

Assessment and conservation of the dragonflies and damselflies (Insecta: Odonata) at the marshes of Smir

Bouchra BENZAOUZ¹, Mohamed MOUNA^{2*}, Mohamed AMEZIAN³, Keith BENSUSAN⁴,
Charles PEREZ⁴ & John CORTES⁴

1. Université Ibn Tofaïl, Faculté des Sciences, Laboratoire de Génétique & de Physiologie Neuroendocrinienne, B.P.133, 14000-Kénitra, Maroc. e-mail : bbenazzouz@yahoo.fr
2. Université Mohammed V-Agdal, Institut Scientifique, Département de Zoologie et Ecologie animale, B.P. 703 Agdal, Rabat. * corresponding author : mouna@israbat.ac.ma / medmouna@yahoo.com
3. Université Abdelmalek Essaadi, Faculté des Sciences, B.P. 2121, 93000 Tétouan, Maroc.
4. Gibraltar Natural History Field Centre, Jew' Gate, Upper Rock Nature Reserve, PO Box 843, Gibraltar.

Abstract. Wetlands are characterized by their high biodiversity. However, these habitats are very vulnerable and are often altered by human activity, which often includes drainage. Many wetlands have disappeared and this trend will continue until ecological awareness increases. The Smir marshes are presently targeted by the tourism industry. Knowledge of the Odonata of the marshes is important because these insects are useful indicators of habitat quality. Therefore, an inventory of Odonata living in the Smir marshes was carried out over thirteen months, demonstrating the importance of this area in terms of biodiversity. The status of the species collected is examined in order to promote the protection of the marshes and their living organisms. The biogeography of these insects is also considered so as to assess their origin.

Key words: Odonata, biogeography, Red list, conservation, marshes of Smir, Morocco.

Evaluation et conservation des libellules et demoiselles (Insectes : Odonates) dans les marais de Smir.

Résumé. Les zones humides sont caractérisées par une grande richesse biologique. Elles sont cependant très vulnérables, fréquemment plus ou moins dégradées et risquent de disparaître du fait des activités humaines, et particulièrement du fait du drainage des terres et de la pollution. Les marais de Smir sont en outre actuellement très convoités par l'industrie du tourisme. La connaissance des Odonates des marais de Smir est une nécessité, car ce groupe d'insectes peut être utilisé pour appréhender rapidement la qualité de leur environnement dans son ensemble. Un inventaire des odonates des marais de Smir a ainsi été effectué durant treize mois. La richesse du milieu et le statut de conservation des espèces a été établi en vue de souligner l'importance de ce site et le protéger. Une analyse biogéographique a été effectuée en vue de déterminer leur origine.

Mots clés : Odonates, biogéographie, Liste rouge, conservation, marais de Smir, Maroc

INTRODUCTION

Wetlands show a high diversity of plant and animal species. They are also characterised by their high potential for succession and by the fact that they retain rainwater and fulfil a role in water purification.

Loss of wetlands, especially through drainage for cultivation, filling in for construction, or their use as dumps, has occurred widely in many countries. Wetlands are therefore among the most threatened habitats globally because of overexploitation, pollution and non-sustainable development.

Besides the numerous threats already generated by human activities, the marshes of Smir are located in a region of considerable interest for tourism development, a process associated with excessive urbanization and loss of natural habitats. Monitoring the effects of these activities on populations of organisms is necessary to improve environmental policy, nature conservation and sustainable management of the site.

For several years, Moroccan wetlands have been the subject of considerable scientific research, conservation and protection because of their importance to biodiversity. The Smir wetland complex is known as a site of important ecological and biological interest (SIBE) and is a stopover site for migrating birds before and after crossing the Strait of Gibraltar (Ennabili & Ater 1996).

The object of our study was to identify the Odonata community and species assemblages in the Smir wetlands, as, being rather easy to identify and diverse in their ecological requirements (Fernet & Pilon 1970, Corbet 1980, 1993, Goffart *et al.* 2006), these organisms may be used as indicators of overall habitat quality.

This assessment is likely to shed light on the health of the marshes of Smir. This can then help managers in the development of conservation and restoration plans for the area.

