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Odonata as indicators of environmental impacts in rivers, case of wadi El-Kébir-East (northeastern Algeria)

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Abstract

This paper presents results of two monitoring programs carried out in two decades during April 1993-May 1994,and April 2015 May 2016 in the East Wadi of El-Kébiri, a protected area (PNEK) of eastern Numidia (northeastern Algeria). Monitoring was located in areas with different degrees of anthropogenic impacts. Selected environmental variables were recorded during the monitoring periods. . The Odonata fauna and biological indices were used to characterize development of the study area, after two decades and to assess the quality of the environment. The alteration of this river has resulted in a marked simplification of the original (1993-1994) odonatological fauna. Over the past two decades, odonatological species richness has decreased from 14 to 7 species inventoried during the 1993 and 2015 seasons. The phenology of adult was extended until early December 2015, possibly as a result of global warming. Odonata are identified as useful as indicators of environmental change in the monitored river systems. The majority of species such as the Gomphidae are not tolerant of increased contamination and changes in structure of the river. Only some species such as *Lestes vridis, Platycnemis subdilatata, Ischnura graellsii* and *Ceriagrion tenellum*, appear to be adapted to changed conditions and became dominant in heavily disturbed sites. The species disappeared from these sites are clearly associated with good water quality and less disturbance, which highlights the importance of the conservation of the habitats of freshwater and regular monitoring

Keywords: Odonata, ecology, anthropogenic, environmental impacts, El-Kébir-East wadi, Northeastern Algeria.

1. Introduction

Rivers are ecologically valuable ecosystems usually with a rich fauna that consists of communities with complex structure and high biological value. However, their specific typology makes them vulnerable to environmental changes, particularly those related to environmental changes and particularly anthropogenic disturbances. These often result of an irreversible degradation of their biota [1-2]. Around the Mediterranean basin and the Maghreb countries especially, population growth and the development of industrial and agricultural activities together with landscape and climate change in recent decades have increased contamination and disturbance of aquatic systems. Such drivers of change contributed to making assessment of the chemical and biological quality of inland waters through monitoring a major responsibility of environmental protection organizations (cnepru-mesrs projects) and one of the main concerns of hydroecological research [3]. Different groups of macroinvertebrates are excellent indicators of human impacts in aquatic ecosystems. Most of them have narrow ecological requirements and are very useful as bioindicators of environmental conditions [4-5-6]. Amongst the fauna of rivers, Odonata (dragonflies and damselflies) are frequently used to assess the ecological status of local watersheds [7-8], to monitor the ecological integrity of freshwater ecosystems [9-10], to assess habitat restoration [11], and study the effects of global climate change [12]. In northeastern Algeria, the El-Kébir wadi has suffered environmental damage over recent years. Rapid climate change is affecting water availability [13] and landscape degradation including the establishment of Dams across the El-Kébir-East wadi and its tributaries have profoundly altered the regional hydrology. Also near by the river, the establishment (since 2013) of a construction site for building bridges linking the East-West highway has had a major impact. This part of the river has become a veritable garbage dump, in that it receives a variety of liquid and solid waste discharges. Before the present study was carried out, the only available data on the environmental parameters and the Odonata fauna of this stretch of El-Kebir-East date back to the nineties [14]. This study aims to assess the status of this part of the river in the past two decades. The objectives are multiple: (1) to obtain a new checklist of Odonata from El-Kébir-East wadi, (2) to record autochthonous species and species diversity in order to estimate the health of the environment after two decades, (3) to identify the main environmental factors influencing the spatial distribution of the Odonata species in the study area.

2. Materiel and methods

The catchment area of El-Kébir-East wadi and its main tributaries comprises 1, 600 km^2 of eastern Numidia in the extreme north-east of Algeria. It is characterized by considerable topographic and geologic variety and is limited to the north by the Mediterranean Sea, to the south by the Medjerda watershed, to the west by the Mafragh and to the east by the Algerian-Tunisian border **(Fig. 1)**. It has two parallel mountain ranges: Djebel Ghorra and Djebel Oum Ali, separated by the Bougous valley.

