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Inventory and phenology of mayflies of the middle Atlas sources

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Key words: Mayflies, Inventory, Phenology, Middle atlas.

Abstract

The mayflies are one of the most primitive levels of benthic invertebrates macro and most abundant in fresh water sources Moroccan. Sampling fauna of 6 stations spread along the river systems in the way Atals (Morocco) 11 species have been recorded: 6 species belonging to the family of the Baetidae. *Baetis rhodani* has a wide distribution since she was found in all stations and is the largest workforce. These catches have led to the time of emergence and seasonal abundance of the species.

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Introduction

Ephemeroptera (Mayflies) of freshwater, by their biodiversity and their differential sensitivity to the various forms of pollution are biological indicators preferred to testify to the quality of present and past water and the habitat that they occupy (Kaesler *et al* 1973). Very sensitive to pollution, their presence in number indicates a water well oxygenated and of very good quality (Alba Tercedor, 1996, 2000; Verneaux and Thomas, 1967). Any pollution causes a reduction in diversity and the elimination of the species, gender, or families the most polluosensibles.

As with any wet area in a fresh water source, each has special requirements (oxygenation, nature of the bed, temperature). Faced with a one-time or chronic pollution, certain animal species will disappear, others thrive. The sources of the Middle Atlas, the birthplace of endemism fauna Moroccan sits a considerable number of benthic Macro invertebrates, amongst which the mayflies that are considered to be sentinels of wetlands bioindicators. Theoretically, the sources of fresh water are considered as a reference state it is the paradise of the proliferation of such an order, but have t - it of the State of the place. Research dedicated to this order, are either very fragmentary and be limited in time and space.

The settlement of mayflies of Morocco is poorly known. Indeed, the first wildlife inventory dedicated to this group was directed by Dakki and El Agbani (1983), and is that in 1989, only El Alami has conducted research focused on the study of one of the main Mediterranean hydrographic networks the Laou Ephemeroptera (El Alami, 1989). Until the put date apart from some work (ElJoubari, 2015; El Alami & Dakki, 1998; Giudicelli & Dakki, 1984; El Alami, 2002; Dakki & Tachet, 1987; Bonada *et al.,* 2004; Alaoui, 2006; Errochdi *et al*., 2012) no work has been undertaken to establish a complete inventory of Ephemeroptera colonizing the sources of the Middle Atlas.

This study aims to establish an inventory of fauna species of mayflies in 5 sources (Ain Regrag (AR), Sidi Bouali (SB), Tataw (T), Arbalou Aberchane(AA), Tit Zil (TZ) and a stream the Wadi Guigou (O. Gui.) of the Middle Atlas, in order to provide information on the ecology and distribution of their stands.

This initial stage is often used as basis of an inventory as complete as possible of different taxa that can be encountered in the waters of the water system and would thus enrich the list of Moroccan biodiversity.

Material and methods

Study Sites

The choice of stations was based on the idea of having points distributed throughout the watersheds studied, to maximize the diversity of habitats and ecosystems prospects and have a great variability of thermal and hydrological characteristics likely to act on the distribution and ecology of this order. During the benthic research we have done in the Middle Atlas.

We selected six stations of studies: three main sources to monthly sampling and three sites designed for 2 companions of picking during the months of March and may during the years 2014 2015 when all larval forms are present but who have not yet begun their final maturation. The six stations, covering a distance of more than 300 Km, have been represented in Fig.s 1 and 2, their mapping is described in table 1.

Main stations

Source Tataw of Imouzzer Marmoucha (T)

Located in the eastern part of the Middle Atlas Northern and bordered to the East by the Valley of the average Moulouya, Immouzer Marmoucha is a hinge between the Middle Atlas and the Eastern Morocco (Fig. 1 & 2). The commune belongs to the water of the pleated Middle Atlas, which is characterized by the outcrop of limestone and dolostone of the Jurassic period allowing a storage of groundwater. Its waters are a source of drinking water and irrigation.

Source Regrag (AR)

Ain Regrag is a special type of source of fresh water in North African Mountain. Part of the hydro geological unit of the Causse way Atlasique. She deaf aquifer material of the corridor Fez-Taza, a slick,

which covers an area of 1500 Km 2 and based on a waterproof substrate formed by the Triassic argilodoleritique. The main value of this exsurgence (AR), lies in its particularity, permanent running water high volume (table 1)

Source Sidi Bouali (SB)

The main source and its resurgence are completely natural, like Ain Regrag, Sidi Bouali source is located within liasiques through its spiritual value, and until the last years touches the source was not plundered by anthropogenic activities, the neighbouring population sought rather to preserve.

Secondary stations

Source Aghbalou Aberchane (AA)

This resurgence (Fig. 1 and 2), about 7 m wide, out of the basalts to 4 m distance from the bed of the Guigou and 1 m above the latter. Because of its high flow rate, it is the main source of the Guigou. It is located at 1920 m of altitude and 800 m upstream of Foum Khnag and about 15 km south of Timhdite.

The water is cold (9 to 10°C in summer), while in the Guigou, just before the confluence of the source, the temperature reaches 25°C in August (Dakki, 1986).

Source Tit Zill

This resurgence (Fig. 1 and 2), gushes at 1571 m. The total flow of the waters flowing in the Guigou would be 400-700 l/s (C.E.I.B.M., 2015). The herbaceous cover of the substrate is less important, but bryophytes are abundant on the surface of the blocks running fast, the rest is essentially Pebble gravel and sand; It is covered 70% of aquatic phanerogams.

Wadi Guigou to the bridge of Hamza

Located at an altitude of 1520 m, the Wadi Guigou borders the rural Guigou Boulemane province, reached 7 to 11 m width.

