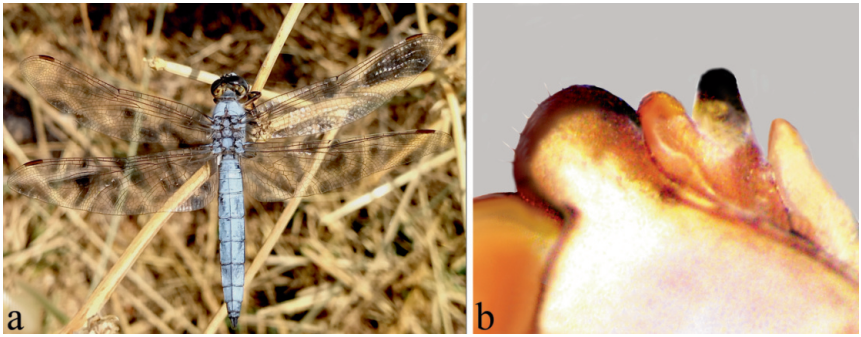

Fig. 18. ***Orthetrum brunneum*****, a) dorsal view of male, b) lateral view of male secondary genitalia.**

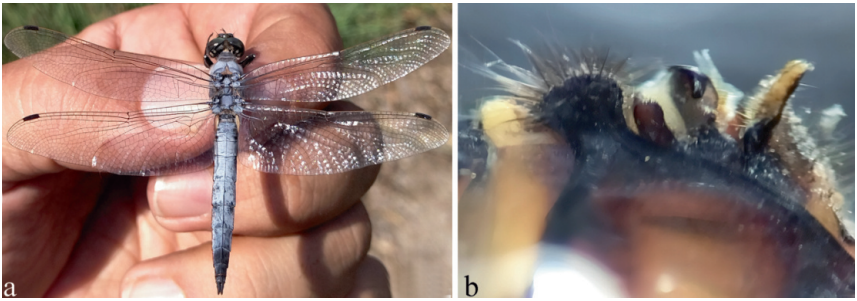

Fig. 19. ***Orthetrum cancellatum*****, a) dorsal view of male, b) lateral view of male secondary genitalia.**

Orthetrum cancellatum (Linnaeus, 1758) (Fig. 19)

Loc. 18: 1♂, 25.VIII.2023

Comments: The black terminal segments of the abdomen (Fig. 19a), together with the rounded hamule and the sharply pointed anterior lamina of the male (Fig. 19b), are the key diagnostic features of *O. cancellatum*. This species is less widespread and less common than *O. coerulescens* and *O. brunneum* in Iran; therefore, it is not surprising that only one specimen was collected during the present study. However, two additional individuals were observed flying low and fast above the water.

Orthetrum sabina (Drury, 1773) (Fig. 20)

Loc. 2: 2♂♂, 11.VIII.2023, 2♀♀, 9.IV.2024; **Loc. 3**: 2♂♂, 11.VIII.2023; **Loc. 4**: 1♀ 12.VIII.2023, 1♂, 10.IV.2024; **Loc. 15**: 1♂ 1♂, 22.VIII.2023, 20.IV.2024; **Loc. 16**: 1♂ & 1♀ 23.VIII.2023, 1♂, 21.IV.2024; **Loc. 17**: 1♂ & 1♀, 24.VIII.2023; **Loc. 19**: 2♂♂, 26.VIII.2023, 1♂ & 1♀ 24.IV.2024; **Loc. 20**: 1♂, 27.VIII.2023, 1♂, 25.IV.2024; **Loc. 21**: 1♂ & 1♀, 28.VIII.2023; **Loc. 22**: 1♂, 2♀♀, 29.VIII.2023.

Fig. 20. *Orthetrum sabina*, a) dorsolateral view of female, eating a horsefly, b) lateral view of male secondary genitalia.

Comments: A tuft of orange hairs on the anterior lamina of the male genitalia (Fig. 20b) and the bulbous base of the abdomen in both sexes are diagnostic characteristics of *O. sabina*. This species is abundant and widespread in Iran and was found in several localities during the current study.

