
New data on the dragonfly fauna (Odonata) of the Moulouya River Basin and the Oriental Region, Morocco

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Taybi, A. F., Mabrouki, Y., Berrahou, A., Sbaa, M., Brochard, C., 2019. New data on the dragonfly fauna (Odonata) of the Moulouya River Basin and the Oriental Region, Morocco. *Arxius de Miscel·lània Zoològica*, 17: 85–108, Doi: <https://doi.org/10.32800/amz.2019.17.0085>

Abstract

New data on the dragonfly fauna (Odonata) of the Moulouya River Basin and the Oriental Region, Morocco. We present new faunistic and distributional data on dragonflies (Odonata) from the east of Morocco, comprising the administrative Oriental Region and the Moulouya River Basin and covering an area of 119,268 km². A checklist of 47 species belonging to 19 genera and seven families is provided. *Pseudagrion s. sublacteum* (Coenagrionidae), *Aeshna mixta* (Aeshnidae), *Sympetrum sinaiticum* and *S. meridionale* (Libellulidae) are new for Eastern Morocco, while *Paragomphus genei* (Gomphidae) is new for the Moulouya watershed. Our surveys yield evidence of breeding of *Zygonyx torridus* in the Moulouya River, of *Sympetrum sinaiticum* in the Oriental province, and also of *Boyeria Irene*, which remained unrecorded for more than three decades. We confirm the occurrence of *Brachythemis impartita* in the study area, by providing new sightings. Our results also revealed the range expansion of several other species whereas some previously known species in the region were not found. We found a clear dominance of the Palearctic elements, mainly Mediterranean, with a high proportion of Ibero–Maghrebian endemic species. This chorotype pattern is similar to patterns observed for other macroinvertebrate groups in the same study area.

Data published in GBIF (Doi: [10.15470/dikubb](https://doi.org/10.15470/dikubb))

Key words: Dragonflies, inventory, Eastern Morocco, Ramsar site, Nador lagoon, Monitoring, New records

Resumen

Nuevos datos sobre la fauna de libélulas (Odonata) de la cuenca del río Moulouya y la región oriental de Marruecos. Se ofrecen nuevos datos faunísticos y de distribución de libélulas (Odonata) en el este de Marruecos, en una zona que comprende la región administrativa Oriental y la cuenca del río Moulouya, con una extensión de 119.268 km². Se proporciona una lista de 47 especies pertenecientes a 19 géneros y siete familias. *Pseudagrion s. sublacteum* (Coenagrionidae), *Aeshna mixta* (Aeshnidae), *Sympetrum sinaiticum* y *S. meridionale* (Libellulidae) son nuevos registros en el este de Marruecos, mientras que *Paragomphus*

genei (Gomphidae) es un nuevo registro en la cuenca del Moulouya. Nuestros estudios evidencian la reproducción de *Zygonyx torridus* en el río Moulouya, de *Sympetrum sinaiticum* en la provincia Oriental y de *Boyeria irene*, del que no existían registros desde hace más de tres décadas. Confirmamos asimismo la presencia de *Brachythemis impartita* en la zona del estudio y ofrecemos datos sobre nuevas observaciones. Los resultados ponen también de manifiesto la expansión del hábitat de varias especies más, si bien otras previamente detectadas en la región no han podido observarse en esta ocasión. Constatamos un claro dominio de elementos paleárticos, principalmente mediterráneos, con una elevada proporción de especies endémicas ibero–magrebíes. Este patrón corotípico es similar a los observados en grupos de macroinvertebrados en la misma zona de estudio.

Datos publicados en GBIF (Doi: [10.15470/dikubb](https://doi.org/10.15470/dikubb))

Palabras clave: Libélulas, Inventario, Este de Marruecos, Emplazamiento de Ramsar, Laguna de Nador, Observación, Nuevos registros

Resum

*Noves dades sobre la fauna de libèl·lules (Odonata) de la conca del riu Moulouya i la regió oriental del Marroc. S'ofereixen noves dades faunístiques i de distribució de libèl·lules (Odonata) a l'est del Marroc, en una zona que comprèn la regió administrativa Oriental i la conca del riu Moulouya, amb una extensió de 119.268 km². Es proporciona una llista de 47 espècies pertanyents a 19 gèneres i set famílies. *Pseudagrion s. sublacteum* (Coenagrionidae), *Aeshna mixta* (Aeshnidae), *Sympetrum sinaiticum* i *S. meridionale* (Libellulidae) són nous registres a l'est del Marroc, mentre que *Paragomphus genei* (Gomphidae) és un nou registre a la conca del Moulouya. Els nostres estudis evidencien la reproducció de *Zygonyx torridus* al riu Moulouya, de *Sympetrum sinaiticum* a la província Oriental i de *Boyeria irene*, del qual no hi havia registres des de fa més de tres dècades. Confirmem així mateix la presència de *Brachythemis impartita* a la zona de l'estudi i oferim dades sobre noves observacions. Els resultats també posen de manifest l'expansió de l'hàbitat de diverses espècies més, si bé d'altres detectades prèviament a la regió no s'han pogut observar en aquesta ocasió. Constatem un clar domini d'elements paleàrtics, principalment mediterranis, amb una elevada proporció d'espècies endèmiques iberomagrebines. Aquest patró corotípico és similar als observats en grups de macroinvertebrats a la mateixa zona d'estudi.*

Dades publicades a GBIF (Doi: [10.15470/dikubb](https://doi.org/10.15470/dikubb))

Paraules clau: Libèl·lules, Inventario, Est del Marroc, Emplaçament de Ramsar, Llacuna de Nador, Observació, Nous registres.

Received: 25/03/2019; Conditional acceptance: 27/05/2019; Final acceptance: 06/06/2019

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Introduction

Our planet currently faces a rush of unprecedented extinctions due to anthropogenic activity, causing an irreversible loss of biological information with unpredictable consequences (Kerr and Currie, 1995; Rands et al., 2010). The extinction of thousands species and the degradation of natural ecosystems is expected in the coming decades (Western, 1992; Barnosky et al., 2011), including aquatic ecosystems. Continental freshwaters harbour a disproportionate amount of the world's biodiversity (Darwall et al., 2008). In consequence, the loss of biodiversity within inland waters would be much greater than in other ecosystems (Ricciardi and Rasmussen, 1999; Dudgeon, 2000; Dudgeon et al., 2006). Freshwater ecosystems are already degraded through a range of human activities, such as pollution from pesticides, wastewater, agricultural and mine run-off, and physical alteration through channelization and impoundments that impact heavily on hydrology and benthic habitats (Brautigam, 1999).

Several bio-assessment studies on aquatic ecosystems using macroinvertebrates communities in Eastern Morocco recently emerged with the aim of improving knowledge of species occurrence and distribution (Mabrouki et al., 2016a, 2017a, 2018a; Taybi et al., 2016a, 2017a, 2017b, 2018a), which is a prerequisite for biodiversity protection (Millán et al., 2014; Taybi, 2016).

Odonates constitute a privileged taxonomic group for the study and the conservation of aquatic environments thanks to good taxonomic knowledge and their well-known ecological requirements (Dommanget, 1989). Biologists are now considering dragonflies as convenient biological indicators of a healthy environment and recommend preservation of the habitats frequented by these insects (Degabriele, 2013). The dragonfly fauna of the Oriental Region in Morocco and the Moulouya River Basin are relatively well known, thanks to Jacquemin and Boudot, (1999), Boudot and De Knijf (2012) and El Haissoufi et al. (2015). Together, these authors have listed 43 species in the study area.

Despite these publications, knowledge on the occurrence of dragonflies from several rather inaccessible regions is still poor and some 'blank areas' persist. To fill this gap, several field surveys were conducted between 2014 and 2018, with 110 localities sampled all along the Moulouya River watershed, including the Anzegmir River (High Atlas slope), the Melloulou River (Middle Atlas slope) and the Za River (High Plateau). Other sampling stations cover the Oriental Region, ranging from Nador and Saidia in the north to Figuig and Bouanane in the south.

The main goal of this study was to increase knowledge of the dragonfly fauna of East Morocco, and to identify the chorotypes to which they belong.

Material and methods

Study area

Morocco is currently divided into 12 regions, including the Oriental Region (fig. 1), which occupies almost all the eastern side of the country and covers an area of 88,681 km² (see Taybi et al., 2017b for details). The Oriental Region includes the wilaya of Oujda (Oujda–Angad prefecture) and the provinces of Berkane, Driouch, Figuig, Guercif, Jerada, Nador and Taourirt. The watershed of the Moulouya (fig. 1), which includes nearly 43,412 km² of eastern Morocco, covers much of the Oriental Region. With a length of 600 km, the Moulouya is the largest Moroccan river and flows into the Mediterranean. Its main tributaries are the Oueds Ansegmir, Melloulou, Za and Msoun, all permanent. Other tributaries are presently intermittent (3–5 flash floods on average per year) (Bensaad et al., 2017; Mabrouki et al., 2017b).

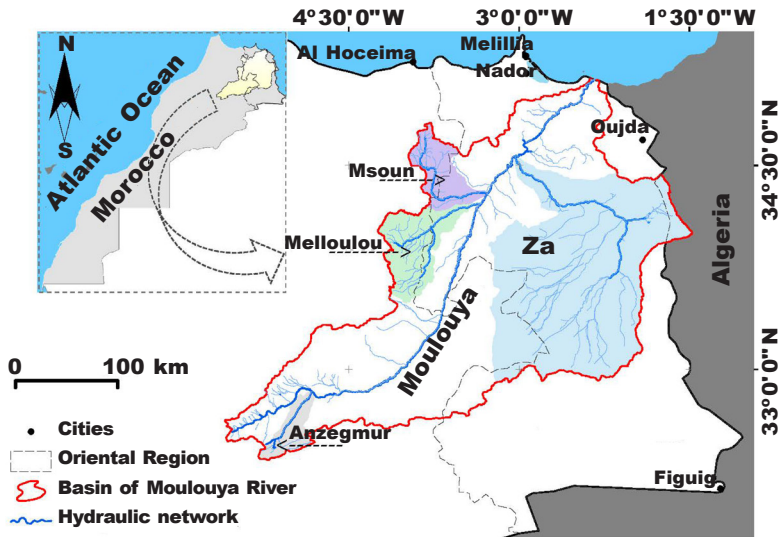


Fig. 1. Location of the Oriental Region of Morocco and of the Moulouya River Basin with details of the main tributaries.

Fig. 1. Localización de la Región Oriental de Marruecos y de la cuenca del río Moulouya con detalles de los principales tributarios.

Sampling

During field surveys conducted from 2014 to 2018 more than 100 localities were investigated in the Moulouya River Basin and the Oriental Region (see appendix for the complete list of localities). Most of these sampling sites were visited at least three times.

