Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

New and interesting data on distribution and ecology of Mayflies from Eastern Morocco (Ephemeroptera)

Youness Mabrouki [1]*, A. F. Taybi[1], M. El Alami[2], A. Berrahou[1]

1 Université Mohamed Premier, Faculté des Sciences, Département de Biologie, Laboratoire Sciences de l'eau, l''environnement et du Développement Durable (LEEDD), B.P. 524, 60000 Oujda, Maroc.
2 Université Abdelmalek Essaadi, Faculté des Sciences de Tétouan, Laboratoire Diversité et Conservation des systèmes biologiques (LDICOSYB), BP. 2121, 93000 Tétouan, Maroc.

Received 21 Mars 2017,
Revised 17 April 2017,
Accepted 24 April 2017.

Keywords

- ✓ Faunal inventory,
- ✓ Endemic species,
- ✓ New records,
- ✓ Oriental Morocco,
- ✓ Moulouya basin,
- ✓ Mayflies.

younes_mab@hotmail.fr
y.mabrouki@ump.ac.ma
Phone: (+212) 699623611

Abstract

The Moulouya's watershed and the Oriental Morocco have been always considered as the poorest in terms of Ephemeroperological settlement. Thanks to our repetitive campaigns, and the difficult territories carried out for the first time, including the High Plateaus, the oriental Sahara and the oriental parts of the Rif, Middle Atlas and the High Atlas, we have been able to identify at least 23 species of the entire study area representing almost half of the Moroccan Ephemeral fauna. This work is dedicated to the monitoring of mayflies populations and update the few data available on this group, mentions new records and attempts to clarify the distribution of this order by giving an overview of the ecology of every single found species.

Abbreviations codes: SIBE : Site of Biological and Ecological Interest **;** C : campaign **;** L : larvae**;** * : first record

Introduction

Despite the efforts for their conservation, the aquatic ecosystems of the basin of Moulouya River and Oriental Morocco suffered from a serious degradation that continues in an accelerated way [1]. Indeed, such degradation is becoming increasingly worrying because of the multitude pollution sources from domestic, industrial and agricultural backgrounds [2-4]. This anthropogenic activity, worsened and accentuated by drought episodes, leads to a significant impact on aquatic biodiversity [5-7].

As well, aquatic macroinvertebrates play a key role both in biodiversity and their function in the food network in the production and ecosystem stability [8]. These communities are the first elements affected by the physical and chemical changes of habitat, making them useful for the monitoring of the ecological integrity of surface waters [9]. For cons, the conservation of biodiversity requires a good knowledge of species and their role in the ecosystem. In this connection, Berrahou [10] was the first to try the biotypology of the Moulouya Wadi based on benthic macroinvertebrates in Oriental Morocco. Other studies have emerged thereafter [including 11-15].

The initial work carried out on the Ephemeroptera in Oriental Morocco and the basin of Moulouya River is due to Lestage [16], which mentioned the presence of *Oligoneuriella rhenana* (Imhoff, 1852) in the Oujda region. Seventy years later, Berrahou *et al.* [10] have studied them in part, in work carried out on a large portion of the basin, to identify nine species: *Baetis pavidus* (Grandi, 1949) ; *Baetis rhodani* (Pictet, 1843) ; *Procloeon pennulatum* (Eaton, 1870) ; *Pseudocloeon neglectus* (Navás, 1913) ; *Cloeon dipterum* (Linnaeus 1761) ; *Caenis luctuosa* (Burmeister 1839) ; *Oligoneuriopsis skhounate* (Dakki & Giudicelli, 1980) and *Choroterpes picteti* (Eaton 1871). Thereafter, El Alami [17] added a species to the list of Oriental Morocco's mayflies in a work dedicated especially for this group; it is *Ecdyonurus ifranensis* Vitte & Thomas, 1988 cited in Nador region. Finally and most recently the work of Taybi [6], which reveals main results, presented in this document.

To update the scarce data on the geographical distribution of Ephemeroptera in the basin of Moulouya River and Oriental Morocco, we prospected 45 stations along the catchment area of the great ecosystem, with the large permanent streams: Oued Anzegmir (side of the High Atlas), Oued Melloulou (Middle Atlas side) and Oued Za (High Plateaus), visited at least during three sampling campaigns. Complemented by 43 stations distributed all

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

over the Oriental Morocco, from the regions of Nador and Saidia North, Figuig southeast and finally Talessint and Bouanane southwest.

2. Materiel and methods

2.1. *Study area*

Morocco is currently divided according to the new administrative division into 12 regions including Oriental Region (Figure 1) which occupies the entire eastern end of the country, and covers an area of 88 681 km^2. This area is bounded to the north by the Mediterranean Sea, east and south by the Morocco - Algerian border and to the west by the administrative regions Tangier-Tetouan, Al Hoceima, Fez-Meknes and Draa-Tafilalt. The Oriental region includes the wilaya of Oujda (Oujda-Angad prefecture) and the provinces of Berkane, Taourirt, Jerada, Nador, Figuig, Driouch and Guercif.

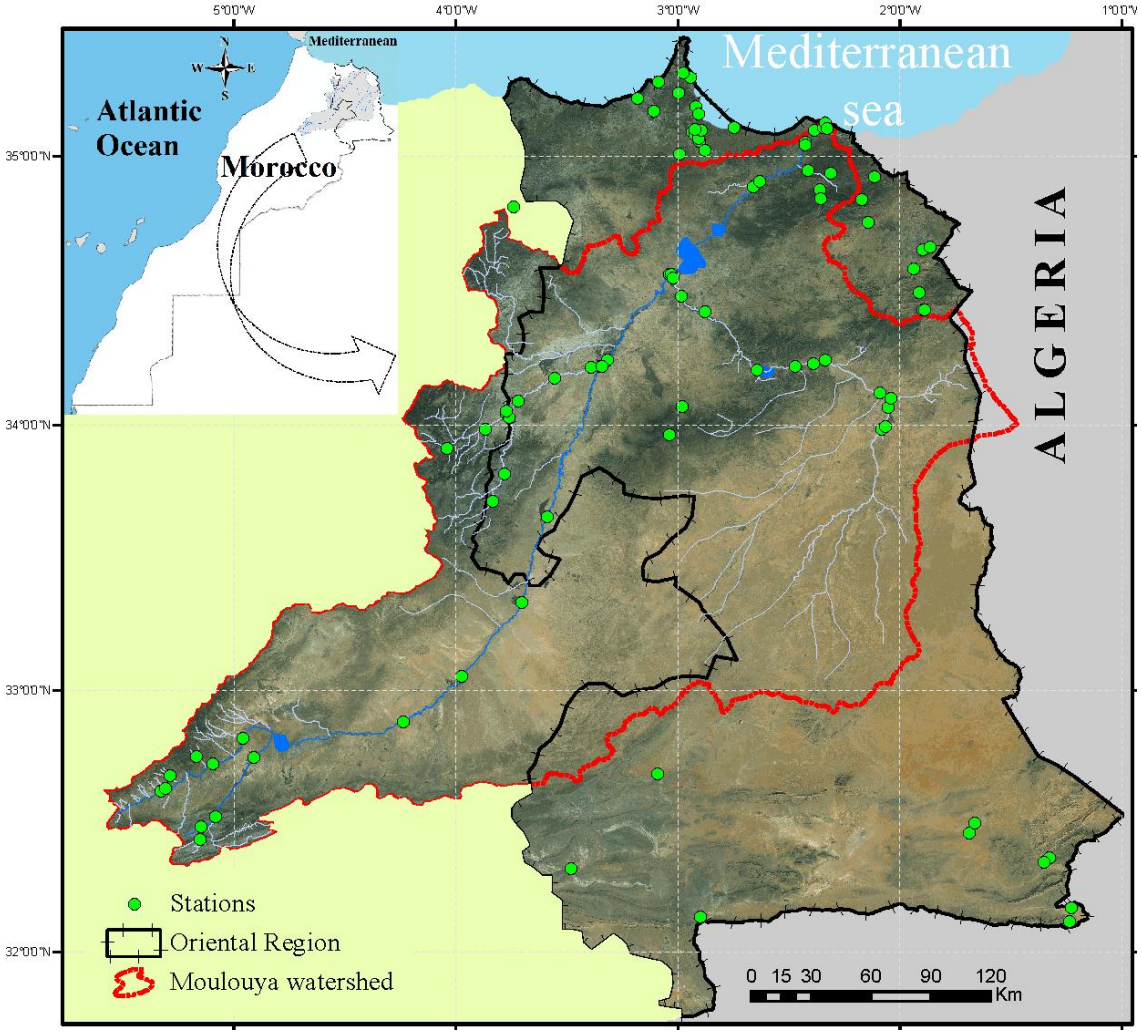

Figure 1. Location of the Eastern Morocco and the Moulouya's watershed with the stations of the study

The watershed of the Moulouya (Figure 1), which covers nearly 74 000 km^2 to the east of Morocco, covers much of the Oriental region. It is bordered to the northeast by the Mediterranean, northwest through the chain of Beni Bouyahi to the west by the mountains of eastern Rif and Middle Atlas pleated, south by the High Atlas. Its limit corresponds to Morocco-Algerian border. With a length of 600 km, the Moulouya is the largest North African river flowing into the Mediterranean. It starts at the junction of the High and Middle Atlas chains, and flows primarily one southwest - northeast axis. Its main affluents are perennial: Anzegmir Wadi, Melloulou Wadi and Za Wadi, and other tributaries flow only during the floods (3-5 floods on average per year) that last from hours to some days. The river flows through various Mediterranean bioclimatic zones, which are a function of altitude and continentality.

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

The field surveys were conducted between 2011 and 2016, in which 45 stations have been carried out along the watershed of the great Moulouya, with large permanent rivers: Oued Anzegmir (side of the High Atlas) Oued Melloulou (Middle Atlas side) and Oued Za (High Plateaus) visited at least during three sampling campaigns. Completed by 43 stations distributed all over Oriental Morocco, from the regions of Nador and Saidia North, Figuig southeast and finally Talessint and Bouanane southwest.
The samples of benthic fauna, essentially qualitative, were carried out by a kick net, landing nets and clamps. The capture of some adults has been carried out using an entomological net. Meanwhile, a detailed description of the aquatic environment is made (appendices). In addition the various impacts which the stations are subjected to, are offered in the following works [2-7].
The identified species are conserved in alcohol at 96 ° or 70% in duly labeled tubes and deposited in the collection of aquatic macroinvertebrates of the Laboratory of Water Sciences, environment and sustainable development of the University Mohammed Premier Oujda. The identification has been done by using the keys of Dakki & Giudicelli [18] ; Belfiore [19] ; Thomas & Vitte [20] ; Alba-Tercedor & El-Alami [21] ; El Alami [17]; and the realization of the maps has been done by using the ArcGIS software.

3. Results

A total of 24 mayfly species, belonging to 8 families and 17 genera, are reported from the Oriental Morocco and the basin of Moulouya River, including the High Plateau, the oriental Sahara and the oriental parts of the Rif, Middle Atlas and the High Atlas.

Family Baetidae Leach, 1815

Genus *Acentrella* Bengtsson, 1912

Acentrella almohades* Alba-Tercedor & El Alami, 1999

Materiel examined S1: C1-C2, 7L ; S2: C1-C2, 4L ; S3: C1-C2, 4L.

Ecology: In the Rif, it has been sampled in large rivers with temperate winter, in an altitudinal margin comprised between 20 and 840m [17]. In the basin of Moulouya River, it is restricted to the Oriental Middle Atlas, in an altitudinal margin comprised between 750 and 931m, where it frequents the alongside of streams and headwaters rivers.

Distribution: Ibero-Moroccan endemic species, only known from Morocco (Rif and Atlas) and southern Spain [17, 21]. So far, the only species known in Morocco has been *A. almohades*; in Tunisia, it is replaced by its congener *A. sinaica* (Boumaiza & Thomas 1995).
Due to the great similarity between the two species, it seems necessary to review the identification of specimens of *A. sinaica* to confirm its presence in the Iberian Peninsula and North Africa [21]. In Morocco *A. almohades* has a relatively small horizontal distribution since it is mainly located in the Rif area and Middle Atlas, where it likes the big rivers of the western Rif situated between the Tingitane peninsula and the Ouezzane region [17].
This is a new species for the watershed of the Moulouya, where its distribution is restricted to the upstream of Melloulou River (Figure 2) that correspond to the southeast side of the Middle Atlas.

