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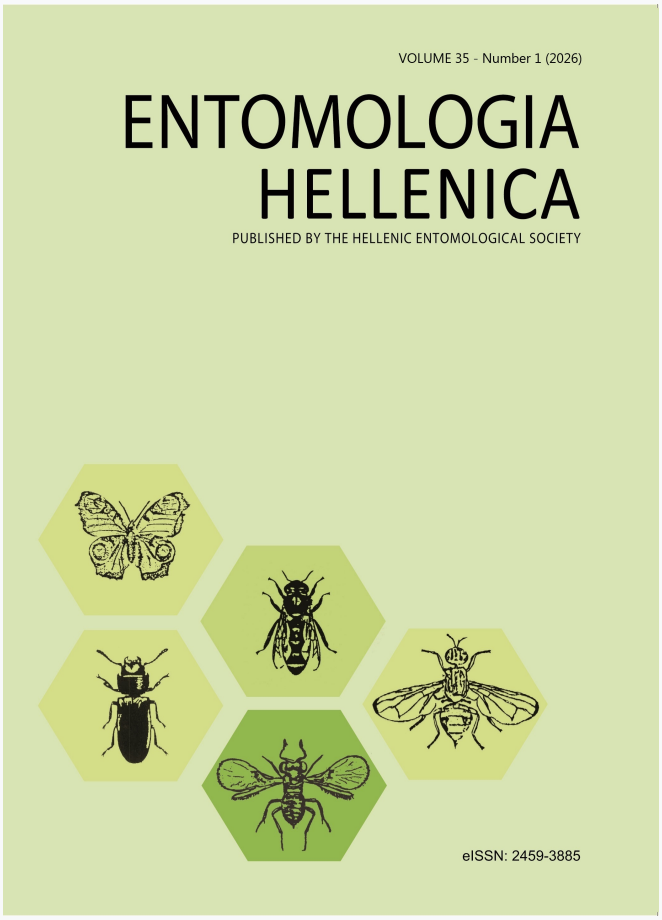

Reappearance of the endangered species Calopteryx exul (Odonata, Zygoptera) in western Algeria, after 120 years

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Reappearance of the endangered species *Calopteryx exul* (Odonata, Zygoptera) in western Algeria, after 120 years

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ABSTRACT

Morton's 1905 report of *Calopteryx exul* Selys, 1853 in Sebdou, was the only historical record of this zygopteran species in western Algeria. This article reports a new locality for this species in western Algeria, in the Ouarsenis region, on the southern slopes of the western Tellian Atlas, at Oued El-Gherga, municipality of Youssoufia-Tissemsilt. A total of 19 individuals and 8 exuviae of *C. exul* were encountered in September 2022 on a 900 m stretch of the Oued El-Gherga river (from its point of contact with oued El Assa to its point of contact with Oued Bourafedh), this site represents the second locality of record for this endangered species in the west of the country.

KEY WORDS: Damselfly, Maghreb, North Africa, Biodiversity.

Introduction

Zygoptera are small, slender insects with folded wings at rest, a long abdomen, widely -spread eyes and slow flight (Sutherland et al. 2025). North Africa is home to five endemic species of Zygoptera (*Calopteryx exul* Selys, 1853, *Enallagma deserti* Selys 1871, *Ischnura saharensis* Aguesse 1958, *Lestes numidicus* Samraoui, Weekers and Dumont, 2003 and *Platycnemis subdilatata* Selys 1849). Of the four species of the family Calopterygidae known from North Africa, *C. exul* is the only endemic (Samraoui et al. 2010), and is classified as 'EN' on the IUCN red list (Boudot 2018).

In Algeria, the species has received significant research attention in the northeast, as evidenced by the extensive literature documenting its historical distribution. It has been the subject of several studies concerning its biology, such as the description of the larval stages (Khelifa 2012) and reproductive behaviour (Khelifa 2017, Mellal et al. 2018, Khelifa 2019), ecology, i.e. environmental preferences (Khelifa 2013, Khelifa 2016, Mahdjoub et al. 2023), flight period, apparent sex ratio (Khelifa 2016) and the dynamics of its geographical range (Chelli et al. 2019, Elafri 2022).