The samples of benthic fauna (including Odonata larvae) were collected using kick nets and landing nets, exuviae were collected from the riparian and shoreline vegetation using clamps, and adults were caught by entomological hand nets. Samples were identified to species level, placed in labelled tubes with 70 % or 96 % ethanol, and deposited in the collections of aquatic macroinvertebrates at the Laboratory of Water Sciences, Environment and Sustainable Development of the University Mohammed Premier from Oujda (Morocco). Most of the adults were identified in the field and released soon after.

Abbreviations

#, the species new for Moulouya River Basin; * species for the entire area; M, localities at the Moulouya River; S, localities at the Melloulou River; Z, localities at the Za River; N, localities in Nador province; O, localities in the Oujda province; F, localities in the Figuig province; IUCN, International Union for Conservation of Nature.

Results

Thirty-nine species, belonging to 19 genera and seven families, were recorded during this study, so that the checklist of species ever found in the studied region is 47 (GBIF dataset: [10.15470/dikubb](https://doi.org/10.15470/dikubb)).

Family Calopterygidae

***Calopteryx haemorrhoidalis* (Vander Linden, 1825)**

Material examined: M3, 03–V–14 (2 males, 1 female); M7, 02–V–14 (1 male); M20, 23–VI–14 (1 female); M21, 23–VI–14 (1 male); M22, 23–VI–14 (1 female); S1, 27–III–14 (1 male); S4, 22–III–14 (2 females); O1, 27–IV–16 (2 males); O3, 28–IV–16 (2la); O4, 28–IV–16 (1 male, 2 larvae); O5, 30–VI–18 (2 males); O12, 01–II–15 (3 males, 4 females); O13, 01–II–15 (2 males); O20, 18–XI–15 (1 female); O21, 31–V–17 (3 females); N3, 02–V–16 (5 males, 6 females, 1 larva); N4, 30–IV–16 (>10 males, >10 females); N15, 13–VIII–18 (10 males, 12 females); N25, 13–VIII–18 (3 males, 2 females).

Distribution: West Mediterranean species with Atlantic extension. In Morocco, it is described as very common and widespread in the northern part of the country, including the area studied (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). Figure 2 shows the present and previously published records of this species in the area studied.

Family Lestidae

***Lestes barbarus* (Fabricius, 1798)**

Material examined: M2, 03–V–14 (3 larvae); M19, 22–VI–14 (1 male); Z3, 19–III–14 (1 male).

Distribution: Holo-Mediterranean species with oriental extension. In Morocco, it is known from the northern part of the country (Jacquemin and Boudot, 1999). In the Moulouya watershed, it has been reported around Tafrante spring (Boudot and De Knijf, 2012). During the sampling period, *L. barbarus* was found in the upper Moulouya and Za, and near the Sebra River (fig. 2).

***Chalcolestes viridis* (Vander Linden, 1825)**

Material examined: M4, 03–V–14 (1 male, 3larvae); M5, 02–V–14 (2 males, 1 female); S8, 08–VI–14 (1 male); S9, 15–VIII–14 (1 female); O1, 27–IV–16 (2 males, 1 female); O9, 19–IX–15 (1 male); O12, 01–II–15 (2 females); O22, 31–V–17 (3 males, 1 female); N14, 28–VIII–18 (1 male); N15, 13–VIII–18 (1 male, 2 females); N30, 03–IX–18 (3 males, 4 females).

Distribution: West-Palaearctic species. In Morocco, it is considered common in the northern part of the country (Jacquemin and Boudot, 1999). In the Moulouya watershed, the species seems to be confined to the Beni Snassen Mountains and is known only from the Zegzel valley (Boudot and De Knijf, 2012). Figure 2 shows the present and previously published records of this species in the area studied.

***Sympecma fusca* (Vander Linden, 1820)**

Material examined: M1, 03–V–14 (2 larvae); M3, 03–V–14 (3 larvae).

Distribution: Western Palaearctic species distributed in Morocco in the northern part of the country (Jacquemin and Boudot, 1999). In the Moulouya watershed, it was recently reported at Anzegmir (Boudot and De Knijf, 2012) and this distribution is confirmed here by our records from the Upper Moulouya (fig. 2).

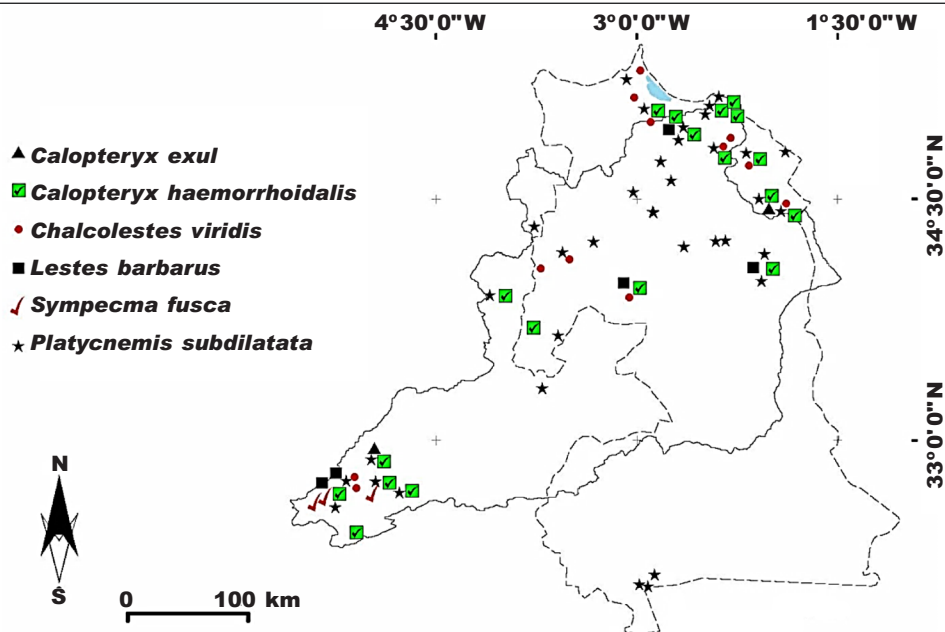


Fig. 2. Distribution of the known records of Calopterygidae, Lestidae and Platycnemididae species in the study area (present and previously published information).

Fig. 2. Distribución de los registros conocidos de especies de Calopterygidae, Lestidae y Platycnemididae en el área de estudio (información actual y publicada anteriormente).

Family Coenagrionidae

Ceriagrion tenellum (Villers, 1789)

Material examined: M3, 03–V–14 (3 larvae); M5, 02–V–14 (2 males, 2 larvae); M9, 14–VI–14 (1 male); M11, 14–VI–14 (1 male); M20, 23–VI–14 (3 males, 1 female); M21, 23–VI–14 (1 male); Z9, 07–VIII–14 (3 males, 4 females); O5, 30–VI–18 (2 females); O17, 27–VII–16 (1 male); N4, 17–VIII–18 (> 10 males, > 10 females); N5, 10–VIII–18 (1 male); N14, 28–VIII–18 (1 male); N15, 13–VIII–18 (6 males, 6 females); N25, 13–VIII–18 (3 males); N27, 19–VIII–18 (2 females); N30, 03–IX–18 (5 males).

Distribution: Western Mediterranean. The species seems to be confined to northern Morocco (Jacquemin and Boudot, 1999). In the Moulouya watershed it has already been reported in the watersheds of the Zegzel, Anzegmir and Boulojoul rivers (Boudot and De Knijf, 2012). The species is found throughout the studied area (fig. 3).

Coenagrion caerulescens (Fonscolombe, 1838)

Material examined: M1, 03–V–14 (3 larvae); M2, 03–V–14 (4 larvae); M4, 03–V–14 (1 male); M5, 02–V–14 (3 males); M19, 22–VI–14 (2 males, 2 females); M10, 14–VI–14 (1 male, 2 females, 2 larvae); Z3, 19–III–14 (2 males, 3 females, 2 larvae); Z8, 17–V–14 (2 females); Z9, 07–VIII–14 (4 males, 6 females, 3 larvae); Z10, 19–VII–14 (3 males); O1, 27–IV–16 (3 males, 3 females); O12, 01–II–15 (1 male); O15, 06–VI–16 (4 males, 3 fema-

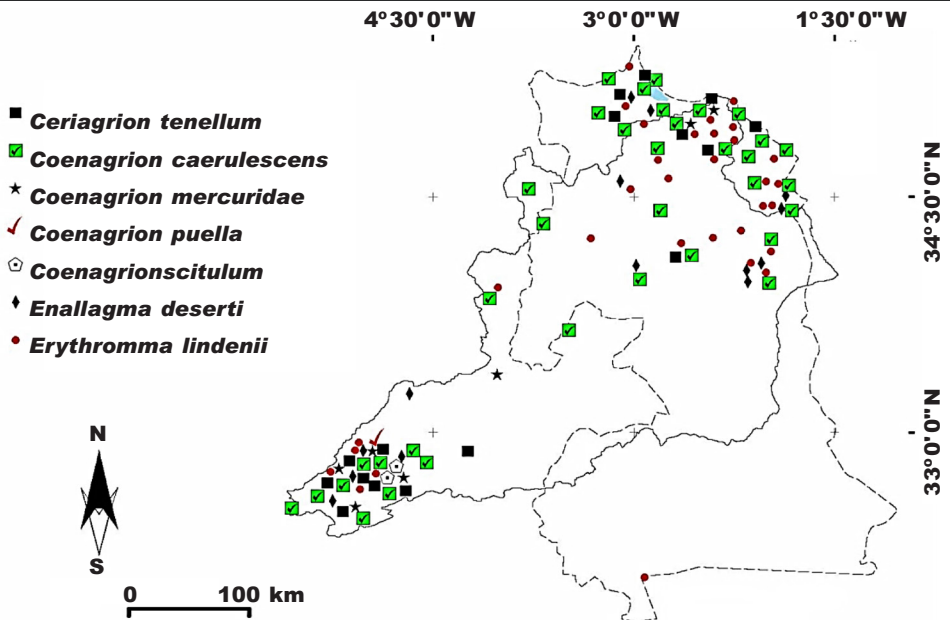


Fig. 3. Distribution of the known records of Coenagrionidae species in the study area (present and previously published information).

Fig. 3. Distribución de los registros conocidos de especies de Coenagrionidae en el área de estudio (información actual y publicada anteriormente).

les); O16, 17–VII–16 (>20 males, >20 females); O17, 27–VII–16 (1 female); O20, 29–V–17 (2 males, 3 females); O22, 31–V–17 (6 males, 7 females); O25, 20–III–18 (6 males, 5 females); N3, 02–V–16 (4 males, 5 females); N4, 17–VIII–18 (10 males, 12 females); N14, 28–VIII–18 (4 males, 3 females); N15, 13–VIII–18 (5 males, 2 females); N20, 04–X–17 (2 males); N23, 07–X–17 (1 male); N25, 13–VIII–18 (4 males, 3 females); N30, 03–IX–18 (3 males, 6 females).

