International Journal of Research in BioSciences
Volume 11 Issue 1, pp. (1-8), January 2022
Available online at http://www.ijrbs.in
ISSN 2319-2844

Research Paper

Freshwater zooplankton behavior under temperature effects in a semi-arid Mediterranean area

Nadia Bouguenaya, Sara Lebid and Macho Anani*
GREENLAB. Djillali Liabes University. 22000. Sidi Bel Abbes. ALGERIA

(Received July 27, 2021, Accepted November 19, 2021)

Abstract

Four consecutive years study of the correlation between zooplankton of Sidi Mohammed Benali Lake two kilometers north of Sidi Bel Abbes northwestern Algeria in a pure Mediterranean climatic area and the temperature showed an inverse parabolic correspondence. Also, linear regression trend possesses a negative slope which symbolizes also an inverse proportionality. This study illustrated then that as the temperature remains below an annual average one, zooplankton quotas were quite substantial but once it grown above this frontier, which appears to be a significant barrier, these populations diminished and declined very quickly. Our results thus corroborate those found in the scientific literature and show, if needed, that freshwater zooplankton populations are also subject to temperature variations as marine zooplanktons do and that these variations are of the same kind and trend. Global warming could then be very disastrous to aquatic life and augurs a catastrophic scenario to the whole of the life's chain all over our planet.

Keywords: Zooplankton, Climatic Parameters, Mediterranean, Temperature, Sidi Mohammed Benali Lake.

Introduction

Dynamics of zooplankton of Lake Sidi Mohammed Benali near Sidi Bel Abbes northwestern Algeria on the Mediterranean coast showed a very rich biodiversity including Copepods, Cladocerans and Rotifers. Some less numbered Ostracods populations have also been reported but one did not consider them because their number was too of no consequence compared to the other three families already mentioned. One have thus discovered a whole rich and diverse fauna that has emerged conveyed by winds that brought a certain part of it and the supplying pipe which run a lot of species from the watershed hurtling highlands on one side and southern Dhaya Mountains on the other hand. To the north, some water infiltration can descend Tessala welling up in the mountains and emerging under the lake surface. Animal species that live there feed on phytoplankton or cannibalize themselves. Unfortunately, these species live in a very threatened habitat as climatic changes our planet suffered in recent years, show that global warming is a bad reality and unfortunately it is here to stay[1-9]. Also, some models have treated the possible evolutions of the climate and are all worsening the future[10-11]. It is really very interesting to investigate the way planktonic populations react with temperature and this study has been conducted in this order.

Materials and Methods

Location of the lake

Reported studies concerning the relation between planktonic populations and temperature show that this latter influence negatively the effective of these populations and that growing temperature is lethal for fauna. Nevertheless these studies were further concerning marine plankton rather than freshwater ones[12-20] even if some few works considered fluvial areas[21-22] and even lakes [23-26].

Figure 1: Sidi Bel Abbes, northwestern Algeria (NASA, 1999)

As shown in figure 1, located northwest of Algeria 56 km south from the Mediterranean Sea, Sidi Bel Abbes is a wide industrial city established in the core of an agricultural region with a strong cereals disposition. At an average elevation of 470 m and bordered to the north by the Tessala chain mountainous culminating around 1100 m at Jebel Attouche it is borded in the South by the Dhaya Sierra Mountains which rises over 1400 m. To the west the Sebaa Chioukh (or Seven Sages) mountains do poorly with their 710 m and east Beni Chougran reaches 900 m with difficulty.

Figure 2: Sidi Mohammed Benali lake's location (Google Earth, 2021)

Sidi Bel Abbes lies therefore at the bottom of the river valley of Wadi Mekerra and is for that reason often subject to heavy flooding of this unpredictable river. The region mainly receives its northwest rains due to polar flows that borrow the furrow above the Alboran Sea at the extreme south west of the Mediterranean basin. They extend from September to late May although some almost June are also quite humid. The really dry months are July and August. Nevertheless, these rains are not very important and some “humid” months are also very dry without a drop of rain[27].