This has greatly contributed to the understanding of the several aspects of the species' vital requirements. It should be mentioned that *C. exul* has passed unnoticed for a whole century, from Martin's research at the beginning of the 20th century until the beginning of the 21st, when several populations were rediscovered in the Seybous basin (Khelifa et al. 2016). Our observation fits into this context, adding a new locality for this threatened damselfly, which represents the second record in western Algeria. It also important to compare this new site with other places where the species is present in Algeria, to

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explore new horizons on the bio-ecology and conservation measures of this endangered species.

Materials and Methods

Study area

Oued El Gherga is one of the watercourses in the north-east of the Province of Tissemsilt (Fig. 1). It starts at 35°52'53.3"N 2°01'53.9"E and ends at 35°59'26.6"N 2° 11'07.1"E, with an average altitude of 840 m. It straddles the two municipalities of Theniet El Had and Youssoufia, starting at the town of Theniet el Had and the surrounding area. This river has a total length estimated at 31.6 km, and flows through the town of Youssoufia, from which it takes its ancient name 'Oued El Gherga'. A large part of its course flows through the Djbel Arour national forest before emptying into the Derder dam, municipality of Tarek Ibn Ziad, in Ain Defla province. The water from O. El Gherga, has a medium flow, all year round, with a remarkable increase during the winter season, when the water from the treatment plant is discharged directly into the Oued after treatment. The riverbanks are used for arboriculture and market gardening. The riparian vegetation consists of *Fraxinus excelsior* Linnaeus 1753, *Salix*

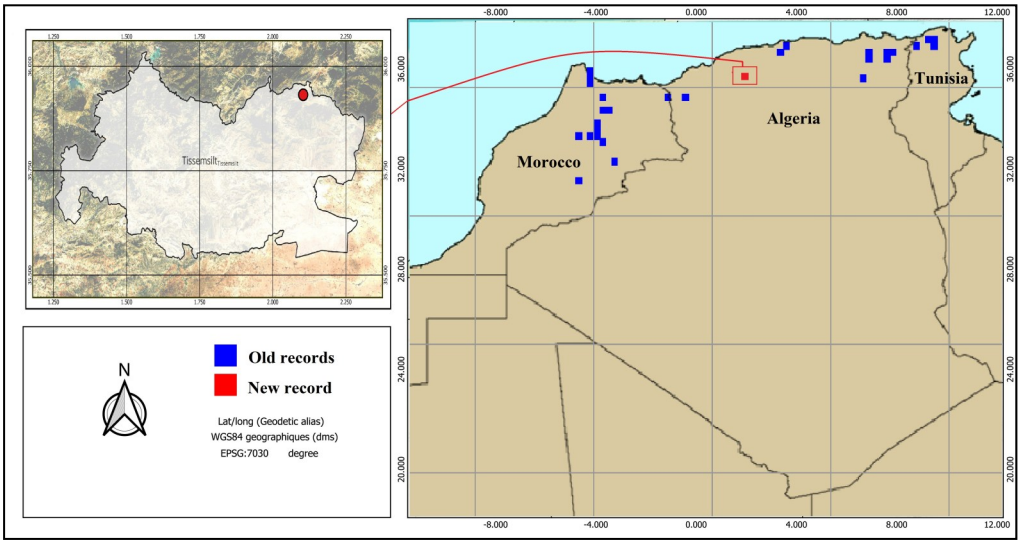

FIG. 1: Geolocation of the study area.

alba Linnaeus 1753, *Nerium oleander* Linnaeus 1753 and *Rubus fruticosus* Linnaeus 1753 (Fig. 2).

The region, where the wadi we studied flows, is located in a semi-arid bioclimatic zone with cold winters, characterised by a dry season from May to September and a wet season from October to April. Over the course of the year, temperatures generally range from -1°C to 33°C and rarely fall below -5°C or rise above 36°C, with July being the hottest month. Rainfall averages around 400 mm per year, with February being the wettest month. Wind speeds are highest in winter, exceeding 12.0 kph, and lowest in summer. The dominant winds are north-westerly, while south-westerly winds associated with the Sirocco occur for approximately 14 days per year (W.S. 2024).