MATERIALS AND METHODS

Introduction to the Smir wetlands

Geographical location

The Smir wetlands are located in the extreme northwest of Morocco, between 35°38' N and 35°46' N, and 05°15' W and 05°28' W. They are bordered to the north by Jbel Zem-Zem (435 m), to the west by the mountains of Haouz, to the south by the city of M'diq and to the East by the Mediterranean Sea (Fig. 1). This zone is made up of a complex of marshes that lie on the alluvial lowlands of the Smir river and covers 175 hectares. The complex consists of the Smir river, the lagoon into which it flows, and shallow marshes with narrow channels covered by tall aquatic vegetation. An artificial connection ensures permanent contact with the sea.

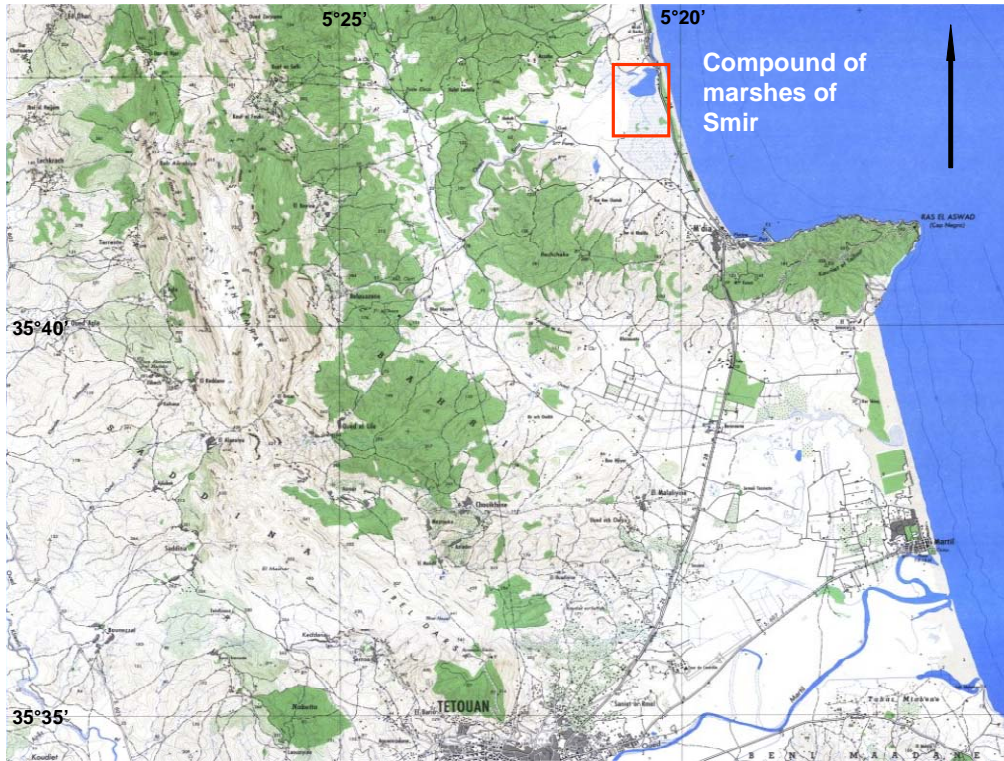


Figure 1. Location of the Smir wetlands (Map of Morocco – 1/50000, sheet Tétouan NI-30-XIX-4a).