Distribution: West Mediterranean species and the most abundant and most widespread *Coenagrion* in Morocco (Jacquemin and Boudot, 1999), including the area studied (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). Figure 3 shows the present and previously published records of this species in the area studied.

***Enallagma deserti* (Selys, 1871)**

Material examined: M2, 03–V–14 (1 female); M5, 02–V–14 (1 male); O2, 27–IV–16 (1 female); O10, 18–XI–15 (2 males, 1 female); O16, 17–VII–16 (2 males, 3 females); N3, 02–V–16 (1 male); N30, 03–IX–18 (3 males, 1 female).

Distribution: Maghrebian endemic species widely distributed in northern Morocco (Jacquemin and Boudot, 1999). In the studied area, the species was recorded from the upper Moulouya and Za rivers (Boudot and De Knijf, 2012) and now in the eastern Middle Atlas, in the vicinity of Debdou, Oujda, and finally at Nador Mount (fig. 3).

***Erythromma lindenii* (Selys, 1840)**

Material examined: M4, 03–V–14 (5 larvae); M5, 02–V–14 (6 larvae); Z1, 19–III–14 (1 male, 2 larvae); Z2, 19–III–14 (1 male, 3 females, 3 larvae); Z4, 19–III–14 (1 male); Z5,

17–V–14 (1 male, 6 females); Z7, 17–V–14 (4 males, 5 females); Z8, 17–V–14 (3 males, 4 females); Z12, 19–VII–14 (3 males, 2 females); O4, 28–IV–16 (2 females); O5, 30–VI–18 (2 males); O7, 14–IV–18 (2 males, 1 female); O9, 19–IX–15 (3 males, 4 females); O11, 18–XI–15 (1 male); O16, 17–VII–16 (4 males, 5 females); O19, 20–VII–17 (1 male); O21, 31–V–17 (3 males, 4 females); N4, 17–VIII–18 (7 males, 3 females); N14, 28–VIII–18 (2 females); N27, 19–VIII–16 (1 male, 2 females).

Distribution: Holo-Mediterranean species, widely distributed and very common throughout Morocco, including the study area (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). Figure 3 shows the present and previously published records of this species in the area studied.

Pseudagrion s. sublacteum* (Karsch, 1893)

Material examined: N27, 19–VIII–16 (1 male, 1 female).

Distribution: the only Moroccan currently known species of the large genus *Pseudagrion*. *Pseudagrion sublacteum* is an Ethiopian species showing isolates in Morocco and (under *P. s. murtoni* Schmidt in Ris, 1936) the Levant, which are remnants of an ancient continuous range dating from past pluvial periods, subsequently fragmented by the aridification of the Sahara during the second half of the Holocene (Jacquemin and Boudot, 1999; Boudot et al., 2009). Until now it was known only more to the west in the Fez–Meknes, Rabat–Salé–Kenitra, Beni–Mella–Khénifra and Marrakech–Safi Regions (Jacquemin and Boudot, 1999; Boudot et al., 2009) and so it is new for the Oriental Region at a small tributary of the Selouane River near La'azib (fig. 4).

***Ischnura graellsii* (Rambur, 1842)**

Material examined: M19, 22–VI–14 (3 males, 4 females, 6 larvae); M20, 23–VI–14 (1 male, 3 females, 2 larvae); M21, 23–VI–14 (2 males, 4 females); M22, 23–VI–14 (1 male); Z12, 19–VII–14 (4 males, 6 females); O3, 28–IV–16 (2 males, 1 female); O4, 28–IV–16 (3 males); O5, 30–VI–18 (3 females); O8, 22–II–16 (2 males); O14, 06–VI–16 (1 male); O16, 17–VII–16 (10 males, 13 females); O17, 27–VII–16 (3 males); N1, 17–VIII–18 (1 male, 1 female); N2, 01–V–16 (3 larvae); N3, 02–V–16 (7 males, 3 females); N4, 17–VIII–18 (> 10 males, > 10 females); N11, 31–VIII–18 (3 males, 1 female); N14, 28–VIII–18 (3 males, 3 females); N15, 13–VIII–18 (> 10 males, > 10 females); N23, 07–X–17 (2 females); N24, 08–X–17 (1 male); N30, 03–IX–18 (4 males, 4 females).

Distribution: strict West Mediterranean species, limited to the Iberian Peninsula and the Maghreb. In Morocco, it is extremely common throughout the North and West of the country (Jacquemin and Boudot, 1999). The species is thus ubiquitous throughout the Moulouya Basin, where it is well established from the estuary and coastal marshes to the eastern High Atlas (Boudot and De Knijf, 2012). Figure 4 shows the present and previously published records of this species in the area studied.

***Ischnura saharensis* Aguesse, 1958**

Material examined: M4, 03–V–14 (1 male); M11, 14–VI–14 (2 males); M14, 14–VI–14 (2 males, 1 female); M18, 22–VI–14 (3 females); Z2, 19–III–14 (2 males, 1 female, 5 larvae); Z3, 19–III–14 (4 larvae); Z4, 19–III–14 (5 larvae); Z7, 17–V–14 (1 male); Z9, 07–VIII–14 (> 20 males, > 20 females, 10 larvae); Z10, 19–VII–14 (3 males, 4 females); S8, 08–VI–14 (2 males, 1 female); S9, 15–VIII–14 (1 female); S10, 15–VIII–14 (2 females); S11, 15–VIII–14 (2 males); O2, 27–IV–16 (3 males, 4 females); O11, 18–XI–15 (3 females); O14, 06–VI–16 (1 female); O16, 17–VII–16 (> 20 males, > 20 females); O17, 27–VII–16 (2 males); O20, 29–V–17 (1 male, 3 females); O25, 20–III–18 (13 males, 12 females); F9, 22–XI–16 (7 males, 6 females).

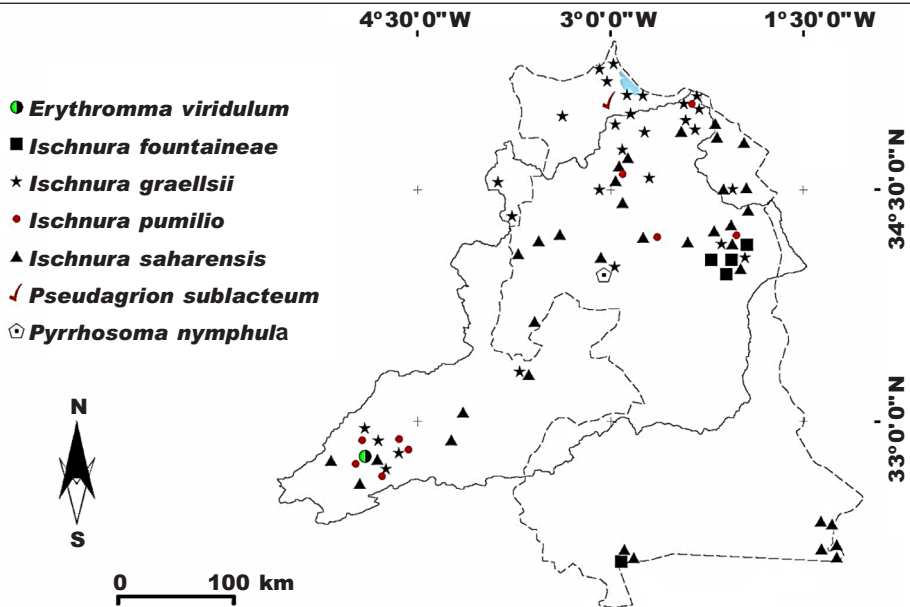


Fig. 4. Distribution of the known records of Coenagrionidae species in the study area (present and previously published information).

Fig. 4. Distribución de los registros conocidos de especies de Coenagrionidae en el área de estudio (información actual y publicada anteriormente).

Distribution: this *Ischnura* is a Saharan and Sub-Saharan endemic which reaches eastern Libya, Niger and northern Chad (Dumont, 2014; Boudot and Kalkman, 2015). It is widespread and common throughout Morocco, including the Oriental Region and the Moulouya River Basin (Boudot and De Knijf, 2012). Figure 4 shows the present and previously published records of this species in the area studied.

Family Platycnemididae

Platycnemis subdilatata (Selys, 1849)

Material examined: M2, 03-V-14 (7 larvae); M4, 03-V-14 (6 larvae); M19, 22-VI-14 (1 male, 3 larvae); Z1, 19-III-14 (8 larvae); Z3, 19-III-14 (2 larvae); Z6, 17-V-14 (2 females); Z8, 17-V-14 (1 male, 3 females); Z9, 07-VIII-14 (2 males); Z10, 19-VII-14 (1 female); S9, 15-VIII-14 (1 male); S10, 15-VIII-14 (2 females); S11, 15-VIII-14 (1 male, 2 females); O4, 28-IV-16 (1 female); O7, 14-IV-18 (2 males, 1 female); O10, 18-XI-15 (2 males); O25, 20-III-18 (3 males, 2 females); N3, 02-V-16 (2 males); N11, 31-VIII-18 (1 female); N23, 07-X-17 (1 male, 3 females); F9, 22-XI-16 (1 male).

Distribution: Maghrebian endemic widely distributed from northern Morocco to northern Tunisia (Jacquemin and Boudot, 1999; Boudot and Kalkman, 2015). It is common throughout Morocco, including the Oriental Region and the Moulouya River Basin (Boudot and De Knijf, 2012). Figure 2 shows the present and previously published records of this species in the area studied

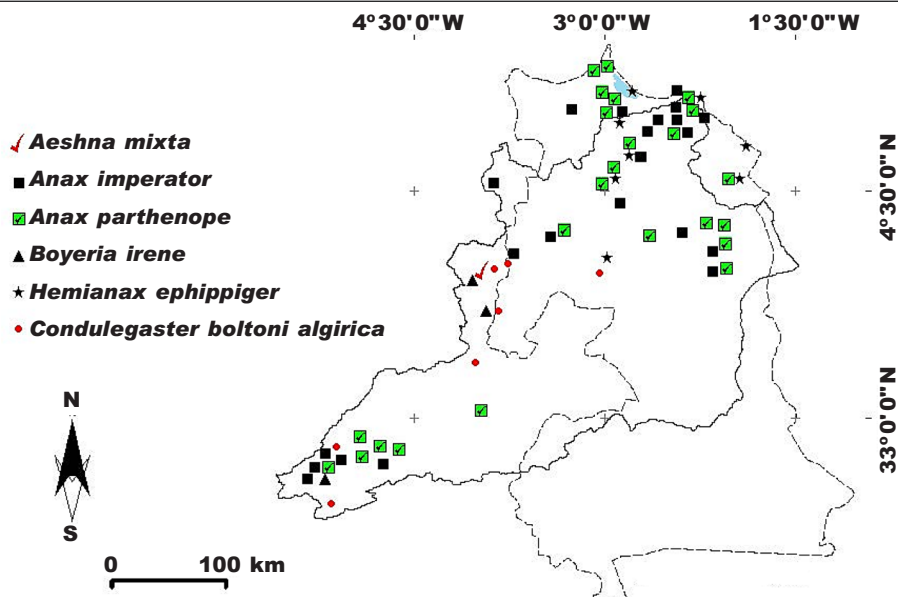


Fig. 5. Distribution of the known records of the Aeshnidae and Cordulegastridae species in the study area (present and previously published information).