Transect sampling

For odonates, we adopted the transect method, which involved a fixed transect 900 m long along a watercourse, visited at monthly intervals for a year, with visual counts of adult odonates and targeted searches for exuviae.

FIG. 2: General view of Oued El Ghergua, the new habitat of Calopteryx exul, municipality of Youssoufia- Tissemsilt, Algeria, (02-IX-2022). Photo: M.M.

In order to determine the properties of the water flowing in the wadi, physico-chemical parameters (water temperature, pH, TDS (Total Dissolved Solids), electrical conductivity and dissolved oxygen) were measured seasonally in situ using a YIERYI portable digital water quality analyser and a RCYAGO portable dissolved oxygen meter. For turbidity, B.O.D. (Biochemical Oxygen Demand) and C.O.D. (Chemical Oxygen Demand) water samples were taken at the same location for laboratory analysis. The main aim of these analyses is to find out the specific characteristics of the waters preferred by this species so that they can be compared later with other places where the probability of the species being present seems very high.

Samples were taken in a single location (35°56'07.0 'N 2°05'38.6 'E, Alt: 843 m), in four occasions, as follows: 1/1/2022, 3/4/2022, 5/7/2022 and 2/9/2022. Individuals of *C. exul* and other accompanying odonates were counted, identified and enumerated on photographic evidence using a Nikon P100 camera, zoom: X120, but never captured given their threatened protection status. The identity of the species has been confirmed by specialist Régis Krieg-Jacquier.

Results

Records

On 2/9/2022, a total of 19 individuals, 7♂ (Fig. 3) and 12♀ (Fig. 4), and 8 exuviae (Fig. 5) of *C. exul* were recorded in a 900 m section of the Oued El Gherga stream (from its point of contact with Oued El Assa to the point of contact with Oued Bourafedh), (Fig. 6). The odonatological assemblage found on the site consists of 12 species (Table 1), the most dominant being *Platycnemis subdilatata* Selys 1849, while,

FIG. 3: *Calopteryx exul* male, on Oued El Ghergua, the new habitat, municipality of Youssoufia- Tissemsilt, Algeria, (02-IX-2022). Photo: M.M.

FIG. 4: *Calopteryx exul* female, on Oued El Ghergua, the new habitat, municipality of Youssoufia- Tissemsilt, Algeria, (02-IX-2022). Photo: M.M.

FIG. 5: *Calopteryx exul* exuvia, on Oued El Ghergua, the new habitat, municipality of Youssoufia- Tissemsilt, Algeria, (02-IX-2022). Photo: M.M.