Sympetrum Newman, 1833

Sympetrum fonscolombii (Selys, 1840) (Fig. 21)

Loc. 4: 1♀, 12.VIII.2023, 1♂ & 1♀, 10.IV.2024; **Loc. 5**: 1♂ & 1♀ 11.IV.2024; **Loc. 8**: 2♂♂ & 2♀♀, 15.VIII.2023, 1♂, 13.IV.2024; **Loc. 14**: 1♂ & 2♀♀ 21.VIII.2023, 2♀♀, 19.IV.2024; **Loc. 17**: 1♀, 24.VIII.2023; **Loc. 18**: 1♂, 25.VIII.2023, 2♂♂

23.IV.2024; **Loc. 19**: 1♂ & 1♀, 26.VIII.2023; **Loc. 20**: 2♂♂, 25.IV.2024; **Loc. 21**: 1♂ & 1♀, 28.VIII.2023, 1♀, 26.IV.2024; **Loc. 22**: 1♂, 29.VIII.2023;

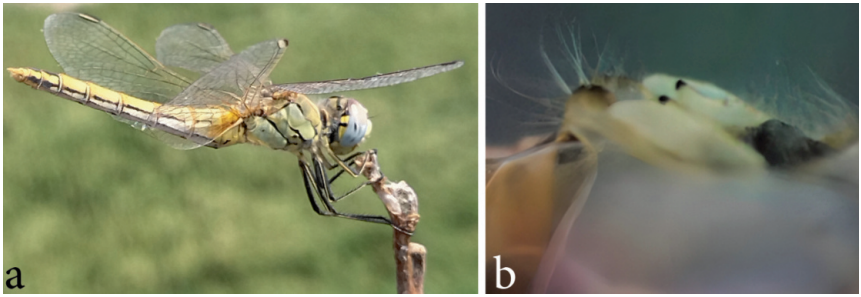

Fig. 21. *Sympetrum fonscolombii*, a) perching juvenile female in lateral view, b) lateral view of male secondary genitalia.

Comments: In the secondary genitalia of males, the hook of the hamule is notably smaller (Fig. 21b) compared to those of other congeneric species. *S. fonscolombii* is a migratory species with a broad distribution throughout Iran, and adults can usually be found year-round. This species is the second most widespread in the present study, after *Pantala flavescens*. One female was captured at night, attracted to light.

Sympetrum sanguineum (Müller, 1764) (Fig. 22)

Loc. 10: 1♂, 17.VIII.2023

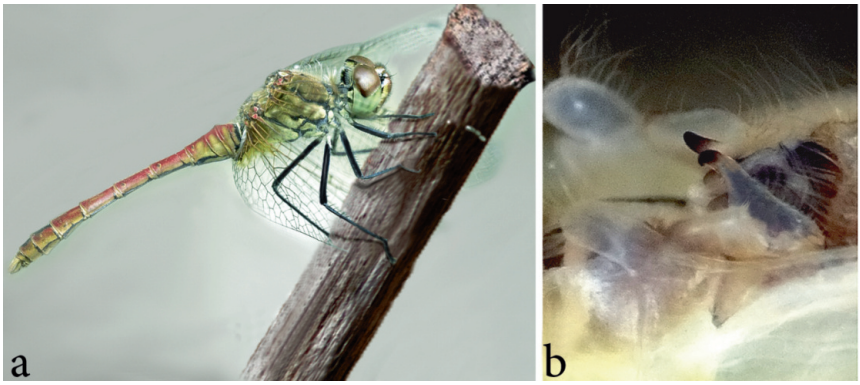

Fig. 22. *Sympetrum sanguineum*, a) lateral view of an immature male, b) lateral view of male secondary genitalia.

Comments: The deep red coloration, bright red face, and all-black legs of the male (Fig. 22a) make this species easily recognizable. Furthermore, in males, the hook of the hamule is large and curved (Fig. 22b). *S. sanguineum* is mainly distributed in the northern and western regions of Iran. It appears to be rare in the study area, as it was collected from only one location in Zanjan Province.