Fig. 5. Distribución de los registros conocidos de especies de Aeshnidae y Cordulegastridae en el área de estudio (información actual y publicada anteriormente).

Family Aeshnidae

Aeshna mixta Latreille, 1805 *

Material examined: S2, 23–III–14 (1 female, 3 larvae).

Distribution: Euro–Siberian species well established in the Mediterranean Basin. In Morocco, it has been reported from the Middle Atlas, the Coastal Meseta, the Central Plateau and the Rif (Jacquemin and Boudot, 1999; El Haissoufi et al., 2015). *Aeshna mixta* is new for the Moulouya Basin and the whole Eastern Morocco, where it was found in the upper Melloulou River in the easternmost part of the Middle Atlas (fig. 5).

Anax imperator Leach, 1815

Material examined: M1, 03–V–14 (1 male, 1 larvae); M3, 03–V–14 (1 exuvia); M5, 02–V–14 (1 male); M15, 24–V–14 (1 female); M19, 22–VI–14 (1 larva); M21, 23–VI–14 (1 male); Z1, 19–III–14 (1 larva); Z5, 17–V–14 (1 male); Z7, 17–V–14 (1 exuvia); Z10, 19–VII–14 (1 female); S8, 08–VI–14 (1 male); S10, 15–VIII–14 (1 females, 1 larva); O15, 06–VI–16 (2 males, 1 female); N15, 13–VIII–18 (1 male, 1 female).

Distribution: Afro–European species. In Morocco, it is considered one of the most common and frequent Anisoptera in the country (Jacquemin and Boudot, 1999), and this applies also to the Moulouya watershed and the Oriental Region (Boudot and De Knijf, 2012). Figure 5 shows the present and previously published records of this species in the area studied.

***Anax parthenope* Selys, 1839**

Material examined: M4, 03–V–14 (1 female, 1 exuvia); M12, 14–VI–14 (2 females); M16, 24–V–14 (1 male, 1 female, 1 larva); Z2, 19–III–14 (1 male, 1 female); Z3, 19–III–14 (2 males); Z9, 07–VIII–14 (3 males, 3 females, 3 larvae, 1 exuvia); O5, 30–VI–18 (1 male); O16, 17–VII–16 (2 males, 2 females, 1 exuvia); N1, 17–VIII–18 (5 males, 6 females); N4, 17–VIII–18 (2 males, 1 female); N14, 28–VIII–18 (2 males); N20, 04–X–17 (1 female); N30, 03–IX–18 (1 male).

Distribution: Palearctic species reaching eastern Asia. *Anax parthenope* is widespread throughout Morocco, including the area studied here (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). Figure 5 shows the present and previously published records of this species in the area studied.

***Boyeria irene* (Fonscolombe, 1838)**

Material examined: S1, 27–III–14 (2 larvae); S4, 22–III–14 (1 larva).

Distribution: West Mediterranean species. In Morocco, *B. irene* is known from the Middle Atlas, the High Atlas, the Anti-Atlas and the Rif (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). In the Moulouya Basin, although *B. irene* was detected previously in the Kiss River between Boumia and Kerrouchen by Jacquemin and Boudot (1999), no imago has since been found in the region. However, the larvae of this large species, which are easy to identify in the field, were found in the upper Melloulou River Basin, in small spring brooks flowing into the main stream (Oued El Bared and Berkine rivers), in the easternmost Middle Atlas (fig. 5).

***Hemianax ephippiger* (Burmeister, 1839)**

Material examined: O2, 27–IV–16 (1 male); O7, 14–IV–18 (1 male); O16, 17–VII–16 (1 male); O25, 20–III–18 (1 female); N25, 13–VIII–18 (1 male, 1 female); N29, 01–IX–18 (1 male).

Distribution: This species is found throughout intertropical Africa, the Arabian Peninsula and the Mediterranean Basin and its annual long distance migrations allowed it to sporadically reach Iceland, South America, the Caribbean (Lambret and Boudot, 2013), Thailand and Japan. It is widely distributed throughout Morocco (Jacquemin and Boudot, 1999) although most previous records came from the Atlantic coast and from the southern foothills of the Atlas, where the species spends a part of the winter on the wings on the northern fringe of the Sahara, waiting for higher temperatures to cross the mountains to the north. The first record of an autochthonous population from the Moulouya watershed is recent, with two freshly emerged males and numerous exuviae found at the Mechra Hammadi and Mohammed V dam lakes (Boudot and De Knijf, 2012). During our study, *H. ephippiger* was found near Debdou, Oujda and in the brackish wetlands surrounding Saidia, Nador Lagoon and even on its dune cord (fig. 5).

Family Gomphidae

***Gomphus simillimus maroccanus* Lieftinck, 1966**

Material examined: M11, 14–VI–14 (3 larvae); M14, 14–VI–14 (2 larvae); M21, 23–VI–14 (1 female); Z3, 19–III–14 (4 larvae); O1, 27–IV–16 (1 female); O9, 19–IX–15 (1 male, 1 larva); N15, 13–VIII–18 (1 female); N23, 07–X–17 (2 larvae).

Distribution: Maghrebian endemic. *G. simillimus maroccanus* is widespread in the northern part of Morocco (Jacquemin and Boudot, 1999), including the area studied (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). In full agreement with this general distribution, we recorded it for the first time in the catchment area of the Nador lagoon and Msoun rivers (fig. 6).

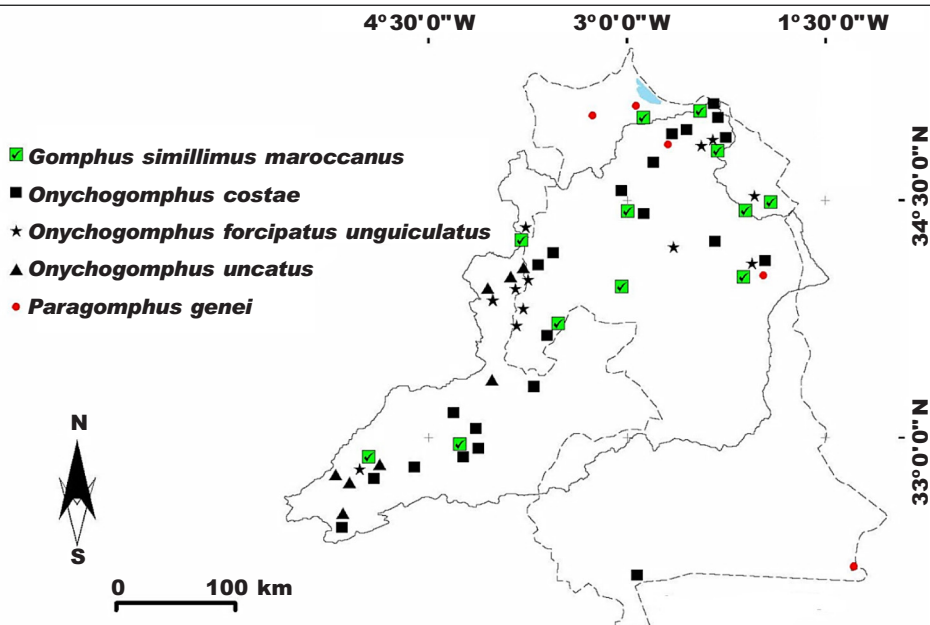


Fig. 6. Distribution of the known records of the Gomphidae species in the study area (present and previously published information).

Fig. 6. Distribución de los registros conocidos de especies de Gomphidae en el área de estudio (información actual y publicada anteriormente).

***Onychogomphus costae* Selys, 1885**

Material examined: M7, 02–V–14 (3 larvae); M10, 14–VI–14 (1 larva); M13, 14–VI–14 (1 larva); M17, 07–VII–14 (2 larvae); M20, 23–VI–14 (1 female); Z4, 19–III–14 (2 females); Z6, 17–V–14 (1 male); S8, 08–VI–14 (6 larvae); S9, 15–VIII–14 (3 larvae); O22, 31–V–17 (1 female, 1 larva).

Distribution: Ibero–Maghrebian species. In Morocco, *O. costae* is well scattered throughout the northern part of the country (Jacquemin and Boudot, 1999). It is widely distributed in the Moulouya watershed and in the Oriental Region (Boudot and De Knijf, 2012). Findings from this study greatly increase its range in the Oriental Region and the catchment area of the Moulouya (fig. 6).

***Onychogomphus forcipatus unguiculatus* (Vander Linden, 1820)**

Material examined: M10, 14–VI–14 (1 female, 2 larvae); Z9, 07–VIII–14 (1 male); S1, 27–III–14 (1 male, 3 females, 3 larvae, 1 exuvia); S2, 23–III–14 (1 female, 2 larvae, 3 exuvia); S3, 23–III–14 (1 female, 3 larvae); S4, 22–III–14 (4 larvae); S5, 15–VI–14 (1 female, 1 larva); S6, 08–VI–14 (1 male); S7, 08–VI–14 (2 larvae); N23, 07–X–17 (1 female).

Distribution: West–Mediterranean endemic. This species is widely distributed in northern Morocco (Jacquemin and Boudot, 1999). In the area studied, it was reported in the east of the Middle Atlas, and the Za, Isly and Zegzel rivers (Jacquemin and Boudot, 1999, Boudot and De Knijf, 2012). We found it very abundant in the Oriental Region and in the Moulouya Basin, especially in the upper Melloulou River catchment (fig. 6).

***Onychogomphus uncatus* (Charpentier, 1840)**

Material examined: M5, 02–V–14 (1 female); M8, 02–V–14 (1 male); S2, 23–III–14 (1 male, 1 larva); S3, 23–III–14 (1 male).

Distribution: West Mediterranean species. In Morocco, this species is mainly mountainous (Jacquemin and Boudot, 1999) as it favours swift waters. In the area studied, *O. uncatus* was previously reported at Outat El Haj and in the east of the Middle Atlas (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). We found it in the upper Moulouya and Melloulou rivers (fig. 6).

***Paragomphus genei* (Selys, 1841) #**

Material examined: M19, 22–VI–14 (1 male); Z3, 19–III–14 (1 larva); N1, 17–VIII–18 (2 males); F5, 22–V–16 (3 larvae).