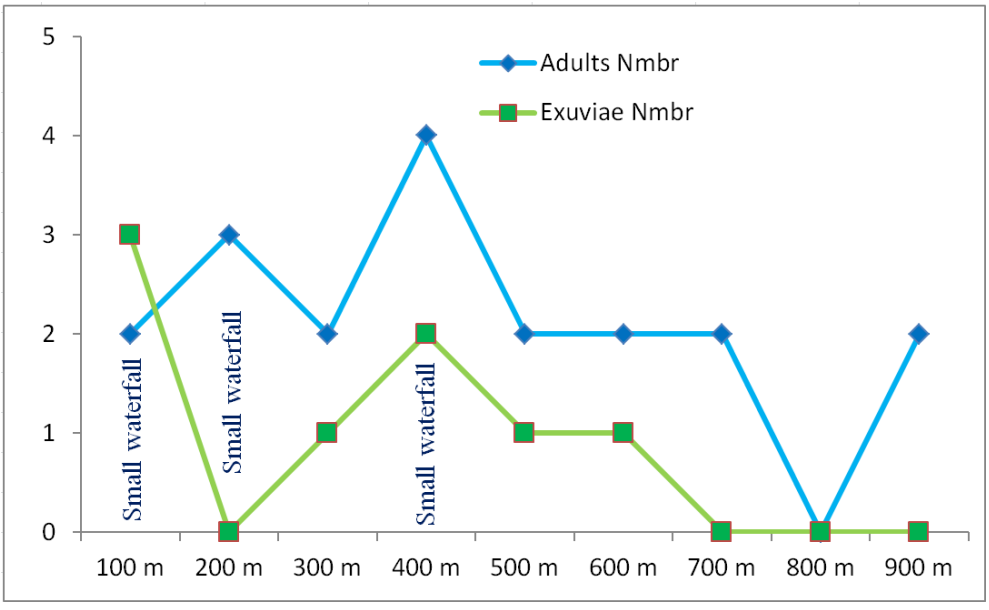

FIG. 6: Distribution of *C. exul* imagos and exuviae along the surveyed section.

Table 1. Dragonfly species observed in the study area.

Species	Abundance
Calopteryx haemorrhoidalis (Van Der Linden, 1825)	++++
Chalcolestes viridis (Vander Linden. 1825)	+++
Platycnemis subdilatata Selys, 1849	+++++
Aeshna mixta (Latreille, 1805)	++
Anax imperator Leach, 1815	++
Anax parthenope (Sélys, 1839)	++
Orthetrum cancellatum (Linnaeus, 1758)	+
Orthetrum brunneum (Fonscolombe, 1837)	+
Orthetrum chrysostigma (Burmeister, 1839)	++
Sympetrum fonscolombii (Sélys, 1840)	+
Trithemis annulata (Palisot de Beauvois, 1807)	++
Trithemis kirbyi (Sélys, 1891)	++

Orthetrum cancellatum (Linnaeus, 1758), *Orthetrum brunneum* (Fonscolombe 1837) and *Sympetrum fonscolombii* (Sélys 1840), were the least represented.

Habitat

The most important abiotic factor for larval development in odonates is water temperature. As temperatures rise, spring, with an average of 16.9°C, is the season when odonates begin to appear. A maximum average is recorded in summer at 23.7°C, while in winter, as the temperature drops to an average of 5.1°C, odonates disappear almost completely (Mairif et al. 2023). During autumn, the season in which *C. exul* was observed, the temperature was around 9.2°C.

The average pH of the water did not vary remarkably between seasons, ranging between 7.25 to 8.15. On the other hand, TDS varied from 278 ppm in winter to 1005 ppm in summer. Dissolved oxygen in the water varied from 6.6 mg/l in the summer to 9.1 mg/l in the winter and electrical conductivity between 425 and 1107 S/m, respectively. Water clarity was better in the summer (11.5 ntu), while opacity was high in the winter (190.3 ntu).

For organic pollution, the B.O.D. measurement showed values ranging from 3 to 10.5 mg O_2/L over the seasons and for C.O.D. the values varied from 18 to 57 mg O_2/L, which reflected moderate organic pollution in our wadi (Table 2).

Discussion

Historically, *Calopteryx exul* has marked its presence in several localities from east to west, namely: Oued Boumerzoug in Constantine (Sélys 1849, McLachlan 1897, Martin 1901), Between Blida and Media (Kolbe 1885), Sebdou, province of Tlemcen (Morton 1905). Algiers, O. El Guerra province of Taref, Rhummel, province of Mila (Martin 1910), the work of this author represents the last appearance of the species in Algeria, before its disappearance for almost a century. In the 21st century, several rediscoveries have been made since 2007, focusing on distinct subpopulations along Oued Seybouse (Khelifa et al. 2011,

Table 2. Variation in water parameters in Oued El Gherga, TDS: total Dissolved Solids, EC: electric conductivity, BOD: Biochemical Oxygen Demand, COD: Chemical Oxygen Demand.