Genus *Baetis* Leach, 1815

***Baetis pavidus* Grandi, 1949**

Material examined : M1 : C1-C2, 23L ; M2 : C1-C2, 41L ; M3 : C1-C2-C3, 50L ; M4 : C1-C2-C3, 178L ; M5 : C1-C2-C3, 200L/3♂/5♀ ; M7 : C1-C2-C3, 350L/7♂/12♀ ; M8 : C1-C2-C3, 145L ; M9 : C1-C2-C3, 100L ; M10 : C1-C2-C3, 80L ; M11 : C1-C2-C3, 184L ; M12 : C1-C2-C3, 141L ; M13 : C1-C2-C3, 91L ; M14 : C1-C2-C3, 71L ; M15 : C1-C2-C3, 87L ; M16 : C1-C2-C3, 150L ; M17 : C1-C2-C3, 114L ; M18 : C1-C2-C3, 90L ; M19 : C1-C2-C3, 158L ; M20 : C1-C2-C3, 158L ; M21 : C1-C2-C3, 200L ; M22 : C1-C2-C3, 76L ; Z1: C1, 19L ; Z2: C1, 4L ; Z3: C1-C2-C3, 89L ; Z4: C1-C2-C3, 91L ; Z5: C1-C2-C3, 40L ; Z6: C1-C2-C3, 57L ; Z7:

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

C1-C2-C3, 119L ; Z8: C1-C2-C3, 147L ; Z9: C1-C2-C3, 250L ; Z10: C1-C2-C3, 100L ; Z12: C1-C2-C3, 80L ; S1: C1-C2-C3, 98L ; S2: C1-C2-C3, 21L ; S3: C1-C2-C3, 36L ; S4: C1-C2-C3, 198L ; S5: C1-C2-C3, 27L ; S6: C1-C2-C3, 28L ; S7: C1-C2-C3, 78L ; S8: C1-C2-C3, 100L ; S9: C1-C2-C3, 142L ; S10: C1-C2-C3, 110L ; S11: C1-C2-C3, 80L ; O1: 27/04/2016, 13L ; O3: 28/04/2016, 2L ; O2: 27/04/2016, 3L ; O4: 28/04/2016, 3L ;O5: 28/04/2016, 1L ;O6: 1-4/12/2015, 2L ;O8: 22/02/2016, 3L ; O9 ; 19/09/2015, 5L ;O10: 18/11/2015, 2L ;O11: 18/11/2015, 6L ;O12: 01/02/2015, 3L ; O13: 01/02/2015, 10L ; O14: 6/06/2016, 1L ; O15: 06/06/2016, 17L ; N1: 30/04/2016, 5L ; N3: 2/05/2016, 16L ;N4: 30/04/2016, 20L ;N5: 30/04/2016, 3L ; N6: 2/05/2016, 6L ; N8: 2/05/2016, 1L ; N10 : 5-6-7/02/2015, 12L ; N11: 12/05/2016, 4L ;N13: 12/05/2016, 20L ; N15 : 05/04/2014 12L ; F3: 22/05/2016, L ; F5: 22/05/2016, L.

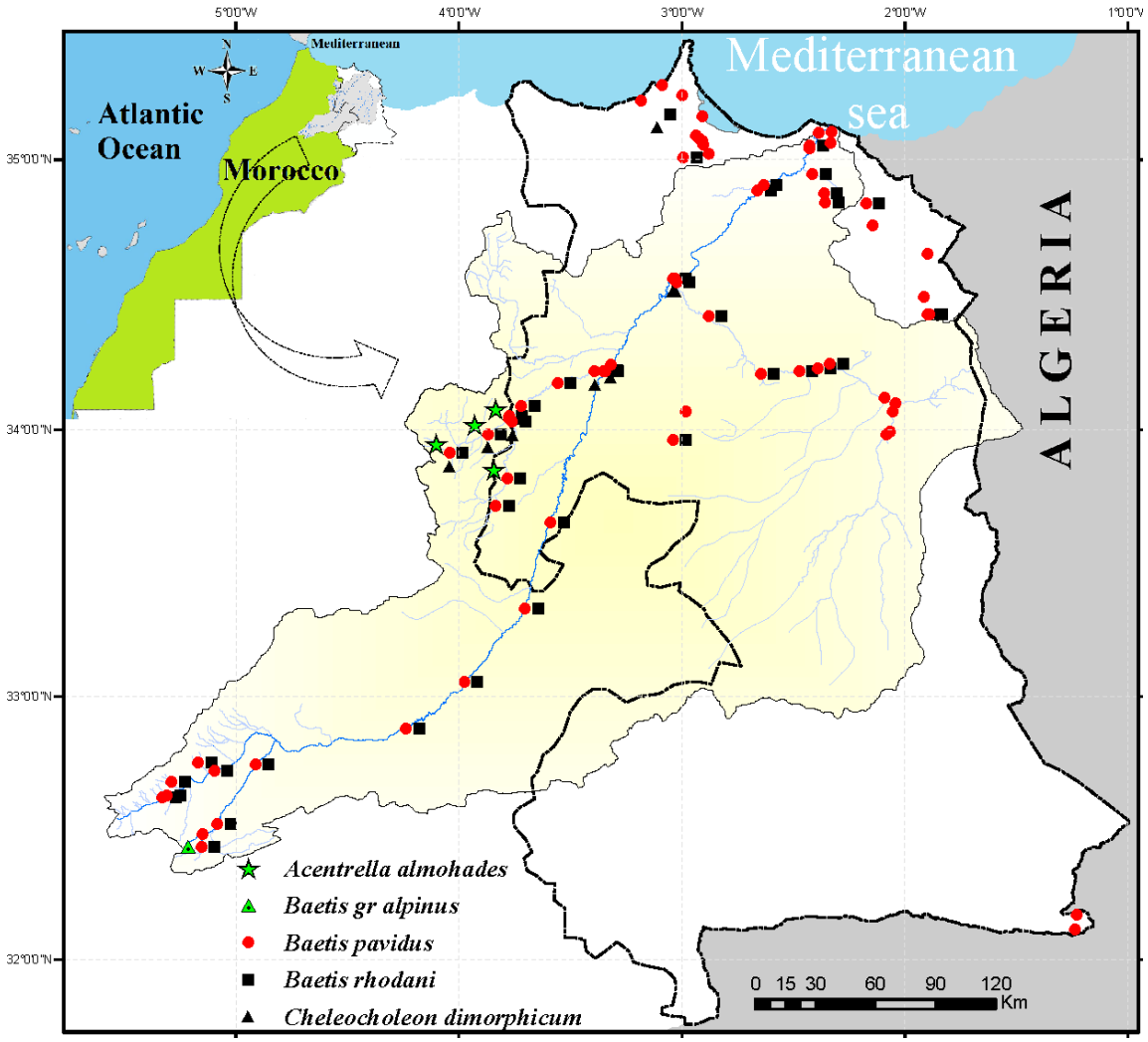

Figure 2. Distribution of *A. almohades*, *B.* gr *alpinus*, *B. pavidus*, *B. rhodani* and *C. dimorphicum* in the study area

Ecology: Rheophilous and thermophilous [22], *B. pavidus* is a eurytopic species in the Oriental Morocco and the basin of Moulouya River where it is present in almost all the major perennial rivers. It occupies an altitudinal margin comprised between 2 and 1895m and it colonizes all types of habitat (source and their emissaries, streams and rivers).

Distribution: Atlanto-Mediterranean species [23], its range spread from Italy to the Iberian Peninsula, and from France to the Maghreb [24-27]. It has a wide distribution in Moroccan waters; it frequents the major river systems of the Middle Atlas [28], High Atlas [29], Central Plateau [30] and those of the Rif [17].

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

This is probably the most abundant species in Oriental Morocco and the watershed of the Moulouya (Figure 2), where it was cited along the river and the High Atlasic emissary Oued Anzegmir [10, 14] and finally the Oued Za [11]. Harvested in most of the carried stations where it's the most eurytope species. It regresses only in temperate, standing or with very low current water.

***Baetis rhodani* Pictet, 1843**

Material examined : M1 : C1-C2, 31L ; M2 : C2-C3, 40L ; M3 : C1-C2-C3, 57L ; M4 : C1-C2, 183L ; M5 : C1-C2-C3, 58L ; M7 : C1-C2-C3, 356L/14♂/25♀ ; M8 : C1-C2-C3, 230L ; M9 : C1-C2-C3, 200L ; M10 : C1-C2-C3, 140L ; M11 : C2-C3, 23L ; M12 : C2, 15L ; M13 : C2-C3, 45L ; M14 : C1-C3, 15L ; M15 : C1-C2-C3, 19L ; M16 : C1-C2, 13L ; M17 : C2-C3, 17L ; M19 : C1-C2-C3, 11L ; M20 : C1-C2-C3, 20L ; M21 : C2-C3, 29L ; Z6: C2, 3L ; Z7: C3, 10L ; Z8: C1-C2-C3, 13L ; Z9: C1-C2-C3, 90L ; Z10: C1-C2-C3, 18L ; Z12: C2-C3, 11L ; S1: C1-C2, 134L ; S2: C1-C2-C3, 237L ; S3: C1-C2-C3, 189L ; S4: C1-C2-C3, 300L ; S5: C1-C2-C3, 145L ; S6: C1-C2-C3, 57L ; S7: C1-C2-C3, 89L ; S8: C1-C2-C3, 90L ; S9: C1-C2, 20L ; S10: C1, 3L ; S11: C1-C2, 3L ; O1: 27/04/2016, 8L, /1♂/4♀ ; O4: 28/04/2016, 5L ;O10: 18/11/2015, 4L ;O11: 18/11/2015, 11L ;O12: 01/02/2015, 17L ;O14: 6/06/2016, 3L. ; O15: 06/06/2016, 1L ; N4: 12/05/2016, 14L ;N12: 12/05/2016, 5L.

Ecology: In the Middle Atlas, the species has been observed in cold and temperate habitats of high and medium altitudes and disappears in the hottest and the lively current stations [31]. This species is eurytope in the watershed of the Moulouya where it is widely distributed. It occupies a wide variety of habitats characterized by a stony bottom, as sources, streams, rivers and at all altitudes. The same remark was made in the Rif [17].

Distribution: Western-Palearctic species, with a latitudinal distribution covering Europe and the Mediterranean countries [26, 27, 32]. In Morocco, it is one of the most ubiquitous species, where it is known from the Rif [17], the Central Plateau [33], the Middle Atlas [31] and finally the High Atlas [29].
As *B. pavidus*, it is one of the most abundant species in the Oriental Morocco and the basin of Moulouya River (Figure 2), where it was recorded from the entire river and his High Atlasic emissary Oued Anzegmir [10, 14] and the Oued Za [11]. During the period of the study, *B. rhodani* has been found occupying almost the same habitats as *B. pavidus* (sources and their outfalls and rivers), it regresses only in temperate waters of low altitude.

Baetis* gr *alpinus* (Pictet 1843)

Material examined M7: C1, 3L.

Ecology: In the Moulouya it was sampled in the north side of the High Atlas, in a fresh source flowing into the Anzegmir river. It is characterized by a dense aquatic and riparian vegetation, the bottom substrate consists mainly of gravel and stones, located at 1895m in a pristine environment free from any human activity.

Distribution: In Morocco, *B. alpinus* group is represented by three species: *B. maurus* Alba-Tercedor 1983 which has been described from the Middle Atlas ; *B. berberus* Thomas & Bouzidi, 1986, which is a Moroccan stenotopic and endemic species described from the High Atlas and finally, *B. punicus* Thomas, Boumaiza & Soldán, 1986 an Ibero-North African species, was described for the first time in Tunisia [32] and then, recorded from Algeria [34] and the Iberian Peninsula [35]. In Morocco *B. punicus* has been cited for the first time in the Rif, where it has a very wide range [17].
This species is new to the watershed of the Moulouya, where it is located only in the north side of the High Atlas (Figure 2). It seems to prefer sources and their emissaries. The species appears especially during the cold period when the flow velocities is strong enough.

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Genus *Cheleocloeon* Wuillot & Gillies, 1993

***Cheleocholeon dimorphicum* (Soldán & Thomas, 1985)**

Material examined : M16 : C1-C2, 3L ; M17 : C1, 2L ; M18 : C1, 2L ; M19 : C2-C3, 4L ; S1: C1-C2-C3, 5L ; S2: C1-C2-C3, 4L ; S3: C1-C2-C3, 4L ; S6: C2, 1L ; S10: C2, 1L ; S11: C1-C2, 4L ; N12: 12/05/2016, 4L.
Ecology: It occupies the permanent streams with stony bottom, rich in plant debris and with relatively high current [17]. In the basin of Moulouya River and Oriental Morocco, this species deals with a wide range of habitats in an altitudinal margin comprised between 79 and 931m.