The current, lively upstream of the bridge, becomes low downstream. The substrate, formed mainly of pebbles, gravels and Sands with equal importance, covers a well-developed Herbarium and algae.

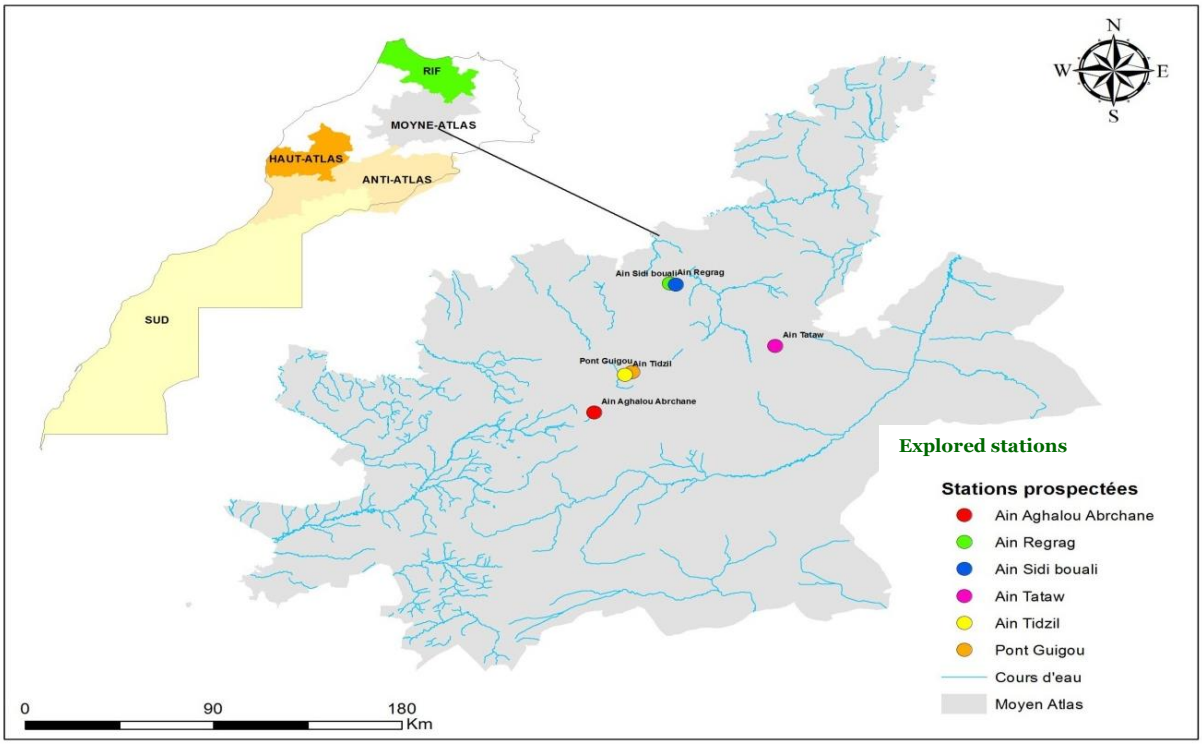

Fig. 1. Geographical situation of the stations of studies.

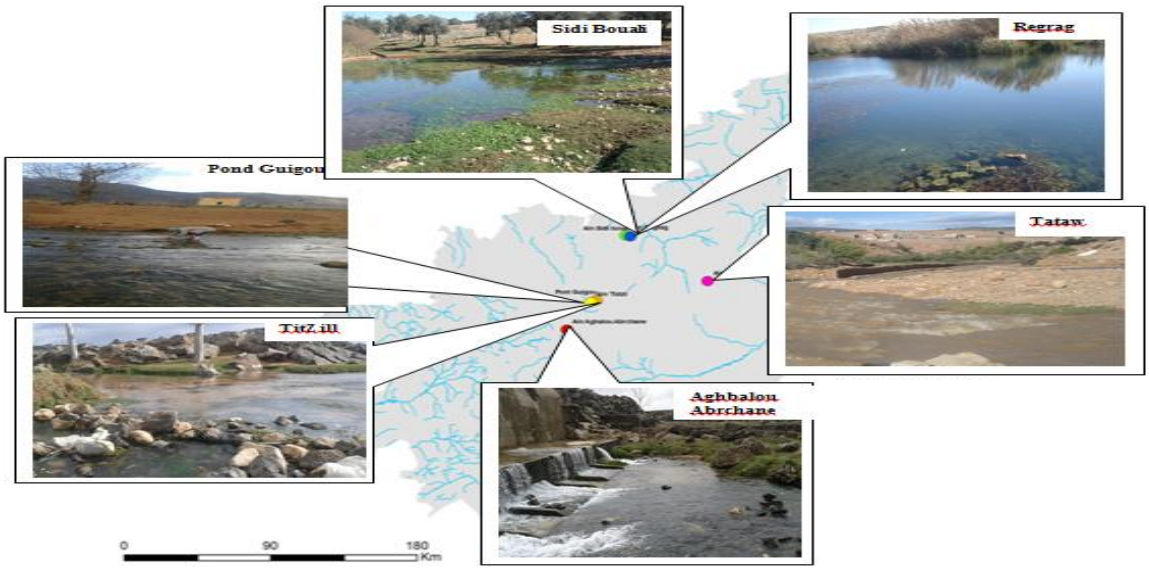

Fig. 2. Illustrated situation of stations studies at the midlle Atlas.

Table 1. Settings map and abiotic of the study sites.