Sympetrum striolatum (Charpentier, 1840) (Fig. 23)

Loc. 4: 1 ♂ , 12.VIII.2023; 1 immature ♂ , 10.IV.2024; **Loc. 15**: 1 ♂ & 1 ♀ , 22.VIII.2023, 1 ♀ , 20.IV.2024; **Loc. 16**: 2 ♂♂ , 23.VIII.2023, 2 mature ♂♂ , 21.IV.2024; **Loc. 22**: 1 ♂ , 29.VIII.2023

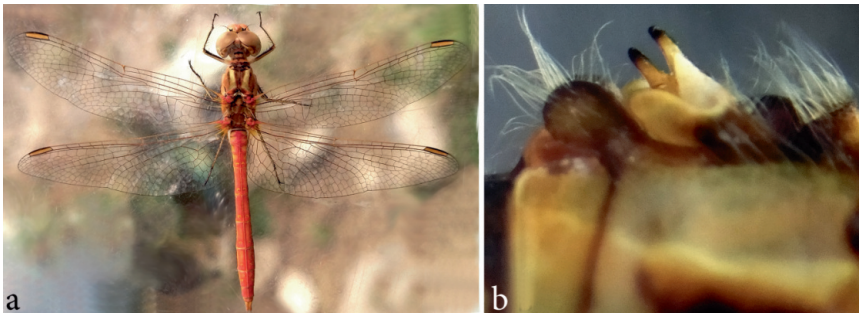

Fig. 23. *Sympetrum striolatum*, a) dorsal view of male, b) lateral view of male secondary genitalia. Note: The frontal bases of wings are red with surrounding safran veins, which cannot be seen in Europe. But additional specimens with the same character from other parts of Iran are available to the author.

Comments: In *S. striolatum*, the male secondary genitalia feature an anterior branch of the hamule that is long and slightly curved but not apically hooked (Fig. 22), in contrast to *S. sanguineum*. *S. striolatum* is primarily found in the mountainous regions of northern and central Iran, although it was relatively scarce in the study area.

Crocothemis Brauer, 1868

Crocothemis erythraea (Brullé, 1832) (Fig. 24)

Fig. 24. *Crocothemis erythraea*, a) dorsal view of male, b) ventral view of male secondary genitalia.

Loc. 17: 1♂ & 1♀ **,** 24.VIII.2023, 2♂♂ **,** 22.IV.2024; **Loc. 18:** 1♂ , 25.VIII.2023, 1♂ & 2 ♀♀ , 23.IV.2024

Comments: The male of this medium-sized dragonfly exhibits a striking all-red coloration. This distinctive feature, along with its broad abdomen, facilitates its identification and differentiates it from most Iranian dragonflies, with the exception of the oriental scarlet, *Crocothemis servilia*. Accurately distinguishing *C. erythraea* from *C. servilia* necessitates careful examination and should be corroborated by structural details. *C. erythraea* is slightly larger than *C. servilia* and has a less pronounced dark mid-dorsal line on its abdomen. In males of *C. erythraea*, the hook of the hamule possesses two teeth (Fig. 23b), whereas in *C. servilia*, it has a single tooth (Boudot et al., 2021). This species was recorded only in Qazvin Province; however, its apparent scarcity is likely an artefact of limited sampling and may not reflect its true distribution in the region.

Crocothemis servilia (Drury, 1773) (Fig. 25)

Loc. 2: 1 ♂ & 2 ♀ ♀ , 11.VIII.2023; **Loc. 3**: 2 ♂ ♂ , 9.IV.2024; **Loc. 17**: 1 ♂ & 1 ♀ , 24.VIII.2023, 1 ♀ , 22.IV.2024; **Loc. 20**: 2♂♂ & 2♀♀ , 27.VIII.2023, 2♂♂ & 1♀ , 25.IV.2024; **Loc. 21**: 2♂♂ & 2♀♀ , 28.VIII.2023, 1♂ , 26.IV.2024; **Loc. 22**: 1♀ , 29.VIII.2023

Fig. 25. *Crocothemis servilia*, a) dorsolateral view of male, b) ventral view of male secondary genitalia.