Then, as shown in figure 2, Lake Sidi Mohamed Ben Ali or SMB Lake is located two kilometers north of the city ring road of Sidi-Bel-Abbes, covers an area of 40 hectares and possesses a water capacity that can exceed 3 million cubic meters. Depth of this lake reaches 25 to 30 meters. The Lake SMB Lambert coordinates are (X1 = 195.5, 220.7 = Y1) (X2 = 195.9, Y2 = 22.6). It is located in a basin whose edges have an altitude ranging from 481 m in the south to 456 m north. It is exposed to winds mainly from the northwest and lies on a natural brown limestone plain ground. This retention bowl corresponds to a flood accumulator from the Wadi Mekerra which overflows and floods its plain in autumn and sometimes by the end of winter acting principally as a clarifier of raw particles.

Climatology

Also, the lake is in south front of Tessala Mountains, which represent a watershed that feeds the lake North often during rainy periods. Then, the lake is located in the cool sub-humid Tellian Atlas climate. Average temperature of the coldest month is 4 ° C and reaches 30 ° C for the hottest one. This area is also characterized by cold and rainy winters. The lake receives, also, rainfalls between 350 and 450 mm per year (Lebid et al., 2015). It is also surrounded all around by a set of trees consisting mainly of Aleppo Pine, Cypress, Acacia, Poplar, Aspen, Ashe, Melea and Casuarina. Many released fish operations were carried out in the lake in order to enrich its biodiversity so they have contributed greatly to affect plankton populations living there.

Sampling method

From 2015 to 2018, a study has been conducted in order to determinate zooplankton populations numbering by sampling method. Primary objective of sampling is to build a sample arranged in such a way that observations may be generalized to the entire considered population without much significant loss of meaning or precision. For this purpose, there is currently the probabilistic method that involves the collection of any sample by random selection in the parent population. Each individual must have exactly the same statistical chance as others to participate in the survey and then satisfies some distribution significant allocation criteria and to try to meet this allocation in the sample of individuals interviewed.

The method used in our work states, then, that there is no reason why a properly collected sample in a given population does not have the same characteristics as the same parent population and that these characteristics cannot be generalized to the whole parent population without significant loss of crucial information or precision in the figure of the original population assessment. Temporal evolution describes the average number of individuals collected during a considerable time, while the spatial variation describes the average number of individuals obtained for each station. The study of zooplankton population in the SMB lake was achieved through a water sampling using a plankton net consisting of a blütter silk 64 µm void mesh and one meter in length continued with a cylindrical canvas held by a 25 cm diameter metal ring at its end. Since the contents of the container are 500 mL of water, two samples should be taken to obtain a concentration of individuals per liter of water. Since working on living species without the use of formaldehyde made the task a bit difficult in the enumeration and characterization. Thus, sorting by taxon samples often requires significant time and thus represents a certain limitation to ecological studies on zooplankton.

The spatio-temporal study of the zooplankton population of Lake Sidi Mohamed Ben Ali was carried out at the rate of one sampling every month per station from July 2015 until July 2019, and the identification was carried out at using the determination keys work of Dussart (1967) and Amoros (1984). Values obtained are average values for each station. The temporal sampling is therefore the result of an average analysis so that these samples are optimal and that the variations in climatic factors do not have much influence on our results. Thus, the longer the sampling duration, the more the results would reflect a better reality, even if we thought that duration of four years was quite representative and explicit and could give a good idea on the evolution of plankton populations as a function of time.

From a spatial point of view, twelve (12) stations, three for each cardinal point, stretching all around the contour of the lake were prospected, and this from the outlet which is located immediately to the south of the lake, proceeding towards the east then the north, to finish west at the left of our starting point. Note that these samples were taken in the direct coastal zone of the lake, less than one (1) meter from the edge, as shown in figure 3.