Distribution: It is a Maghrebian endemic species [27, 36]. The species was found for the first time in Morocco in the High Atlas at Tensift river [37], then it has been recorded in the Rdat river [38], N'Fis [39] and Khettarats of Marrakech [40] and finally in the Rif, where it was registered in several localities [17].
This is an unprecedented species in the watershed of the Moulouya and Oriental Morocco; our study can significantly expand its distribution area. In fact, these taxa occupy the Middle Moulouya, upstream and downstream of Oued Melloulou and finally the Nador region (Figure 2).

Genus *Cloeon* Leach, 1815

***Cloeon dipterum* Linnaeus 1761**

Material examined : M1 : C2-C3, 87L ; M2 : C2-C3, 59L ; M3 : C2-C3, 14L ; M4 : C2-C3, 49L ; M5 : C2-C3, 16L/3♂/1♀ ; M8 : C3, 3L ; M10 : C2-C3, 10L ; M11 : C3, 3L ; M14 : C3, 1L ; M15 : C1-C3, 2L ; M21 : C1-C2-C3, 100L ; M22 : C1-C2-C3, 190L ; Z2: C1-C2-C3, 13L ; Z3: C3, 20L ; Z4: C2-C3, 4L ; Z5: C2-C3, 12L ; Z6: C2-C3, 5L ; Z7: C2-C3, 4L ; Z9: C2-C3, 10L ; Z10: C3, 4L ; Z12: C2-C3, 2L ; S5: C3, 1L ; S6: C2, 1L ; S8: C2-C3, L ; S9: C3, 1L ; S10: C3, 1L ; O2: 27/04/2016, 6L ;O6: 1-4/12/2015, 8L ;O9 : 19/09/2015, 1L ; O16 : 17/07/2016, 3L ; N3: 2/05/2016, 15L ;N4: 30/04/2016, 3L ;N9 : 18/05/2015, 7L ; N10 : 5-6-7/02/2015, 4L ; N12: 12/05/2016, 10L ;N14: 12/05/2016, 9L ;F2 : 21/05/2016, 26L/12♂/20♀ ; F3: 21/05/2016, 3L ; F8: 19/01/2015, 2L.

Ecology: In the catchment area of the Moulouya and Oriental Morocco, it occupies calm biotope of the rivers and hot springs. We had sampled it mostly from the adjacent small ponds resulting from the decline of water levels, as in the stations of the downstream of the Moulouya.

Distribution: Probably Holarctic species [23]. *C. dipterum* presents a wide latitudinal distribution since it can be found throughout Europe, even Siberia in the Asian continent [41] and North America from Quebec to Canada [42]. Its southern boundary reaches the southern Mediterranean countries [25-27]. In Morocco, this species has a wide distribution. It was recorded from the Middle Atlas [43], the High Atlas [29] and finally from the Occidental and Central Rif [17].

This is a widely distributed species in the study area (Figure 3). In fact? it has been found in most conducted stations in the basin of Moulouya River and Oriental Morocco, especially during the summer.

Cloeon* gr *simile* Eaton, 1870

Material examined: N14: 12/05/2016, 2L ;F5: 22/05/2016, 3L.

Ecology: In Morocco, this species has been collected from north coastal of the Rif system [17]. While in Algeria, specimens of *simile* group were found in the Sahara [44]. In the basin of Moulouya River and Oriental Morocco, the two habitat types (coastal and inland) are occupied by this group of species in an altitudinal

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

margin comprised between 87 and 902m, this is why we believe it is likely represented by two different species (view the variety of habitats and different bioclimatic zones).

Distribution: With a distribution exceeding the Palearctic region, this species has been reported in European rivers in lentic upper zones [45]. In Algeria, it has been noted by several authors [25, 44] and recently it has been cited in Oued Abdi [26] and in north Tunisia [27]. In Morocco, it has been only known from the north of the Rif [17].

This is an unprecedented species for the basin of Moulouya River and the Oriental Morocco; we mention it for the first time in the Oriental Rif and Sahara (Figure 3).

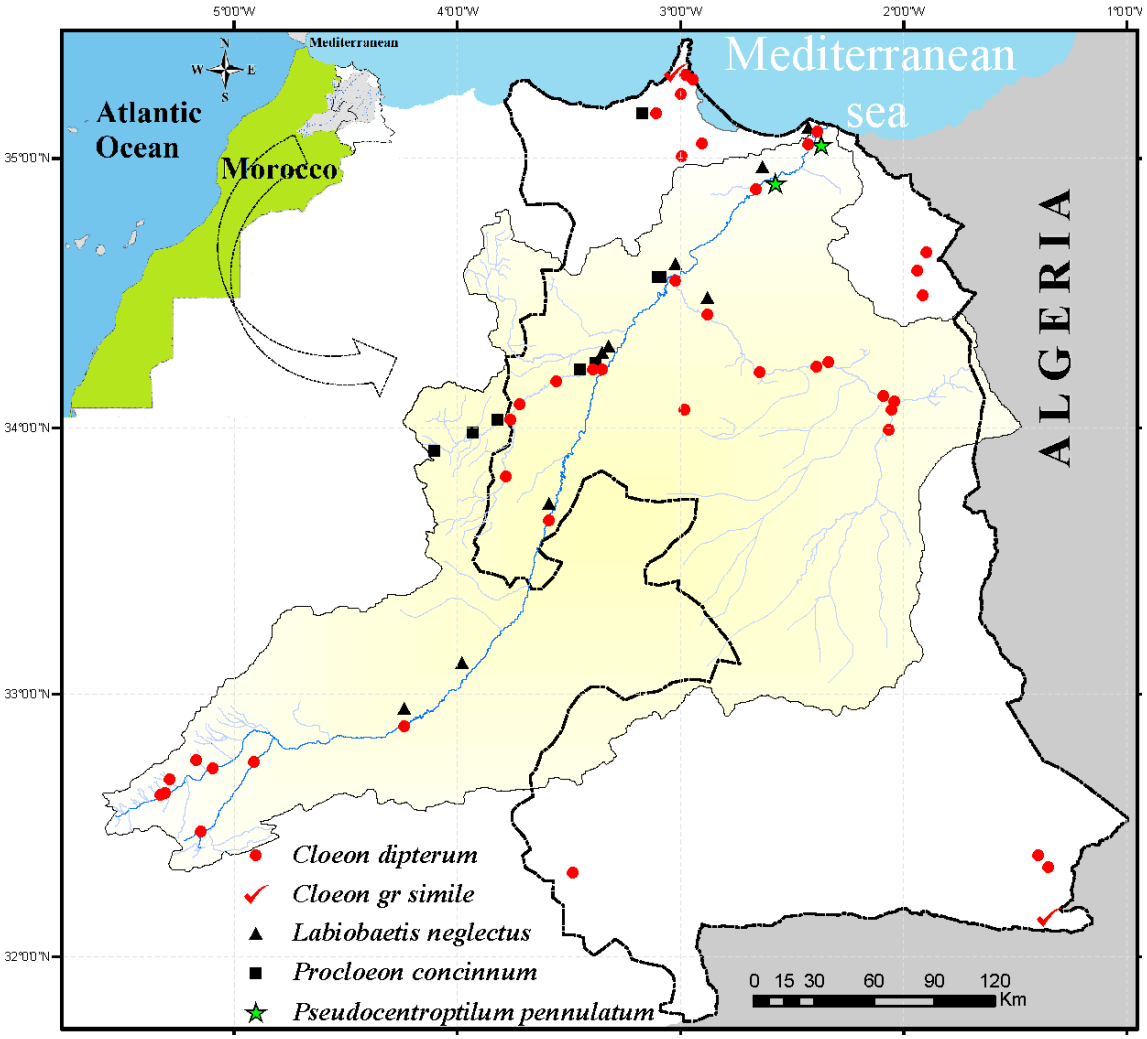

Figure 3. Distribution of *C. dipterum, C.* gr *simile,* L. neglectus, *P. concinnum,* and *P. pennulatum* in the study area

Genus *Labiobaetis* Novikova & Kluge, 1987

***Labiobaetis neglectus* (Navás, 1913)**

Material examined : M11 : C2, 2L ; M12 : C3, 4L ; M14 : C2, 3L ; M15 : C2, 4L ; M20 : C2-C3, 2L ; M21 : C3, 1L ; Z10 : C1, 1L ; Z12 : C2, 2L.

Ecology: In the catchment area of the Moulouya, this species shows a thermophilic character as it began to appear with the warming water (from the second campaign). It occupies the middle and lower streams,

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

characterized by a wide floodplain and high flow during the summer, in an altitudinal range comprised between 9 and 640m.

Distribution : An endemic Ibero-Maghrebian element, was widely distributed in Morocco, where it was recorded from the Middle Atlas [28], the Central Plateau [30], the High Atlas [46], and finally the Western Rif [17].
In Oriental Morocco, it has been previously reported between "Cap de l'Eau" and "Oued Sebra" [14]. This is a rare species in the study area; we found it in very low numbers, occupying the Middle and Lower Moulouya and finally the downstream of Oued Za (Figure 3).

Genus *Procloeon* Bengtsson, 1915

Procloeon concinnum* (Eaton, 1885)

Material examined : M11 : C2-C3, 4L ; M13 : C1-C2, 3L ; M16 : C1-C2-C3, 1L ; M19 : C3, 6L ; M21 : C3, 5L ; Z1: C1, 2L ; Z2: C1, 3L ; Z9: C1-C2, 3L ; Z10: C3, 3L ; Z12: C2, 1L.

Ecology: It is a thermophilic species that has a clear preference for the sandy substrates [17]. In the study area, it has a discontinuous distribution; it prefers the temperate and warm waters of temporary and permanent stations of low and medium altitudes.

Distribution: Ibero-North African endemic species. In Morocco, the first record of *P. concinnum* belong to Navás [47] who discovered it in the region of Tetouan. Since then, the distribution area has been restricted to the Tingitane Peninsula [17].
This is a new species for the Oriental Morocco and the basin of Moulouya River, where it has a wide distribution (Figure 3) with a very low abundance.

Genus *Pseudocentroptilum* Bogoescu, 1947

***Pseudocentroptilum pennulatum* (Eaton, 1870)**

Material examined: M20: C2-C3, 3L ; M21: C2, 1L.

Ecology: In the Lower Moulouya, this species appears to be thermophilic, occupying the lower sections of the river at an altitude comprised between 9 and 50 m. The stations where it has been sampled are characterized by a quite wide major bed, with natural banks carrying a dense vegetation; the bottom substrate consists of pebbles, gravel and sand.

Distribution : It is a Holarctic species with a distribution exceeding the Palearctic region, where it occupies Asia, Europe and North Africa. However, its presence in the countries of Eastern Europe appears to be doubtful [41]. In Morocco, this species has a wide distribution, it was reported for the first time in North Africa by Dakki [28] in the Middle Atlas, and then it was found in the Central Plateau, High Atlas and the Rif [17].
In Oriental Morocco, it has been reported only at the SIBE of Moulouya [14]. After 15 years, we are rediscovering it in the same section of the catchment area (Figure 3).

Family Oligoneuriidae Ulmer, 1940

Genus *Oligoneuriopsis* Crass, 1947

***Oligoneuriopsis skhounate* Dakki & Giudicelli 1980**

Material examined : M11 : C2-C3, 5L ; M12 : C2-C3,12 L ; M13 : C2-C3, 13L ; M14 : C2-C3, 16L ; M15 : C2-C3, 20L ; M16 : C2-C3, 5L ; M17 : C2-C3, 21L ; M18 : C2-C3, 6L ; M19 : C2-C3, 15L ; M20 : C2-C3, 5L ;

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

M21 : C3, 3L ; Z3: C3, 9L ; Z4: C2-C3, 20L ; Z5: C3, 2L ; Z6: C2-C3, 23L ; Z7: C3, 6L ; Z8: C2-C3, 33L ; Z9: C2-C3, 10L ; Z10: C2-C3, 15L ; Z12: C2-C3, 6L ; S5: C3, 6L ; S6: C3, 5L ; S7: C3, 4L ; S8: C2-C3, 14L ; S9: C2-C3, 23L ; S10: C2-C3, 11L ; S11: C2-C3, 14L ; O15: 06/06/2016, 3L.

Ecology: In river systems of Oriental Morocco and the basin of Moulouya River, this species begins to appear up concretely from the second campaign, proportionally with the warming of water until the hot periods (third campaign), then to manifest in a large populations.