	AR	SB	T	OGui	TZ	AA
Province	Sefrou	Sefrou	Boulemane	Boulemane	Boulemane	Ifrane
Commune	Sidi Youssef	Ahl Sidi Lahcen	Immouzzer Marmoucha	Guigou	Guigou	Timhdite
Longitude	-4,734	-4,708	-4,28	-4,895	-4,925	-5,057
Latitude	33,782	33,776	33,476	33,348	33,333	33,149
Altitude (m)	1060	1100	1720	1520	1571	1920
Annualprecipitation (mm)	750,7	750,7	429,17	412.89	412.89	484.4
Thermal gap (M-m)	43.1	43.1	31.6	43.3	43.3	31.6
Flow (l/s)	305	271	430			
The current speed (cm/s)	111	48	76.3	70	78	85
Flow type	Veryfast	Medium	fast	fast	fast	fast
Dominant vegetationcover	Reed, Lily, hornwort	Algae, pteridophytes	Ptéridophytes, spermaphytes	Cryptogammes	Filamentousalgae, bryophytes	Phanergammes
Transparency of the water	High	High	Lowduring the floods	Medium	High	High
Granulometric composition	Sand (10 %) Gravel (20%) Pebble(50%) Block (20%)	Sand (15 %) Gravel (35%) Pebble (40%) Block (10%)	Silt and clay (5%) Sand (5 %) Gravel (20%) Pebble(40%) Block 30%)	Silt and clay (30%) Sand (25 %) Gravel (20%) Pebble (15%) Block (10%)	Silt and clay (5%) Sand (20 %) Gravel (30%) Galet (25%) Block (20%)	Silt and clay (5%) Sand (10 %) Gravel (15%) Galet (40%) Block 30%)

Physicochemical analysis methods

According to standardized methods (Rodier 2009), 9variables have been a follow-up physico-chimique (Température, pH, Conductivité électrique, Dureté calcique, Dureté magnésienne, Chlorures, Sulfates, Matière organique et Oxygène dissous). In order to alleviate the problems related to the conservation of the levies, Measures of temperature, pH, and conductivity were conducted using a multiparameter pH/conductivity/temperature Cyber Scan PC10 parser.

The rest of the reviews was directed by volumetric or spectroscopic assays according to the analytical methods proposed by Rodier (2009), in the laboratory of functional ecology and environment of the Faculty of Sciences and Techniques of Fez.

Benthic sampling method.

In each station, for the study of the most important abiotic parameters, was used for the manipulation of various measuring devices in situ and in the laboratory.

These parameters are essentially interested in latitude, longitude, altitude, depth, width and the texture of the substrate. In order to establish an inventory of the fauna of the larvae of mayflies. The benthic fauna samples were taken with a net Surber (Surber, 1937) of opening rectangular, of emptiness of mesh 0.3 mm and fitted with a framework of surface 0, 05 m 2. The harvested material is preserved in alcohol 70°. Sorting and identification of species are carried out under a binocular magnifying glass through the key of determination Tachet and *et al.* (2006).

and given the complexity of the taxonomic level desired, we resorted to the Professor Majida El Alami experienced specialist of the Mayflies. Taking into account the dates of catches, we can draw a diagram of phenology

Results and discussion

Physicochemical parameters of the Middle

Table 2 is a summary table that presents all of the thermal and physicochemical measures.

Table 2. Results of the physicochemical analyses of the six stations of studies.

Physicochemical parameters of the Medium	O. Gui	TZ	AA	AR	SB	T
Temperature (°C)	15.05	11.75	10.5	18.82	17.74	11.47
pH	7.89	7.33	7.6	7.08	7.2	8.05
Conductivity (µS/cm)	788	631.75	364.75	1100,18	1097,18	354,45
Calcium hardness (mg/l)	144.076	96.22	81.92	110,36	156,89	148,66
Magnesianhardness (mg/l)	52.27	79.05	36.92	33,81	37,21	14,85
Chlorides (mg/l)	52.36	12.51	7.125	219,78	209,45	14,85
Sulfates (mg/l)	56.13	30.08	17.73	18,07	15,78	17,15
Organicmatter (mg/l)	13.4	1.16	0.811	1,04	0,22	2,89
Dissolvedoxygen (mg/l)	2.52	6.56	9.1	5,77	5,13	6,31

The review and interpretation of the results of chemical analyses of water samples collected show that Sidi Bouali waters are calcium hardness with an average concentration of 148.7 (mg/l) but is still lower than the potability standards. The waters of Ain Regrag characterized by hardness and mineralization sources enough. The waters of Tataw to turn weakly mineralized, low temperature and low hardness calcium and magnesian. The Wadi Guigou who is a body of water, we note that the impact of the anthropization and indeed outstanding, reflected in large part by a decrease of dissolved oxygen, this aspect is illustrated by a concentration of 2.52 (mg/l). In addition, there is an increase in the organic load 13.4 (mg/l).

The evolution of these parameters follows pace in two stations TZ and AA but less rigorous because these two sites are sources arise phreatic waters and no surface water. Numerous settlements dotted around the sites surveyed strongly influence the quality of their waters and subsequently of the ecosystems that are completely upset.

Inventory of the Maylies stands

Established wildlife inventory, includes the distribution of stands in the different sampling stations (table 3), a more detailed inventory showing the population of each species in each source during the twelve months of sampling is illustrated in table 4.

Table 3. List fauna of the six studies area of AR, SB, T, AA, TZ and O. Gui.

Classification					Stations					
Branch line	Classe	Ordre	Family	Species	AR	SB	T	AA	TZ	O. GUI
Arthropods	Insects	Ephemeroptera	Baetidae	*Baetis alpinus*	+	+	-	+	+	-
				Baetis rhodani	+	+	+	+	+	+
				Baetis pavidus	+	+	-	-	+	-
				Cloëon sp.	+	+	-	+	-	-
				Procloeon sp.	+	+	-	-	-	+
				Potamanthus sp.	-	+	+	-	-	-
			Caenidae	*Caenis pusilla*	+	+	+	+	+	-
				Caenis luctuosa	+	+	+	+	+	+
				Brachycercus sp.	-	+	-	-	-	-
			Heptageni-dae	*Ecdyonorus ifranensis*	+	+	+	+	+	+
				Heptagenia sp.	+	+	+	+	+	-

Table 4. Abundance of the benthic macrofauna in the six stations of studies.