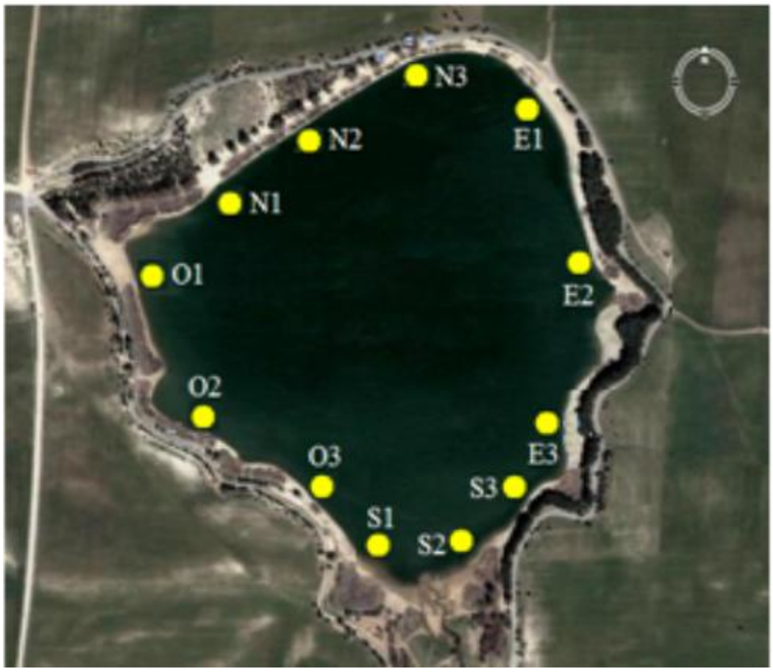

Figure 3: Sampling stations (made with Google earth, 2021)

On the ground, zooplankton were harvested mainly at a depth of around 50 cm which corresponds to the surface layer of water, then the hottest, by a series of horizontal zigzags in order to rake as wide as possible. Once the water has been taken it is collected in sterile bottles. These latter were intended for the identification and enumeration of planktonic fauna. The choice of these stations was therefore motivated by their practicability as well as some of their characteristics which delimit, for each of them, a certain area with more or less similar characteristics.

After filtering the sample, we put the contents in a Petri dish, and then the zooplankton species were identified and counted using an Optical binocular microscope. However, since species identification was laborious and very difficult with living specimens, determination has been limited to zoological groups.
Species were sorted and determined in zoological groups while taking care to respect the following steps:
* Filtration of the contents of the flasks of the twelve stations one by one, thanks to the sampling net. We obtained a biomass which was then treated with formalin at 5°.
* Harvesting and sorting of individuals under a binocular microscope for a preliminar observation.
* Identification with an optical microscope of species thanks to their morphology and using the identification key works of Dussart (1969) and that of Amoros (1984).
* Census and counting of species discovered.
* Calculation of various general characteristics such as abundance, dominance and density of each zoological group.

We ended up with a certain number of individuals grouped together by species. For the sake of not cluttering up our work, we have only retained as significant groupings those of the Copepods, Cladocerans and Rotifers, because the other groups appeared in negligible quantities. During the four years of sampling, various results were obtained but we proceeded by summary and calculation of the global average.

Results and Discussion

Temperature is the first ecological factor which seems essential for aquatic systems. It varies regularly along a longitudinal profile of a body of water as a function of atmospheric temperature, but also greatly vertically. It conditions the development possibilities and the duration of the biological cycle of each species. In a lake, at each point of a longitudinal profile, the temperature is a function of the altitude, the distance from the source, the hydrological regime and the season. The survival of a species is possible between two temperature limits where its action is manifested on the metabolism, the length of the biological cycle, the survival time and the rate of respiration. Temperature also affects the density and viscosity of water, solubility of gases especially oxygen, and the rates of chemical and biochemical reactions. Different temperature variations can also eliminate certain species which leads to an ecological imbalance in the aquatic environment. However, the question is what is this intimate relationship that could exist between zooplankton and temperature? It goes without saying that atmospheric temperature has been considered because it will directly influence the temperature of the water underlying. Why? Because it seems that zooplankton being able to move vertically, they could move towards greater depths and thus reach milder depths without their number decreasing significantly, if one considers that water temperature were the main ingredient of the vitality or decadence of the zooplankton populations. Likewise, there have been no reports of seismic activity which could by one means or another have effects or an impact on the lake's temperature. Also, the lake seems to be far from any underground influence.

According to Figure 4, the months of January, February, March, April, especially May, October, November and December, are the months when the average temperatures are lower than the global average temperature of 17° C. Beyond that and for the months of June, July, August and September the zooplankton vegetate and are even to reach the point of extinction for the month of August, the hottest month. Thus, the month of January records an important quantity of zooplankton followed closely by the month of December where plankton also abounds. However, the most prolific month is May when although the temperatures have really risen they remain slightly below the average temperature and the planktonic species that have proliferated during the previous months will continue to enjoy a mild temperature and then to prosper. However, in the months when the average temperatures remain higher than those of the colder months there is a significant decrease of zooplankton species. Instead of the hottest month of July, these populations are almost on the verge of extinction in August, being catastrophic for the zooplankton, which is dramatically scarce.

