ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Phenological study of the crustaceans and molluscs from three major sources of the Middle Atlas (Morocco).

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ABSTRACT

The Moroccan Middle Atlas is not only the water tower of the Morocco by excellence, is also the paradise of Moroccan faunisticendemism, its sources host a rich fauna is diverse. The present work is the first of its kind dealing with the phenolic study of two orders of the benthic macrofauna (crustaceans and molluscs) colonizing three major sources of the Middle Atlas (AinRegrag, SidiBouali and Tataw).The counting of the results of sampling reported 19260 collected individuals are crustaceans that dominate with 71% and it is this group that has a clear dependence of seasonality and more particularly the Amphipod *Gammarusmarmouchensis*. For what is gastropods, while it is true that there is a declining enrolment in summer, can't do however come forward to a dependence on the season factor. Also need - it report the detection of the kind *Pseudamnicola*sp and *Horatia* sp. for the first time to the Middle Atlas.
Keywords: Gasteropds, crustaceans, phenology, sources, Middle Atlas.

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ISSN: 0975-8585

INTRODUCTION

Considering the geographical position and the geological structure of mountains of the Middle Atlas (Morocco),several sources of fresh water, normal and high volume take birth. These ecosystems often considered State of the references are ideal habitats for a rich and diverse fauna. A high level of endemism and a diverse mixture of Iberian Peninsula, Northern parts of Africa (Palaearctic) and Paleotropical elements are characteristic of the Middle Atlas freshwater fauna [1-2-3-4]. These benthic communities integrate various sources of disturbance, as well natural that anthropogenic and respond by changes in their structure parameters, such as the number of species and abundance for example [5-6]. As a result, their monthly variability study turns a great necessity and will serve to link the qualitative and quantitative variations observed with environmental conditions. Apart from some hydro biological investigations based on the study of aquatic invertebrates of the sources of the Middle atlas [7, 8] which had served as the basis for studies on other lotic systems, no work has treated the phenological aspect of the ecology of these wildlife groups, yet the phenology is not only a marker of climate, but also a key element of adaptation of human beings living to environmental changes. The present study has for objectives to review the monthly variability of crustaceans and molluscs; two important groups of the limnetic macrofauna in three of the biggest sources of the Middle Atlas (AinRegrag, SidiBouali and Tataw). In addition, to the assessment of the life cycle of these groups. These surveys will also document the evolution of biodiversity in this crenal system and can thus contribute to implementing highlight, yet unimagined noise and a quick implementation of the corrective measures.

MATERIAL AND METHODS

Study sites

This sample of stations includes a wide variety of biotopes of the crenal. Thus, the range of temperatures of the waters is between 8.7°C and 19°C. They are located at different altitudes, different bioclimatic floor, different types of substrates and different socioeconomic settings and offer a variety of biotopes and seem so well reflect the diversity of the habitats of the crenal in this massif (table 1).

Table 1: Abiotic parameters of the three stations of studies

Bioticparameters	Ain Regrag	Sidi Bouali	Tataw
Altitude (m)	1060	1100	1720
Annualprecipitations (mm)	750,7	750,7	429,17
Thermal gap (M-m)	43.1	43.1	31.6
Flow (l/s)	305	271	430
The current speed (cm/s)	111	48	76.3
Flow type	Veryfast	Medium	fast
Dominant vegetationcover	Reed, Lily and hornwort	Algae, pteridophytes	Pteridophytes, spermaphytes
Transparency of the water	High	High	Lowduring the floods
Granulometric composition	Sand (10%) Gravel (20%) Pebble (50%) Block (20%)	Sand (15%) Gravel (35%) Pebble (40%) Block (10%)	Silt and argile(5%) Sand (5%) Gravel (20%) Pebble (40%) Block (30%)

Source Tataw of ImouzzerMarmoucha (T):

Located in the eastern part of the Middle Atlas, ImmouzerMarmoucha is a hinge between the Middle Atlas and the Eastern Morocco (figure 1). The region is characterized by the outcrop of limestones and of dolomites of the Jurassic allowing the storage of underground water, where from flow the emergences of Tataw. The massive presence of the inhabitants of local communities, livestock, pumping, diversions and measures to capture at the level of the source, are risks that threaten the quality of its waters by

compromising its various uses and thus reduce the chances of a socio-economic progress of the region. Independently already of climate change.

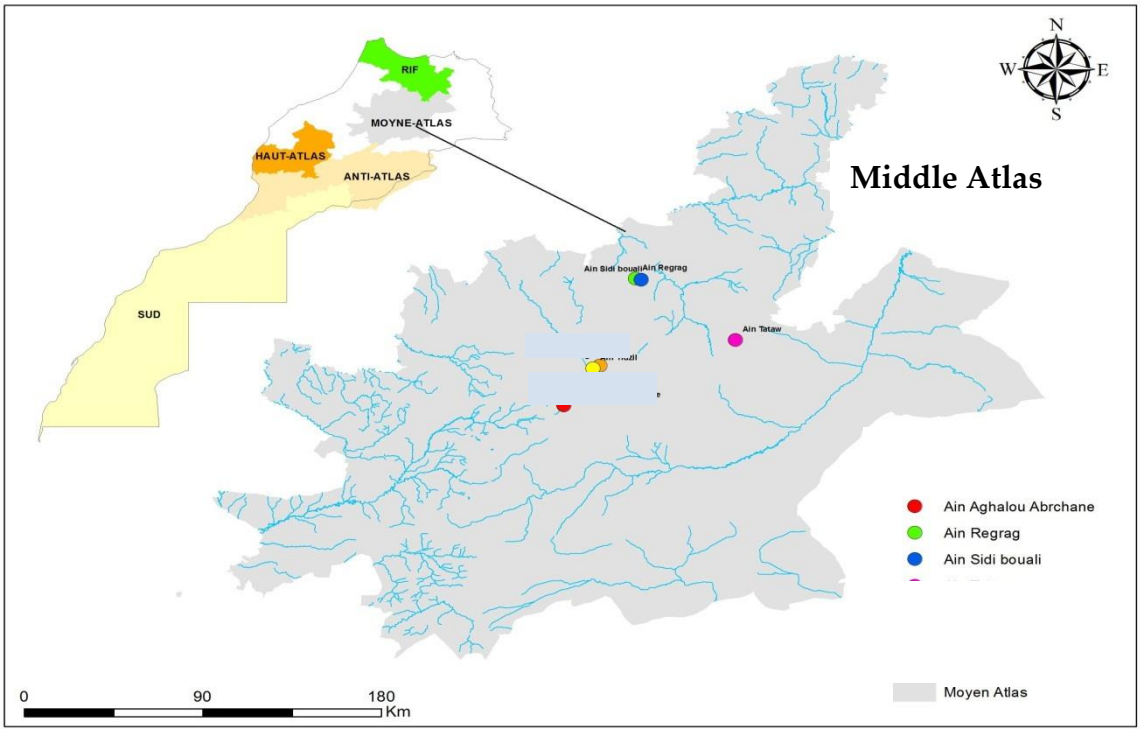
Source Regrag (AR)