Distribution: Afrotropical species scattered in northern Morocco only (Boudot et al. 2009; Boudot and De Knijf, 2012; Boudot and Kalkman, 2015). The record of *P. genei* from the Oriental Region is very recent, reported in the easternmost part of the Rif (El Haissoufi et al., 2015) and in the very south close to the Algerian border near Bouanane (Boudot and Kalkman, 2015). We found it as a new species for the Moulouya watershed, with larvae found at the Abbou Lekhal (Figuig area) and Lakhrouf rivers (Za watershed), while two males were found near the Sebra river and near Nador within the Eastern Rif (fig. 6).

Family Cordulegastridae***Cordulegaster boltonii algerica* Morton, 1916**

Material examined: M4, 03–V–14 (1 male); M7, 02–V–14 (1 male); S2, 23–III–14 (1 female); S4, 22–III–14 (1 male); S6, 08–VI–14 (1 male).

Distribution: Maghrebien endemism. In Morocco, most of the populations known to date on this lotic species belonged to the central–western Rif and the eastern Middle Atlas with the easternmost localities recently reported from Debdou surroundings on the northern escarpment of the Rekkam Plateau (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). We found it associated with mountainous areas in the upper Anzegmir and Melloulou Basins and in the upper Moulouya (fig. 5).

Family Libellulidae***Brachythemis impartita* (Karsch, 1890)**

Material examined: M18, 22–VI–14 (1 male); Z9, 07–VIII–14 (1 male); N15, 13–VIII–18 (2 males, 1 female).

Distribution: Afrotropical species with South–European extension species. The main range of *B. impartita* covers a large part of sub–Saharan Africa north of the Congo Democratic Republic. The species shows a second range north of the Sahara in the Mediterranean, namely in the Maghreb, Spain, Portugal, Sicily, Sardinia, Cyprus, and in the Levant. Both ranges are connected by the Nile valley, where the species is well established. Its close relative, *B. leucosticte*, occurs in most of the southern half of Africa and Madagascar (Dijkstra and Matushkina, 2009) and both species overlap in the middle part of the African continent. The occurrence of *B. impartita* in Eastern Morocco from the lower Moulouya Basin at the Mechra Hammadi dam lake and ex–Hassan II reservoir on Oued Za to the Algerian border at a small dam lake on the Douis River in the Oued Zelmou Basin near Bouanane (SW Figuig province) (Boudot and De Knijf, 2012) was confirmed by our new records at the Arabat or Ouled Settout dam near Nador (fig. 9).

***Crocothemis erythraea* (Brullé, 1832)**

Material examined: M4, 03–V–14 (1 male, 1 exuvia); M5, 02–V–14 (2 males, 1 female, 1 larva); M17, 07–VII–14 (2 males); M19, 22–VI–14 (1 female, 2 larvae); M21, 23–VI–14 (2

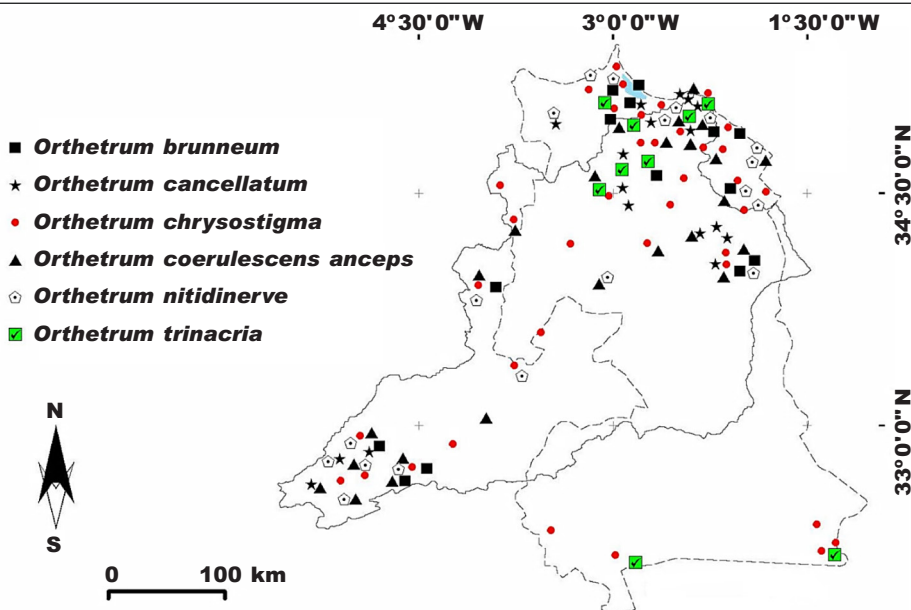


Fig. 7. Distribution of the known records of Libellulidae species in the study area (present and previously published information).

Fig. 7. Distribución de los registros conocidos de especies de Libellulidae en el área de estudio (información actual y publicada anteriormente).

males); Z1, 19–III–14 (1 male, 1 female, 2 larvae); Z3, 19–III–14 (2 larvae); Z9, 07–VIII–14 (3 males, 2 females); S7, 08–VI–14 (1 male); S9, 15–VIII–14 (2 females); S10, 15–VIII–14 (1 male); O9, 19–IX–15 (2 males, 1 female); O16, 17–VII–16 (5 males, 3 females); O18, 27–VIII–16 (3 males, 4 females); O21, 31–V–17 (1 male); O24, 02–VI–16 (1 male); O25, 20–III–18 (3 males, 3 females); N1, 17–VIII–18 (4 males, 3 females); N5, 10–VIII–18 (1 male); N12, 12–V–16 (1 male); N15, 13–VIII–18 (1 male, 2 females); N30, 03–IX–18 (2 females); F5, 22–V–16 (1 male); F9, 22–XI–16 (2 females).

Distribution: Primarily an Afrotropical species which secondarily invaded Western Europe and central and south–western Asia (Boudot and Kalkman, 2015). *Crocothemis erythraea* is widespread and common in Morocco, including the Moulouya watershed and the Oriental Region (Jacquemin and Boudot, 1999; Boudot et al., 2009; Boudot and De Knijf, 2012). Figure 9 shows the present and previously published records of this species in the area studied:

***Orthetrum brunneum* (Fonscolombe, 1837)**

Material examined: O17, 27–VII–16 (1 male); O22, 31–V–17 (2 males, 1 female); N4, 17–VIII–18 (2 males, 3 females); N5, 10–VIII–18 (1 male); N12, 12–V–16 (1 male); N19, 17–VI–17 (1 male).

Distribution: Eurasian species ranging from the Atlantic to north–western China. *Orthetrum brunneum* remains scattered in Morocco (Jacquemin and Boudot, 1999; Boudot and Kalkman, 2015). In eastern Morocco, the species has been reported from the upper and lower Moulouya as well as in the Za and Isly rivers (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). We found it at Arghbal and Wertass springs, in addition to the watershed of Nador lagoon and its surrounding (fig. 7).

***Orthetrum cancellatum* (Linnaeus, 1758)**

Material examined: M1, 03–V–14 (1 female); M4, 03–V–14 (1 male, 1 female); M17, 07–VII–14 (1 female); M20, 23–VI–14 (1 male); M22, 23–VI–14 (1 male); Z6, 17–V–14 (1 female); Z10, 19–VII–14 (1 male, 1 female); N15, 13–VIII–18 (1 male, 3 females); N24, 08–X–17 (1 male); N25, 13–VIII–18 (1 female).

Distribution: This *Orthetrum* has a Palearctic distribution. In Morocco, it is widespread in the northern part of the country (Jacquemin and Boudot, 1999). In eastern Morocco, it was recorded from the upper and lower Moulouya and from the Za River watershed (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012), which is confirmed here. We also found it in the Nador province. Figure 7 shows the present and previously published records of this species in the area studied.

***Orthetrum chrysostigma* (Burmeister, 1839)**

Material examined: M5, 02–V–14 (1 male, 1 female); M11, 14–VI–14 (1 female); M13, 14–VI–14 (2 males); M15, 24–V–14 (1 male); M17, 07–VII–14 (2 females); M18, 22–VI–14 (1 male); Z3, 19–III–14 (2 males, 2 females); Z5, 17–V–14 (2 males); Z9, 07–VIII–14 (4 males, 3 females); Z11, 19–VII–14 (1 male); Z12, 19–VII–14 (3 males, 1 female); O4, 28–IV–16 (3 males, 3 females); O5, 30–VI–18 (2 males); O9, 19–IX–15 (1 female); O16, 17–VII–16 (2 males, 1 female); O17, 27–VII–16 (1 male); O21, 31–V–17 (2 males, 1 female); O22, 31–V–17 (2 males, 2 females); O23, 31–V–17 (1 female); O24, 02–VI–16 (1 male); N1, 17–VIII–18 (2 females); N6, 02–V–16 (4 males, 2 females); N10, 07–II–15 (1 male, 1 female); N12, 12–V–16 (1 male); N14, 28–VIII–18 (1 female); N15, 13–VIII–18 (3 males, 4 females); N19, 17–VI–17 (1 male); N23, 07–X–17 (1 male, 1 female); N25, 13–VIII–18 (2 males); N27, 19–VIII–18 (2 males); N30, 03–IX–18 (3 males); F5, 22–V–16 (2 males); F8, 21–XI–16 (1 male); F9, 22–XI–16 (1 female).

Distribution: an Afrotropical species distributed throughout most of the African continent, southern Europe and southwestern Asia (Boudot and Kalkman, 2015). It is the most common *Orthetrum* in Morocco and is well established in the north of the Oriental Region (Jacquemin and Boudot, 1999), which is confirmed by our present records whereas our findings in the Figuig surroundings show it extends south of the region as expected (fig. 7).

***Orthetrum coerulescens anceps* (Schneider, 1845)**

Material examined: M2, 03–V–14 (1 male); M3, 03–V–14 (1 female); M12, 14–VI–14 (1 male); M17, 07–VII–14 (2 females); Z1, 19–III–14 (1 male); Z3, 19–III–14 (1 female); Z7, 17–V–14 (1 male); Z9, 07–VIII–14 (2 males); O1, 27–IV–16 (1 male); O5, 30–VI–18 (1 male, 1 female); O25, 20–III–18 (1 male); N15, 13–VIII–18 (3 males); N23, 07–X–17 (1 female).

Distribution: a so-called 'Oriental' subspecies ranging from Central Asia and Pakistan to parts of the Mediterranean and to the western Maghreb. It overlaps and hybridizes with the nominotypical subspecies in part of the Mediterranean and the Balkans. It is common and widely distributed in northern Morocco, including the north of the Eastern Morocco (Jacquemin and Boudot, 1999; Boudot et al., 2009; Boudot and De Knijf, 2012; Boudot and Kalkman, 2015), which is confirmed by our present records. Figure 7 shows the present and previously published records of this species in the area studied.

***Orthetrum nitidinerve* (Selys, 1841)**

Material examined: O9, 19–IX–15 (1 female); O25, 20–III–18 (1 male); N10, 07–II–15 (1 female); N24, 08–X–17 (1 male); N30, 03–IX–18 (2 males, 1 female).