Distribution: Endemic Ibero-Maghrebian species, native to North Africa, *O. skhounate* is widespread in the Spanish rivers [20, 48, 49]. In Morocco, this species shows a wider distribution. In fact, it was recorded from the Middle Atlas [18], the High Atlas [29] and finally from the Rif [17].
In the basin of Moulouya River and Oriental Morocco, this species has been mentioned for the first in the Middle and Lower Moulouya [10, 14], after that, it has been reported along the river of Za [11]. Our study can significantly enlarge its range of distribution, since we discover it for the first time in the rivers of Melloulou and Cherraa (Figure 4).

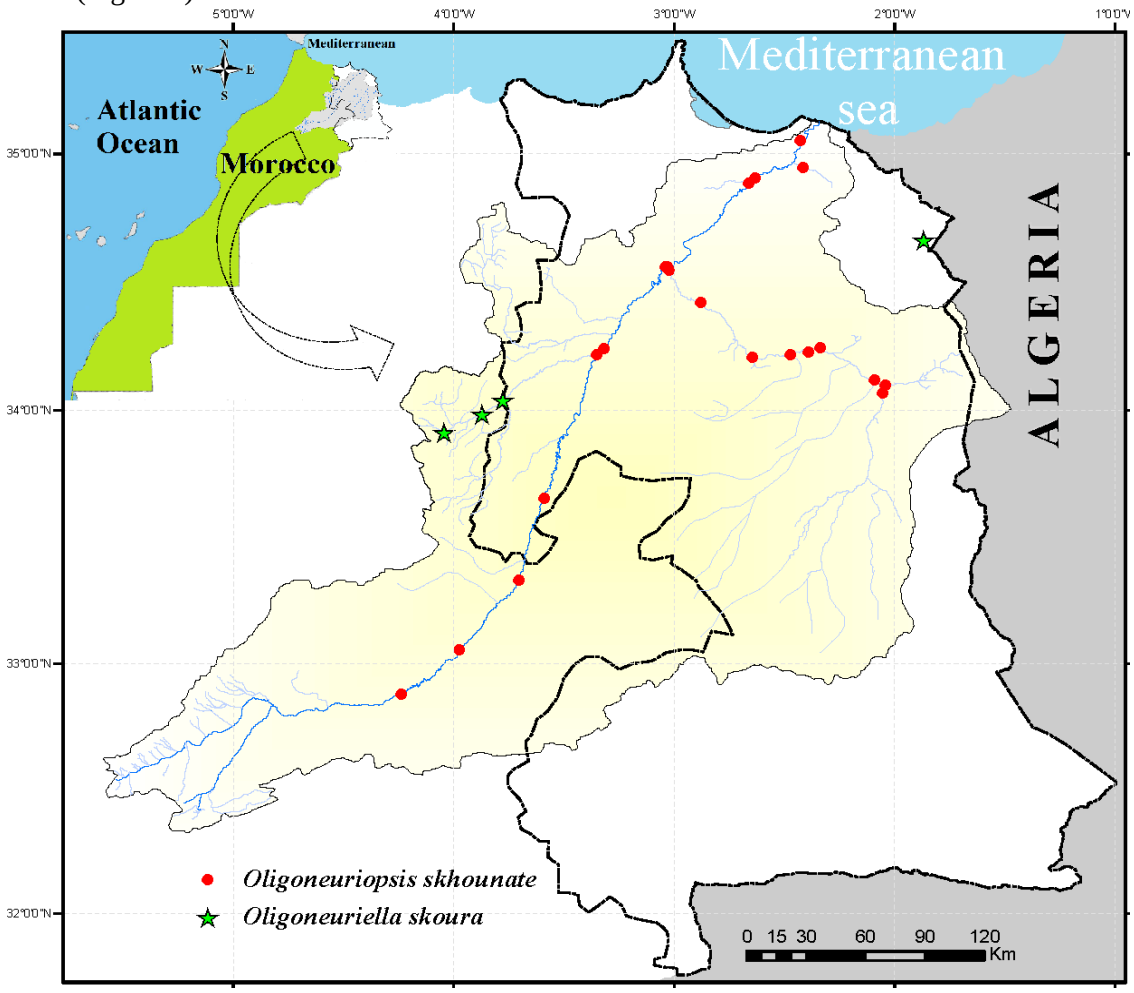

Figure 4. Distribution of *O. skhounate* and *O. skoura* in the study area

Genus *Oligoneuriella* Ulmer, 1924

Oligoneuriella skoura* Dakki & Giudicelli, 1980

Material examined: S1: C1, 1L ; S2: C1, 3L ; S3: C1, 1L.

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Ecology: *O. skoura* is rheophilic, it can be found in the strong current rivers (rarely in areas with low current) and stony bottom. In the study area, this species is restricted to the Eastern Middle Atlas (the upstream of Oued Melloulou), where it has been sampled only during the first campaign.

Distribution: Maghrebian species, it has been known only from Algeria (northern areas) and Morocco (Atlasic areas) [17], where it seems to be absent in the Rif and Central plateau.
In Eastern Morocco, it has been recorded by Lestage [16] under *O. rhenana* (Imhoff 1852) in the vicinity of Oujda's region. The drying of permanent running water and climate change have contributed since the disappearance of the species from this area; we couldn't find it despite the many prospecting campaigns. However, we have discovered it for the first time in the watershed of the Moulouya where it is restricted to the Eastern Middle Atlas, which corresponds to the upstream of the Oued Melloulou (Figure 4).

Family Heptageniidae Needham, 1901

Genus *Ecdyonurus* Eaton, 1868

***Ecdyonurus rothschildi* Navás 1929**

Material examined : M3 : C1-C2-C3, 12L ; M4 : C1-C2-C3, 10L ; M5 : C1-C2-C3, 12L ; M7 : C1-C2-C3, 6L ; M8 : C1-C2-C3, 14L ; M9 : C1-C2-C3, 21L ; M10 : C1-C2-C3, 2L ; M11 : C1-C2-C3, 16L ; M12 : C1-C2, 8L ; M13 : C1-C2-C3, 12L ; M14 : C1-C2-C3, 6L ; M15 : C1-C2-C3, 14L ; M16 : C1-C2-C3, 6L ; M17 : C1-C2-C3, L ; M18 : C1-C2-C3, 3L ; M19 : C1-C2-C3, 3L ; M20 : C1-C2-C3, 20L ; M21 : C1-C2, 23L ; Z3: C1-C2, 6L ; Z4: C1-C2-C3, 8L ; Z5: C1-C2-C3, 16L ; Z6: C1-C2-C3, 20L ; Z7: C1-C2-C3, 8L ; Z8: C1-C2-C3, 7L ; Z9: C1-C2-C3, 12L ; Z10: C1-C2-C3, 10L ; Z12: C1-C2-C3, 8L ; S1: C1-C2-C3, 31L ; S2: C1-C2-C3, 20L ; S3: C1-C2-C3, 13L ; S4: C1-C2-C3, 21L ; S5: C1-C2-C3, 22L ; S6: C1-C2-C3, 18L ; S7: C1-C2-C3, 12L ; S8: C1-C2-C3, 14L ; S9: C1-C2-C3, 5L ; S10: C1-C2-C3, 8L ; S11: C1-C2-C3, 8L ; O4: 28/04/2016, 15L ;O12: 01/02/2015, 8L.

Ecology: This is the most thermophilic species of the Heptageniidae family, in the watershed of the Moulouya and Eastern Morocco. *E. rothschildi* is widespread in the permanent stations of low and medium altitude with strong current. It is replaced by *Rhithrogena* sp1 and *Rhithrogena* sp2 in torrential systems of high altitudes with fresh cold water.

Distribution : This endemic Ibero-Maghrebian species with wide-ranging in North Africa [16, 25, 26, 27, 36]. It has also a wide distribution in Morocco where it occupies almost all the rivers in lowland and foothills [50]. It was reported from the Middle Atlas [28], the High Atlas [29] the Central Plateau [30] and finally the Rif [17].
The species has been previously recorded from Oriental Morocco and the basin of Moulouya River [11, 14]. However, we allow its first record from the watershed of Oued Melloulou and Beni Snassen's massif (Figure 5).

***Ecdyonurus ifranensis* Vitte & Thomas, 1988**

Ecology: This species is thermophilic and alticole in watercourses of the Middle Atlas (1520-2020 m) and the Rif (20-1300 m) [17].

Distribution: This Moroccan endemic has been described from a Middle Atlas material. Old records of *E. forcipula* (Pictet, 1843) in the Middle Atlas [50] and the High Atlas [29] would be attributed to *E. ifranensis* after the description of the latter [17]. It has big range of distribution in the river systems of the western Rif [17].

In the Oriental Morocco, it was reported only in eastern area of the Rif (Figure 5) from a single locality [17]. Despite many attempts, we're have not been able to find it.

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Genus *Rhithrogena* Eaton, 1881

***Rhithrogena* sp1 :**

Materiel examined:M3 : C1, 3L ; M4 : C1, 1L ; M5 : C1, 1L ; M7 : C1-C2-C3, 7L ; M8 : C1-C2, 2L ; M9 : C1-C2, 2L ; M10 : C1-C2, 2L ; S1: C1, 2L ; S2: C1-C2, 3L ; S3: C1-C2, 3L ; S4: C1-C2-C3, 3L ; S5: C1-C2, 4L ; S6: C1-C2 2L ; S7: C1, 1L.

Ecology: This species is localized in permanent higher watercourses belonging to the upper watershed of the Moulouya. It is probably wintry and reached its ecological optimum in the spring, in waters characterized by strong current, low mineralization, highly oxygenated and thoroughly stony bed.
Due to the variety of habitats where the specimens were sampled and the high species richness of these taxa in Morocco, we believe that it could be a multiple species and / or subspecies, but we cannot specify more currently due to the absence of adults in our nets.

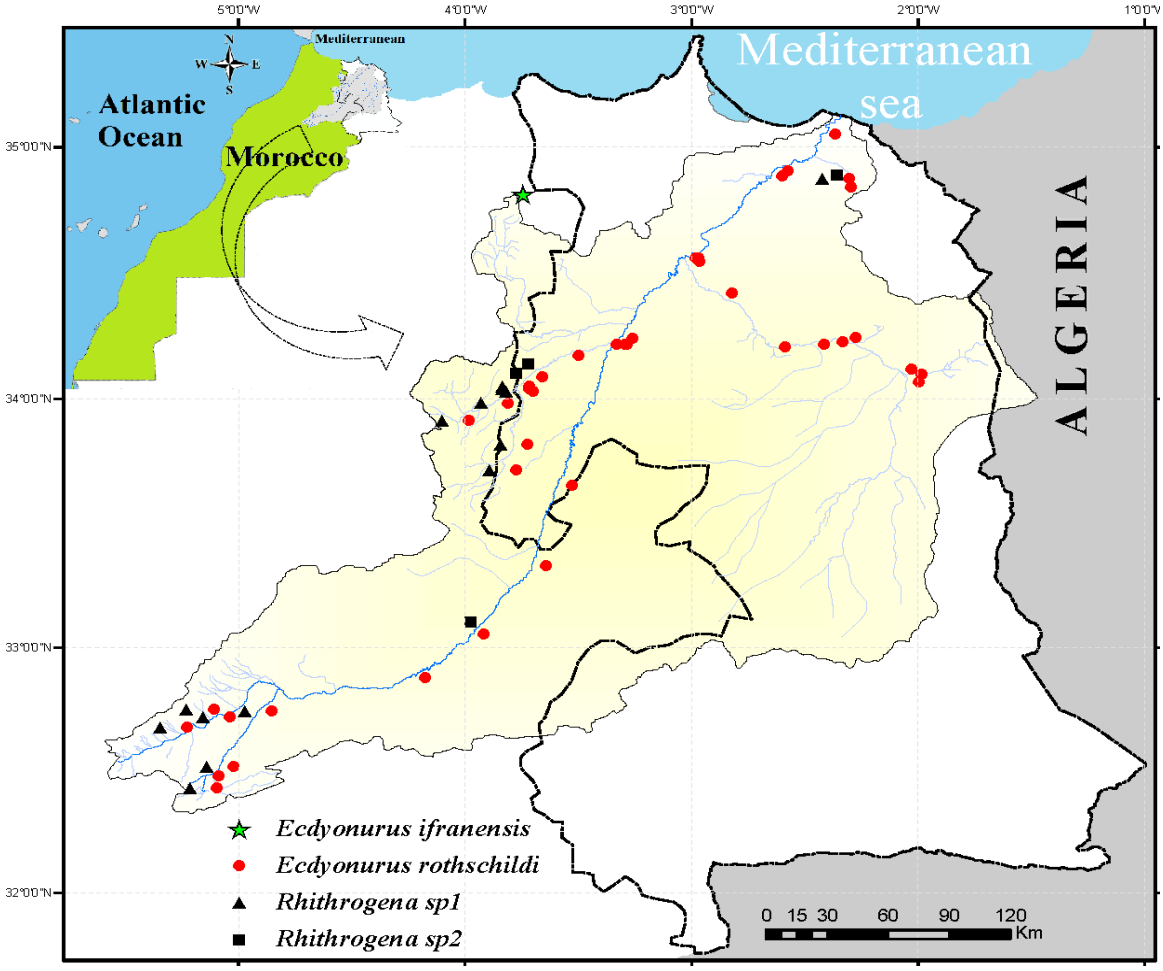

Figure 5. Distribution of *E. ifranensis*, *E. rothschildi*, *Rhithrogena* sp1 and *Rhithrogena* sp2 in the study area

***Rhithrogena* sp2.**

Material examined: M11: C1, 3L ; S7: C2, L ; S8: C1, 3L ; O12: 01/02/2015, 2L.