	T	AR	SB	AA	TZ	OGUI	Total
Baetis alpinus	0	1	18	20	0	0	39
Baetis rhodani	79	259	224	73	192	0	827
Baetis pavidus	0	96	7	0	11	0	114
Cloëon sp.	0	28	11	8		0	47
Procloeon sp.	0	17	6	0	0	9	32
Potamanthus sp.	39	0	36	0	48	0	123
Caeni spusilla	10	1	42	8	51	0	112
Caenis luctuosa	51	101	147	31		16	346
Brachycercus sp.	0	8	0	0	0	0	8
Ecdyonorus ifranensis	0	66	127	59	21	13	286
Heptagenia sp.	0	16	24	16	3	0	59
TOTAL	1993						

Thousand nine hundred four twenty thirteen (1993) larvae of mayflies were collected in the organizations during the twelve months of picking and have been divided into six families, the majority family is that of the Baetidae, it includes six species (*Baetis alpinus, Baetis rhodani, Baetis pavidus, Cloëon* sp., *Procloeon* sp. and *Potamanthus* sp.),

This family represents 59,308% of the population followed by the family of the comortant Caenidae 3 species (*Caenis pusilla, Caenis luctuosa* and *Brachycercus* sp.) recording a percentage of 23.382%, and finally the more minority.

Family of the Heptagenidae with two species (*Ecdyonorus ifranensis* and *Heptagenia* sp.) with a percentage of 17.311% (Fig. 3).

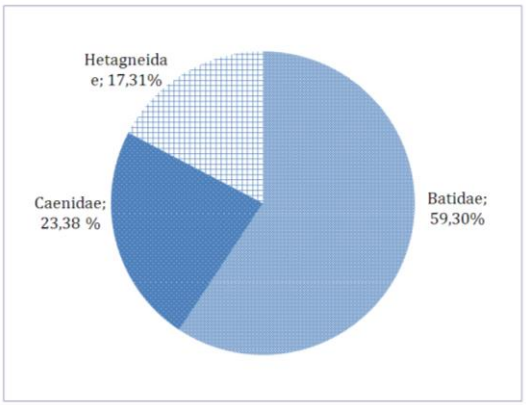

Fig. 3. Relative percentage of different families.

The stand of mayflies is clearly unbalanced in favour of a single species, Baetisrhodani, characterized by a high phenotypic plasticity; She is the most prolific, the most abundant and the most frequent; It represents 41.495% of captured specimens (Fig.3)

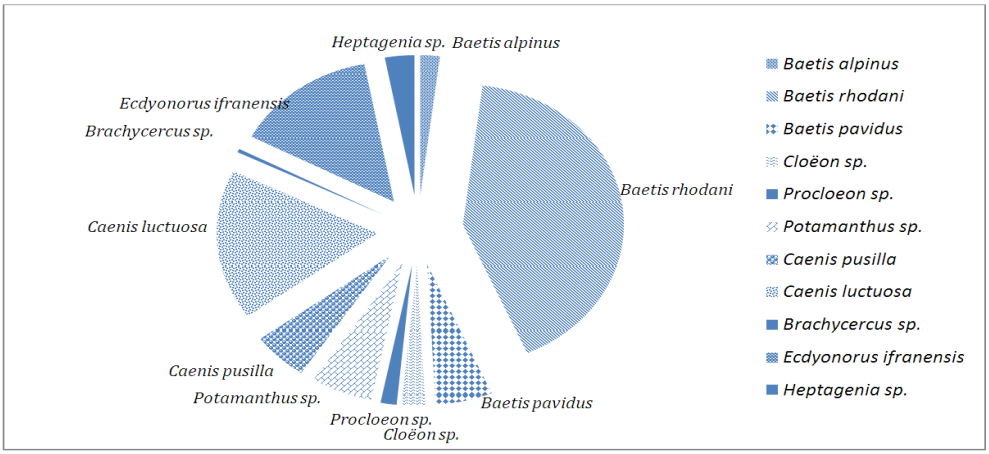

Fig. 4. Relative abundance of species harvested in the six stations of studies.

Phenology

The temporal profile of stands of mayflies, reveals a net change in spacetime terms of descriptors that order parameters.

Baetis alpinus

The first citation of *Baetis alpinus* Picter, 1843-45 in North Africa was reported in 1978, in the courtyard of the Wadi Guigou to the Middle Atlas (Dakki, 1979). The larvae of this species seem to find as his favourite biotope in the emissaries of sources of high and medium altitude. (El Alami and Dakki, 1998). She was found in the crenal of Sidi Bouali and Ain Regrag (Fig. 5).