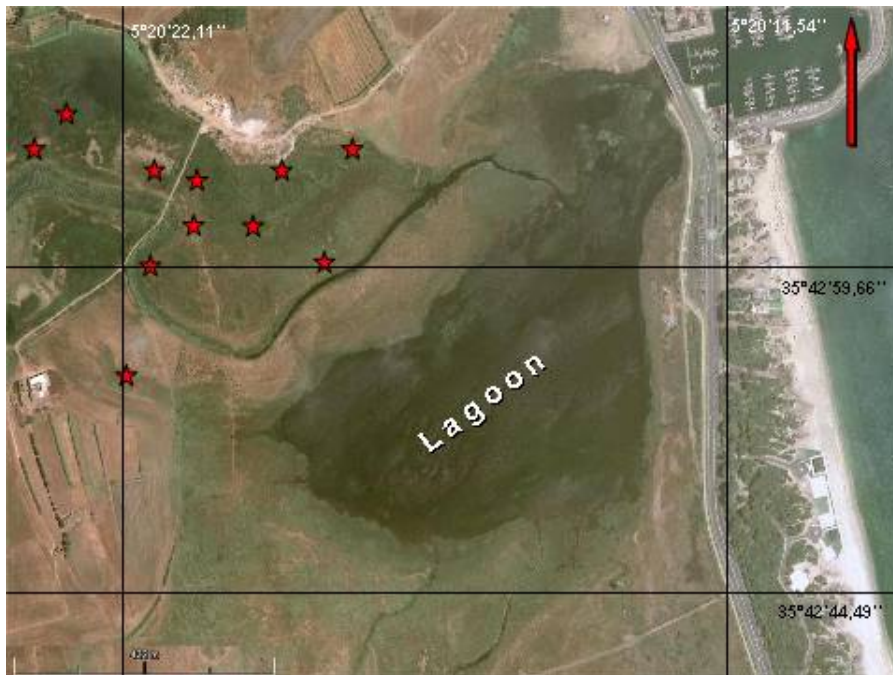


Figure 2. Location of the main sampling sites (stars) in the Smir lagoon (Google Earth™ mapping service, modified).

Hydrology

Several springs with contrasting water chemistry and flow control the hydrology of the Smir wetlands (Dakki *et al.* 2005):

– The water from the Smir river, which decreased considerably in volume after the construction of the Smir dam in 1991.

– The underlying ground water and local streamlets of the Smir basin, which also contribute to the lagoon but are less important.

– The entrance of seawater at the mouth of the Smir river, facilitated by the construction of the marina "Kabila". These waters have a greater influence on the saltmarsh, which contains *Chenopodiaceae* ("Sansouire") and *Juncus* rush ("Jonchaie") habitats surrounding the lagoon.

Table I. List of Odonates collected in the marshes of Smir.

Suborder	Family	Species*	Sampling period
Zygoptera	Coenagrionidae (6.7%)	<i>Ischnura graellsii</i> (Rambur 1842)	March to November
	Lestidae (6.7%)	<i>Sympetma fusca</i> (Vander Linden 1820)	May to June
Anisoptera	Aeshnidae (33.3%)	<i>Aeshna mixta</i> Latreille 1805	November
		<i>Aeshna isoceles</i> (Müller 1767)	April to May
		<i>Hemianax ephippiger</i> (Burmeister 1839)	March to November
		<i>Anax imperator</i> Leach 1815	April to November
		<i>Anax parthenope</i> Selys 1839	March to November
	Libellulidae (53.3%)	<i>Crocothemis erythraea</i> (Brullé 1832)	March to October
		<i>Diplacodes lefebvreii</i> (Rambur 1842)	May to October
		<i>Orthetrum chrysostigma</i> (Burmeister 1839)	April to October
		<i>Orthetrum cancellatum</i> (Linné 1758)	May
		<i>Orthetrum trinacria</i> (Selys 1841)	April to November
		<i>Sympetrum striolatum</i> (Charpentier 1840)	January to November
		<i>Sympetrum fonscolombii</i> (Selys 1840)	March to November
	<i>Sympetrum meridionale</i> (Selys 1841)	November	

* All taxa pertain to the nominotypical subspecies

– The domestic wastewaters of the town of M'diq in the southern part of the marshes, which at present are fast increasing with the expansion of the town.

Climate

The climate of the basin of the Smir river is typically Mediterranean, characterized by mild and humid winters and hot and dry summers. The region is very windy; the predominant winds are mostly from the west (Gharbi) between October and February and from the east (Charki) between May and October (El Gharbaoui 1987). The annual average temperature is 16.1°C. The average during the hottest month (August) is 26°C and the average during the coldest month (February) is 11°C. The annual rainfall is higher than 600 mm and shows a maximum from October to April (Ater & Dakki 1995).

Vegetation

The Smir marshes and their immediate vicinity contain a very rich flora (Bendaanoun 1991; Ennabili & Ater 1996). The development of the vegetation depends on the degree of submersion, salinity and the organic content of the water (Ennabili & Ater 2005). The complex can be divided into two zones (i) a lagoon (80 % of the actual surface area of the wetland) with small groups of *Tamarix* (ii) and a marsh where Chenopodiaceae (glassworts or "Salicorne") (*Arthrocnemum macrostrachyum*) and Juncaceae (*Juncus maritimus*) prevail in brackish and salt areas, and where a vegetation typical of freshwater marshes prevails in areas lacking a marine influence. Additionally, the extreme south of the marshes is impacted by a high sewage water input. Here, Typhaceae (Bulrushes) replace Cyperaceae (Sedges) progressively, as this last group does not tolerate such high organic pollution (Ennabili & Ater 1996).