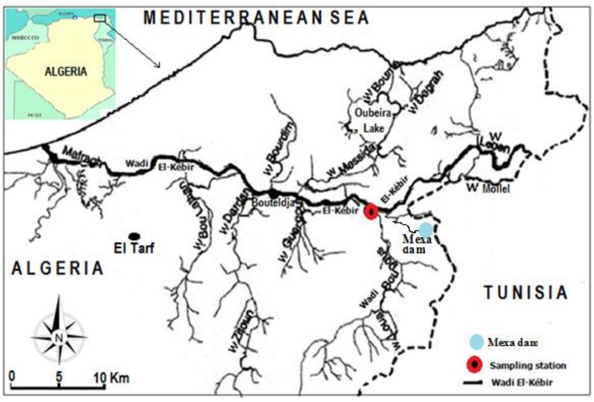

Figure1. Localization of sampling station at Wadi El-Kébir-East

The1780 km long El-Kebir-East hydrosystem, originates from the mountains of Ain Draham in Tunisia, it descends through steep wooded slopes into a rocky valley before entering the lowland plains of El-Tarf, and Bouteldja. Two main tributaries are the Ballouta wadi which begins in the east (of which 90% of the course is in Tunisia) and the Bougous wadi in the west (Algerian wadi), the junction (in the south of the commune of Ain Assel) of these two water courses forms the El-Kébir-East wadi in Mexa. Here in 1984, the Mexa dam was constructed by the ANB (national agency of the dams). After crossing the gorge of Mexa, El-Kébir-East wadi takes its course (almost the remaining 2/3 of its course) parallel to the coast at less than 100 m of altitude with a gentle slope before joins other watercourses. It crosses the plain of El-Tarf and connect on the left with the Guergour wadi, then the plain of Bouteldja receiving on the same left bank the Bouhalloufa wadi then the Boulathane wadi, while on its right bank, it collects the waters of runoff from the Bou Redim and Bougles wadis. El-Kébir-East wadi crosses, from east to west, the wilaya of El-Tarf over a length of 96 km to debouch in the Mediterranean to the Mafragh in Berrihane. The Kébir-East catchment area is distinguished by its rich fauna and flora, and its wide diversity of wetlands [14-15-16-17-18-19]. The lithological and climatological characteristics specific to the watershed of the Mafragh support a very varied vegetation. This is typified by a series of cork oak occupying much of the catchment and spreading over the entire southern region to the east and a small part to the north.

3. Monitoring and sampling stations

Monitoring undertaken between April 1993 and May 1994 [14], El-Kébir-East wadi, in its part located at the bridge crossed by the road N 44 which connects the town of El-Tarf and the commune of Ain El-Assel (36°46.028' N, 8°21.925' E) was sampled a second time regularly every week from April 2015 to May 2016 between 9:00 am and 3:00 pm GMT. The original selection of the sampling site was based on land use (agriculture, contiguous urban areas and industrial activities specifically related to the installation of the bridge at the East-West highway project construction for which was undertaken in the period between the two sampling studies. The sampling site is located downstream from the Mexa dam built in the 1980s so has been also subjected to considerable changes in water availability previously. Environmental characteristics were recorded according to the following descriptors: air and water temperatures, wadi bed width, water depth, conductivity, salinity, dissolved oxygen, PH, substrate type (blocks, gravel, pebbles, sand), vegetation cover (riparian) and aquatic vegetation (0 = Absent, 1 = Low, 2 = Medium, 3 = Dense), degree of pollution (organic waste) (0 = absence; + = Presence;.++ = dominant). Imagos of the dragonflies were recorded above the water, on stone blocks , in and above the vegetation and in the surrounding of the river. Most species have been identified with the naked eye or with field glasses. Information on their maturity (Teneral, Immature/Mature) and reproductive behavior (Tandem, Copulation and Oviposition) were noted. To confirm autochthon status of the species, larvae were searched for directly along the watercourse, in gravel and sand margins in riverbank vegetation, and then identified using the identification keys of [20].

4. Data analysis

The data were analyzed to characterize changes in the study area over two decades and to evaluate the potential association between species assemblages and abiotic factors. The structure of Odonata assemblages was evaluated using different indices of diversity: richness (S), frequency (Fi), Shannon Wiener diversity index (H'), equitability and dominance in order to determine the possible associations between species richness and descriptors. The notion of integrity or health of ecosystems requires a consideration of the chemical, physical and biological [21]. A Correspondence analysis (CAF) was carried out to characterize typology of the months/seasons by the structuring of the Odonatal procession.

5. Results

5.1. Environmental conditions

Table **1** summarizes the environmental variables recorded in the rival sampling station during the study period. The analysis of these parameters, together with the weather records of the region's meteorological stations over more than two decades (1993-2016) indicated a cold and humid season from October to April and a dry season from May to September.