Ecology: This is the most thermophilic species of this genus. In the Moulouya's watercourses, it is confined to the large eurythermal rivers of middle and lower reaches. It tolerates more large variations in temperature and mineralization of water.

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Distribution: The first citation of this genus in North Africa has been made from a material captured in Algeria [51]. The genus *Rhithrogena* shows a relatively large diversity in Morocco. Indeed, at least twelve species can be found in the Moroccan rivers, five of which have already been described and are confined in the waters of the Atlas area [17]. In the basin of Moulouya River, this genus was already recorded from the upstream [14].

Viewing to the lack of adults, we could not identify our larvae to the specific rank, but we distinguish at least two different taxa, based on the external morphology. They are *Rhithrogena* sp1 occupying upstream of the watershed (including Oued Anzegmir and upstream of Oued Melloulou) and *Rhithrogena* sp2 living specially in the torrential downstream systems (Figure 5).

Family Leptophlebiidae Banks, 1900

Genus *Choroterpes* Eaton, 1881

***Choroterpes (Choroterpes) atlas* Soldán & Thomas 1983**

Material examined : M1 : C2, 1L ; M2 : C2, 1L ; M4 : C2-C3, 6L ; M5 : C2-C3, 22L ; M11 : C3, 3L ; M14 : C2-C3, 4L ; M17 : C3, 2L ; M19 : C3, 3L ; M20 : C2-C3, 9L ; M21 : C3, 5L ; M22 : C2, 1L ; Z4 : C3, 1L ; Z5 : C3, 2L ; Z7: C3, 3L ; Z8: C3, 4L ; Z9: C3, 5L ; Z10: C2-C3, 13L ; Z12: C2-C3, 4L ; S1: C2-C3, 34L ; S2: C3, 12L ; S3: C2, 8L ; S5: C3, 3L ; S6: C3, 7L ; S7: C2-C3, 23L ; S8: C2-C3, 18L ; S9: C1-C2-C3, 50L ; S10: C2-C3, 37L ; S11: C2-C3, 12L ; O12: 01/02/2015, 16L.

Ecology: This thermophilic species has been collected in the majority of cases, from permanent streams, characterized by a medium speed of the current and sometimes trapped in small pools resulting from the decline of water levels. Indeed, the maximum density of this species were reported during the summer.

Distribution: This North African species, found in the three Maghrebian countries except for the deserted areas [25-27, 52]. In Morocco, this species has a very broad range extending from the Rif to its southern limits located between the High Atlas and Anti-Atlas [17].

Berrahou *et al.* [14] are the first to record this species in Oriental Morocco and the basin of Moulouya River under the name of *C. (Ch.) picteti* (Eaton, 1871). Our study allow to expand its distribution area, since this taxa was harvested along the Oued Moulouya, Oued Za, the Oued Zeghzel-Cherraa complex and finally Oued Melloulou (Figure 6).

Choroterpes* (*Choroterpes) volubilis* Thomas & Vitte, 1988

Material examined : S1: C2-C3, 5L ; S2: C3, 5L ; S3: C2, 2L ; S5: C3, 1L ; S6: C3, 3L ; S7: C2-C3, 11L ; S8: C2-C3, 40L/1♂ ; S9: C1-C2-C3, 31L ; S10: C2-C3, 18L ; S11: C2-C3, 4L.

Ecology: This species seems to be more stenotopic than the previous one, since its range is limited to the eastern Middle Atlas. Like *C. (Choroterpes) atlas*, in the watershed of Melloulou, it occupies the edges of the bed where the temperate waters and low current.

Distribution: This Moroccan endemic has been described by Thomas & Vitte [20] from a material coming from the Middle Atlas at the Oued Bençmin and the Rif at Oued Loukkos. Later, El Alami [17] allowed expanding its rifian distribution area.
This is a new species for the study area, we allow its first record in the basin of Moulouya River, where it has a large altitudinal distribution (Figure 6), but still restricted to the eastern Middle Atlas (upstream of Oued Melloulou), cohabiting with its congener *C. (Choroterpes) atlas*.

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Genus *Habrophlebia* Eaton, 1881
Habrophlebia* cf *fusca* (Curtis, 1834)

Material examined : S1 : C3, 6L ; S2: C3, 5L ; S3: C3, 3L ; S4: C1-C2-C3, 14L ; S5: C1-C2-C3, 16L ; S6: C1-C2-C3, 9L ; S7: C2, 1L ; M2 : C1, 1L ; M4 : C2, 1L ; M5 : C2-C3, 3L ; M20 : C3, 2L.

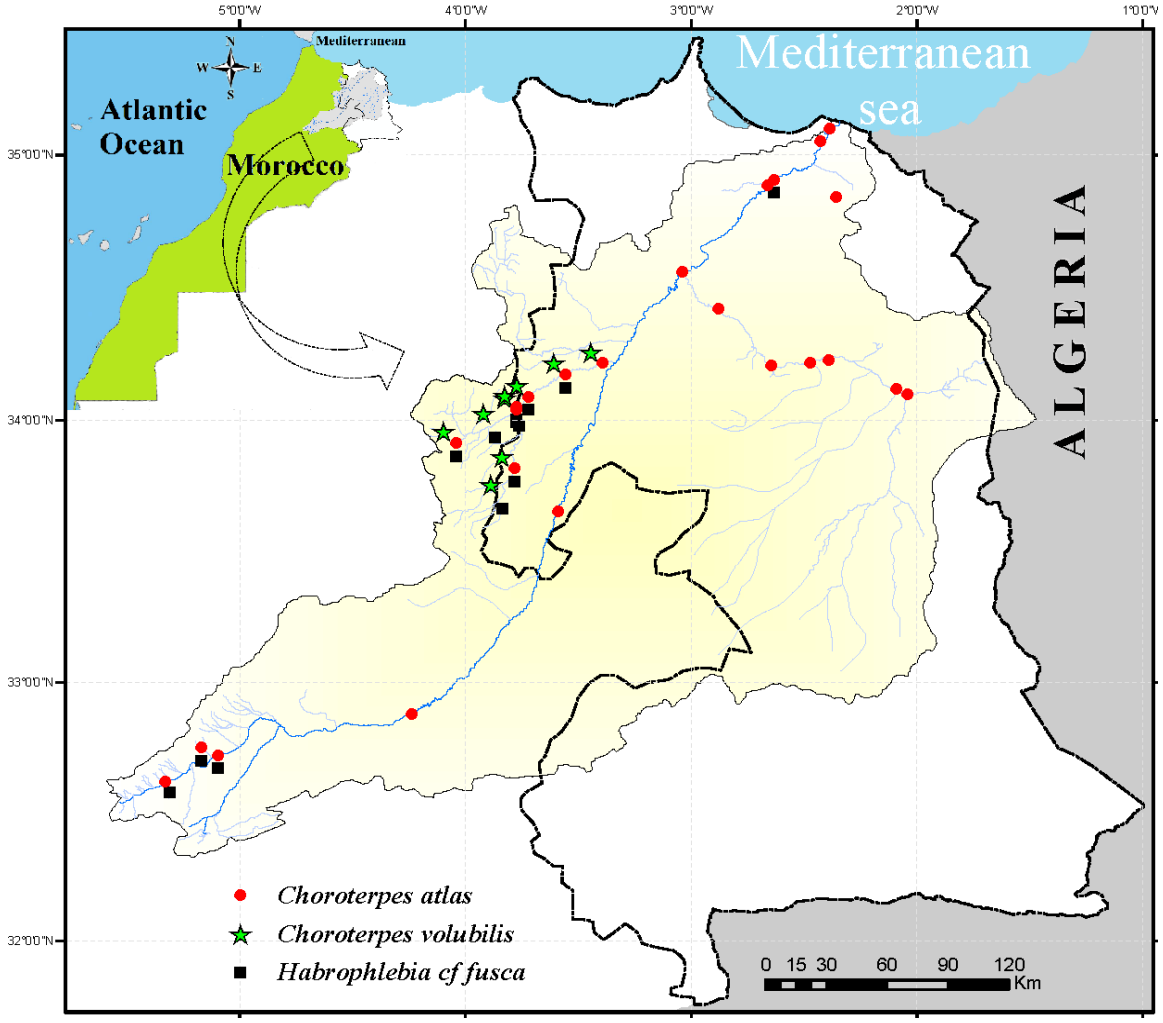

Figure 6. Distribution of *C. atlas*, *C. volubilis* and *H. fusca* in the study area

Ecology: In the catchment area of the Moulouya, the Genus *Habrophlebia* occupies a wide range of habitats, often associated with banks of bed and low current especially during the summer. It began to appear in large populations from the second campaign and reached its ecological optimum in the upstream least mineralized springs. Similarly, we have collected it in the downstream stations, but with very low densities.

Distribution: Euro-Asian-Mediterranean species, widely distributed in the Palearctic. In Morocco, it was listed among the mayflies of Middle Atlas [28, 50], Central Plateau [30] and finally the Rif [18].
This is a new species for the study area, where it has never been mentioned before. The specimens collected in the watercourses of Oued Moulouya, have been attributed to *H. fusca* for the moment until further study, since it was cited before in the Middle Atlas by Dakki [28]. The species seems to be very located in the Oriental Middle Atlas (Figure 6), but it was also harvested in the low sections of Moulouya.

Family Ephemeridae Latreille, 1810

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Ephemera glaucops* Pictet, 1843

Material examined: S1: C3, 2L.

Ecology: In Europe, *E. glaucops* lives especially in lacustrine habitats [19, 53]. In Morocco, it appears as thermophilic [6, 43, 54], and shows a clear preference for calm water, with a very moderate current and rarely lacustrine. It often lives in muddy environments rich with organic matter [53].

Distribution: Western-Palearctic species, with a wide distribution in central and southern Europe and the three countries of the Maghreb. In Morocco, it has been recorded in the Middle Atlas and the Central Plateau [50], the High Atlas [40], and finally in the Rif [17].
This is a new species for the watershed of the Moulouya, where we allow its record from Eastern Middle Atlas, which is the sub-catchment of Oued Melloulou (Figure 7).

Family Polymitarcidae Banks, 190

Genus *Ephoron* Williamson, 1802

Ephoron virgo* (Olivier, 1791)

Material examined : M20 : C1-C2-C3, 15L ; M21 : C1-C2-C3, 20L ; M22 : C1-C2-C3, 31L ; Z9: C2-C3, 7L ; Z10: C1-C2-C3, 4L.

Ecology: In the Moulouya's hydrographic systems, this species seems to be the stenothermal of hot water, since it has a clear preference for the lower reaches of the Oued Za and especially for the Lower Moulouya where the muddy substrate is favorable for the development of the larvae.

Distribution : Western Palearctic species, very common in many European and North African rivers [20, 27, 55]. In Morocco, it was cited for the first time by Eaton [16] and then recovered from the waterways of the Middle Atlas [50], Central Plateau [56] and finally from the Rif [17].
This species has not been yet known from the basin of Moulouya River, neither Eastern Morocco before our study. Therefore, we report its presence for the first in the lower course of the Oued Za and Lower Moulouya (Figure 7), where it was sampled in important number.

Family Ephemerellidae Klapalek, 1905

Genus *Serratella* Edmunds, 1959

Serratella ignita* (Poda, 1761)

Material examined : M4 : C2-C3, 10L ; M5 : C2-C3, 12L ; M7 : C1-C2-C3, 8L ; S1 : C1-C2-C3, 4L ; S4: C2, 4L.

Ecology: Sowa [57] considers that *S. ignita* rubs in both high and low altitudes stations. In the Moulouya, it has been found subservient to the Atlasic areas of the basin, primarily for temporary or permanent of source emissaries. It reaches its ecological optimum in the cool waters, with low mineral content, high mosses and filamentous algae content.