Sampling methods

Samples of Odonata were taken in the northern and western parts of the lagoon of Smir (Fig. 2). No sampling was carried out in the southern part because of the wastewater that poured out into this zone.

This inventory of the Odonata of the Smir marshes is based primarily on adult specimens, which were captured using a butterfly net. The sampling was carried out monthly, from November 2007 to November 2008. In addition, fortnightly samples were taken in April, May and June 2008 and occasional daily samples were taken in mist nets during passerine ringing programmes in autumn and spring. This last method was particularly useful for capturing larger and faster species. Larvae were directly sampled in water by using a hoop net.

The identification of Odonata was based on keys established by Aguesse (1968) and by Jacquemin & Boudot (1999) and on an annotated inventory of the Moroccan population of Odonata by Benazzouz (1988). Currently accepted taxonomy of species was verified using the Fauna Europaea database (<http://www.faunaeur.org>).

RESULTS

Fifteen species of Odonata were collected (Table I), of which two species, *Aeshna isoceles* and *Orthetrum chrysostigma*, are new to the study area. Ten other species had been cited previously (Jacquemin & Boudot 1999; Boudot *et al.* 2009), but have not been collected during our period of study. Thus, the total number of Odonata recorded from the Smir marshes is now 25 species, representing 39% of the species of dragonflies and damselflies known from Morocco (64 species) (Benazzouz 1988, Guemmouh 1988, Boudot *et al.* 2009). This demonstrates the considerable diversity of Odonata in this wetland complex.

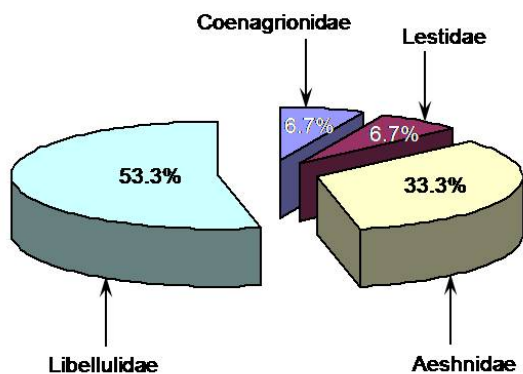


Figure 3. Percentages of Odonata by family in the Smir wetlands.

The long flight period of most species collected, which extends from March to November or even throughout the year, highlights that the adults of many species have an almost permanent presence at the site.

The fifteen species collected belong to two families of Zygoptera and two families of Anisoptera. The suborder Zygoptera is represented by two species belonging to the families *Coenagrionidae* and *Lestidae*. Of the remaining thirteen species of Anisoptera identified, five belong to the family *Aeshnidae* and eight to the *Libellulidae* (Table I, Figure 3). These results show the dominance of the *Libellulidae* (53.3%), followed by *Aeshnidae* (33.3%). The two families of Zygoptera represent only 13.4% of the species met in the marshes.

The ten species known from this zone but not collected during our period of study include six species of Zygoptera: *Lestes barbarus* (Fabricius, 1798), *Lestes virens virens* (Charpentier, 1825), *Lestes viridis viridis* (Vander Linden, 1825) (*Lestidae*), *Erythromma lindenii* (Selys, 1840), *Ischnura pumilio* (Charpentier, 1825) and *Ceriagrion tenellum* (Villers, 1789) (*Coenagrionidae*) and four species of Anisoptera: *Aeshna affinis* (Vander Linden, 1820) (*Aeshnidae*), *Orthetrum brunneum* (Fonscolombe, 1837), *Orthetrum coerulescens anceps* (Fabricius, 1798) and *Trithemis annulata* (Palisot de Beauvois, 1805) (*Libellulidae*) (McLachlan 1889, Valle 1933, Lieftinck

1966, Dumont 1972, Aguesse 1968, Benazzouz 1988, Guemmouh 1988, Jacquemin 1994, Jacquemin & Boudot 1999, Boudot *et al.* 2009).