	Water (°C)	TDS (ppm)	PH	E.C (S/m)	B.O.D (mg O_2/L)	C.O.D (mg O_2/L)	Dissolved oxygen	Turbidity (NTU)
Summer	23.7	1005	8.15	425	10.5	57	6.6	11.5
Autumn	9.2	512	7.51	780	5	27	7.9	108
Winter	5.1	278	7.25	1107	3	18	9.1	190.3
Spring	16.9	373	7.65	664	4.5	40.1	8.3	98.2

Khelifa et al. 2016). In 2019, at a distance of 240 km from Seybouse, three subpopulations were discovered at Oued Boussalem, Bejaia province (Chelli et al. 2019), the last population discovered in Algeria was in the Aurès mountains, precisely at Oued El Hamma, Khenchela province (Elafri 2022).

Over the last two decades, a number of studies on odonates have been carried out in the western part of the country, including Samraoui and Menaï 1999, Kabouche 2013, Senouci and Bounaceur 2018, Senouci and Bounaceur 2021, El Bouhissi et al. 2022 and Mairif et al. 2023, without any trace of the named species. From a regional perspective, the historical presence of *C. exul* in western Algeria was previously limited to a single record from Sebdou (Tlemcen), as reported by Morton (1905) based on M. Fountaine's collections. Notably, the species was absent from Morton's observations in Theniet El Had (Ouarsenis), despite the documentation of several other odonates there. Our discovery at Oued El Gherga represents a significant new record for the Ouarsenis region, previously unknown for this species. This new station is geographically isolated, situated 348 km from Oued Sebdou to the west, and at considerable distances from eastern populations: 230 km from Oued Bousselam (Bejaia), 432 km from Oued El Hamma (Khenchela), and 489 km from Oued Seybouse (Guelma). In terms of bioclimatic stage, the new station is located in a semi-arid stage with cold winters, with bioclimatic characteristics more or less similar to those of the Khenchela station (Aurès), the Sybouse station is located in the same bioclimatic stage with temperate winters, while the Bejaia station is located in the subhumid stage with warm winters, for the last decade (Fig. 7), from an altimetric point of view, the new station is at 987 m, almost the same altitude as the Aurès station at 876 m, while the Bejaia and Seybouse stations are at lower altitudes at 231 m and 221 m respectively (Fig. 8). According to Jacquemin and Boudot (1999), the species has marked its presence in North Africa at altitudes ranging from 200 to 2000 m. In terms of habitat, 9/19 individuals recorded were detected in the area of waterfalls (Fig 6), where the speed of water flow is higher, which confirms that fast-flowing streams are preferable for this species (Jacquemin and Boudot 1999, Khelifa 2013, Boudot 2018).

The observation of adults near water bodies is insufficient to confirm a species' permanent presence or reproductive success; thus, the collection of exuviae is essential for validating residency (Doucet, 2016). In this study, successful reproduction at Oued El Gherga was confirmed through photographic evidence of mating pairs (copulatory wheels; Fig. 9) and the presence of exuviae (Fig. 5). Notably, the flight period at this site was restricted to September, which represents a significant phenological shift compared to other Algerian populations. For instance, Khelifa (2013) reported a flight period from early May to late July for the Seybouse River, while in Bejaia, the species appears from mid-April to late May (Chelli et al. 2019).