Table I. Space-time variations of the environmental parameters along wadi El-Kébir-Est

	Seasons	Substratum	Air T(°C) (SD)	Water T(°C) (SD)	PH (SD)	Depth (cm) (SD)	Width (m) (SD)	O_2mg / l	Conductivity	Tutbidity	Aquatic vegetation	Riverside vegetation	Pollution (Organic waste)
Wadi El Kébir-Est	**Season of low waters (May- Oct)**	**Gravel sand**	**25.41 ± 1.57**	**22,80 ± 1,93**	**7,28 ± 0,39**	**18,83 ± 6,59**	**6,98 ± 5,93**	**6,8**	**580**	**21,2**	**1**	**3**	**0**
	Season of high waters (Nov- Apl)	**Gravel sand**	**15,84 ± 3,19**	**13,45 ± 2,32**	**7,43 ± 0,36**	**85,58 ± 64,46**	**12,62 ± 7,31**	**7,9**	**-**	**-**	**0**	**2**	**0**
Wadi El Kébir-Es16)	**Season of low waters (May- Oct)**	**blocks pebbles gravel**	**30,27 ± 4,87**	**24,94 ± 2,82**	**8,06 ± 0,29**	**22,8 ± 4,21**	**2,96 ± 0,20**	**2,5**	**2745**	**28,7**	**3**	**2**	+++
	Season of high waters (Nov- Apl)	**blocks gravel**	**20,50 ± 4,77**	**15,05 ± 1,74**	**7,95**	**-**	**-**	**6,2**	**-**	**-**	**0**	**1**	++

Aquatic and Riverine vegetation: 0 =Absent; 1 = Low; 2 = Medium; 3=Dense; Pollution: 0=absence; + =Presence;++ = dominant SD: Standard deviation

Monthly averages air temperatures of the region showed peaks during the warmest months, corresponding to the low water period, much more marked (30, 27 °C) during the month of August 2015. Minimum values were recorded during the coldest months, corresponding to the high water period recorded during the month of January 1994 (15.84 °C). Water temperatures varied in the year according to the same rhythm as the temperatures of the air. The pH of the water recorded during the low-water period of the year 2015 reached the value of 8.06, because of the temperatures exceeding 30 °C, the conductivity values recorded were quite large, sometimes reaching 2745 µs / cm at 25 °C, turbidity of 28.7 and very low values of dissolved oxygen oscillating between 2.5 mg / l and 6.2 mg / l. On the other hand, the water PH values recorded during the monitoring of 1993/1994 ranged from 7.28 to 7.43, dissolved oxygen between 6.8 and 7.9, conductivity reached the value of 580 µs/cm at 25 °C and a turbidity of the order of 21.2. The depth of the water has shown considerable fluctuations over the last two decades in relation to the large decrease in the width of the major bed. In two decades, the bed has change from an average width of 6.98 ± 5.93 in the summer of 1993 to an average width of 2.96 ± 0.20 recorded during the summer of 2015.water depths of 22.8 ± 4.21 and 18.83 ± 6.59 were recorded during the summers of 2015 and 1993 respectively. Throughout the low-water season, almost

complete drying of the bed characterized the sampling station in 1993. However, during the high-water season, the El-Kébir-East wadi is a flooded hydrological regime prohibiting any possibility of sampling. Riparian vegetation (ripisylve) underwent a significant degradation over the longer time with filling for construction of the new bridge in the road N 44 just above the sampling station. The sandy bottom described in 1993 is now replaced by a muddy silty bottom, which has favored the proliferation of high dynamic plants that completely cover the surface of the waters in summer. At shallow depth, filamentous algae proliferate, undulating in the weak current and often covering the entire bottom.

5.2. Odonata communauties and diversity

5.2.1. Frequency, specific richness and Shannon Weaver index

In total, seven species of Odonata from four families (Lestidae, Platycnemidae, Coenagrionidae, Libellulidae) were recorded in this study (2015/2016). Four species are Zygoptera and three are Anisoptera. The species flight period ranged from May to early December 2015 **(Fig. 2)** and indigenous status was confirmed for three species (*Lestes viridis*, *Platycnemis subdilatata*, *Ischnura graellsii*).

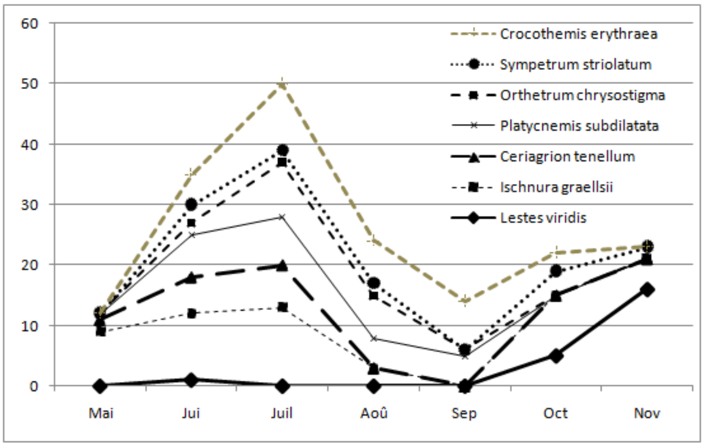

Figure 2. Adult Odonata flight period at Wadi El-Kébir (Survey period: 2015/2016).