AinRegrag is part of the hydrogeological unit of the CausseMidlleAtlasic. AinRegrag is not just a water resource, but also a real resort with its Lake and its flat banks covered by a shaved vegetation which makes a particular type of source of fresh water in North African Mountain. AinRegarg is currently undergoing the effects of anthropogenic pressure accentuated. Several boreholes are set up and draw in the waters of the groundwater, an arboriculture full swing is that risk by runoff affects the physicochemical quality of the water underground. The source also, is the most coveted tourist resort by residents, which would involve organic pollution that may be threatening.

Source SidiBouali (SB):

Located in the middle of an olive grove, at 18 km from the town of Sefrou, the main source and its resurgence are completely natural, like in AinRegrag, SidiBouali source is located within liasic through its spiritual value, and until the last years touches the source didn't was not plundered by the anthropogenic activity.The neighbouring population sought rather to preserve. AinSidiBouali is not better than the other two previous sources, this resurgence of spiritual value also ancient history of the region, is subject to the same constraints, perhaps not with the same magnitude but in a perspective of sustainable development, the risks of a possible deterioration of the quality of its waters are indeed present.

Figure 1: Location of the three stations of studies



Sampling of the macro invertebrate benthic

Schedule of sampling

We conducted monthly samplings from the month of January 2013 until December 2013.

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Method of sampling

For a general sampling, we opted for a net surber to a width of mesh of 400µm. In order to collect, the maximum of Macro invertebrates colonizing the site, we should spend 30-45 minutes on the rocky beaches to return stones and search for invertebrates. The collected samples are fixed in formalin at 40%, and then stored in water from the source to 10%. The sorting of samples is done using the loupe. Zoological groups are separated in the pill boxes containing 70% alcohol. The species in each group are sorted, identified, counted, and classified among functional feeding groups according to [9].

In addition to these biological surveys, samples of water samples for bacteriological and physicochemical analyses was made during the year of study in the same sampling places to have precisely the evolution of these parameters in local time and control their synchronism with the benthic communities of sources.

RESULTS AND DISCUSSION

Inventory of the benthic macrofauna

Established wildlife inventory, includes the distribution of stands in the different sampling stations (table 2), revealing the number of each species in each source during the twelve months of sampling.

Overall wildlife harvests, a total of 19260 individuals belonging to 13 species have been collected in the three stations of study during 12 months of sampling (table 2) including a new species for science of the kind *Horatia* sp. belonging to the class of gastropods. Saw that we had not yet the results of the molecular identification of the individuals in this group all the species will be designated in the manuscript under the name of *Horatia*sp., the species will be described and will be the subject of a publication.

The crusatceans are in the majority on all sites, (Figure 2).

Table 2: Inventory fauna of the three study sites

	Station	J	F	M	Ap	M	J	JL	A	S	O	N	D
Gammarusmarmouchensis	AR	0	0	0	0	0	0	0	0	0	0	0	0
	SB	0	0	0	0	0	0	0	0	0	0	0	0
	T	319	371	564	686	635	742	670	589	486	540	437	306
Gammarusmarocanus	AR	65	73	61	89	83	99	145	204	105	111	98	86
	SB	6	12	18	15	28	95	131	81	135	44	39	28
	T	0	0	0	0	0	0	0	0	0	0	0	0
Gammarusrouxii	AR	75	27	39	41	32	48	64	179	56	38	24	29
	SB	115	104	160	213	541	234	570	474	308	137	131	108
	T	0	0	0	0	0	0	0	0	0	0	0	0
Gammarussp	AR	58	52	55	71	79	70	112	183	97	92	60	73
	SB	9	3	12	11	**20**	93	101	113	109	47	24	15
	T	0	0	0	0	0	0	0	0	0	0	0	0
Potamon fluviatile	AR	4	2	5	6	**2**	**3**	3	2	2	3	4	5
	SB	6	10	5	6	**6**	**4**	3	5	5	6	7	4
	T	0	0	0	0	0	0	0	0	0	0	0	0
Cypridinasp	AR	2	3	3	9	**6**	**5**	3	4	3	3	1	0