DISCUSSION

Biogeography of Odonata collected in the Smir wetlands

According to the biogeographical classification of Moroccan Odonata (Jacquemin & Boudot 1999), the present composition of Odonata species in the Smir wetlands reflects a dominance of Palaearctic species (8/15). This represents 53.3%, showing a clear Mediterranean affinity in relation to the geographical location of the site studied.

The Afrotropical component comes in at second place with four species (26.7%), followed by the Afro-European species group with three species (20%) (Fig. 4). This result demonstrates the confluence of Afrotropical and Palaearctic species in North Morocco.

These data compare well with the biogeographical composition of Odonata in Morocco as a whole (Boudot & Jacquemin 1999) and emphasize the importance of the Smir wetland for biodiversity.

Protection of the Smir wetlands and their Odonata

Odonata are frequently used in programmes to monitor the conservation status of habitats and their biodiversity, since they are considered indicators of overall habitat quality. This group is very sensitive to habitat alteration and survival depends on the richness of aquatic life (Goffart & Dufrene 1993). From this perspective, sites can be classified according to their species richness and status of populations, giving a particular emphasis to those that harbour rare or threatened species.

According to the Red List of Odonata of the Mediterranean Basin (Riservato 2009) based on the classification criteria of the International Union for Conservation of Nature (IUCN 2001), the 25 species described for the Smir marshes belong to the not threatened category (Least Concern). Of these 25 species, only 15 were found in this study. This result suggests a loss of Odonata from this site, in all probability due to a progressive deterioration of the habitat.

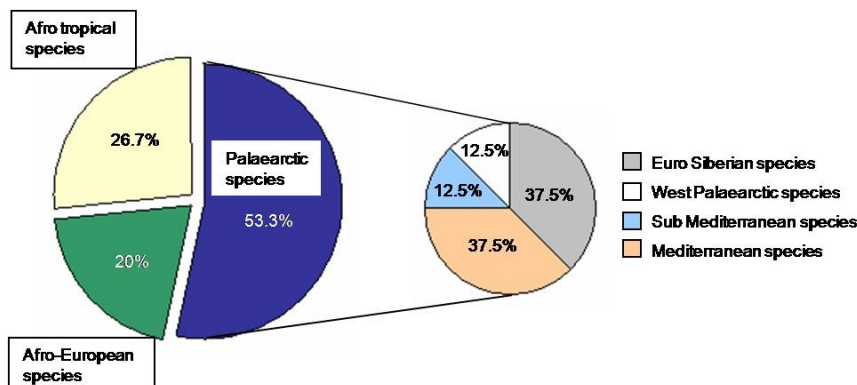


Figure 4. Biogeographical classification of Odonata in the Smir wetlands.

Table II. Conservation status of Odonata collected in the Smir wetlands according to the classification of Jacquemin & Boudot (1999).

Status	Species	Percentage (on 15 species)
Rare species: Red list	- <i>Hemianax ephippiger</i> - <i>Diplacodes lefebvrei</i>	13.3%
Unusual species : Red list	- <i>Aeshna mixta</i> - <i>Aeshna isocoles isocoles</i> - <i>Orthetrum trinacria</i>	20%
Fairly common species	- <i>Sympecma fusca</i> - <i>Orthetrum cancellatum</i> - <i>Sympetrum meridionale</i> - <i>Sympetrum striolatum</i>	26.7%
Very common species	- <i>Ischnura graellsii</i> - <i>Anax parthenope</i> - <i>Anax imperator</i> - <i>Orthetrum chrysostigma</i> - <i>Crocothemis erythraea</i> - <i>Sympetrum fonscolombii</i>	40%

CONCLUSION

The analysis of the results of this work and past literature show that the Smir wetlands are home to 25 species of Odonata, representing 39% of the Moroccan species of dragonflies and damselflies. *Aeshna isocoles* and *Orthetrum chrysostigma* were recorded for the first time in these marshes during this study.

The local community of Odonata can be divided into three biogeographic categories: Palaearctic, Afrotropical and Afro-European, with the Palaearctic being the dominant category. Mediterranean species are well represented.

Five of the species recorded during this work are on the Moroccan red list, representing 19.2% of the rare or threatened Moroccan Odonata. Among the ten species that are absent from our records, *Aeshna affinis* is found in the list of Moroccan rare species (Jacquemin & Boudot 1999). Their absence from our samples indicates that all seven species may be presently considered rare or extinct in the Smir wetlands.