The family Libellulidae is the well represented by three species, *Orthetrum chrysostigma* (10.55%), *Sympetrum striolatum* (07.22%) and *Crocothemis erythraea* (18.88%), followed by Coenagrionidae represented by two species, *Ischnura graellsii* (28.33%) and *Ceriagrion tenellum* (8.33%), followed by the Lestidae family represented by a single species, *Lestes viridis* (12.22%) followed by Platycnemidae represented solely by *Platycnemis subdilatata* (14.44%) **(Fig. 3)**.

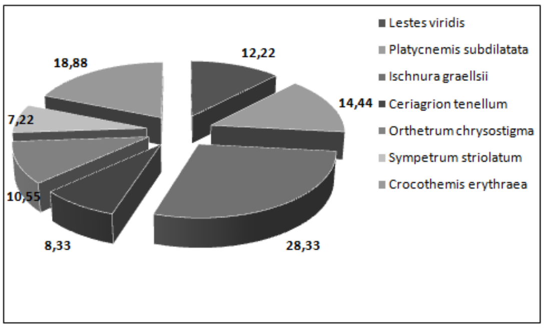

Figure 3. Distribution of frequencies between different species of Odonata at Wadi El-Kébir (Survey period: 2015/2016).

The checklist compiled between May 1993 and April 1994 at this station revealed 14 species belonging to six families of which six species of Zygoptera and eight of Anisoptera. The most common species are Libellulidae : *Orthetrum chrysostigma* (5,55%), *Sympetrum striolatum* (25,74%),*Trithemis annulata*(1,29%), *Trithemis arteriosa* (0,37%) and Coenagrionidae : *Ischnura graellsii* (21,66%), *Coenagrion lindenii* (6,66%), *Erythromma viridulum* (0,37%), *Ceriagrion tenellum* (4,81%), followed by Aeshnidae : *Aeshna mixta* (2,59%) et *Anax imperator* (0,55%) then Gomphidae with two species : *Paragomphus genei* (3,88%) and *Onychogomphus costea* (0,37%) and finally Lestidae represented by *Lestes viridis* (6,85%) and Platycnemidae with *Platycnemis subdilatata* (19,25%) **(Fig. 4).** Indigenous status was confirmed for six species (*Lestes viridis*, *Platycnemis subdilatata*, *Ischnura graellsii*, *Paragomphus genei*, *Onychogomphus costea*, *Orthetrum chrysostigma*) and the flight period ranged from May to November 1993 [14].

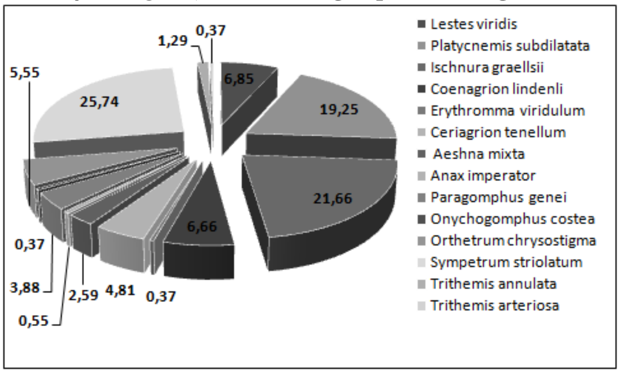

Figure 4. Distribution of frequencies between different species of Odonata at Wadi El-Kébir (Survey period: 1993/1994).

Table II. Status and species richness in the study zone (Survey period: 1993/1994 and 2015/2016).

Family	*Species*	*Survey 1993/1994*		*Survey 2015/2016*	
	Check-list	*Presence / Absence*	*Autochthonous*	*Presence / Absence*	*Autochthonous*
Lestidae	*Lestes viridis*	+	-*	+	*
Platycnemidae	*Platycnemis subdilatata*	+	-*	+	*
Coenagrionidae	*Ischnura graellsii*	+	-*	+	*
	Coenagrion lindenli	+	-	-	-
	Erythromma viridulum	+	-	-	-
	Ceriagrion tenellum	+	-	+	-
Aeshnidae	*Aeshna mixta*	+	-	-	-
	Anax imperator	+	-	-	-
Gomphidae	*Onychogomphus costea*	+	-*	-	-
	Paragomphus genei	+	*	-	-
Libellulidae	*Orthetrum chrysostigma*	+	*	+	-
	Crocothemis erythraea	-	-	+	-
	Sympetrum striolatum	+	-	+	-
	Trithemis arteriosa	+	-	-	-
	Trithemis annulata	+	-	-	-
Total richness	***15***	***14***	***6***	***7***	***3***