Comments: In *C. servilia*, the hamule hook features a single tooth (Fig. 24b). For further details, please refer to the previously mentioned comments on *C. erythraea*. The two species have overlapping distribution ranges in Iran. *C. servilia* has been observed in more locations than *C. erythraea*, and both species were found sympatrically at one of these locations.

Libellula Linnaeus, 1758

Libellula depressa Linnaeus, 1758 (Fig. 26)

Loc. 18: 1♀ observed and photographed, 25.VIII.2023.

Comments: The distinctly broad abdomen and the extensive basal dark markings on both wings (Fig. 26) in both sexes make it easy to distinguish *L. depressa* from other con-

generic dragonflies in Iran. This species is endemic to the Western Palearctic region and is widespread in Iran. However, only one female was found during sampling. Therefore, it seems that this species is rare in the studied area.

Fig. 26. *Libellula depressa*, a perching female in dorsal view.

Pantala Hagen, 1861

Pantala flavescens (Fabricius, 1798) (Fig. 27)

Loc. 2: 1♂, 11.VIII.2023; **Loc. 3**: 1♂, 11.VIII.2023; **Loc. 4**: 2♂♂ & 2♀♀, 12.VIII.2023; **Loc. 7**: 2♂♂, 14.VIII.2023; **Loc. 8**: 2♂♂ & 1♀, 15.VIII.2023: **Loc. 15**: 1♀, 22.VIII.2023; **Loc. 16**: 1 ♀, 23.VIII.2023; **Loc. 17**: 1 ♂, 24.VIII.2023; **Loc. 20**: 2 ♂♂ & 1♀, 27.VIII.2023; **Loc. 22**: 1♂, 29.VIII.2023;

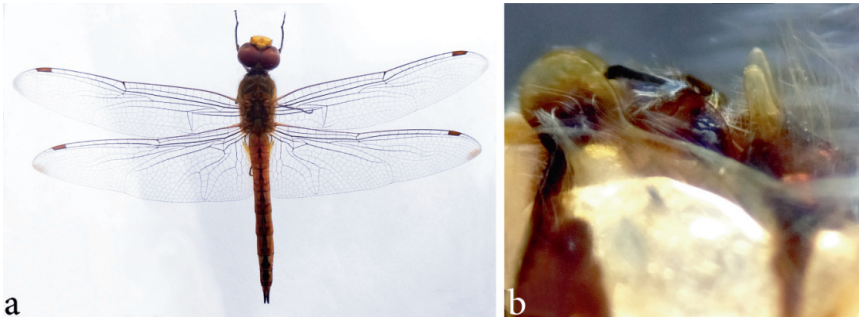

Fig. 27. *Pantala flavescens*, a) dorsal view of male, b) lateral view of male secondary genitalia.

Comments: Large migratory swarms of *P. flavescens* were observed throughout the study area. This species migrates across Iran from Africa to Eurasia (Eastern Europe and Central Asia) (Borisov et al., 2020). To date, there is no evidence of breeding populations in the provinces of Zanjan and Qazvin. This species is considered the most widespread odonate species in the world, as well as within Iran (Schneider et al., 2018).

Discussion

A total of 233 Odonata specimens, representing 23 species, were collected from 22 sites in the Qazvin and Zanjan provinces. Together with five species previously recorded from Qazvin Province - *Lestes barbarus* (Fabricius, 1798), *Onychogomphus forcipatus albotibialis* (Schmidt, 1954), *Aeshna mixta* (Latreille, 1805), *Libellula quadrimaculata* (Linnaeus, 1758), and *Trithemis annulata* (Palisot de Beauvois, 1807) (Sadeghi & Mohammadalizadeh, 2009) the Odonata fauna of the study area now comprises 28 recorded species (See Table 1, Appendix 1, page 26).

This relatively high regional diversity may primarily be attributed to the variety of habitats present. However, Odonata are facing several environmental threats in the studied area. As illustrated in Figures 2-4 and based on the author's direct field observations, habitat loss due to the degradation of water bodies is one of the major threats. Additional threats to odonate populations in the study area include climate change and multiple sources of pollution, notably wastewater dischargeand agricultural runoff contaminated with a range of chemicals, particularly pesticides.