Distribution: It is a Trans-Palearctic taxa, distributed all over Europe [55] and Asia [23]. Cited in Algeria [52], Navás [47] was the first to have reported the presence of this species in the Moroccan High Atlas. Since then it has shown a very wide distribution. Ended, it occupies the entire country and reaches its southern boundary at Wadi Dr'a. It was found in the waterways of the Middle Atlas [31], the Central Plateau [30] and finally in the Rif [17].

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

Despite its abundant status in Morocco, the species has not been yet known from the basin of Moulouya River until now. Through our repetitive campaigns and inaccessible territories visited for the first time, we finally allow its citation. Indeed it was harvested from the Atlas area of the basin (Figure 7), it comes from the upstream of Oued Anzegmir (High Atlas), the High Moulouya and upstream Melloulou (Middle Atlas).

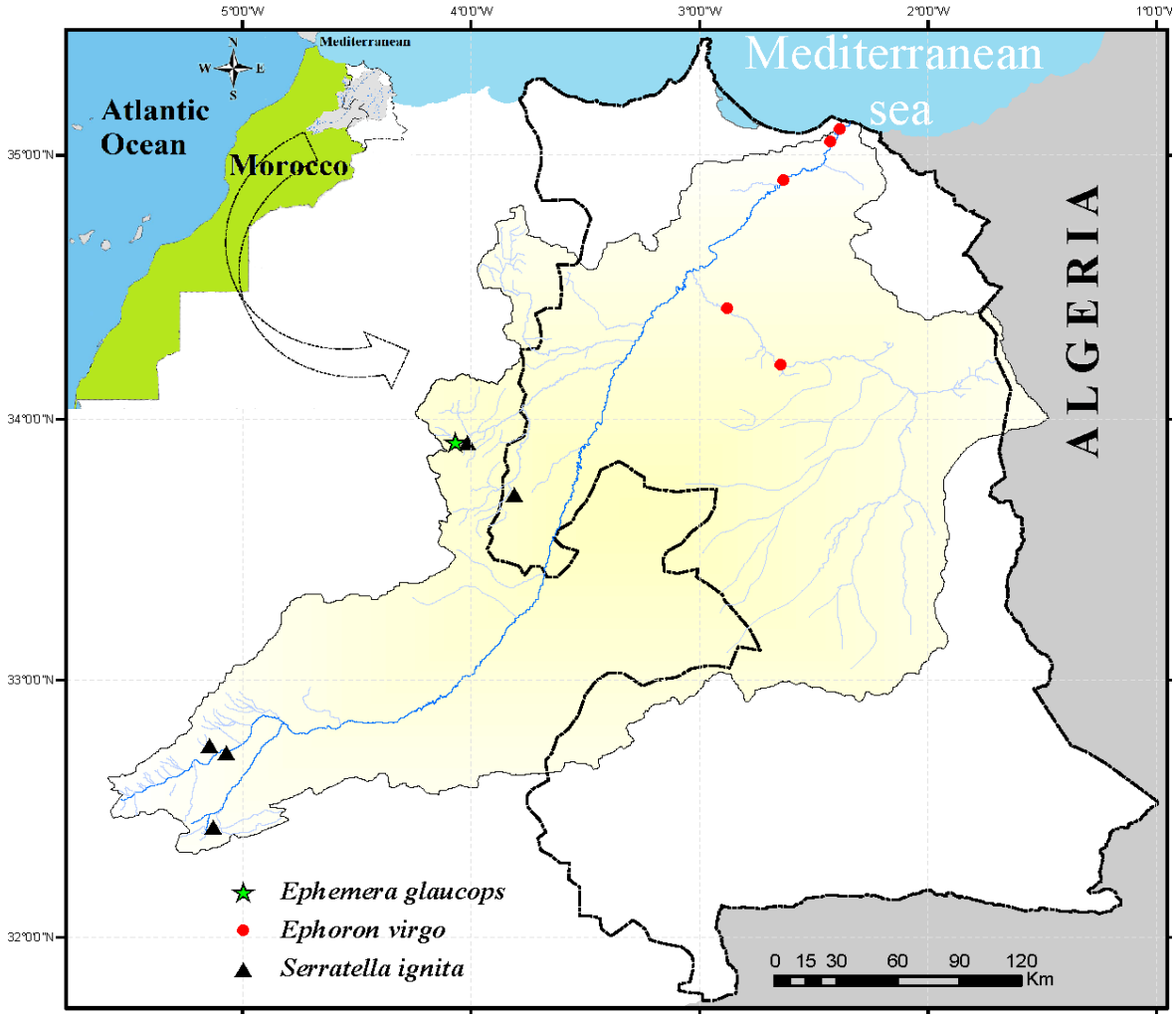

Figure 7. Distribution of *E. glaucops*, *E. virgo*, and *S. ignita* in the study area

Family Caenidae Newman, 1853

Genus *Caenis* Stephens, 1835

***Caenis luctuosa* Burmeister 1839**

Material examined : M4 : C1-C2-C3, 12L ; M5 : C1-C2-C3, 14L ; M11 : C2, 1L ; M12 : C1-C2-C3, 7L ; M13 : C1-C2-C3, 13L ; M14 : C2-C3, 11L ; M15 : C2-C3, 16L ; M16 : C1-C2-C3, 8L ; M17 : C1-C2-C3, 34L ; M18 : C1-C2-C3, L ; M19 : C1-C2-C3, 34L ; M20 : C1-C2-C3, 29L ; M21 : C1-C2-C3, 132L ; M22 : C1-C2-C3, 120L ; Z1: C1-C2-C3, 300L/11♂/16♀ ; Z2: C1-C2-C3, 360L/4♂/7♀ ; Z3: C1-C2-C3, 90L ; Z4: C1-C2-C3, 63L ; Z5: C1-C2-C3, L ; Z6: C1-C2-C3, 76L ; Z7: C1-C2-C3, 54L ; Z8: C1-C2-C3, 80L ; Z9: C1-C2-C3, 100L ; Z10: C1-C2-C3, 35L ; Z11: C1, 1L ; Z12: C1-C2-C3, 14L ; S1: C1-C2-C3, L ; S2: C1-C2-C3, L ; S3: C1-C2-C3, L ; S6 : C2-C3, 3L ; S7: C1-C2-C3, 4L ; S8: C1-C2-C3, 6L ; S9: C1-C2-C3, 17L ; S10: C1-C2-C3, 14L ; S11: C1-C2-C3, 30L ; O5: 28/04/2016, 4L ; O6: 1-4/12/2015, 2L/1♂/6♀ ;O15: 06/06/2016, 13L ; O17: 27/08/2016, 6L ; N1: 30/04/2016, 24L/3♂ ; N2: 01/05/2016, 1L ;N3: 2/05/2016, 7L ;N4: 30/04/2016, 10L ;

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

N5: 30/04/2016, 4L ; N6: 2/05/2016, 9L ; N7: 22/05/2015, 3L ; N9 : 18/05/2015, 10L ; N10 : 5-6-7/02/2015, 23L ; N12: 12/05/2016, 5L ;N13: 12/05/2016, 6L ; N14: 12/05/2016, 9L ;N15 : 05/04/2014, 23L ; N17 : 29/09/2016, 14L ; N16 : 28/09/2016, 4L ; F1 : 21/05/2016, 1L ;F2 : 21/05/2016, 2L ; F3: 21/05/2016, 19L/4♀ ; F3: 22/05/2016, 3L ; F5: 22/05/2016, 24L ; F6: 22/05/2016, 1L ; F7: 21/01/2016, 18L ; F8: 19/01/2015, 3L.

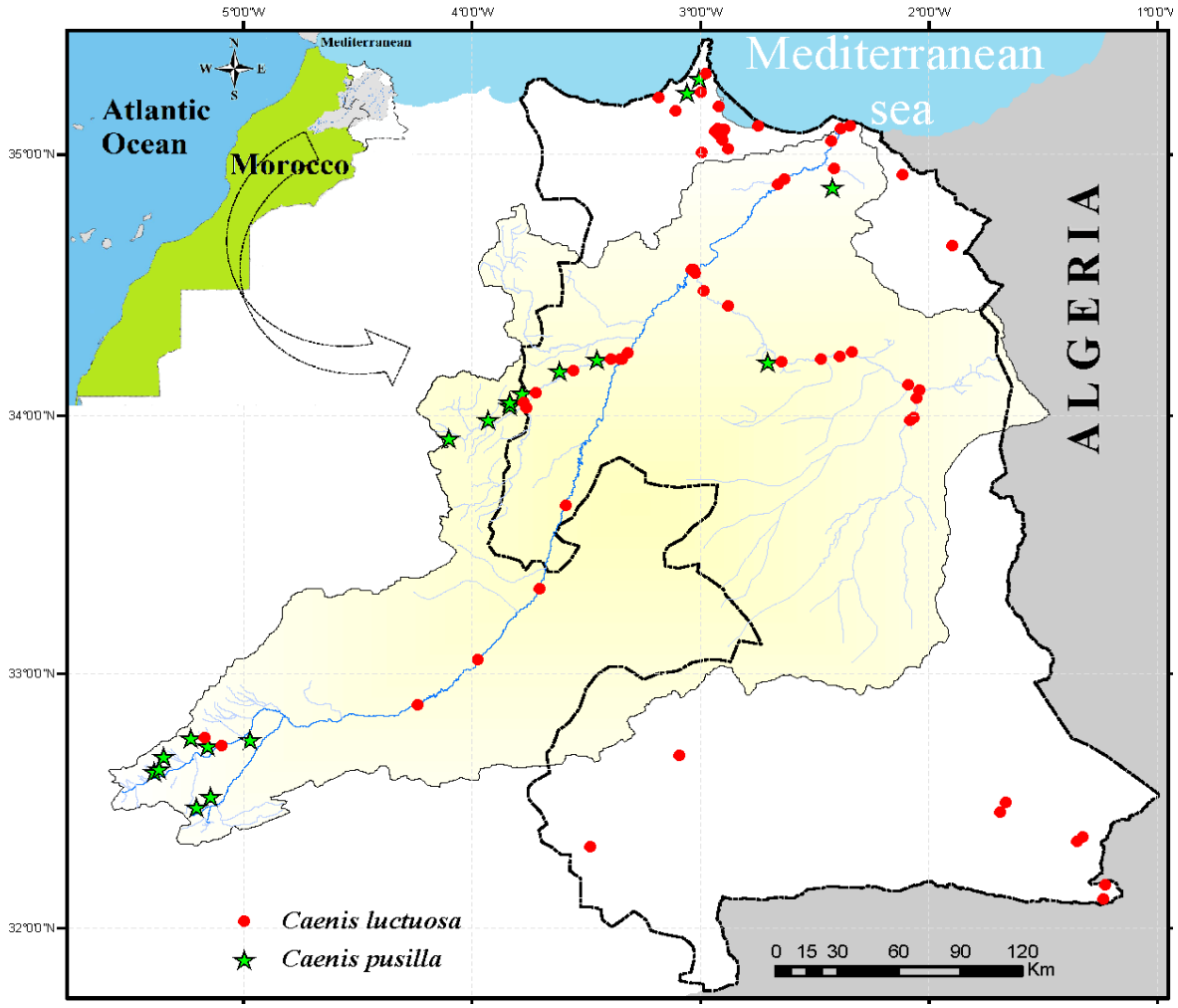

Figure 8. Distribution of *C. pusilla* and *C. luctuosa* in the study area

Ecology: Eurytopic and eurythermal, this species proliferates in both running and standing water, it is widely distributed in the study area where it abounds in mineralized waters of the middle and lower sections. It regresses only in torrential systems as Oued Anzegmir and the upstream catchment of Oued Melloulou formed by both Oued El Bared and Oued Berkin.

Distribution: This is a Palearctic species [23, 25, 26, 27, 55]. It has a wide distribution in Morocco, recorded from the High Atlas [29] the Middle Atlas [43] and the Rif [17].
It has been previously recorded from the river of Moulouya [14] and Oued Za [11]. Our study can show a wide distribution of this species in the Oriental Morocco, extending, in addition of the basin of Moulouya River, from Nador and northern Saidia until Talessint southwest and Figuig southeast (Figure 8).

Caenis pusilla* Navás, 1913

Material examined : M1 : C2-C3, 14L ; M2 : C2-C3, 12L ; M3 : C3, 4L ; M4 : C1, 4L ; M5 : C3, 10L ; M8 : C3, 3L ; M9 : C3, 5L ; M10 : C3, 2L ; Z9: C2-C3, 7L ; S1: C1-C2-C3, 29L ; S2: C1-C2-C3, 19L ; S3: C1-C2-

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

C3, 20L ; S7: C3, 1L ; S8: C3, 3L ; S9: C3, 1L ; S10: C1, 1L ; O4: 28/04/2016, 2L ; N9 : 18/05/2015, 6L ; N10 : 5-6-7/02/2015, 8L.