*: Autochthonous species

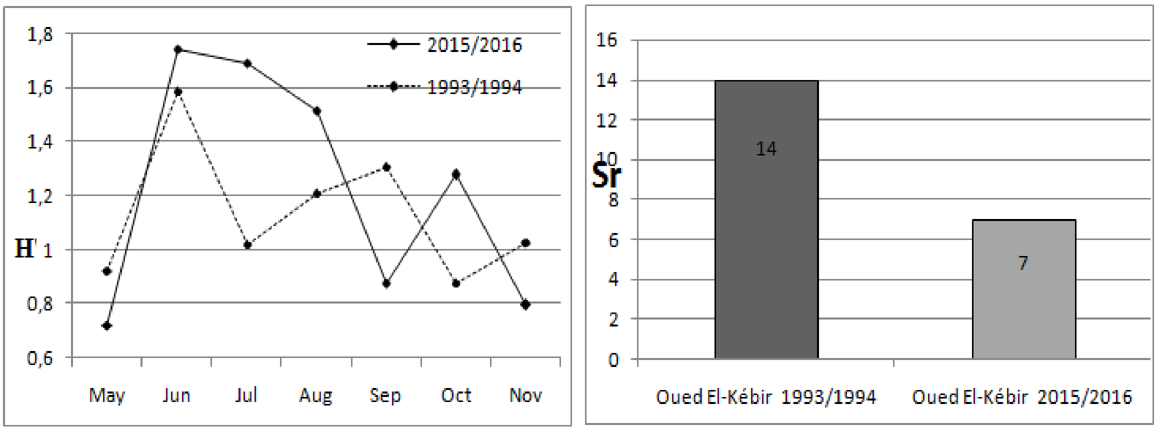

Figure 5. Shannon Weaver index (**H'**) and species richness (**Sr**) at Wadi El-Kébir (Survey periods: 1993/1994 and 2015/2016).

Comapred with the 1993/94 data eight species are absent in the new checklist. Two Zygoptera (*Coenagrion lindenii, Erythromma viridulum*) and six Anisoptera (*Anax imperator*, *Aeschna mixta*, *Paragomphus genei*, *Onychogomphus costea*, *Trithemis arteriosa*, *Trithemis annulata*). Only *Crocothemis erythraea* is added to the new checklist, and is very abundant in the sampling station. The specific richness and the Shannon index showed the same profile and evolved in the same way in space-time, but it was during the monitoring of 1993/1994 that the species richness and the values of the Shannon index were recorded with highest values **Table II** and **(Fig. 5)**.

5.3.*Equitability (E) and dominance index (D)*

The values of the Equitability (E) recorded for the two monitoring are globally close to 1. They indicate that all the species are closer in their abundance. The fall in Equitability values occurred from October for the year 1993, but later from November of the year 2015; this corresponds to the beginning of autumn and to the reappearance in mass of new species in the site especially *Lestes viridis* **(Fig. 6a)**.

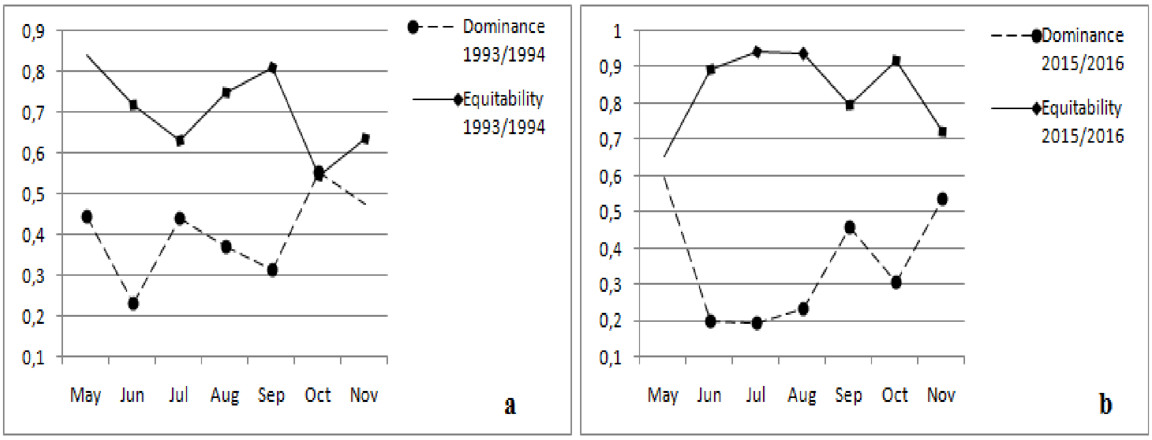

Figure 6. Equitability (E) and Dominance (D) at Wadi El-Kébir (Survey period: 1993/1994 -a- and 2015/2016 -b-).