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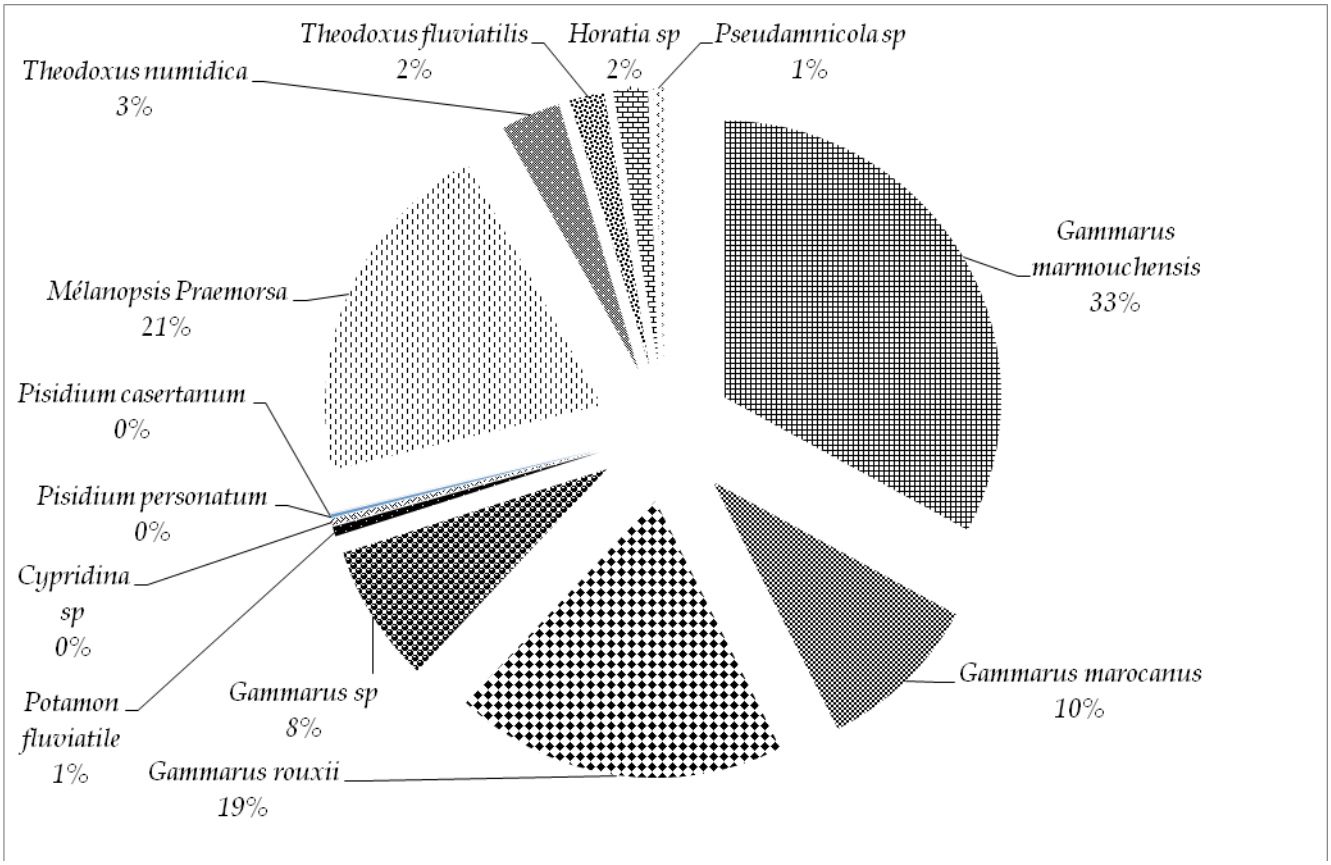
	SB	1	8	2	3	**2**	**4**	3	4	2	1	0	1
	T	0	0	0	0	0	0	0	0	0	0	0	0
Pisidiumpersonatum	AR	1	2	2	2	**6**	**1**	1	0	9	3	0	3
	SB	3	0	0	0	**0**	**0**	0	2	0	0	0	0
	T	0	0	0	0	**0**	**0**	0	0	0	0	0	0
Pisidiumcasertanum	AR	0	0	0	1	0	0	0	0	0	0	1	1
	SB	0	0	0	0	0	0	0	0	0	0	0	0
	T	0	0	0	0	0	0	0	0	0	0	0	0
MélanopsisPraemorsa	AR	0	1	0	0	0	0	0	0	1	0	0	0
	SB	214	189	258	305	**139**	**163**	**175**	**158**	**230**	**244**	**230**	171
	T	199	245	223	230	**183**	**86**	**10**	44	72	79	42	85
Theodoxusnumidica	AR	42	25	38	34	**27**	**12**	**9**	**13**	**51**	**48**	**37**	29
	SB	19	49	44	59	**32**	**28**	**15**	**7**	**12**	**20**	**9**	11
	T	0	0	0	0	**0**	**0**	**0**	**0**	0	0	0	0
Theodoxusfluviatilis	AR	81	19	26	18	**18**	**10**	**7**	**9**	**43**	**72**	**55**	31
	SB	0	0	0	0	0	**1**	**0**	**3**	**0**	**0**	**0**	**0**
	T	0	0	0	0	**0**	**0**	**0**	**0**	0	0	0	0
Horatiasp	AR	15	3	3	19	**19**	**4**	**0**	**10**	**7**	**2**	**16**	5
	SB	14	1	1	1	**57**	**10**	**10**	**18**	**80**	**63**	**22**	5
	T	0	0	0	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Pseudamnicolasp	AR	3	1	0	0	**0**	**4**	**1**	**5**	**7**	**2**	**1**	0
	SB	11	6	9	5	**4**	**7**	**3**	**8**	**11**	**9**	**7**	6
	T	0	0	0	0	0	0	0	0	0	0	0	0

Figure 2: Relative abundance of different taxa collected



ISSN: 0975-8585

Phenological study of the benthic fauna

Mollusc gastropods
Mélanopsispraemorsa

It is a freshwater gastropod that has a distribution mainly Mediterranean [10], to the Morocco it was inventoried at the level of the khattaras of the field of application of water used in the city of Marrakech [11]. This Prosobranchemollusc, which confined in sizeable density AinRegrag and SidiBouali sources is completely absent in the emergence of Tataw this is probably related to the abiotic environmental conditions. Reproduction in *M. praemorsa* is continuous, the populations of this species are several generations successive and overlapping, with maximum recorded during the early spring and autumn (Figure 3). In the studied malacocenoses, *M. praemorsa* is the most abundant mollusk from the Pulmonates and other Prosobranches species.

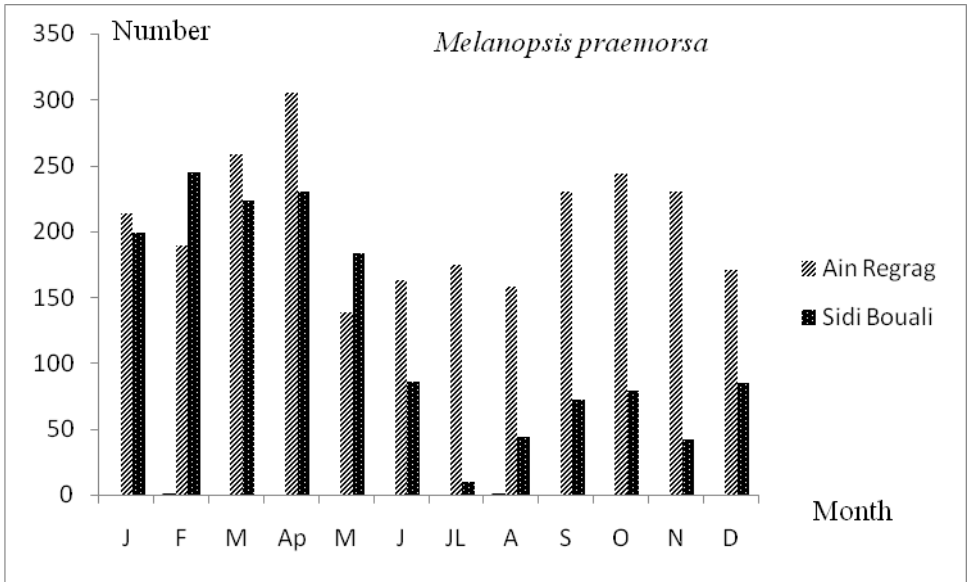


Figure 3: Temporal evolution of *Mélanopsispraemorsa*

Theodoxusnumidica

Its usual habitat lies in running waters and sources [12]. The annual change in the abundance of this species shows several peaks, with the most important are in the month of April 2013 and October 2013 to AinRegrag and the months of September and March 2013 inSidiBouali. For both sources noted the pace of evolution of this gastropod mollusc. It should also be noted that no individual was found in the Source Tataw of ImouzerMarmoucha**(Figure 4**).