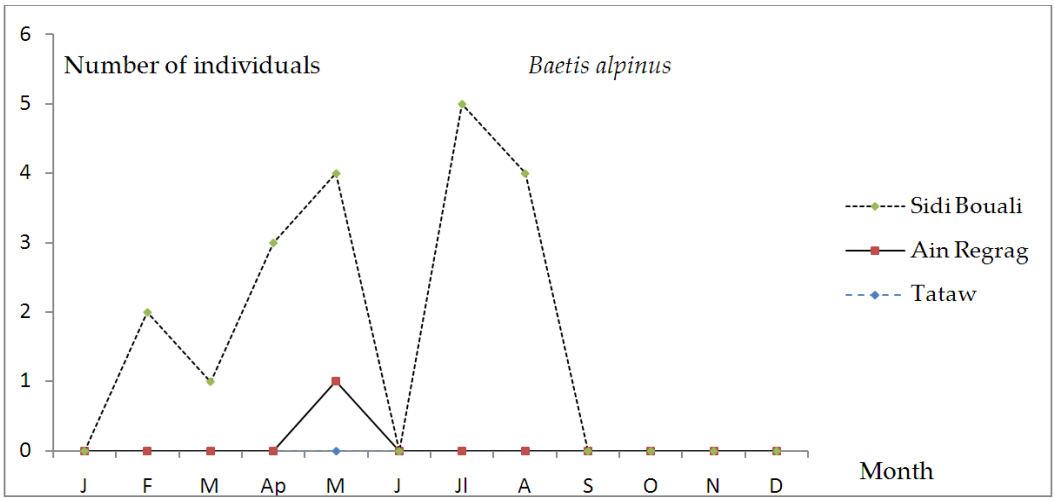

Fig. 5. Time evolution of *Baetis alpinus* in the year 2013.

Baetis rhodani

It is the most eurytope of harvested species and is found in diverse biotopes (sources, emissaries of sources, rivers) and at all altitudes (El Alami & Dakii 1998). This species has a very wide distribution latitudinal covering Europe and countries around the Mediterranean. In Morocco, she is one of the most ubiquitous species and it presents a very wide horizontal distribution (El Alami 2002). She has been cited by (Boumaiza 1995) of Tunisia and Algeria by (Thomas 1989). Our sampling says this preference. *Baetis rhodani* swarms in the 3 sources with the highest abundance at Ain Regrag with maximum of 30 individuals collected in may 2013, this resurgence of average mountain (1150 m above sea level seems to be the ideal habitat for this species (Fig. 6).

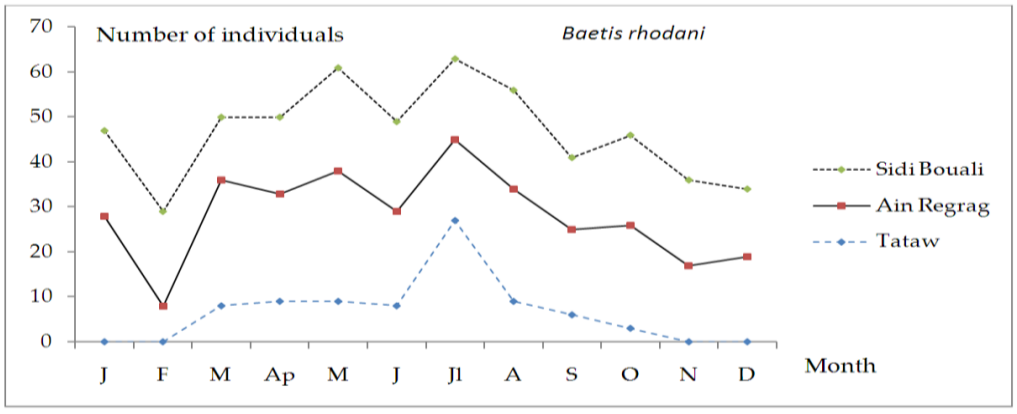

Fig. 6. Temporal evolution of *Baetis rhodani.*

Baetis pavidus

Originally described in a province of Italy (Emilia) grown in 1951, its geographical distribution part of the Iberian Peninsula and the South of France to the North of Africa, (Bauernfeind & Soldan, 2012). The larvae are thermophilic and reophiles (Jacob 2003). In the North of Africa it has been identified in the great river semi arid (Highlands) tolerating moderate pollution (Soldan & thomas 1983). A less wide than that of *Baetisrhodani* breakdown in this taxon. He deserted the staion Tataw, probably because of the freshness of its water 10°C (Fig. 7).

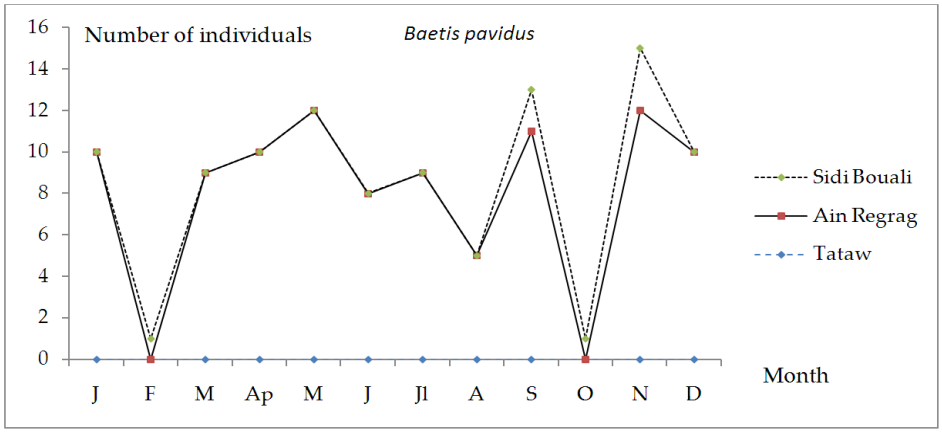

Fig. 7. Temporal evolution of *Baetis pavidus*.

Cloëon sp.

It was harvested in the two Ain Regrag and Sidi Bouali stations with very low densities (Fig. 8) while, generally, it people calm biotopes of the rivers and sources (El Alami and Dakki, 1998).