Any further decline in the population of Odonata in the Smir wetlands would trigger alarm signals on the status of the various habitats in this wetland complex. Causes of decline of these insects in this zone are linked to the destruction and/or alteration of aquatic habitats by human activity. This destruction is mainly caused by wetland draining, construction of banks and the channelling of streams. Disturbance also results from pollution and the eutrophication of surface water due to excessive wastewater discharge from increasingly urbanized adjacent areas.

The wetlands of Smir require an implementation of strategies of conservation, management and monitoring for the protection of their dragonfly and damselfly fauna and their overall biodiversity.

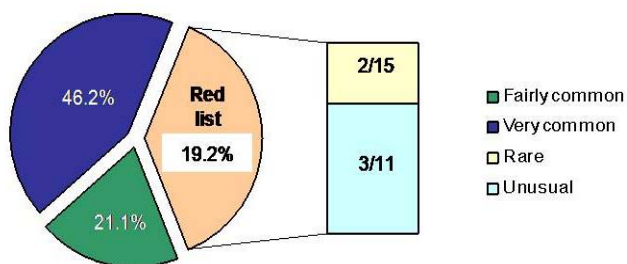


Figure 5. Percentage of categories of threats on the Odonata of the Smir wetlands compared to those of all Moroccan species.

The presence of these Odonata species in the Smir wetlands indicates the site's high biodiversity value. Moreover, according to the conservation status of the Moroccan dragonflies given by Jacquemin & Boudot (1999) (Table 2), of the fifteen species recorded, five (33.3%) are on the Moroccan red list, representing 19.2% of all the red listed Odonata species in Morocco. Two species collected in the Smir wetland belong to the "rare species" category and the other three are "unusual species". In addition, the wetlands harbour ten species of the "fairly common" or "very common" categories of Moroccan Odonata (Table II; Fig. 5).

The importance of the Smir marshes for the diversity of Odonata, and for other biodiversity, and the apparent decline, strongly suggest that it is time to take conservation measures at the watershed level to ensure the site's survival and to restore polluted areas. These should include improving planning strategies for conservation in partnership with the managers of the marshes.

The most urgent measures needed to stabilize the degradation process are the protection of habitat, a halt to any further urbanization, monitoring of water quality, adequate sewage treatment and the creation of managed nature reserves to keep the wetland habitats safe. The establishment of an educational programme for schools and the general public is greatly desired and would greatly benefit to conservation in the area as a whole.

Acknowledgments. This study was supported by the Gibraltar Ornithological & Natural History Society (GONHS) in collaboration with the Moroccan Association of Biodiversity (AMAB). We are pleased to express our thanks to all the participants to this project. It was a part of GIBMANATUR, an Interreg IIIA Gibraltar-Morocco project co-funded by the Government of Gibraltar and the European Union.