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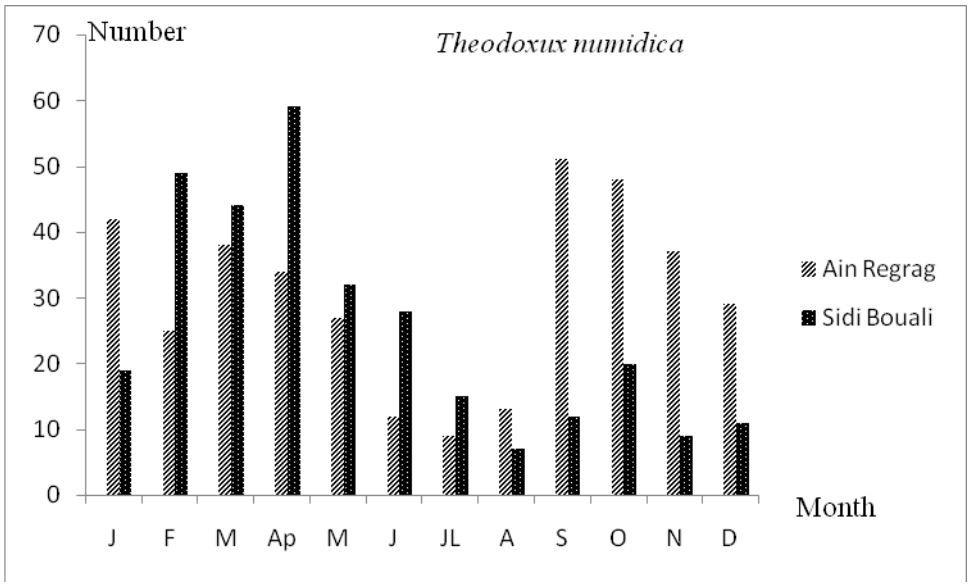

Figure 4: Temporal evolution of *Theodoxusnumidica*.

Theodoxusfluviatilis

Theodoxusfluviatilis or the river neriteisconsists of severalsubspecies. Linnaeus (1758) describes the origin of *Theodoxusfluviatilis* as twospecies for the Balticregion; Neritafluviatilisis a species of fresh water and a case of water brackishNeritalittoralis. Scientific opinion isnowthatthis are not separatespecies but are in fact two different subspecies of the species*Theodoxusfluviatilis*. Theodoxuskindfiled by [13]

This gastropodmolluscreflecting major similarities with *T. numidica* except allure Zebra, isalmost absent of SB AR enjoy a fairly large population of thisspecieswithtwoannualpeaks, the first is in January 2013 the second is in the month of October 2013 (**Figure 5**).

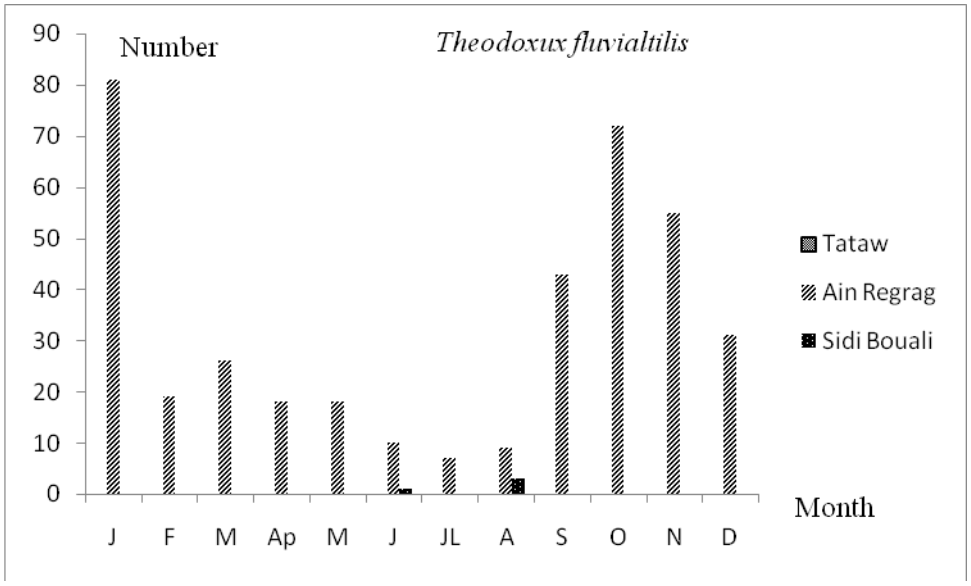

Figure 5: Temporal evolution of *Theodoxusfluviatilis*

***Horatia* sp.**

This new specimen which finds its origins in the South-West of Europe, more exactly the Iberian Peninsula [14] is reported for the first time to the Morocco in AinRegrag and SidiBouali, sources in expectation

of the molecular identification, a specific name will be assigned. A sizable population was recorded in AR is especially in May and October 2013. The SB source is also a home of this species, but with less significant than AinRegrag numbers. Like other gastropods molluscsTataw station is not the ideal refuge for *Horatia* sp. because she did not pay home (**Figure 6**).