Similarly, the values of the dominance index (D) are close to zero and never exceeding 0.6, they were recorded throughout the summer of the year 2015 and ranging between 0.3 and 0.4 during the summer of the year 1993 indicating that no species is dominant except in the early autumn of the two-year monitoring. This autumnal period is

marked by the abundance of allochthonous and ubiquitous species such as *Crocothemis erythraea* and *Sympetrum striolatum* and the summer appearance of *Lestes viridis* **(Fig. 6b)**.

5.4.*Correspondence analysis (CAF) and Typology of months / seasons by the structuring of the Odonatological procession*

The typology of the seasons recorded by the Odonata species inventoried is illustrated by Fig 3 and 4 for the year 2015/2016 and 5 and 6 for the year 1993/1994. The F1 x F2 plan of the CA cumulates 85.51% and 74% of the total variation respectively for the two monitoring periods. From a structural point of view, each season is characterized by a specific diversity of species. Two groups of months corresponding to two seasons are quite distinct **(Fig. 7)**: From May to September for the year 1993 and from May to October for the year 2015. In both cases (1993/94 and 2015/16), these two summer periods are characterized by the presence of more indigenous species than non-native species.

Autumn from the beginning of October to the end of November 1993 was characterized by the exclusive presence of *Lestes viridis* during these two months. However, Autumn 2015 is represented only by the month of November where two species groups, autochthons which has persisted over time (*Lestes viridis*, *Platycnemis subdilatata*, *Ischnura graellsii*) and cosmopolitan (*Crocothemis erythraea*, *Sympetrum strialatum*). All species of Gomphidae recorded in 1993 have disappeared from the site. The flight period was extended by one month during the 2015 season.

6. Discussion

Algerian Odonata are indirectly threatened by the loss or excessive disturbance of their habitats due to increasing urbanization (drying, filling, building) but also by the use and transformation of many watercourses exploited in crop irrigation. Organic pollution (cattle) or chemical pollution (pesticides, insecticides) are, like the rest of the fauna, important factors in the erosion of diversity on the most sensitive organisms [22].

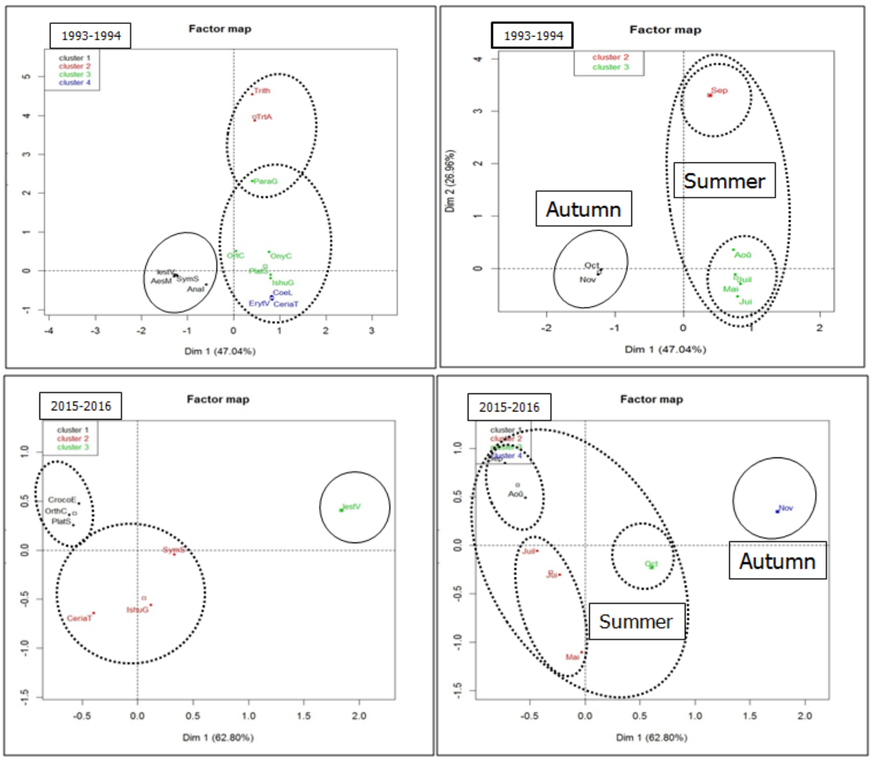

Figure 7. Factorial Correspondences Analysis and typology of months/seasons by structuring the procession Odonata.(Survey periods: 1993/1994 and 2015/2016).