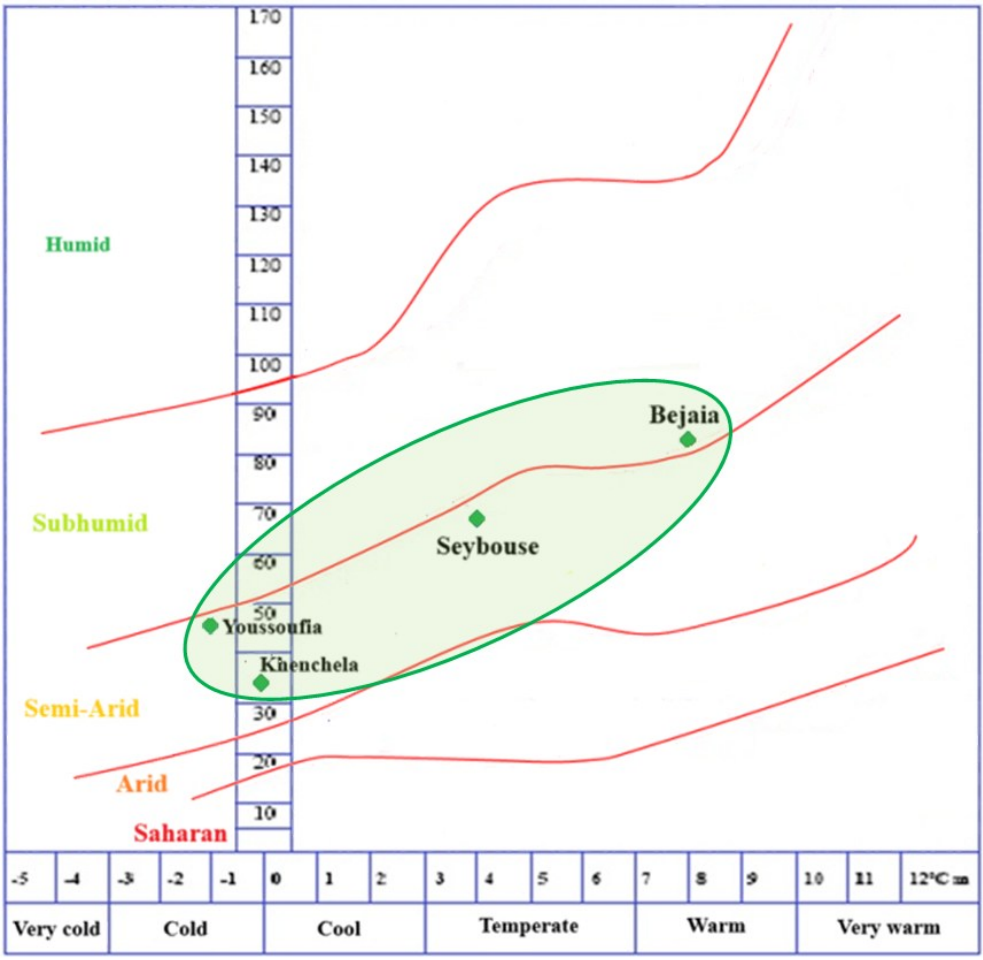

FIG. 7: Projection of *C. exul* stations discovered in the 21st century onto the Emberger's climagram.

Similarly, in the Aurès region, *C. exul* is active for three consecutive months, from April to June (Elafri 2022). The most likely explanation for this late flight is the combined effect of altitude and bioclimatic stage.

The odonatological assemblage associated with *C. exul* at O. El Gherga is made up of 12 taxa, with *Platycnemis subdilatata* being the most abundant species; it is completely different to those recorded at O. Seybouse with 35 species (Khelifa et al. 2011) and O. Bousselam with seven species (Chelli et al. 2019).

The physico-chemical composition and organic matter load of Oued El Gherga are similar to those recorded in the other water bodies. Neverthless, it is important to mention that at Oued El Gherga, the main challenge lies in the wastewater treatment plant and the purified water; currently the plant treats all incoming wastewater, however, with population increase and urbanisation expansion, with a clear impact on odonates (Hafernik and Reinhard 1995, Hannon and Hafernik 2007), it is becoming impossible to treat all incoming water. Moreover, while this wastewater de-

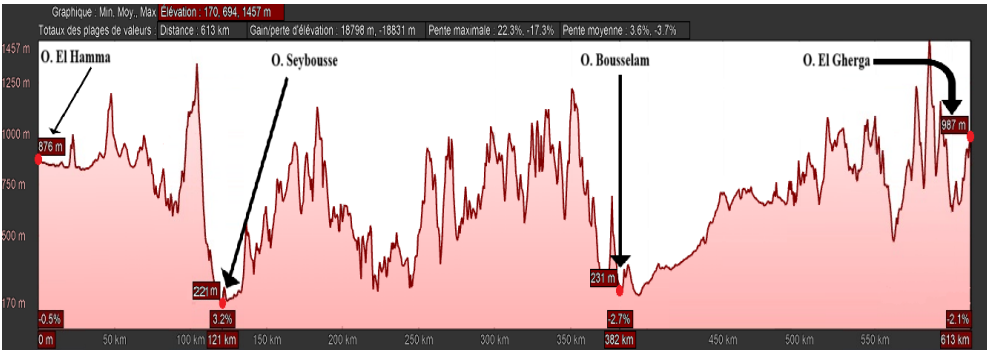

FIG. 8: Altitudinal profile of the *C. exul* stations discovered in the 21st century in Algeria.