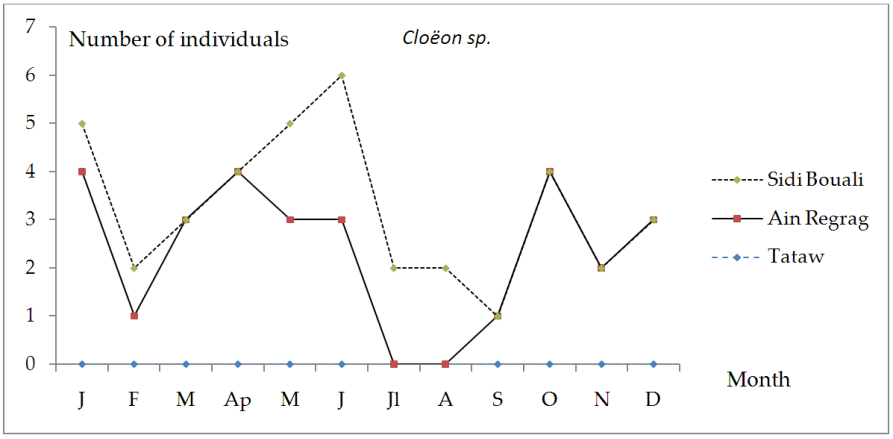

Fig. 8. Temporal evolution of *Cloeon* sp.

Procloeon sp.

To the Morocco, up to now, all the quotes from the Procloeon did not exceed the generic level. The first citation of this kind in the Morocco covers a female imago from Tetouan and Navas (1922) closer to *Procloeon concinnum* (El Alami 2000). It is very rare in our crops and this discontinuous distribution, particularly temperate and warm waters (El Alami and Dakii, 1998), the harvested maximum is 5 individuals at Ain Regrag in January 2013 (Fig. 9).

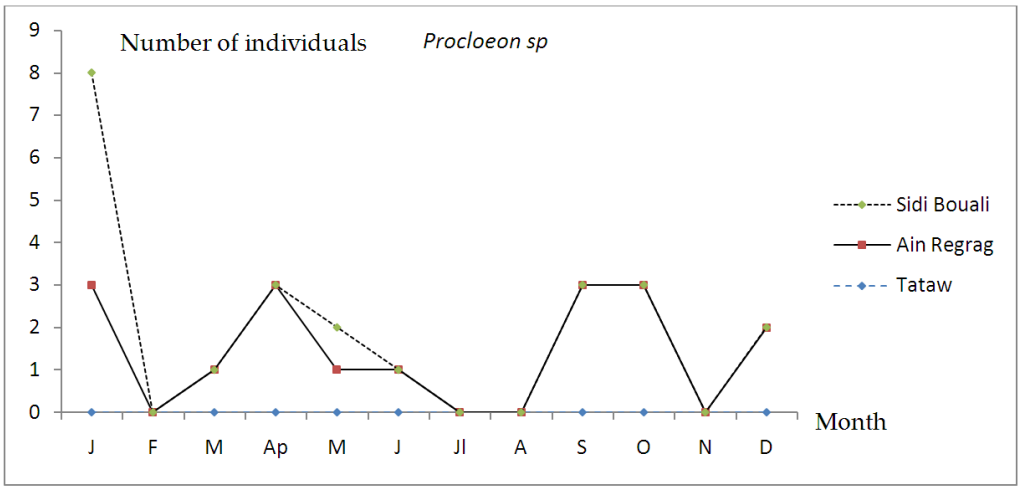

Fig. 9. Temporal evolution of *Procloeon* sp.

Potamanthus sp.

It's Sidi Bouali and Tataw two populations of *Pothamanthus* sp. were able to be located with the presence of larvae near the emergence... To Morocco Potamanthus has been inventoried in the course of the Wadi Khoumane Southeast crossing to the West of the town of Moulay Idriss Zerhoun (Ben Moussa *et al.* 2014), it has been identified in the basin of the Laou (Adam & Dakki, 1998). This species does not appear on the red list but is regarded as potentially threatened its abundance is average it records its maximum at Tataw with trapping of 14 individuals per harvest (Fig. 10).

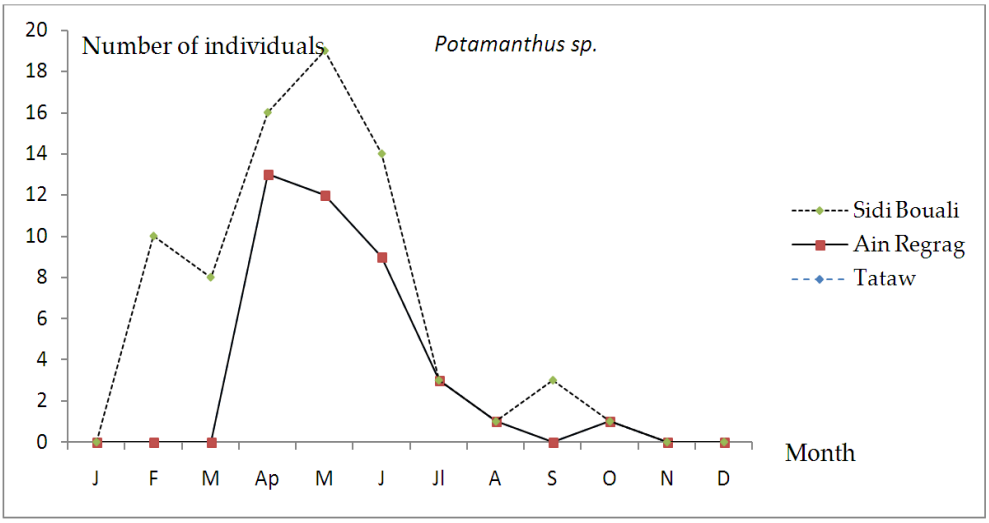

Fig. 10. Temporal evolution of *Potamanthus* sp.