Distribution: an Ibero-Maghrebian species with a wide distribution in northern Morocco, including the Moulouya watershed and the Oriental Region (Jacquemin and Boudot, 1999; Boudot et al., 2009; Boudot and De Knijf, 2012; Boudot and Kalkman, 2015), confirmed by our present records (fig. 7)

***Orthetrum trinacria* (Selys, 1841)**

Material examined: O5, 30–VI–18 (1 male); N6, 02–V–16 (1 male); N15, 13–VIII–18 (3 males, 1 female); N25, 13–VIII–18 (1 male); N27, 19–VIII–16 (1 male).

Distribution: Afrotropical species. Not very common in Morocco that is mostly present in the northern part of the country, although it avoids the mountains (Jacquemin and Boudot, 1999). In eastern Morocco, it was reported from the lower Moulouya and reaches the Algerian border at the Figuig oasis in the south of the Oriental Region (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012). Our present data show that it also occurs in the catchment area of the Nador Lagoon (fig. 7).

***Selysiotthemis nigra* (Vander Linden, 1825)**

Material examined: O7, 14–IV–18 (1 male); F3, 21–V–16 (1 male).

Distribution: this Mesasiatic species known for its migratory temperament ranges from Central and south–western Asia to Spain and Morocco through the Balkans and throughout Italy. Its overall range seems to remain rather constant although records and breeding localities are regularly increasing due the creation of new habitats by humans (irrigation reservoirs, rehabilitation of abandoned industrial sites, etc) (Boudot and Kalkman, 2015). In Morocco, it was discovered for the first time on the northern edge of the Sahara, at the Merzouga lake (Boudot, 2008), then seen at other places within the same climatic zone (Juillerat and Monnerat, 2009; Boudot et al., 2009) and most recently in the Oriental Region (Boudot and De Knijf, 2012) including the northern Mediterranean coast (Boudot and Kalkman, 2015). In eastern Morocco, it is known only from the Mechra Hammadi dam lake and environs, at the Figuig oasis and ca. 40 km southwest of Nador/Mellila (Boudot and De Knijf, 2012; Boudot and Kalkman, 2015). Our records (fig. 8) show that its presence is increasing progressively in Morocco like in most other Mediterranean countries.

***Sympetrum fonscolombii* (Selys, 1840)**

Material examined: M1, 03–V–14 (3 larvae); M3, 03–V–14 (3 larvae); M5, 02–V–14 (4 larvae); M11, 14–VI–14 (1 male, 3 larvae); M14, 14–VI–14 (1 male, 1 female); M16, 24–V–14 (1 male); M18, 22–VI–14 (1 male, 2 females); M21, 23–VI–14 (2 males, 1 female); Z2, 19–III–14 (2 males); Z4, 19–III–14 (3 larvae); Z6, 17–V–14 (1 female, 2 larvae); Z8, 17–V–14 (2 larvae); S9, 15–VIII–14 (1 male); S11, 15–VIII–14 (1 male); O2, 27–IV–16 (1 larvae); O5, 30–VI–18 (1 male); O13, 01–II–15 (1 male); O16, 17–VII–16 (2 males, 2 females); O19, 20–VII–17 (1 male); O22, 31–V–17 (1 female, 1 larvae); O25, 20–III–18 (3 larvae); O26, 25–VIII–18 (1 male); N1, 17–VIII–18 (2 males, 2 larvae); N3, 02–V–16 (1 male, 1 female); N6, 02–V–16 (2 males); N10, 07–II–15 (2 males); N11, 31–VIII–18 (1 male); N13, 12–V–16 (1 male, 1 female); N16, 29–IX–16 (2 larvae); N28, 28–VIII–18 (1 male); N29, 01–IX–18 (1 male); F1, 21–V–16 (1 female); F3, 21–V–16 (1 male); F4, 22–V–16 (1 larvae).

Distribution: an Afro–European species showing a strong migratory behaviour, which brought many records from Japan. It is one of the most common and abundant Anisoptera throughout Morocco (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012; Boudot and Kalkman, 2015), and is confirmed here as the most abundant *Sympetrum* species in the Moulouya watershed and the Oriental Region (fig. 8).

Sympetrum meridionale* (Selys, 1841)

Material examined: O1, 27–IV–16 (1 male); N14, 28–VIII–18 (2 males, 1 female).

Distribution: a Mediterranean and Central Asian species ranging from the Atlantic to Mongolia. It is rather uncommon in Morocco, with only a few recent records (Jacquemin and Boudot, 1999; Boudot and Kalkman, 2015). Until now, this species was mostly known from the northwest of the country and is new here for the Oriental Region and the Moulouya river basin with findings at Debdou and in the Mariouari River (fig. 8).

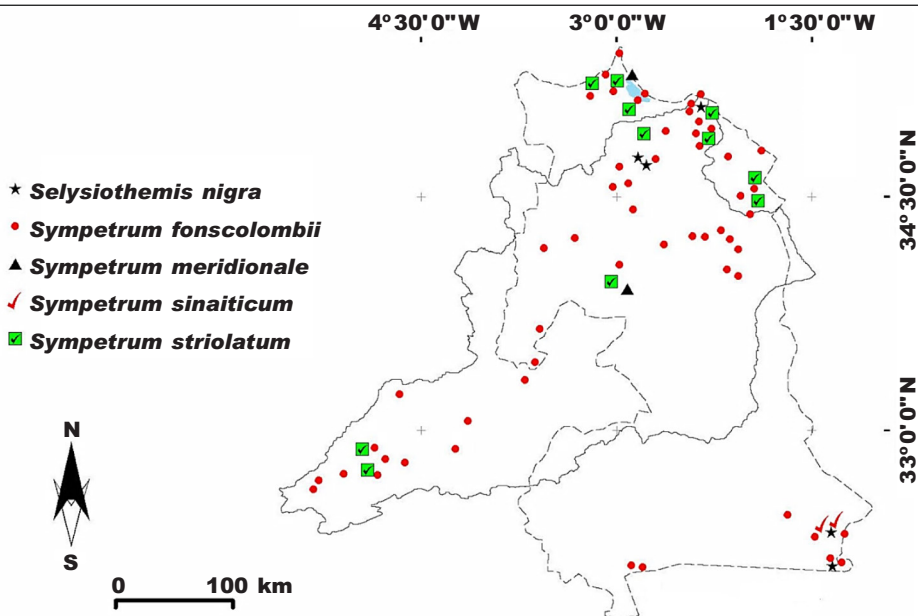


Fig. 8. Distribution of the known records of Libellulidae species in the study area (present and previously published information).

Fig. 8. Distribución de los registros conocidos de especies de Libellulidae en el área de estudio (información actual y publicada anteriormente).

***Sympetrum sinaiticum* Dumont, 1977 ***

Material examined: F2, 21–V–16 (11 larvae); F3, 21–V–16 (4 larvae).

Distribution: a West–Palearctic species ranging from the Levant to southern Algeria, western Morocco and eastern and southern Spain (Juillerat and Monnerat, 2009; Boudot and Kalkman, 2015). In Morocco, it is known from a small number of localities in the south within the northern fringe of the Sahara. This rare and elusive species, which breeds mostly in autumn and winter, is new here for the Oriental Region with its discovery at the two dams Zriga and Sfisef (fig. 8), in the very south (Figuig vicinity).

***Sympetrum striolatum* (Charpentier, 1840)**

Material examined: M10, 14–VI–14 (1 male, 2 larvae); O9, 19–IX–15 (1 female); O16, 17–VII–16 (2 males); O22, 31–V–17 (2 larvae); N3, 02–V–16 (1 male); N6, 02–V–16 (1 female, 1 larvae); N10, 07–II–15 (1 male); N11, 31–VIII–18 (1 male, 1 female); N15, 13–VIII–18 (1 male).

Distribution: a Palearctic species ranging from the Atlantic to Japan. In Morocco, it is mostly known from the northern part of the country (Jacquemin and Boudot, 1999; Boudot and Kalkman, 2015). In the studied area, it was previously known from only the Ansegrim River and the mouth of the Moulouya River and the north of the Oriental Region (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012) which is confirmed here (fig. 8).

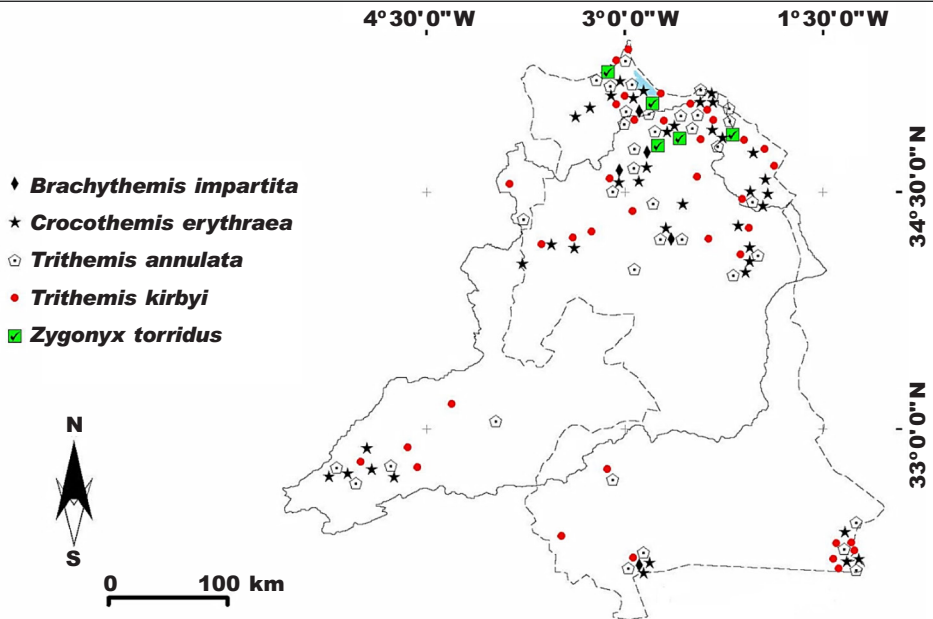


Fig. 9. Distribution of the known records of Libellulidae species in the study area (present and previously published information).

Fig. 9. Distribución de los registros conocidos de especies de Libellulidae en el área de estudio (información actual y publicada anteriormente).

***Trithemis annulata* (Palisot de Beauvois, 1807)**

Material examined: M4, 03–V–14 (1 larva, 3exuvia); M5, 02–V–14 (1 male); M12, 14–VI–14 (1 male, 2 females); M19, 22–VI–14 (1 female); M21, 23–VI–14 (2 males, 1 female); M22, 23–VI–14 (1 male); Z4, 19–III–14 (3 larvae); Z9, 07–VIII–14 (1 male, 2 females, 2 larvae); O2, 27–IV–16 (1 male); O8, 22–II–16 (3 males); O18, 27–VIII–16 (1 female); N4, 17–VIII–18 (5 males, 3 females, 2 larvae); N5, 10–VIII–18 (1 male); N6, 02–V–16 (2 males); N8, 02–V–16 (1 female); N12, 12–V–16 (1 female); N13, 12–V–16 (1 larva); N14, 28–VIII–18 (1 male); N23, 07–X–17 (1 male); N25, 13–VIII–18 (2 males, 3 females); F2, 21–V–16 (1 male.); F7, 20–XI–16 (1 female).