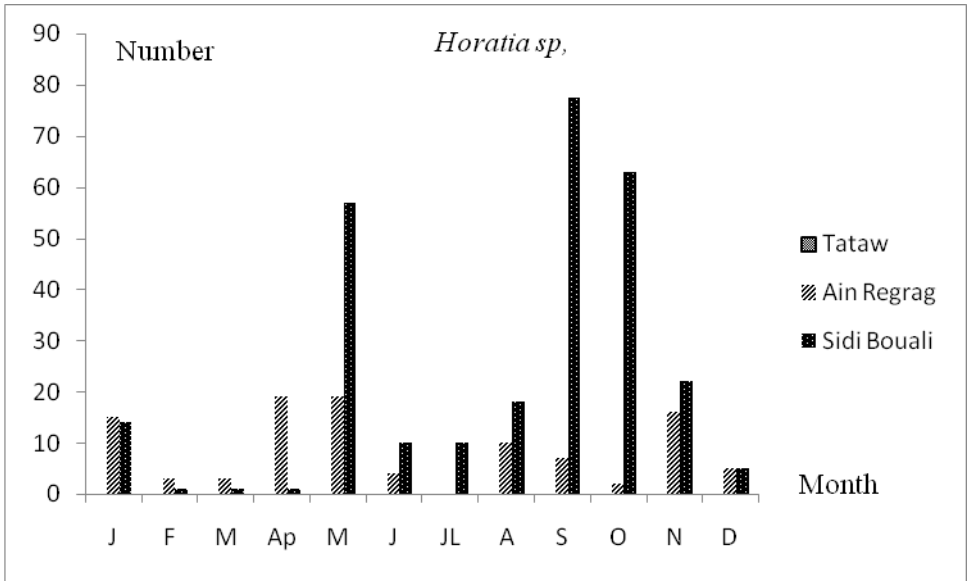

Figure 6: Temporal evolution of *Horatia*sp.

***Pseudamnicola*sp.**

Hydrobiidae is one of the largest families of freshwater gastropods comprised of approximately 400 genera and 1000 species. Despite this high level of diversity, most hydrobiid species inhabit fragile ecosystems in restricted distribution areas.The freshwater genus *Pseudamnicola* Paulucci, 1878, among the most cumbersome in terms of taxonomy, is one of the largest and most diverse groups of Hydrobiidae [15] with around 85 nominal species [16- 17-18-19-20].

Most hydrobiids species are restricted to a small number of localities and/or fragile ecosystems (e.g., springs, streams and ponds), which are largely endangered due to human activities or water shortages. *Pseudamnicola* sp. are known to be extant and exclusively restricted to wells .

This kind for the first time described in the source of the Moroccan Middle Atlas adopts a similar population dynamics has one like *Horatia*sp. also belonging to the family of the hydrobiidae, even if the number of staff is more significantly lower (Figure 7). Then we notice that he favors source sidiBouali as living as AinRegrag environment, while he deserted the Tataw source, it's a kind known by its sentinel appearance [14] and the SidiBouali station is the most protected anthropogenic pollution beyond a State of art confirmed by microbiological and physicochemical analysis performed on the site [21, 22], the highest numbers mark the winter period (Figure 7)

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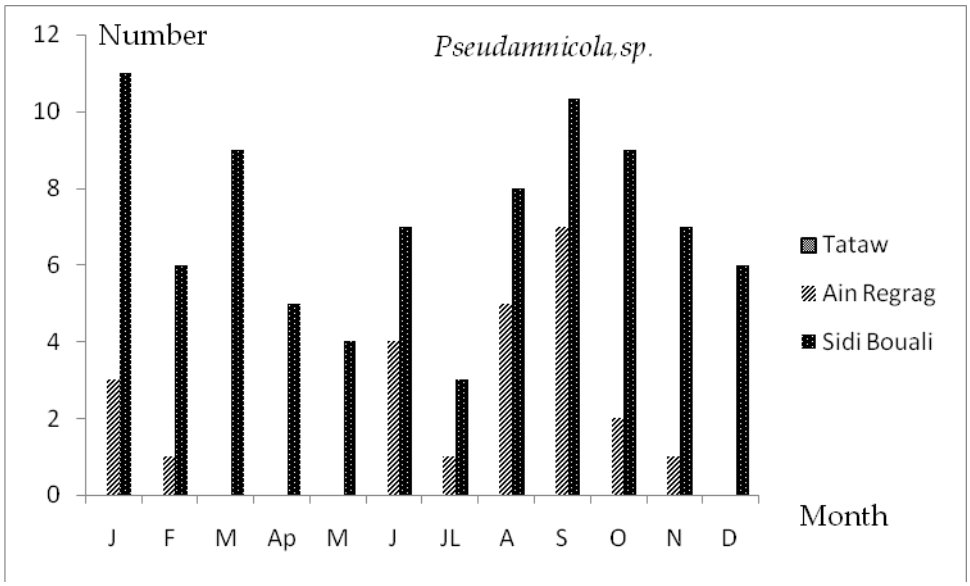

Figure 7: Temporal evolution of *pseudamnicolasp,*

Bivalve mollusc

Pisidiumpersonatum

Its type locality is Qvillebacken near Hofas in Sweden [23]. This small bivalve mollusc in the order of 3 to 4 mm in diameter was reported in small numbers to Tataw and even less to AinRegrag. We cannot speak of a sizable population that the collected maximum is 10 individuals to August 2013 and 6 others in the month of April 2013 in the T station, whereas AR we don't have collected only 3 specimens in January 2013 and 2 others in July 2013 (**Figure 8**).

The why of this spatial disparity would be that, according to the literature, the vegetation, the nature of the substrate, calcium content and the speed of the flow of water contribute significantly in the distribution and the proliferation of molluscs in inland waters [9-24-25].