Ecology: In the basin of Moulouya River, this species has a quite large altitudinal distribution comprised between 12 and 1650m. It inhabits the permanent and temporary stations; nevertheless, it appears to be less tolerant to the thermal variations than *C. luctuosa*, as pointed by Gagneur & Thomas [52] and El Alami [17].

Distribution: Western-Palearctic species, well known from North Africa [27, 52]. In Morocco, this species has quite discontinuous distribution and only known from the High Atlas [29] and the Rif [17].

Our study shows a wide and discontinuous distribution of this species in the watershed of the Moulouya and Oriental Morocco, where it has been considered absent for a long time. Indeed, we allow its record for the first time in the Upper and Middle Moulouya, downstream of Oued Anzegmir (High Atlas), upstream of Melloulou (Middle Atlas), the lower section of the Oued Za (High Plateau) and finely Nador region (Figure 8).

Chorological categories of Mayflies in the Oriental Morocco and the basin of Moulouya River

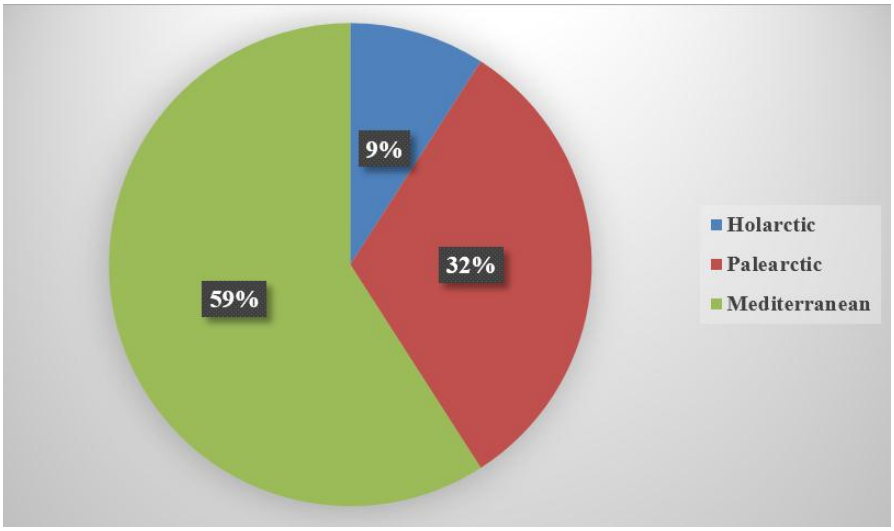

Figure 9. Relative importance of the Mediterranean chorological categories of Mayflies in the study area

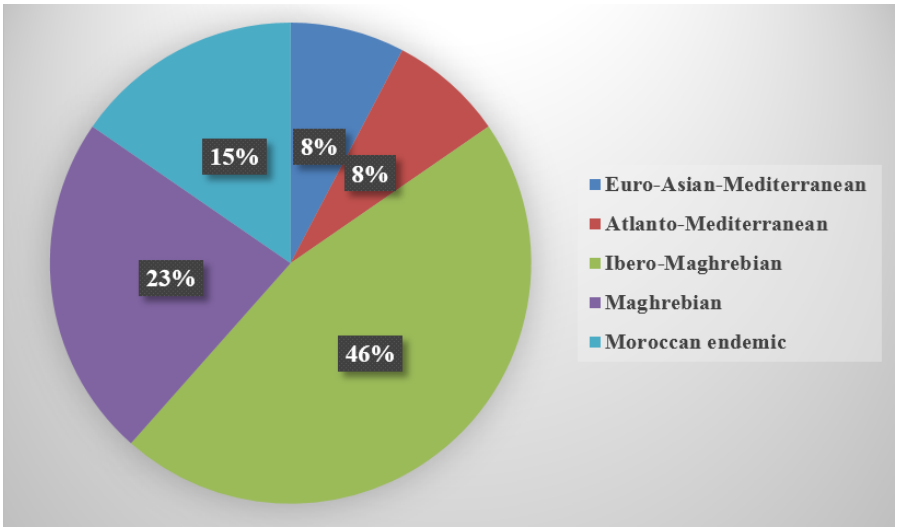

Figure 10. The relative importance of the major chorological categories of mayflies in the study area

4. Conclusion and Discussion

Representing almost half of the species collected in all the Moroccan rivers, the Mayflies population of the basin of Moulouya River and Oriental Morocco rise to 23 species. In the analysis of the composition, this

settlement shows that are essentially composed of Mediterranean species by 59% (Figure 9), followed by those with a wide distribution in the Palearctic (32%). The Cosmopolitans and those elements whose distribution extends beyond the Mediterranean, either in India or in the Afrotropicale region constitute a minority (9%). Within the Mediterranean Ephemeroptera of the basin of Moulouya River and Eastern Morocco (Figure 10), there has been a clear predominance of the Ibero-Maghrebian corotype (46%) which outweighs the Maghrebian (23%) and the Moroccan endemic (15%).

The clear dominance of the Palearctic elements, typically Mediterranean and the high rate of Ibero-Maghrebian endemism in the Ephemeroperological population of the study area, shows a strong similarity to those of Morocco and the Maghreb in general [17]. Our results confirm those of Dakki [43], Sánchez-Ortega & Tierno de Figueroa [58], Bouzidi [29] El Alami [17], Mabrouki *et al.* [5], Taybi *et al.* [59] and Daoudi *et al.* [60] who report, that the communities of the Mediterranean regions are characterized by low species diversity compared to those of Central and Continental Europe while presenting a high rate of endemism.

It is very important to note that some species of mayflies recorded early in the Oriental region have not been found and probably have disappeared. The same remark is done for the Stoneflies [5]; aquatic beetles [61] and freshwater mollusks [59]. Our study shows clearly that a reduction in permanent water bodies, notably with the drying up of several rivers between the 80s-90s includes Oued Isly, Oued Touissit, source and its tributary of Sidi Yahya. With climate change and drought, many species have greatly reduced their regional distribution [15].

References:

1. Dakki M., EL Hamzaoui M. Rapport National. Adm. Eaux et Forêts MedWet/Bur. Ramsar, (1998) 33. Mabrouki Y., Taybi A. F., Bensaad H., Berrahou A., *J. Mater. Environ. Sci.* 7 (1) (2016) 231-243.
2. Mabrouki Y., Taybi A. F., Berrahou A., *Revue des Sciences de l'Eau*. 1-30 (2017) (in press).
3. Taybi A.F., Mabrouki Y., Berrahou A., Chaabane K., *J. Mater. Environ. Sci.* 7 (1) (2016) 272-284.
4. Mabrouki Y., Taybi A. F., Chavanon G., Vinçon G., Berrahou A., *J. Mater. Environ. Sci.* 7 (6) (2016) 2178-2193.
5. Taybi A. F., 2016. PhD thesis, University Mohamed premier, Oujda Morocco. 260.
6. Taybi A. F., Mabrouki Y., Berrahou A., Peris-Felipo F. J., Chaabane K., *J. Mater. Environ. Sci.* 7 (7) (2016) 2445-2452.
7. Wallace J. B., Wester J. R., *Annu Rev Entomol*, 411 (996) 115-139.
8. Barbour M. T., Gerritsen J., Snyder B.D., Stribling JB., EPA/841-B-99-002. U.S. EPA, Office of Water, Washington, D.C. (1999) 197.
9. Berrahou A., PhD Thesis, University Mohamed I, Oujda, (1995) 211.
10. Belouali A., PhD Thesis, University Mohamed Premier, Oujda, (1999) 150.
11. Chergui H., Chavanon G., Berrahou A., Melhaoui M. *Bull. Ins. Sc., Rabat*, 14, 51990) 51–53.
12. Berrahou A., Chavanon G., Belloulali A., Richoux P., *Bull. Mens. Soc. Linn. Lyon.*, 70 (5) (2001) 127-131.
13. Berrahou A., Cellot B., Richoux P., *Ann. Limnol.* 37 (3) (2001) 223-235.
14. Chavanon G., Berrahou A., Millán A., *B. S. E. A.*, 35 (2004) 143-162.
15. Lestage J.A., *Bull. Soc. Hist. Nat. Afr. N.* 16: (1925) 8-18.
16. El Alami M., PhD thesis. University Abdelmalek Essaadi, Tétouan. (2002).
17. Giudicelli J., Dakki M., *Bijdr. Dierkd.*, 54 (1) (1984) 83-100.
18. Belfiore C., Consiglio Nazionale delle Ricerche Verona. (1983) 113.
19. Thomas A.G.B., Vitte B., *Ann. Limnol.* 24 (1) (1988) 61.
20. Alba–Tercedor J., El Alami M., *Aquatic Insects*, 21 (4) (1999) 241–247.
21. Jacob U., *Lauterbornia*. 47: (2003) 59–129.
22. Bauernfeind E., Soldán T., *The Mayflies of Europe*. Apollo Books. (2012) 781
23. Grandi M., *Boll Ist Entomol Univ Studi Bologna.* 17: (1949) 287- 300.
24. Lounaci A., Brosse S., Thomas A.G.B., Lek S., *Ann. Limnol.* 36 (2) (2000) 123.

25. Bebba N.M., El Alami S., Arigue F., Arab A., *J. Mater. Environ. Sci.* 6 (4) (2015) 1164-1177.
26. Zrelli S., Boumaiza M., Bejaoui M., Gattolliat J-L., Sartori M., (2016) *Inland Water Biol*. 3, 99-106.
27. Dakki M., PhD thesis. University of Marseille. (1979) 118.
28. Bouzidi A., PhD Thesis, University Aix-Marseille. (1989) 190.
29. EL Agbani M.A., PhD Thesis. University Claude Bernard, Lyon, (1984) 147.
30. Dakki M., *Bull. Ins. Sc., Rabat,* 42: (1987) 1-99.
31. Boumaiza M., Thomas A., *Bull. Soc. Hist. Nat. Toulouse.,* 131: (1995) 27-33.
32. Navás S.L., *Bol. Soc. Ent. Esp. Madrid,* 18: (1935) 45-50 and 77-100.
33. Thomas A.G.B., Lounaci A., *Bull. Soc. Hist. Nat. Toulouse*. 125: (1989) 27-29.
34. Ubero-Pascal N., Puig M.A., Soler A.G., *Boln Asoc esp Ent.* 22 (1–2) (1998) 151–170.
35. Soldán T., Gagneur J., *Ann. Limnol.* 21 (2) (1985) 141-144.
36. Badri A., PhD Thesis. University Cadi Ayyad. Marrakech. (1985) 124.
37. Badri A., Giudicelli J., Prevot G., *Acta Oecol-Oec Gen,* 8 (4): (1987) 481-500.
38. Ajakane A., PhD thesis, Fac. Sci., Marrakech. (1988) 189.
39. EL Mezdi Z., Giudicelli J., *Science de l'Eau,* 6 (3): (1987) 281-297.
40. Kluge N., *www.Biol.Pu.Ru/win/entomol/kluge/faune-eur.htm* (2001).
41. Randolph P.R., Purdue University. (2002) 514.
42. Dakki M., PhD thesis. University Mohamed V, Rabat. (1986) 181.
43. Verrier M.L., *B Soc Zool Fr,* 77 (5-6) (1952) 292-304.
44. Stüdemann D., Landolt P., Sartori M., Hefti D., Tomka I., 9. Imprimerie Mauron + Tinguely & Lachat SA, Fribourg, (1992) 175.
45. Badri A., PhD Thesis. Univ. Cadi Ayyad, Marrakech. (1993) 192.
46. Navás S.L., *Trab. Mus. Cien.Nat. Barcelona.,* 4: (1922) 119-127.
47. González del Tanago M., García de Jalón D., *Arch. Hydrobiol.,* 97(3): (1983) 395-405.
48. Gallardo-Mayenco A., *Rev. Zool. Baetica.,* 13/14: (2002–2003) 93–110.
49. Dakki M., El Agbani M.N., *Bull. Ins. Sc., Rabat,* 7 (1983) 115.
50. Eaton A.E., *Entomol. mon. mag.* 35: (1899) 4-5.
51. Gagneur J., Thomas A.G.B., *Bull. Soc. Hist. Nat. Toulouse.,* (1988) 124 213.
52. Gagneur G., Thomas A.G.B., Vitte B., *Bull. Soc. Hist. Nat. Toulouse.,* 121: (1985) 141-143.
53. El Mezdi Z., *Verh. Internat. Verein. Limnol.,* 22: (1985) 2106-2109.
54. Alba-Tercedor J., *N.S.,* 4 (2) : (1981) 41-81.
55. El Agbani M.A., Dakki M., Bournaud M., *B. Ecol.,* 23 (1-2): (1992) 103-113.
56. Sowa R., *Acta Hydrobiol.,* 17 (3): (1975) 223-297.
57. Sánchez-Ortega A., Tierno de Figueroa J.M., *Mitt Schweiz Entomol Ges.,* 69, (1996) 77–94.
58. Taybi A.F., Mabrouki Y., Ghamizi M., Berrahou A., *J. Mater. Environ. Sci.* 8 (4) (2017) 1401-1416.
59. Daoudi L., Chavanon G., Taybi A.F., Mabrouki Y., *J. Mater. Environ. Sci.* 8 (2017) (in press).
60. Taybi A.F., Mabrouki Y., Chavanon G., Millán A., Berrahou A., (submitted). - New and additional data on aquatic beetles from Morocco (Coleoptera Adephaga : Gyrinidae, Haliplidae and Dytiscidae).