Distribution: a wide ranging Afro-tropical species covering the whole of Africa and of the Arabian Peninsula which expanded north to southern Europe in the last 40 years. It shows a wide distribution throughout northern Morocco, including the Oriental Region and the Moulouya watershed (Jacquemin and Boudot, 1999; Boudot and De Knijf, 2012; Boudot and Kalkman, 2015), confirmed here by our numerous records in the north and in the south (fig. 9).

***Trithemis kirbyi* (Selys, 1891)**

Material examined: M6, 02–V–14 (1 male); M18, 22–VI–14 (1 female); M20, 23–VI–14 (1 male); Z4, 19–III–14 (2 larvae, 1 exuvia); Z5, 17–V–14 (1 male); Z10, 19–VII–14 (1 male, 1 female); S10, 15–VIII–14 (1 female); O6, 23–IV–16 (3 males, 4 females); O7, 14–IV–18 (3 males); O8, 22–II–16 (2 males); O18, 27–VIII–16 (1 female); O23, 31–V–17 (1 female); O25, 20–III–18 (1 male, 2 larvae, 1 exuvia); N1, 17–VIII–18 (1 female); N2, 01–V–16 (1 male);

N4, 17–VIII–18 (1 male, 2 females); N5, 10–VIII–18 (1 male, 1 female); N6, 02–V–16 (2 males); N11, 31–VIII–18 (1 male); N14, 28–VIII–18 (1 male, 1 female); N15, 13–VIII–18 (2 males, 3 females, 1 larvae); N17, 29–IX–16 (2 exuviae); F3, 21–V–16 (1 male); F4, 22–V–16 (1 larva, 2 exuviae); F7, 20–XI–16 (2 males); F8, 21–XI–16 (1 male, 1 female).

Distribution: an African species expanding East through the south of the Arabian Peninsula and Iran to western India and Pakistan. *Trithemis kirbyi* expanded north recently, colonizing most of the Iberian Peninsula and reaching France in the last 12 years taking advantage of the strongest heat waves linked to climate warming and to its ability to disperse and to breed opportunistically in any kind of water habitat (Polette et al., 2017). It is widespread in the watershed of Moulouya and Morocco in general (Boudot et al., 2009; Boudot and De Knijf, 2012; Boudot and Kalkman, 2015), as confirmed by our present data (fig. 9).

***Zygonyx torridus* (Kirby, 1889)**

Material examined: M19, 22–VI–14 (1 male, 1 larvae); M20, 23–VI–14 (3 larvae, 1 exuvia); O21, 31–V–17 (1 male); N20, 04–X–17 (1 female); N25, 13–VIII–18 (1 male).

Distribution: an Afrotropical species which reaches India and has a relict disjunct Mediterranean sub-range covering Morocco, the Canary Islands, mainland Spain, southern Portugal, Sicily and the Levant (Jacquemin and Boudot, 1999; Kunz et al., 2006; Boudot and Kalkman, 2015). In Morocco, the species seems to be scattered and very local, and in the East it has been found until now only from the lower Moulouya (Boudot and De Knijf, 2012; Boudot and Kalkman, 2015), which is confirmed here by our five records, all pertaining to the lower area of the Moulouya watershed (fig. 9).

Discussion

Based on the chorological system detailed by Jacquemin and Boudot (1999) (fig. 10), it seems clear that the odonatological fauna of the Moulouya watershed and eastern Morocco consists essentially of Palearctic elements including mostly Mediterranean species (72% of the total species), followed by widely distributed taxa (28%).

Among the Mediterranean elements, there is a predominance of species with a strictly West Mediterranean distribution (47%), followed by endemic species in the broadest sense (37%), while the Holomediterranean species are only a minority (16%). The endemic species are mainly those with a Maghrebian chorotype distribution (21%), followed by the Ibero-Maghrebian taxa (16%). The clear dominance of the Palearctic elements, typically Mediterranean, and the high rate of Ibero-Maghrebian endemics in the Odonatological population of the study area, shows a strong similarity to the chorotypes found for other insect groups (Mabrouki et al., 2016a, 2017a, 2018b; Taybi et al., 2017b, 2018b) and emphasizes the rather low survival of the typical Afrotropical species following the aridification of the Sahara in the last 3,000–4,500 years. The latter are mostly *Paragomphus genei*, *Orthetrum chrysostigma*, *Zygonyx torridus*, *Crocothemis erythraea*, *Trithemis annulata* and *T. kirbyi*. Global warming presently affects the distribution range of Odonata in the Mediterranean, with some species being on the decline due to habitat alteration and, others, well adapted to warmer and dryer conditions, and increasingly recorded in southern Europe (Degabriele, 2013; Polette et al., 2017).

The dominance of species with broad distributions points to the high dispersal ability of the Odonata community in East Morocco, similar to what is known in other parts of Morocco (Jacquemin and Boudot, 1999).

A resilient behaviour of the community, with frequent vagrant individuals searching for new habitats, enables species survival in a very changing environment where a semiarid climate prevails (Boudot and De Knijf, 2012). This behaviour pattern has also been observed for other groups, such as riparian carabids, aquatic beetles and bugs, stoneflies and mayflies (Daoudi et al., 2017; Mabrouki et al., 2016a, 2018b; Taybi et al., 2017b, 2018b) emphasizing the dominant meta-community behaviour for most macroinvertebrates.

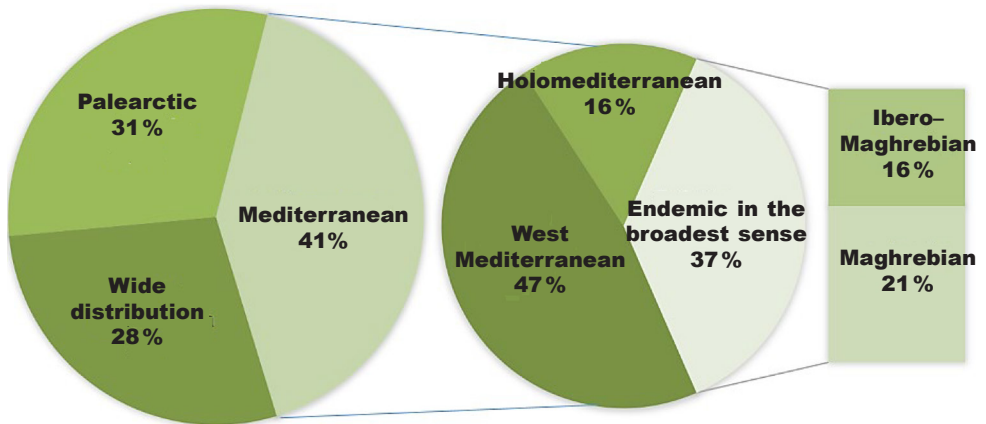


Fig. 10. Main chorological categories of the studied species.

Fig. 10. Principales categorías corológicas de las especies estudiadas.

The results of this study and data from the literature show that the Moulouya watershed and eastern Morocco currently contain a total of 47 Odonata species, which corresponds to 74 % of the Moroccan Odonata fauna (El Haissoufi et al., 2015). This number of species is linked to a high variability and heterogeneity of aquatic habitat in the studied area, going from lotic or lentic soft waters to lotic or lentic brackish waters (Chavanon et al., 2004).

Most of the species found during this work showed a significant increase in localities in the region. The discovery for the first time in the East of Morocco of four new Odonata species: *Pseudagrion sublacteam*, *Aeshna mixta*, *Sympetrum sinaiticum* and *S. meridionale*. While *Paragomphus genei* is a new species for the Basin of Moulouya River. We provide evidence of breeding of *Zygonyx torridus* in the Moulouya River and new sights of *Boyeria irene* after more than 30 years of apparent absence in the region. Lastly, some species typical of semi-arid and arid environments, like *Selysiotthemis nigra* and *Brachythemis impartita*, appear to expand their settlements in the region together with several other species, which match their current status in other parts of the Mediterranean and Maghrebian regions. Conversely, some species previously reported from East Morocco could not be found again during the present study; this could be due either to their hidden behaviour or difficulty of identification in the field, or to true a decrease in response to more and more limited good quality water resources and increasing anthropic pressures. Obviously, like in most of the North African territory, the regional aquatic ecosystems are increasingly threatened through water abstraction, habitat loss and modification, industrial effluents, domestic sewage, invasive species and agricultural runoff including fertilizers, pesticides and drainage of water (Garcia et al., 2010; Bensaad et al., 2017; Mabrouki et al., 2016b, 2017b; Taybi et al., 2016b; Yahya et al., 2017). It is well known that this tends to reduce species richness of freshwater organisms in impacted areas throughout the Maghreb (Garcia et al., 2010; Mabrouki et al., 2016a; Taybi et al., 2017a, 2018a). In fact, among the species previously known in the region, eight have not been found again, namely *Coenagrion puella*, *C. scitulum*, *Erythromma viridulum*, *Ischnura fountaineae*, *I. pumilio*, *Pyrrhosoma nymphula*, the near threatened *Coenagrion mercuriale* and the endangered *Calopteryx exul* according to their IUCN status. It is hoped that findings from the present work will increase awareness of these insects and their habitats and the importance of their conservation.

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Appendix 1. Sampling sites with indications of locality, geographic coordinates, sampling dates and habitat type: DM, dam; AQ, abandoned quarry; AC, artificial channel; AP, artificial pond; RV, river; LG, lagoon; PD, natural pond; AS, artificial spring; NS, natural spring; GS, green space.

Apéndice 1. Puntos de muestreo con indicación de la localidad, coordenadas geográficas, fechas del muestreo y tipo de hábitat: DM, presa; AQ, cantera abandonada; AC, canal artificial; AP, estanque artificial; RV, río; LG, laguna; PD, estanque natural; AS, primavera artificial; NS, manantial natural; GS, espacio verde.