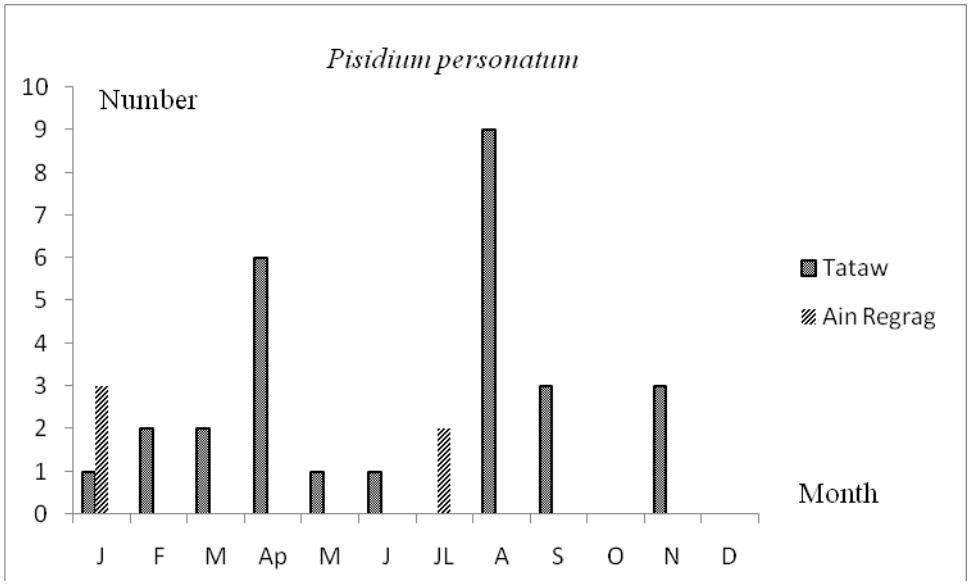

Figure 8: Temporal evolution of *Pisidiumpersonatum*

Pisidiumcasertanum

This taxon is the most common species of the genus Pisidium and is truly cosmopolitan, distributed all over the world [26 -27]. Its populations are reported in habitats, ranging from the ephemeral ponds to Lakes [27-28], *Pisidiumcasertanum*is an excellent taxon to study the Adaptive reproductive biology and is commonly used as a biological indicator Arctic [29].

This species to slightly puffy rounded shell of the order of 3 mm in diameter, has been collected that has three Tataw recovery with an individual at each sampling, so we can discuss an annual population in this case due to lack of data digital evolution of this specimen (**Figure 9**).

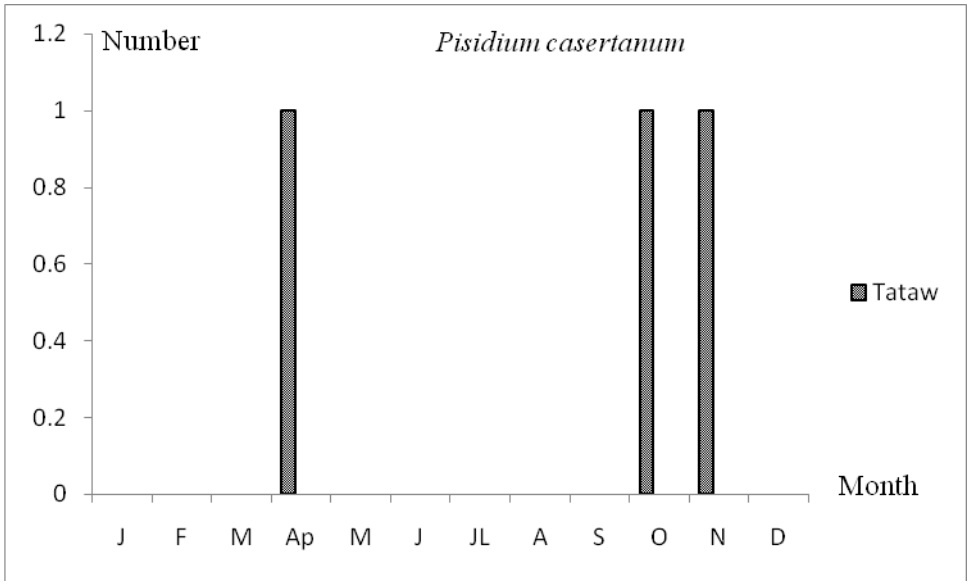

Figure 9: Temporal evolution of *Pisidiumcasertanum*

Crustaceans

Gammarusmarmouchensis

Discovered for the first time in 2006 in the source Tataw to ImmouzerMarmoucha[8], freshwater shrimp to the brownish colour, found nowhere else in Morocco, chose the Tataw source as a unique refuge for live and reproduce, this ecological characteristic makes G.marmouchensis a rare and vulnerable endemic species. This species has many affinities with the species *Gammarusacalceolatus*Queensday, 1971 of AguelmaneSidi Ali (Middle Atlas, Morocco) to the very large populations with maximas that peak 800 individuals collected in July 2013 (Figure 10), its reproductive cycle as well as its population dynamics have duly explained by literature [8 -21].

Gammarusmaroccanus

Described for the first time by [3] is an endemic species which has been collected in a first time in the Bourkaiz source located 14 km west of the city of Fez, to 540 m of altitude and at the level of the WadiBourkaiz.(Middle Atlas, Morocco), Then in the falls of Sefrou 840 m above sea level (Middle Atlas, Morocco). The annual change in the abundance of this species varies during the year for the two emergences SB and AR. Thus, observed that harvested individuals peaks lie in the month of August 2013 to AR and in July and September 2013 to SB. We also note that workforce quadrupling during the summer

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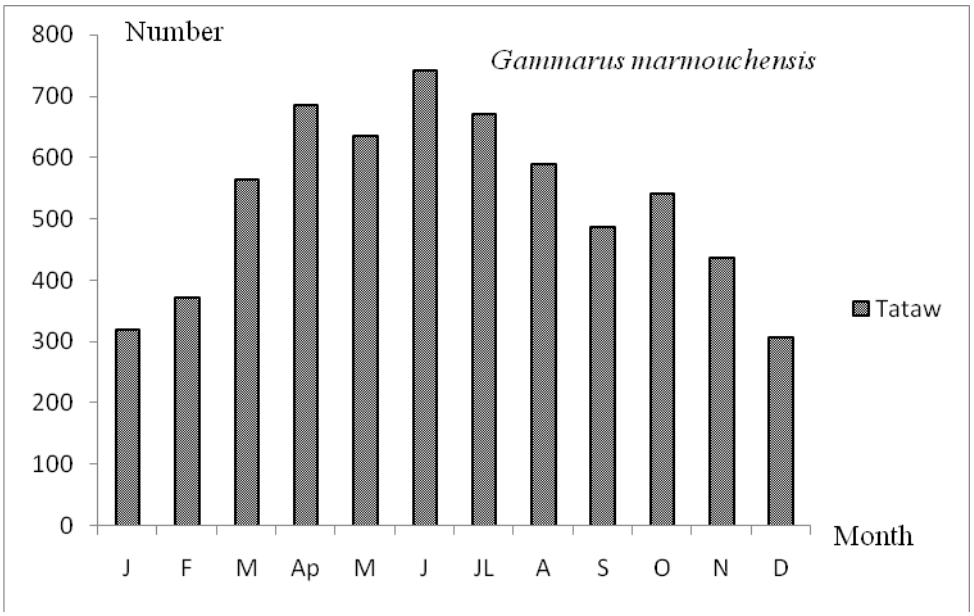