The analysis of the climate data recorded made it possible to distinguish in the region a cold and humid season from October to April and a dry season from May to September. Precipitation is defined by a very irregular distribution and increases from West to East and from North to South. Thus, their dominant distribution during the wet season may expose the region during this period to repeated floods from one year to the next. The surface water flow of the Mafragh basin is characterized by a period of high water, from November to April and a period of low water, from May to October. Environmental parameters and physico-chemical indicators of water quality are often subject to spatial and temporal variations induced by anthropogenic activities that modify the characteristics of water and affect its quality [23]. Thus, measurements of these parameters during the study period revealed the degree of pollution accumulated over the last two decades in this biotope. The PH values recorded in 2015 revealed an alkaline environment, while temperatures exceeding 30 °C during the summer period necessarily induce fairly high conductivity values. This highlights a pollution of the area recorded in recent years in connection with industrial wastewater and the accumulation of solid and organic waste mainly related to the construction site for the installation of the new bridge in the road N44 just above the sampling station, which negatively affected the odonatological biodiversity in this sector. This result is conform to the findings of [10], which showed that urban and agricultural pollution could negatively affect Odonata communities. The distribution of Odonata is determined by physical factors (sunshine, precipitation) and by biological factors (food availability, competition and predation) [24]. In the study area, the average temperature varied greatly from one year to the next. Its values reveal a strongly increasing gradient, particularly accentuated during the summer of 2015. Thus, the year 2015 ranks well ahead of the hottest years, ahead of the year 2014. The months of October and November themselves have beat all records, exceeding 26 °C, which exceptionally favored the prolongation of the period of emergences and therefore the phenology of the imagos of Odonata until the beginning of December 2015. This result is not in perfect agreement with the known flying period for most Odonata in the Mediterranean [25- 18] and with adult phenology (May-November) recorded in the same site two decades ago [14]. Similarly, the influence that the water temperature has on the distribution of Odonata assemblages is mainly emphasized by many [23-26-27]. The temperature of the water, strongly influenced by the environmental conditions, represents a crucial abiotic factor in the development and the growth of the larvae [23]. The warm waters influence the type and the beginning of the emergences. Each species has a "limit" beyond which emergence is triggered. According to [28], the beginning of the emergence for the same species may vary from site to site and from year to year due to temperature differences during spring. Ripisylve is known to contribute to the maintenance of ecosystem balances. For example, riparian forest cover regulates not only water temperature and primary production through the interception of light, but also the supply of non-native organic matter to aquatic consumers. However, in this section of the El-Kébir-East wadi, there is then a degradation of the initial riparian stream described in 1993 [14]. These variations have caused not only a considerable reduction in bed width, bank erosion and destabilization of trees and shrubs as well as associated fauna, but also an increase in the temperature of the water. Hot water increases primary production and thus reduces the dependence of aquatic food webs on non-native carbon sources [29-30]. According to [31-32]. The impact of forest operations may persist for decades after the disturbance, even after the riparian return to mature status. For example, many studies have reported post-harvest changes in water chemistry, hydrology, bed morphology, biodiversity and rates of transformation of organic matter [31-33-34-32-35]. Other studies have shown that modification of riparian vegetation can lead to massive and abrupt intake of fine sediment into streams [36] thereby altering the quality of the sediment and affecting the most sensitive organisms [37-38] as is the case in this section of El-Kébir-East. As for the aquatic vegetation, this latter is the main actress of the good functioning of the lotic and lentic ecosystems. Present at different levels, plants greatly influence the nature of