Appendix – The prospected stations with indications of the locality, altitude, geographic coordinates and type of the aquatic environment.

Code	Stations	GPS	Alt (m)	Sampling dates	Kind of habitat
M1	Ait Boulmane	32°36'56.6" N 5°19'49.2" W	1650	03/05/14-13/06/14-14/07/14	RV
M2	Ait Oha Ohaki	32°37'28.7" N 5°18'32.8" W	1640	03/05/14-13/06/14-14/07/14	RV
M3	Source Arbalou	32°40'33.4" N 5°17'20" W	1670	03/05/14-13/06/14-14/07/14	RV
M4	Krouchene=Irhdis	32°44'49.6" N 5°10'17.1" W	1616	03/05/14-13/06/14-14/07/14	RV
M5	Boumia	32°43'3.4" N 5°5'52.7" W	1515	02/05/14-14/06/14-15/07/14	RV
M6	Zaïda	32°49'3" N 4°57'33" W	1455	02/05/14-14/06/14-15/07/14	RV
M7	Anzar Oufounas	32°25'45" N 5°9'24.8" W	1895	02/05/14-14/06/14-15/07/14	NS

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

M8	Aval Anzar Oufounas	32°28'41.66" N 5°8'53.42"W	1780	02/05/14-14/06/14-15/07/14	RV
M9	Anzegmir avant barrage	32°31'4.1" N 5°5'3.2" W	1702	02/05/14-14/06/14-15/07/14	RV
M10	Aval Anzegmir	32°44'32" N 4°54'51" W	1455	02/05/14-14/06/14-15/07/14	RV
M11	Tamdafelt	32°52'43.86" N 4°14'16.4"W	985	02/03/14-14/06/14-15/07/14	RV
M12	Missour	33°3'7.96" N 3°58'41.7" W	870	02/05/14-14/06/14-15/07/14	RV
M13	Outat Al Haj	33°19'46.8" N 3°42'14.2" W	770	02/05/14-14/06/14-15/07/14	RV
M14	Tindint	33°39'11" N 3°35'20.6" W	640	02/05/14-14/06/14-15/07/14	RV
M15	Moulouya Amont Melloulou	34°12'59.3" N 3°21'6.8" W	362	23/03/14-24/05/14-07/07/14	RV
M16	Moulouya Aval Melloulou	34°14'29.86" N 3°19'13.4"W	355	23/03/14-24/05/14-07/07/14	RV
M17	Moulouya Amont Za	34°33'36.3" N 3°2'33.4" W	230	23/03/14-24/05/14-07/07/14	RV
M18	Moulouya aval Za	34°33'41.09" N 3°1'49.77"W	222	03/04/14-24/05/14-22/06/14	RV
M19	Sebra	34°53'11" N 2°39'45" W	60	03/04/14-24/05/14-22/06/14	RV
M20	Safsaf	34°54'27.53" N 2°38'8.86"W	50	18/03/14-18/05/14-23/06/14	RV
M21	Pont Hassan II	35°3'5.7" N 2°25'42.4" W	9	18/03/14-18/05/14-23/06/14	RV
M22	Pré-Estuaire	35°5'51.4" N 2°23'19" W	3	18/03/14-18/05/14-23/06/14	RV
S1	Sources O El Bared	33°54'40.2" N 4°2'40.7" W	931	27/03/14-01/06/14-11/07/14	RV+NS
S2	Amont O El Bared	33°58'59.01" N 3°52'15.8"W	630	23/03/14-08/06/14-07/08/14	RV
S3	Douar Ifrane	34°2'20.8" N 3°46'34.1" W	570	23/03/14-08/06/14-07/08/14	RV
S4	Sources Berkine	33°42'43.25" N 3°50'5.83"W	1150	22/03/14-14/06/14-07/08/14	RV+NS
S5	Amont Berkine	33°48'58.2" N 3°47'7.4" W	970	27/03/14-15/06/14-15/08/14	RV
S6	Pont Oued Zebzit, Berkine	34°1'36.6" N 3°45'38.6" W	595	23/03/14-08/06/14-15/08/14	RV
S7	Confluence Zebzit Oued El Bared	34°3'02.25" N 3°46'34.1" W	565	23/03/14-08/06/14-15/08/14	RV
S8	Douar Imzaghrou	34°5'15.75" N 3°43'14.7" W	525	23/03/14-08/06/14-15/08/14	RV
S9	Pont Taddarte	34°10'21.4" N 3°33'25.4" W	445	23/03/14-08/06/14-15/08/14	RV
S10	Entrée Guercif	34°12'53.5" N 3°23'34.1" W	377	23/03/14-08/06/14-15/08/14	RV
S11	Aval Melloulou	34°13'1.15" N 3°20'40.4" W	363	23/03/14-15/06/14-15/08/14	RV
Z1	Oued Charef	33°58'53.5" N 2°5'7.5" W	925	19/03/14-17/05/14- 07/08/14	RV+NS
Z2	Pond sur l'Oued Charef	33°59'33.1" N 2°4'11" W	918	19/03/14-17/05/14-07/08/14	RV
Z3	Petite cascade	34°3'56.8" N 2°3'20.2" W	900	19/03/14-17/05/14-07/08/14	RV
Z4	Oued Lakhrouf	34°5'54.8" N 2°2'38.1" W	897	19/03/14-17/05/14-07/08/14	RV
Z5	Grandes cascades	34°7'5.7" N 2°5'26.8" W	875	19/03/14-17/05/14-07/08/14	RV
Z6	Amont pont Gafait	34°14'31.61"N2°20'11.98"W	785	19/03/14-17/05/14-07/08/14	RV
Z7	Pont de Gafait	34°13'36.8" N 2°23'34.5" W	767	19/03/14-17/05/14-07/08/14	RV
Z8	Gafait	34°14'21.6" N 2°24'34.8" W	750	19/03/14-17/05/14-07/08/14	RV+AS
Z9	Barrage Oued Za	34°12'23.1" N 2°38'52.3" W	625	19/03/14-17/05/14-07/08/14	RV+DM
Z10	Amont Taourirt	34°25'15.6" N 2°52'52.9" W	370	07/06/14-19/07/14-19/07/14	RV
Z11	Aval de Taourirt	34°28'44.51" N 2°59'10.3"W	295	03/04/14-07/06/14-19/07/14	RV
Z12	Melg el Ouidane	34°32'46.51" N 3°1'31.1" W	240	03/04/14-07/06/14-19/07/14	RV
O1	Debdou	33°57'32.64"N 3°2'26.9"W	1344	27/04/16	AS
O2	Mares pas loin de	34°3'51.4"N 2°58'54.1"W	880	27/04/16	PD

Journal of Materials and Environmental Sciences
ISSN : 2028-2508

JMES, 2017 Volume 8, Issue 8, Page 2839-2859

http://www.jmaterenvironsci.com /

	Debdou				
O3	Source Tiffert,	N35°2'16.8" 2°25'36.0"W	83	28/04/16	NS
O4	(Béni znassen) en aval de Zeghzel	34°53'08.3"N 2°20'34.1"W	268	28/04/16	RV
O5	Ain chabbak	N35°6'18.7" 2°20'45.0"W	2	28/04/16	PD
O6	Bassin Oujda	34°39'03.5"N 1°53'59.2"W	627	07/11/15 - 26/02/16 - 23/04/16	AP
O7	SIBE Saïdia	35°07'09.8"N 2°20'15.3"W	0	21/02/16	PD
O8	Canal de Saïdia	35°05'59.0"N 2°19'42.1"W	9	22/02/16	AC
O9	Jbel Mehser	34°29'24.1"N 1°54'57.6"W	1268	19/09/15	AS
O10	Source Himer	34°25'32,5"N 1°53'54"W	1030	18/11/15	NS
O11	Amont Himer	34.2530,2 N 1.5331,1 W	1019	18/11/15	RV
O12	Source Zeghzel	34°50'20.3"N 2°21'21.6"W	442	01/02/15	AS
O13	Ain Sfa	34°45'12.3"N 2°08'36.0"W	652	01/02/2015	AS
O14	Ain Almou	34°50'15.2"N 2°10'22.5"W	1200	06/06/2016	AS
O15	Cherraa	34°56'43.6"N 2°24'48.5"W	80	06/06/2016	PD
O16	Carrière abandonnée	34°34'50.8"N 1°56'13.9"W	719	17/07/2016	AQ
O17	Source Aghbal	34°55'14.0"N 2°06'52.5"W	307	27/07/16	AS
O18	Canal Berkane	34°56'06.8"N 2°18'41.1"W	154		AC
N1	Saguia Selouane	35°05'14.3"N 2°56'03.8"W	84	30/04/16	AC
N2	Kariat Arkmane	35°06'16.5"N 2°44'55.1"W	19	01/05/16	AC
N3	Dardoura	35°03'11.0"N 2°54'18.9"W	134	02/05/16	RV
N4	Oued Ouzej	35°00'21.8"N 2°59'30.8"W	168	30/04/16	RV
N5	Oued Selouane	35°04'36.7"N 2°55'29.1"W	52	30/04/16	RV
N6	O Messoussate	35°03'48.6"N 2°54'23.0"W	68	02/05/16	RV
N7	Marchica (1)	35°10'47.2"N 2°55'19.3"W	5	22/05/15	PD
N8	Marchica (2)	35°09'19.9"N 2°54'24.3"W	3	02/05/16	LG
N9	Rio de Oro	35°17'14.9"N 2°56'37.7"W	12	18/05/15	RV
N10	Mont Gourougou	35°13'55.2"N 2°59'57.1"W	542	05/02/15-06/02/15-07/02/15	RV
N11	Oued Tifassour	N35°16'21.0" 3°5'14.4"W	17	12/05/16	RV
N12	Oued Oumassine	N35°9'50.0" 3°6'36.0"W	79	12/05/16	RV
N13	Oued Kert	N35°12'48.9" 3°11'1.4" W	6	12/05/16	RV
N14	Oued Mariouari	35°18'21.6"N 2°58'38.9"W	85	12/05/16	RV
N15	Barrage Arabat	35°01'03.9"N 2°52'36"W	102	05/04/14	DM
N16	Canal Bouareg	35°05'37.1"N 2°53'36.3"W	26	28/09/16	AC
N17	Canal Granja	35°05'47.2"N 2°55'29.4"W	40	29/09/16	AC
F1	Raknat Naam	32°27'11.3"N 1°41'18.7"W	1168	21/05/16	DM
F2	Barrage Zriga	32°21'29.5"N 1°19'36.4"W	1026	21/05/16	DM
F3	Barrage Sfissef	32°20'23.9"N 1°21'04.6"W	1005	21/05/16	DM
F4	Seguia de Figuig	32°06'47.3"N 1°14'08.8"W	902	22/05/16	AC
F5	O Abbou Lekhal	32°10'05.3"N 1°13'42.4"W	868	22/05/16	RV
F6	Dayat Lahjal	32°29'29.9"N 1°39'47.6"W	1161	22/05/16	PD
F7	Oued Anwal	32°40'46.60"N 3°5'39.74"W	1194	21/01/16	RV
F8	Oued Aït Aïssa,	32°19'N 03°29'W	1121	01/19/16	RV

Abbreviations. M: station at the Moulouya Wadi; S: station at Melloulou river; Z: station at ZA river; N: station at Nador province; O: station at Oujda province; F: station at Figuig province; DM: Dam; AQ: abandoned quarry; AC: artificial channel; AP: artificial pond ; RV: river; LG: Lagoon; PD: pond; AS: arranged source ; NS: natural source.