Figure 10: Temporal evolution of *Gammarusmarmouchensis*

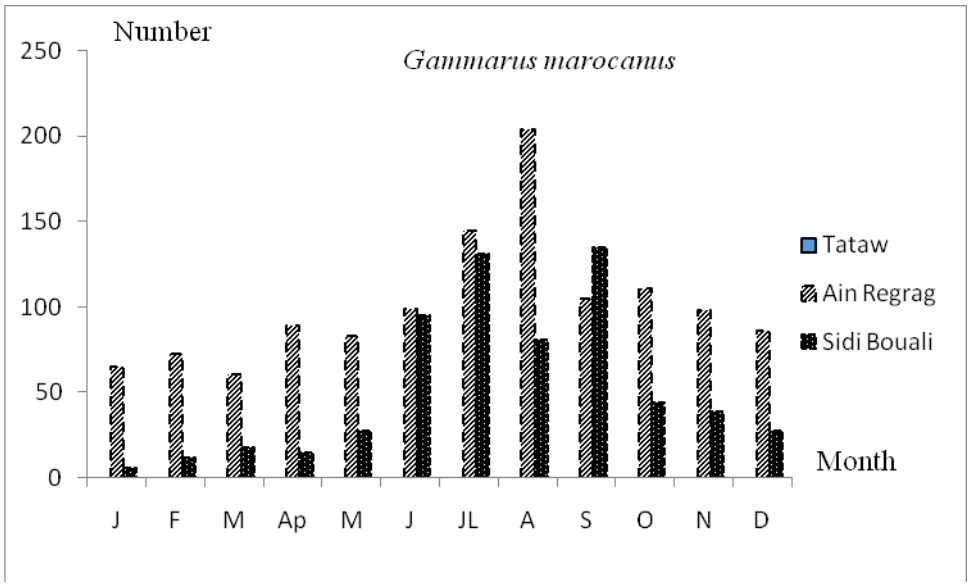

Figure 11: Temporal evolution of *Gammarusmarocanus*

Gammarusrouxii

Reported for the first time in the Morocco in a small water course through the city of ImmouzzerKander (Middle Atlas) at 1500 m [3], it was harvested in several sources from the Saïss plain in the vicinity of the city of Fez [30].She lives very often in the company of *G. gauthieri* and *G. maroccanus*[3]. This tiny Scuds in the order of 3-4 mm than at the beginning of the identifications believed that there home just in SidiBouali, revealed his presence in AinRegrag, but numbers much lower. In the resort of SidiBouali, attracts attention in its evolution annual it is especially this exponential increase since the beginning of spring until the end of the summer(100 individual in January 2013 to 600 specimen collected in July 2013), so that this number remains low throughout the year in the resurgence of AinRegrag put aside from a slight increase in the month of August 2013 (**Figure 12**).

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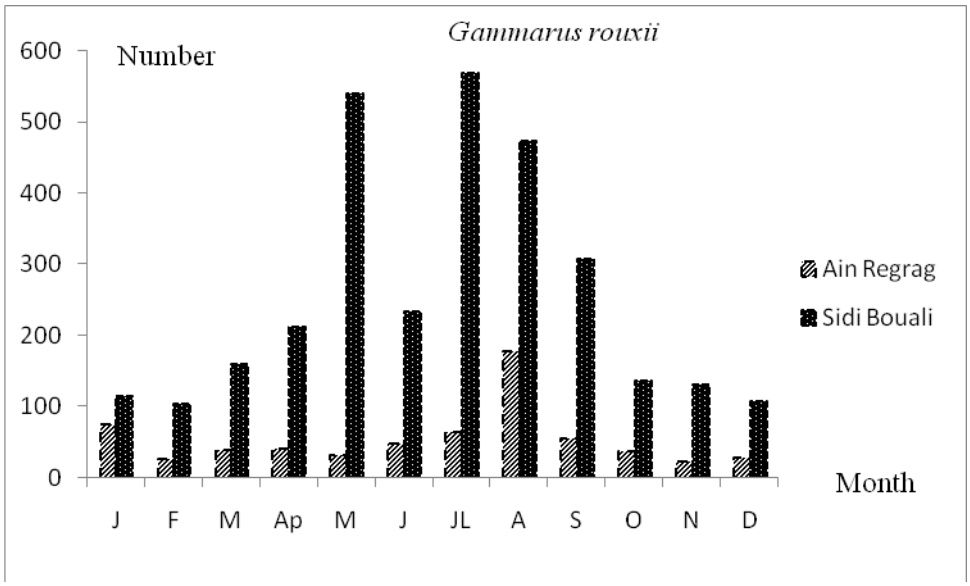

Figure 12: Temporal evolution of *Gammarusrouxii*

***Gammarus* sp.**

Species inventoried for the first time by [30] in the waterfalls of Sefrou has an altitude of 840 m, we found her in AinRegrag and SidiBouali, reporting sources new species, is to analyze the molecular identification results. This population of *Gammarus sp*., staff approaching those of *Gammarusmarocanus* and having the same temporal profile as this, records his digital pic to August 2013 with a staff of 183 individuals. SidiBouali, this species in very low numbers since the end of autumn to the end of the spring, will be subject to a fairly significant increase since the month of May to the month of October with a maximum in the month of August of 113 harvested specimens (**Figure 13).**

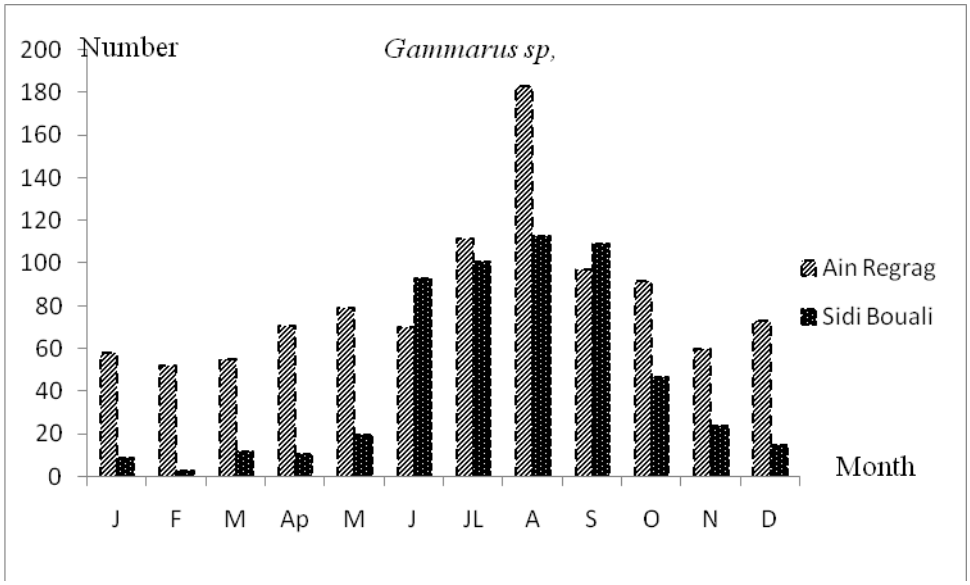

Figure 13: Temporal evolution of *Gammarus*sp.