Code	Localities	Coordinates		Alt (m)	Sampling dates	Habitat
M1	Ait Boulmane	32.61572	-5.33033	1,650	03.05.14 – 13.06.14 – 14.07.14	RV
M2	Ait Oha Ohaki	32.62463	-5.30911	1,640	03.05.14 – 13.06.14 – 14.07.14	RV
M3	Source Arbalou	32.67594	-5.28888	1,670	03.05.14 – 13.06.14 – 14.07.14	RV
M4	Krouchene = Irhdis	32.74711	-5.17141	1,616	03.05.14 – 13.06.14 – 14.07.14	RV
M5	Boumia	32.71761	-5.09797	1,515	02.05.14 – 14.06.14 – 15.07.14	RV
M6	Zaïda	32.81750	-4.95916	1,455	02.05.14 – 14.06.14 – 15.07.14	RV
M7	Anzar Oufounas	32.42916	-5.15688	1,895	02.05.14 – 14.06.14 – 15.07.14	NS
M8	Aval Anzar Oufounas	32.47823	-5.14817	1,780	02.05.14 – 14.06.14 – 15.07.14	RV
M9	Anzegmir avant barrage	32.51780	-5.08422	1,702	02.05.14 – 14.06.14 – 15.07.14	RV
M10	Aval Anzegmir	32.74222	-4.91416	1,455	02.05.14 – 14.06.14 – 15.07.14	RV
M11	Tamdafelt	32.87885	-4.23788	985	02.03.14 – 14.06.14 – 15.07.14	RV
M12	Missour	33.05221	-3.97825	870	02.05.14 – 14.06.14 – 15.07.14	RV
M13	Outat Al Haj	33.32966	-3.70394	770	02.05.14 – 14.06.14 – 15.07.14	RV
M14	Tindint	33.65305	-3.58905	640	02.05.14 – 14.06.14 – 15.07.14	RV
M15	Moulouya amont Melloulou	34.21647	-3.35188	362	23.03.14 – 24.05.14 – 07.07.14	RV
M16	Moulouya Aval Melloulou	34.24162	-3.32038	355	23.03.14 – 24.05.14 – 07.07.14	RV
M17	Moulouya Amont Za	34.56008	-3.04261	230	23.03.14 – 24.05.14 – 07.07.14	RV
M18	Moulouya Aval Za	34.56141	-3.03049	222	03.04.14 – 24.05.14 – 22.06.14	RV
M19	Sebra	34.88638	-2.66250	60	03.04.14 – 24.05.14 – 22.06.14	RV
M20	Safsaf	34.90764	-2.63579	50	18.03.14 – 18.05.14 – 23.06.14	RV
M21	Pont Hassan II	35.05158	-2.42844	9	18.03.14 – 18.05.14 – 23.06.14	RV
M22	Pré-Estuaire	35.09761	-2.38861	3	18.03.14 – 18.05.14 – 23.06.14	RV
S1	Sources O El Bared	33.91116	-4.04463	931	27.03.14 – 01.06.14 – 11.07.14	RV + NS
S2	Amont O El Bared	33.98305	-3.87105	630	23.03.14 – 08.06.14 – 07.08.14	RV
S3	Douar Ifrane	34.03911	-3.77613	570	23.03.14 – 08.06.14 – 07.08.14	RV
S4	Sources Berkine	33.71201	-3.83495	1,150	22.03.14 – 14.06.14 – 07.08.14	RV + NS
S5	Amont Berkine	33.81616	-3.78538	970	27.03.14 – 15.06.14 – 15.08.14	RV
S6	Pont Oued Zbzit	34.02683	-3.76072	595	23.03.14 – 08.06.14 – 15.08.14	RV
S7	Confluence Zbzit O. El Bared	34.05062	-3.77613	565	23.03.14 – 08.06.14 – 15.08.14	RV
S8	Douar Imzaghrou	34.08770	-3.72075	525	23.03.14 – 08.06.14 – 15.08.14	RV
S9	Pont Taddarte	34.17261	-3.55705	445	23.03.14 – 08.06.14 – 15.08.14	RV
S10	Entrée Guercif	34.21486	-3.39280	377	23.03.14 – 08.06.14 – 15.08.14	RV
S11	Aval Melloulou	34.21698	-3.34455	363	23.03.14 – 15.06.14 – 15.08.14	RV
Z1	Oued Charef	33.98152	-2.08541	925	19.03.14 – 17.05.14 – 07.08.14	RV + NS
Z2	Pond O. Charef	33.99252	-2.06972	918	19.03.14 – 17.05.14 – 07.08.14	RV
Z3	Petite cascade	34.06577	-2.05561	900	19.03.14 – 17.05.14 – 07.08.14	RV
Z4	Oued Lakhrouf	34.09855	-2.04391	897	19.03.14 – 17.05.14 – 07.08.14	RV
Z5	Grandes cascades	34.11825	-2.09077	875	19.03.14 – 17.05.14 – 07.08.14	RV
Z6	Amont Gafait	34.24211	-2.33666	785	19.03.14 – 17.05.14 – 07.08.14	RV
Z7	Pont de Gafait	34.22688	-2.39291	767	19.03.14 – 17.05.14 – 07.08.14	RV
Z8	Gafait	34.23933	-2.40966	750	19.03.14 – 17.05.14 – 07.08.14	RV + AS
Z9	Barrage Za	34.20641	-2.64786	625	19.03.14 – 17.05.14 – 07.08.14	RV + DM
Z10	Amont Taourirt	34.42100	-2.88136	370	07.06.14 – 19.07.14 – 19.07.14	RV
Z11	Aval de Taourirt	34.47903	-2.98619	295	03.04.14 – 07.06.14 – 19.07.14	RV
Z12	Melg el Ouidane	34.54625	-3.02530	240	03.04.14 – 07.06.14 – 19.07.14	RV
O1	Debdou	33.95906	-3.04080	1,344	27.04.16	AS
O2	Mare à Debdou	34.06427	-2.98169	880	27.04.16	PD
O3	Source Tiffert	35.03800	-2.42666	83	28.04.16	NS
O4	Aval Zegzel	34.88563	-2.34280	268	28.04.16	RV
O5	Ain chabbak	35.10519	-2.34583	2	28.04.16 – 30.07.18	PD
O6	Bassin Oujda	34.65097	-1.89977	627	07.11.15 – 26.02.16 – 23.04.16	AP
O7	SIBE Saïdia	35.11938	-2.33758	0	21.02.16 – 14.04.18	PD
O8	Canal de Saïdia	35.09972	-2.32836	9	22.02.16	AC
O9	Jbel Mehser	34.49002	-1.91600	1,268	19.09.15	AS
O10	Source Himer	34.42569	-1.89833	1,030	18.11.15	NS
O11	Amont Himer	34.42505	-1.89252	1,019	18.11.15	RV
O12	Source Zegzel	34.83897	-2.35600	442	01.02.15	AS
O13	Ain Sfa	34.75341	-2.14333	652	01.02.2015	AS
O14	Ain Almou	34.83755	-2.17291	1,200	06.06.2016	AS
O15	Cherraa	34.94544	-2.41347	80	06.06.2016	PD
O16	Carrière Oujda	34.58077	-1.93719	719	17.07.2016	AQ
O17	Source Aghbal	34.92055	-2.11458	307	27.07.16	AS
O18	Canal Berkane	34.93522	-2.31141	154	27.08.16	AC
O19	Mares à Saïdia	35.11780	-2.32913	0.37	20.06.17	PD
O20	Sidi Moussa	34.40722	-1.88527	1,096	29.05.17	RV
O21	Beni Waklane	34.84000	-2.26000	795	31.05.17	RV
O22	Wertass	34.89275	-2.30036	249	31.05.17	RV
O23	Laâyoune	34.59505	-2.45497	586	31.05.17	RV
O24	Tancherfi	34.42425	-2.55922	818	02.06.16	RV
O25	Oued Isly	34.79005	-1.88816	454	03.06.17 – 20.03.18	RV
O26	Cap de l'eau	35.13389	-2.40193	10	25.08.18	GS
N1	Sagua Selouane	35.08730	-2.93438	84	30.04.16 – 17.08.18	AC
N2	Kariat Arkmane	35.10458	-2.74863	19	01.05.16	AC
N3	Dardoura	35.05305	-2.90525	134	02.05.16	RV
N4	Oued Ouzej	35.00605	-2.99188	168	30.04.16 – 17.08.18	RV
N5	Oued Selouane	35.07686	-2.92475	52	30.04.16 – 10.08.18	RV
N6	O Messoussate	35.06350	-2.90638	68	02.05.16	RV
N7	Marchica (1)	35.17977	-2.92202	5	22.05.15	PD
N8	Marchica (2)	35.15552	-2.90675	3	02.05.16	LG
N9	Rio de Oro	35.28747	-2.94380	12	18.05.15	RV
N10	Mont Gourougou	35.23200	-2.99919	542	05.02.15 – 06.02.15 – 07.02.15	RV
N11	Oued Tifassour	35.27250	-3.08733	17	12.05.16 – 31.08.18	RV
N12	Oued Oumassine	35.16388	-3.11000	79	12.05.16	RV
N13	Oued Kert	35.21358	-3.18372	6	12.05.16 – 31.08.18	RV
N14	Oued Mariouari	35.30600	-2.97747	85	12.05.16 – 28.08.18	RV
N15	Barrage Arabat	35.01775	-2.87666	102	05.04.14 – 13.08.18	DM
N16	Canal Bouareg	35.09363	-2.89341	26	29.09.16	AC
N17	Canal Granja	35.09644	-2.92483	40	29.09.16	AC
N18	Souk Mercredi	35.11313	-2.74400	0	27.10.2016	PD
N19	Lagune Nador 3	35.19405	-2.92588	0	17.06.2017	PD
N20	Oued Ikhalfiwan	35.27786	-3.08961	8	04.10.2017	RV
N21	Embouchre Kert	35.22505	-3.19369	1	04.10.2017	RV
N22	Aval O. Selouane	35.12997	-2.88383	1	01.12.17	RV
N23	Amont Msoun	34.32897	-3.76688	549	07.10.17	RV
N24	Driouech	34.97279	-3.37491	277	08.10.17	RV
N25	Afluent barrage O. Settout	35.02837	-2.85896	137	13.08.18	RV
N26	Marchica (coté Beni Nsar)	35.23812	-2.89885	1	15.08.18	PD
N27	La'zib	35.05172	-2.96294	110	19.08.18	RV
N28	Cap de trois fourches	35.43733	-2.97768	19	28.08.18	GS
N29	Al Mohandis	35.15030	-2.78625	2	01.09.18	
N30	Oued Azeouagh	35.13908	-3.02340	164	03.09.18	RV + AS
F1	Raknat Naam	32.45313	-1.68852	1,168	21.05.16	DM
F2	Barrage Zriga	32.35819	-1.32677	1,026	21.05.16	DM
F3	Barrage Sfisef	32.33997	-1.35127	1,005	21.05.16	DM
F4	Seguia de Figuig	32.11313	-1.23577	902	22.05.16	AC
F5	O Abbou Lekhal	32.16813	-1.22844	868	22.05.16	RV
F6	Dayat Lahjal	32.49163	-1.66322	1,161	22.05.16	PD
F7	Oued Anwal	32.67961	-3.09437	1,194	20.11.16	RV
F8	Oued Ait Aïssa	32.31666	-3.48333	1,121	21.11.16	RV
F9	Barrage Zelmou	32.13333	-2.90000	880	22.11.16	DM