the bottom, the temperature as well as the rate of oxygenation. They also serve as support and food for imagos and split the ecosystem into diversified micro-habitats[23] indicates that emergent larvae preferentially seek shoreline areas with rigid stems for emergence where more larvae successfully complete their metamorphoses. It has also been shown that adult odonata prefer high and rigid plants because their heights and open structures facilitate thermoregulation [39-40-41]. In this part of the river, the aquatic vegetation has met edaphic conditions conducive to its proliferation, and completely invaded the surface of the water in a few months indicating that the environment is unbalanced. This surplus vegetable production, which becomes a discomfort and causes many nuisances, is due to an excess of fertilizing elements to which have been added other factors such as the amount of significant sunshine resulting from the current global warming, the high temperature water and the very slow current speed. At shallow depth, the oxygen consumption caused by the respiration of the important algal biomass eventually created anoxic conditions whose larvae were the first victims. Smothered literally by the plants, the river lives badly in this stretch of El-Kébir-East, because the light no longer penetrates it and the slowly decomposing of the dead leaves causes an accumulation of mud. Within a few years, this stretch of the river has naturally been filled and, as the amount of dissolved oxygen decreased, the odonatological diversity has regressed rapidly, passing in two decades from a specific richness of 14 species inventoried in the same site and with the same sampling effort in the year 1993[14] to a richness of 7 species in the year 2015. This section of El-Kébir-East wadi is a stream that we can consider to be poor in fauna (as to the presence / absence of taxa and their abundance) if compared with other Algerian wadis. A total of 35 species have been recorded at Seybouse wadi [42], 19 species at Isser wadi [43], 13 species at El Harach wadi [44] and 19 species at Bouarroug wadi [45]. However, these differences appear to be related to hydrology and habitat heterogeneity and need to be considered as they influence aquatic biodiversity [46]. The comparison with the biological indices used made it possible to deduct that it was during the 1993/1994 monitoring that the highest species richness and Shannon index were recorded. The specific richness depends, in fact, on the ecological conditions at the level of each station; It is rather higher than the biotope, heterogeneous and less influenced by anthropogenic activities. Two decades ago, the site was characterized by its shallow waters, with a sandy substrate, loaded with O_2 and organic matter. The families of Gomphidae, Libellulidae, Platycnemigidae and Coenagrionidae have a preference for calm or stagnant waters with the above characteristics. The species belonging to these families were harvested in large numbers in this section of the wadi at that time of the year [14]. Nowadays, only small Zygoptera (*Lestes vridis*, *Platycnemis subdilatata*, *Ischnura graellsii* and *Ceriagrion tenellum*) that can nest in lotic and lentic habitats have been able to adapt and resist the new environmental conditions. They are species with a low ecological valence. They are associated with microhabitats where low vegetation was present. Together, these species are perfectly adapted to the floods of the El-Kébir wadi which, while destroying part of their populations periodically, have a structuring effect on their habitat (sediment sorting, cleaning gravel beds, removing surplus organic matter Out of bed). Indeed, organisms are selected by habitat and only species adapted to the physical characteristics of the habitat and its regime of spatial and temporal variations can sustain themselves durably [47-48]. Other adaptation strategies are very common in the Mediterranean region where wetlands can dry out during the summer [17-49-50] and of which *Lestes viridis* is a good example. This adapts itself by summering in the adult stage in the fresh and shady areas of the region undergoing a pre-reproductive diapause of three to four months [14] and only reappears later in the breeding season when the temperature drops and the water level rises. On the other hand, semi-voltines and partivoltines only thrive in permanent streams [25]. Finally, the very low representation of Anisoptera species with the exception of a few *Orthetrum chrysostigma* species observed accidentally in the study station should be noted. All the Anisoptera recorded during the 1993/1994 monitoring, in particular the eurecae species with high respiratory requirements such as the Gomphidae, were replaced by ubiquitous and allochtonous species such as *Sympetrum striolatum* and *Crocothemis*

erythraea observed in large numbers in this part of the river in 2015/16. Absence of the Gomphidae in this river stretch is most likely migratory or erratic since they have succeeded through the years to successfully colonize other rivers of the region offering them better conditions, as is the case of *Paragomphus genei* inventoried in the Brabtia Reserve and at Bouarroug wadi for the first time in 2014 [45]. The observation of the disposition of the species on the two axes of the FA shows their separation into two groups of months corresponding to two distinct seasons for the two years of sampling. Nevertheless, in 2015, reinforced by the high temperatures (global warming), the summer season was extended to late November and early December and the autumn season was very short (November), characterized by a massive return of *Lestes viridis* for breeding. In general, the alteration of this river has resulted in the more or less brutal simplification of the odonatological fauna of origin, the disappearance of certain species more sensitive than others to the different types of disturbance, eventually the appearance of organisms adapted to the new environmental conditions, or the proliferation of ubiquitous or pollu-resistant taxa so long as the environmental conditions are not too unfavorable, in which case they disappear in their turn. Thus, Odonata would not be perfectly bio-indicators of the quality of an environment, but would play an important role in the characterization of the environments and consequently in their management.

7. Conclusion

The main factors responsible for the distribution of odonata group in this part of El-Kébir-East wadi are the pollution and high water temperatures, which has affected water quality (2) the construction of the bridge, with liquid and solid effluents associated with this site and the loss of riparian, a disturbance that caused a change in bed width and water flow. In this sense, the effect of the anthropogenic impact recorded during the 2015/2016 monitoring, in particular the contamination of water on Odonata populations, is evident, as shown by the decline in species richness and biological indices used. The quality of river water during the 1993/1994 monitoring without strong impacts was better. In addition, we have also demonstrated that Odonata can be used as indicators of environmental impacts in rivers. Their responses to impacts differ; the majority of species are not tolerant of increased contamination and changes in river structure, but some species appear to have adapted to these changes and become dominant in highly disturbed sites. Rare or extirpated species appear to be associated with good water quality, which highlights the importance of freshwater habitat conservation.

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