Potamonfluviatile

This species of freshwater crab family Potamidae, also known as riverscrab, like the calm rivers, in plain and up average altitude, is the only characteristic of cancer of inland of the North African waters wildlife. However, no specific to this species ecological work was carried [31]. This essentially nocturnal species prefer

ISSN: 0975-8585

more or less calm water, as plain water on average altitude, under stones in the open water or on the edge, even in the dry river beds [31]. During our surveys, we noticed the presence of a population of individuals in different age groups. The maximas are recorded in AinSidiBouali in February 2013 (10 individuals) and in November (7 individuals), AinRegrag, the scenario is a little different with low numbers throughout the year, and a maximum recorded during the month of April 2013 collection however Tataw source is not a refuge for this species (**figure 14**), the reasons responsible for this absence would forefront abiotic parameters of the middle with all of their components.

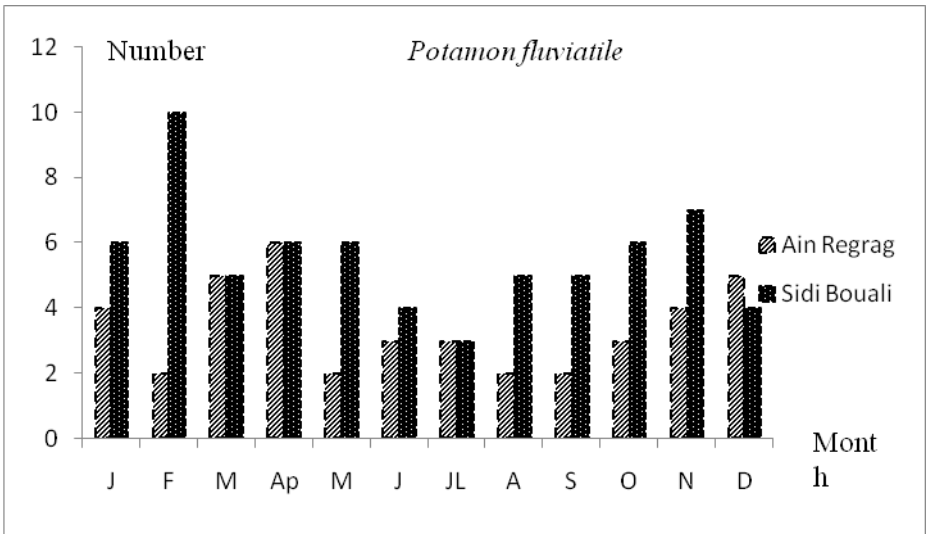

Figure 14: Temporal evolution of *Potamonfluviatile*

***Cypridina*sp.**

Invertebrates of small size usually less than 0.5 mm. Ostracods *Cypridinia* have played a major role in the studies of bioluminescence, a physiological faculty that allows them to withstand desiccation [32]. To the Morocco *Cypridina*sp. has been identified in the Bourgerg estuary in 1987 [33].

Figure 15 shows the seasonal variations that undergoes the community of this species in the different study stations. The first conclusion that can be draw is that this ostracode this year permanently in Ain Regrag and Sidi Bouali sources deserted station Tataw**.** The second remark is that its numbers are rising in winter and spring while they decline in summer and fall until total annihilation in Sidi Bouali in November and December in Ain Regrag. There are the highest in February 2013 in Sidi Bouali with 8 individuals collected during the harvest of the month of April 2013 at Ain Regrag by sampling 9 specimens (**Figure 15**).

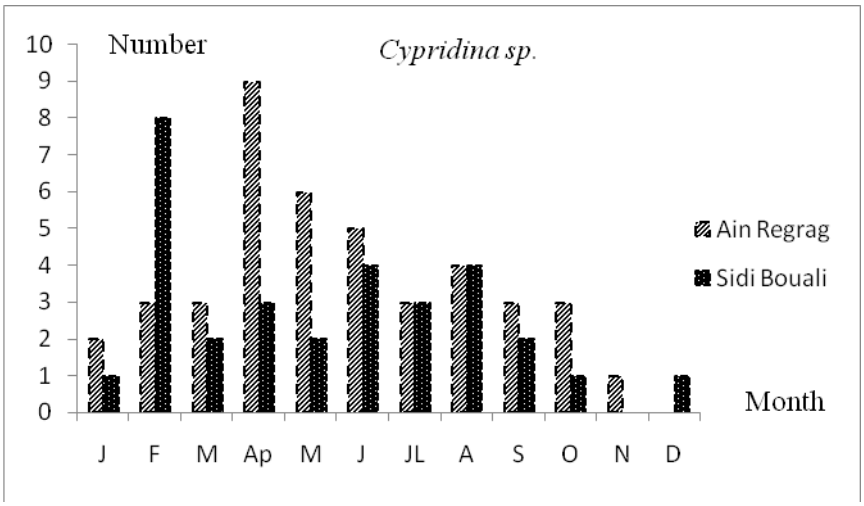

Figure 15: Temporal evolution of *Cypridina* sp.

ISSN: 0975-8585

CONCLUSION

It is not possible to decide only by means of temporal approach, the phenological behavior of species, several factors would come into games and the first would be the life cycle of each species, but through this study we were ableto estimate a mean phenological divergence between the two taxonomic groups studied (arthropod crustaceans and shellfish) is even within the same group, on this resign ourselves on three salient point:crustaceans are the most ubiquitous group they show a clear dependence with respect to the factor season, and more precisely the Amphipod *Gammarusmarmouchensis*, The mollusk *Pseudamnicloa* it also knows a decline in membership during this summer would be the originally holartique. The source Tataw who is prone to strong anthropogenic pressure host the smaller number of species that which confirms the pollution factor upset the phenology of the limnics populations that colonize the bottom of sources

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