Caenis pusilla

In their research on the mayflies of the Morocco (El Alami & Dakki, 1997) cited that this species inhabits the stations permanent and temporary; Nevertheless, she seems to be less tolerant to thermal variations than *C. luctuosa* (winner & Thomas, 1988) and adapts better to the fast flowing. This species was found in the three emergences, but it has a higher abundance in source Sidi Bouali, however, people harvested during the 12 months of sampling are still down nine individuals by picking which means a low abundance (Fig. 11)

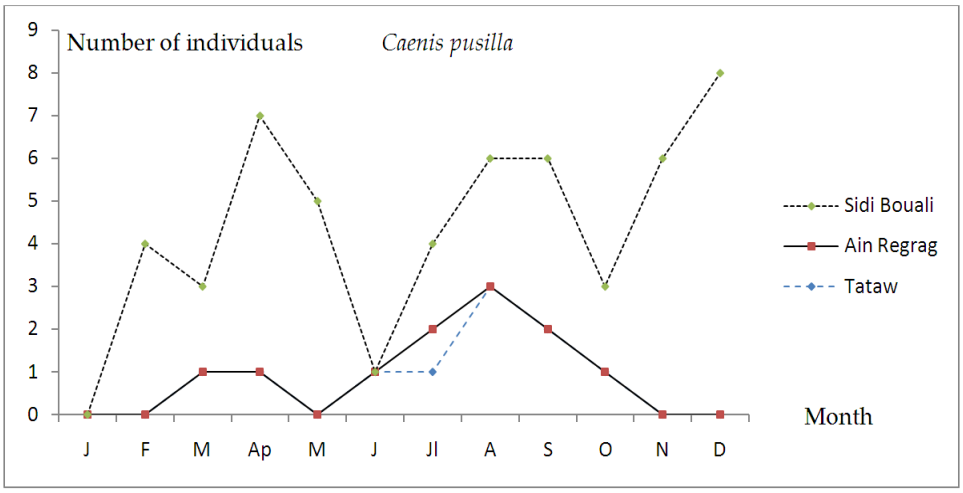

Fig. 11. Time evolution of *Caenis pusilla*.

Caenis luctuosa

Eurytope and eurytherme, in Ain Regrag, Sidi Bouali and Tataw, this taxon swarms as in other Moroccan networks (Dakki & El Agbani, 1983), Tunisians (Boumaiza & Thomas, 1986) and Algerians (winner & Thomas, 1988) in the mineralized waters of the middle and lower classes (El Alami & Dakki, 1998). Despite its intermittently in the source Tataw known by the phenomenon of flooding, its abundance in the host communities ranks in the range "average abundance" given the average numbers harvested by picking oscillate around 14 individuals per sample (Fig. 12).

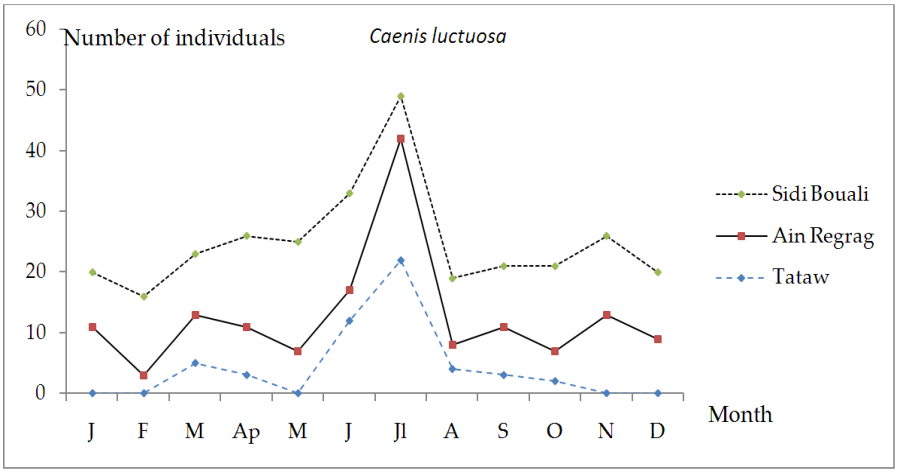

Fig. 12. Temporal evolution of *Caenis luctuosa*.

Brachycercus sp.

In his exhaustive review on the family of caenidae, (Berner & Pescador, 1988) pupalqualit Brachycercus from the rest of the family, certainly because of its characteristics of the stadium. Such holartique, Neotropical and lies mainly in the North of Africa, its first citation in Africa in 1978 by Dakki (1979). In the river Guigou in the Middle Atlas. This species was found in a single station (Ain Regrag), characterized by a background rich in aquatic plants, with a very intermittent presence, in an abundance more than not 6 individuals by levy as the maximum recorded in August, Rocky, *Brachycercus* sp. nevertheless remains a very occasional species (Fig. 13).

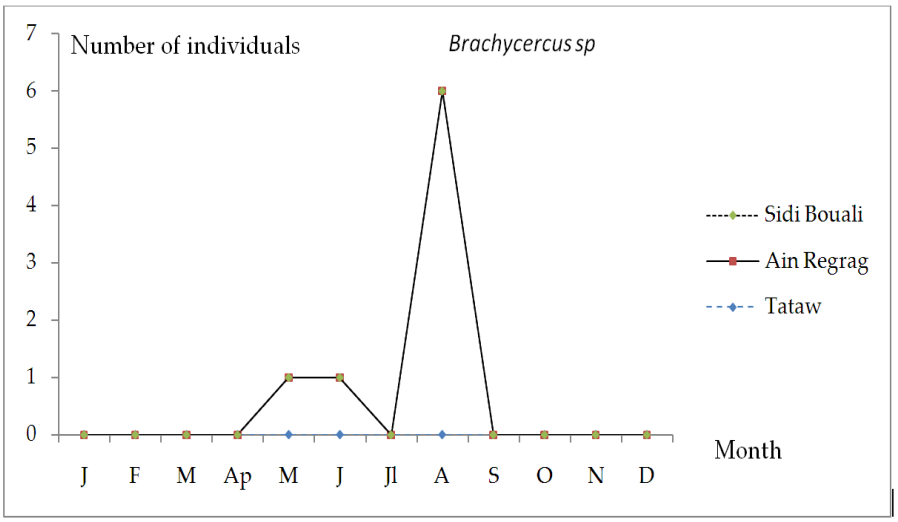

Fig. 13. Temporal evolution of *Brachycercus* sp.