rives only from domestic use, if industrial units are added in the future, the treated water poured into the wadi could lead to the disappearance of this protected species.

Although the discovery of this population is great news for a species threatened with extinction, *C. exul* is still exposed to many threats, especially as it is particularly sensitive to environmental changes (Chelli et al. 2020), firstly, the habitat destruction by construction of multiple bridges as part of the project to twin the NR14, which crosses the wadi on four occasions. These engineering structures have a negative impact on the species and on odonates as a whole

FIG. 9: Formation of the copilatory heart between pairs of *Calopteryx exul* on Oued El Ghergua, the new habitat, municipality of Youssoufia- Tissemsilt, Algeria, (02-IX-2022). Photo: M.M.

(Schutte et al. 1997). Pollution is another problem for *C. exul*, following the example of the cases reported at O. Seybouse and O. Bousselam (Khelifa et al. 2016, Khelifa and Mellal 2017, Chelli et al. 2019). Prolonged drought and the building of dykes to pump water to irrigate crops, directly affect odonate populations by lowering the water level and sometimes drying up the watercourse completely (Khelifa 2013, Khelifa et al. 2021). Generally speaking, in North Africa, human pressure on watercourses remains intense (Boudot et al. 2009). Faced with this situation, it is important to adopt a clear and effective protection policy, based on well-studied and well-defined strategies, both in terms of objectives and actions, in order to safeguard this threatened species in its natural habitat, by preserving the physical environment, in particular the vegetation, and maintaining the physico-chemical characteristics of the water in which it lives. In terms of existing protection measures, the species is included in the list of non-domestic species protected in Algeria (Decree 12-235), this protection must be preceded by a precise census in order to geo-locate the places where it exists, as well as the size of each population. Internationally, an IUCN red list summary sheet is reserved for this species (Boudot 2018). Encouraging for *C. exul* in the Ouarsenis is the fact that there are other unexplored lotic watercourses, such as O. Bouarbi, O. El Anser, O. El Kebir and O. El Hammam, which are not affected by human activity and are very well preserved, due to their distance from towns and security constraints, which makes them highly likely sites for this critically endangered species.

Although this discovery was not expected to form part of an exhaustive inventory of odonates in the province of Tissemsilt, it prompts us to consider extending the field of research to the whole of the province, and in particular to areas similar to that of the discovery, in the years to come.

In conclusion, after the station discovered in the far north, in the province of Bejaia with a subhumid climate in 2019, and the station discovered in the east of the country, more precisely in the province of Khenchela with a semi-arid climate in 2022, our station with a semi-arid climate represents the second record site of *C. exul* in the west of the country, more than a century after the first observation, which took place in 1905, in the region of Sebdou, in the province of Tlemcen. In Tissemsilt, the presence of permanently flowing wadis and the availability of running water, free of all kinds of pollutants, such as Oued El Ghargha, have enabled this zygopteran species to settle in and reproduce, resulting to a westwards extended current range. It is likely that this is not the only place in the province that harbours this species, as there are many similar permanent-flow wadis located mainly in the north-western part of the province, such as Oued Bouarbi, Oued Lardjem and Oued El Kebir, where we were unable to verify the presence or absence of the species, due to the unstable safety conditions in the region. Nevertheless, this observation remains very important and gives hope for a more stable status of this species in Algeria and North Africa in general.

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Conflict of interest

The author of the manuscript with the above title declares that they don't have any financial interests or personal relationships that could have direct or indirect effect on the work

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