The suborder Anisoptera is represented by three species of Aeshnidae, 13 species of Libellulidae, and two species of Gomphidae. The suborder Zygoptera includes six species of Coenagrionidae, two species of Lestidae, and one species each of Calopterygidae and Platycnemididae.

Since no studies have been conducted on the Odonata of Zanjan Province to date, all 17 species reported in the present study are considered new provincial records. In Qazvin Province, nine species had already been documented (Sadeghi & Mohammadalizadeh, 2009), while 15 species are newly reported in this study.

Adult Odonata were more prevalent during August 2023 than in April 2024, which aligns with their typical flight period during the warmer months (Pires et al., 2019). Northwest Iran experiences a cold, mountainous climate during the winter months, characterized by heavy snow and sub-freezing temperatures, while its summers are dry and hot (Heidari & Movarrari, 2019).

The family Libellulidae comprised the majority of the collected species. Members of this family typically prefer standing water but are known to occupy a wide range of aquatic habitats (May & Matthews, 2008). The most dominant species observed were *Pantala flavescens, Sympetrum fonscolombii,* and *Orthetrum sabina*. Notably, *P. flavescens* formed large migratory swarms. According to Vieira & Cordero-Rivera (2015), this migratory species possesses an invasive nature that enables it to successfully adapt to different types of habitats. In contrast, several species were rare, each observed at only one site: *Anax imperator, Anax parthenope, Sympetrum sanguineum, Orthetrum cancellatum, Onychogomphus lefebvrii, Calopteryx splendens splenden* morph intermedia, and *Erythromma viridulum*.

The most species-rich sites were Locations 4 (Zanjanrood River) and 18 (Ovan Lake), each hosting eight species. Ovan Lake is a small alpine lake situated at an altitude of 1,800 meters above sea level, surrounded by a dense belt of reeds. The fact that it is located within a protected area may contribute to the high diversity of odonate species found around this lake. Location 4 is part of the Zanjanrood River, one of the largest rivers in Zanjan Province, which flows from the southeast to the northwest of the province, traversing various landscapes. This diversity of landscapes provides a range of habitats for different species of Odonata.

In contrast, location 12 yielded only one species, while locations 5, 6, 7, 8, 10, and 11 hosted just two species each. Odonates were entirely absent at eight of the 30 surveyed sites. Furthermore, seven species were recorded at only one site. These findings may suggest that environmental factors negatively impact Odonata populations in the study area. Human activities, such as habitat pollution, agriculture, and dam construction, along with environmental changes including drought, global warming, and desertification, are significant threats to Odonata in Iran. Some of these environmental changes that can affect Odonata populations are illustrated in Figures 2-4. Although all species recorded have a widespread distribution and are classified as Least Concern (LC) according to the IUCN (International Union for Conservation of Nature) Red List of Threatened Species—except for *Ischnura intermedia*, which is listed as Near Threatened (NT)— at least some populations may not be in optimal condition. A regional assessment of the status of Odonata populations in Iran is recommended, particularly for species inhabiting vulnerable or degraded ecosystems.

The Near Threatened species, *I. intermedia*, is endemic to West Asia. It was first described in Turkey (Dumont, 1974) and has since been reported in Iran, Syria, Iraq, Turkmenistan, and Cyprus. It prefers slow-flowing streams and channels with marshy vegetation, such as patches of reeds (Smallshire & Swash, 2020).

The recorded abnormality in the caudal appendages of a male *Ischnura pumilio* may indicate either a genetic defect or the influence of environmental factors. Structural abnormalities in Odonates and other animals can arise from environmental changes and stress (Gladysz et al., 2016; Jeremiason et al., 2016). Numerous studies on various groups of insects have demonstrated that pesticides can lead to a range of developmental disorders in the affected taxa (Madden et al., 1992; Heylen et al., 2011; Castro et al., 2021; Bartling et al., 2023). The locality where the malformed specimen was collected (Site 1) is a small stream flowing through fruit orchards where various pesticides, including Diazinon, Benomyl, Nuarimol, Dinocap, Chlorpyrifos, Phosalone, and Malathion, are frequently applied (based on personal communication with the orchard owners). However, the relationship between these pesticides and the observed anomaly cannot be confirmed or denied; therefore, further investigations are recommended to determine the potential existence of such a relationship.