Ecdyonorus ifranensis

Deriving from the name Ifrane city in Middle Atlas (Morocco), *Ecdyonorus ifranensis* is a species strongly pigmented and mixed in the larval State. The *Ecdyonurus* larvae are characteristic clean, well-oxygenated water and this is indeed the case of source Sidi Bouali, the source the best preserved of anthropogenic activities, a State of Affairs confirmed by physicochemical analyses sucites. This species found refuge in this source with an average abundance of 10, 6 individuals per sample. It is of lower numbers in Ain Regrag, then she disappears completely from the source Tataw (Fig. 14).

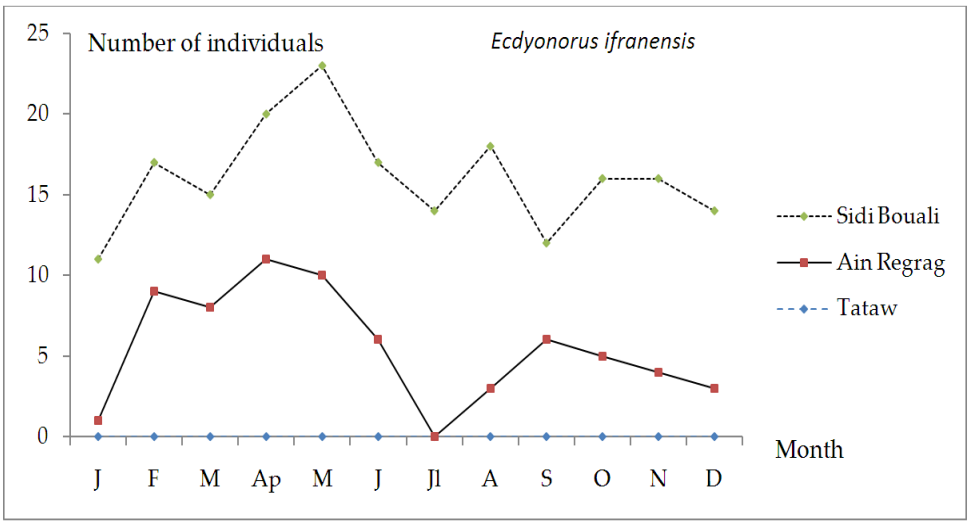

Fig. 14. Temporal evolution of *Ecdyonorus ifranensis.*

Heptagenia sp.

Less alticole, she chose the two sources of average mountain as favorite biotope, she don't confine the Tataw source at high altitude and temperature fresh, choice reasons could be multiple (altitude, temperature, vegetation cover).

It should also be noted that his presence in Ain Regrag is episodic, it, the result of random, or sampling are other biotic and abiotic environmental factors which are responsible for? Only a thorough study of the ecology of this species could answer this question (Fig. 15).

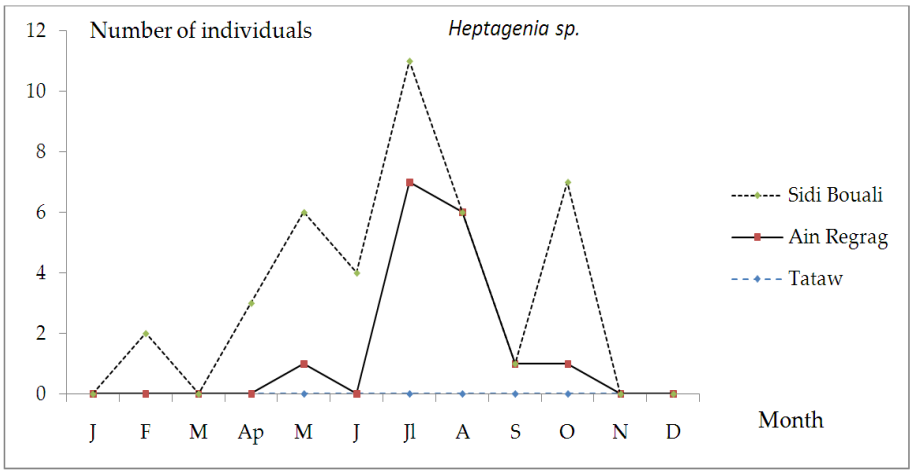

Fig. 15. Temporal evolution of *Heptagenia* sp.

Conclusion

These results of samples we can draw the following conclusions:

• We note the presence of 11 species are all common to the Middle Atlas

• Phenology of the species depend on several abiotic factors of the environment (Temperature, electrical conductivity, dissolved oxygen, organic matter, speed of the current...):

• *Baetis rhodani* is more dominant and the most prolific of all the collected specimens

The study revealed the presence of a relatively rich and diversified fauna, and should be followed by work on the distribution of larvae and their biomass as well as their life cycle.

Acknowledgements

We thank Professor Majida El Alami of the laboratory of ecology of the Faculty of science Abdelmalek Essadii Tetouan Morocco, she did enjoy his knowledge with a very open mind.

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