References

- Aguesse P. 1968. *Les Odonates de l'Europe Occidentale, du Nord de l'Afrique et des Iles Atlantiques*. Masson, Paris, 258 p.
- Ater M. & Dakki M. 1995. Potentialités écologiques et socio-économiques des marais côtiers de Smir (côte méditerranéenne du Maroc) : principales menaces et chances de conservation. Actes du séminaires sur les Marais Smir-Restinga (Maroc), écologie et propositions d'aménagement. *Trav. Inst. Sci.*, Rabat, Mém. h. sér., pp.1-8.
- Benazzouz B. 1988. Etude du cycle biologique et du polymorphisme larvaire et imaginal chez *Ischnura graellsii* (Rambur, 1842) (Odonata, Zygoptera) au Maroc. Thèse Doc. 3^{ème} Cycle, Univ. Mohammed V, Fac. Sci., Rabat, 183 p.
- Bendaanoun M. 1991. Contribution à l'étude écologique de la végétation halophile, halohygrophile et hygrophile des Estuaires, Lagunes, Delta et Sebkhass au littoral atlantique et méditerranéen et du domaine continental du Maroc : Analyse climatique, pédologique et chimique ; phytoécologique, phytosociologique et phytogéographique. Perspective de gestion, d'aménagement et de développement. Thèse de Doctorat d'Etat ès-Sciences. Faculté des Sciences, Marseille, 680 p.
- Boudot J.P., Kalkman V.J., Azpilicueta Amorín M., Bogdanović T., Cordero Rivera A., Degabriele G., Dommanget J.L., Ferreira S., Garrigós B., Jović M., Kotarac M., Lopau W., Marinov M., Mihoković N., Riservato E., Samraoui B. & Schneider W. 2009. Atlas of the Odonata of the Mediterranean and North Africa. *Libellula Supplement* 9, 256 p.
- Corbet P. 1980. Biology of Odonata. *Ann. Rev. Ent.*, 25, 189-217.
- Corbet P. 1993. Are Odonata useful as bioindicators ? *Libellula*, 12, 3/4, 91-102.
- Dakki M., Hamman F. & Hammada S. 2005. Cartographie des habitats naturels d'une zone humide côtière méditerranéenne: les marais de Smir (région de Tétouan, Maroc). In: Bayed A. & Scapini F. (éds.) - Ecosystèmes sensibles de la Méditerranée: cas du littoral de Smir. *Trav. Inst. Sci.*, Rabat, sér. générale, n° 4, pp. 9-15.
- Dumont H.J. 1972. Contribution à la connaissance des Odonates du Maroc. *Bull. Soc. Sci. Phys. Maroc*, 52, 3-4, 149-179.
- El Gharbaoui A. 1987. Les climats : Géographie physique et géologie. Grande Encyclopédie du Maroc, Vol. 3, pp.14-31.
- Ennabili A. & Ater M. 1996. Flore (*Pteridophyta* et *Spermatophyta*) des zones humides du Maroc méditerranéen. Inventaire et Ecologie. *Acta Bot. Malacit.* 21, 221-239.
- Ennabili A. & Ater M. 2005. Diversité floristique et production de biomasse des macrophytes des marais de Smir. Ecosystèmes côtiers sensibles de la méditerranée : cas du littoral de Smir. Recherche de base pour une gestion intégrée. *Trav. Inst. Sci.*, Rabat, sér. Générale, 4, pp. 17-25.
- Fernet L. & Pilon J.-G. 1970. Les Odonates, indicateurs de la nature du milieu. *Naturaliste Can.*, 97, 401-420.
- Goffart P. & Dufrière M. 1993. La surveillance de l'état de l'environnement Wallon par la méthode des bioindicateurs : résultats de quatre années de suivi des odonates. *Gomphus*, 9, 3, 59-83.
- Goffart P., De Knijf G., Anselin A., & Tailly M. 2006. Les Libellules (Odonata) de Belgique: Répartition, tendances, et habitats. Gembloux, Groupe de Travail Libellules. *Gomphus & CRNFB*, 398 p.
- Guemmouh R. 1988. Contribution à l'étude de quatre représentants du genre *Orthetrum* (Odonata : Libellulidae) au Maroc : Ecologie, répartition, géographie et croissance larvaire. Thèse Doctorat 3^{ème} cycle, Univ. Mohammed V, Fac. Sci. Rabat, 187 p.
- IUCN. 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN, Gland, Switzerland and Cambridge, UK. Available online at <http://www.iucnredlist.org>.
- Jacquemin G. & Boudot J.-P. 1999. Les Libellules (Odonates) du Maroc. Société Française d'Odonatologie, Bois d'Arcy, 150 p.
- Jacquemin G. 1994. Les Odonates du Rif. *Odonatologica*, 23, 3, 217-237.
- Lieftinck M.A. 1966. A survey of the Dragonfly fauna of Morocco (Odonata). *Bull. Sci. Nat. Belg.*, 42, 35, 1-63.
- McLachlan R. 1889. Neuroptera collected by Mr. Walker, R.N., on both sides of the straits of Gibraltar. *Ent. Month. Mag.*, 1, 25, 344-349.
- Riservato E., Boudot J.P., Ferreira S., Jović M., Kalkman V.J., Schneider W., Samraoui B. & Cuttelod A. 2009. The Status and Distribution of Dragonflies of the Mediterranean Basin. IUCN report, Gland, Switzerland & Malaga, Spain, 33 p.
- Valle K.J. 1933. Inventa entomologica itineris Hispanica et Marrocani, quod a. 1926 fecerunt Harald et Hakan Lindberg. XVIII. Odonata. *Soc. Scient. Fenn. Comment. Biol.*, 4, 7, 1-8.

Manuscript received 5 September 2009

Accepted in revised form 27 December 2009