Structural abnormalities in mating-related organs, such as the male terminal appendages used for clasping during copulation, may significantly impact reproductive fitness within species (Bergsten et al., 2001; Wojcieszek and Simmons, 2012). The additional right inferior appendage observed in the malformed *I. pumilio* specimen could potentially hinder mating by preventing a secure grip on the female pronotum. However, as this specimen was preserved in ethanol, no behavioral observations were possible.

Acknowledgement

I would like to express my sincere gratitude to Martin Schorr and the International Dragonfly Fund (IDF) for providing the grant that made this study possible. I would also like to thank Dr. Reinhard Jödicke for his insightful comments which greatly improved the manuscript. I am grateful to Dr. Holger Hunger for his meticulous editing, which significantly improved the language and flow of the paper. Mahnaz Barmshuri, Lida Karami, and Mehdi Behbood are thanked for their assistance during the field trips.

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Appendix 1

Table 1: Checklist of the Odonata fauna of the Qazvin and Zanjan provinces, Iran.

	Zanjan Province		Qazvin Province	
Recorded Odonata from study area	Recorded previously	Recorded in the present study	Recorded previously	Recorded in the present study
Anisoptera				
Aeshna mixta	-	-	✓	-
Anax imperator	-	✓	-	-
Anax parthenope	-	-	✓	✓
Crocothemis erythraea	-	-	-	✓
Crocothemis servilia	-	✓	-	✓
Libellula depressa	-	-	✓	✓
Libellula quadrimaculata	-	-	✓	-
Pantala flavescens	-	✓	-	✓
Trithemis annulata	-	-	✓	-
Sympetrum fonscolombii	-	✓	✓	✓
Sympetrum sanguineum	-	✓	-	-
Sympetrum striolatum	-	✓	-	✓
Orthetrum brunneum	-	✓	✓	✓
Orthetrum cancellatum	-	-	-	✓
Orthetrum coerulescens anceps	-	✓	-	✓
Orthetrum sabina	-	✓	-	✓
Onychogomphus forcipatus albotibialis	-	-	✓	-
Onychogomphus lefebvrii	-	✓	-	-
Zygoptera				
Lestes barbarus	-	-	✓	-
Sympecma fusca	-	✓	-	✓
Calopteryx splendens morph intermedia	-	-	-	✓
Ischnura pumilio	-	✓	-	✓
Ischnura intermedia	-	✓	-	✓
Ischnura elegans	-	✓	-	✓
Ischnura fountaineae	-	✓	-	-
Enallagma cyathigerum	-	✓	-	✓
Erythromma viridulum	-	-	-	✓
Platycnemis dealbata	-	✓	-	✓

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Reference cited in the text should read as follows: Tillyard (1924), (Tillyard 1924), Swezey & Williams (1942).

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Swezey, O. & F. Williams, 1942. Dragonflies of Guam. Bernice P. Bishop Museum Bulletin 172: 3-6.
Tillyard, R., 1924. The dragonflies (Order Odonata) of Fiji, with special reference to a collection made by Mr. H.W. Simmonds, F.E.S., on the Island of Viti Levu. Transactions of the Entomological Society London 1923 III-IV: 305-346.

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The manuscript should end with a list of captions to the figures and tables. The latter should be submitted separately from the text preferably as graphics made using one of the Microsoft Office products or as a high resolution picture saved as a .jpg .tif or .ps file. Pictures should be at least 11 cm wide and with a minimum 300 dpi resolution, better 360 dpi. Line drawings and graphics could have 1200 dpi for better details. If you compose many pictures to one figure, please submit the original files as well. Please leave some space in the upper left corner of each picture, to insert a letter (a, b, c...) later. Hand-made drawings should be scanned and submitted electronically. Printed figures sent by the post could be damaged, in which case authors will be asked to resubmit them.

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