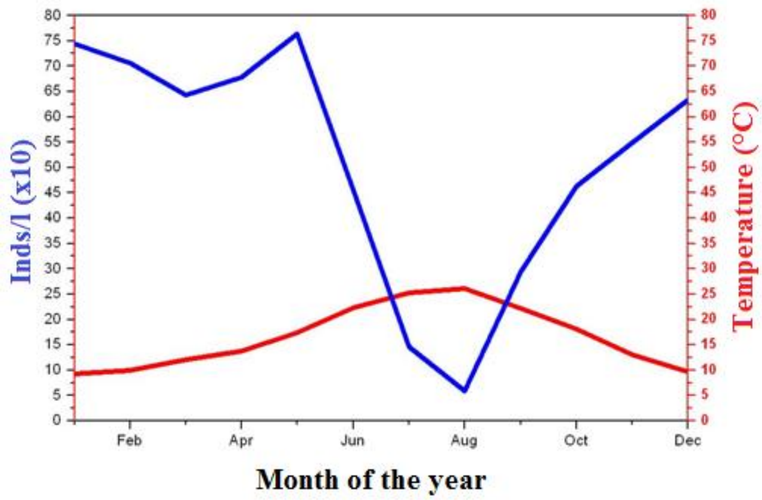

Figure 4: Linear evolution of the plankton

The curves in Figure 4 clearly show that there is an almost perfect inverse relationship between zooplankton and temperature. These two asymmetric curves show that zooplankton decreased when the temperature increased and on the contrary increase when the temperature decreased again. Nevertheless, the curves in the following figure are more mathematically explicit and clearly show this relationship of inverse proportionality. As a result, figure 4 shows the inverse proportionality relationship that exists between annual temperature rise and zooplankton populations, which is mathematically:

$$N(Inds/L) = -33\,T + 1060. \quad (1)$$

N is the number of individuals listed per liter, including all specimens surveyed and those per liter of liquid collected. T is the temperature in Celsius degrees.

This first approach already appears to be serious given the fact that this line is decreasing over the entire interval. Its slope remains negative, which shows that any increase in temperature results in a drastic decrease in the quotas of zooplankton. This decrease is even total and leads to a virtual extinction of zooplankton species when the temperature is at its highest, around 32 °C, which is evidently hypothetic since zooplankton didn't disappear at all at this temperature.
The figure 5 shows better what was the evolution of planktonic populations the whole year.
In addition, quadratically:

$$N(Inds/L) = -3T^2 + 65\,T + 300. \qquad (2)$$

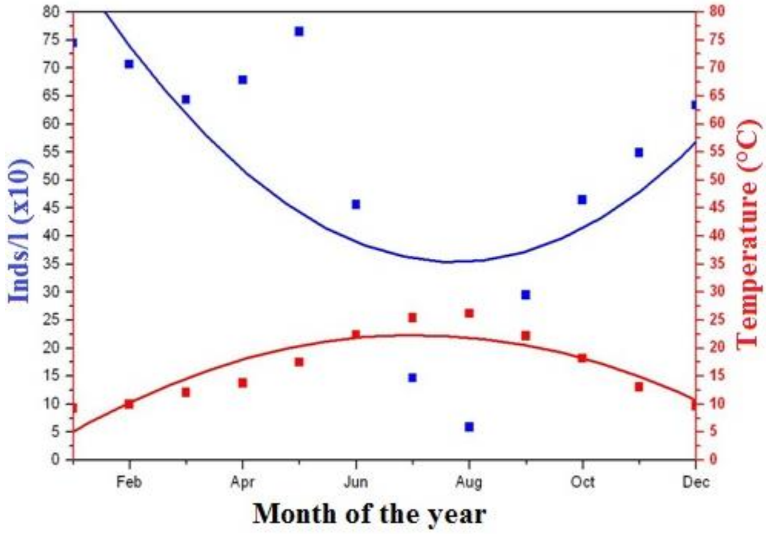

Figure 5: Evolution of plankton the year whole

This shows that the trend is very pronounced however, this curve only gives an indication of the trend because according to our equation there would be no more plankton at 25.5 ° C, which is obviously false. This means that after reaching a maximum long enough, the decrease is quite rapid. It signifies, also by extrapolating, the fact that zooplankton are particularly allergic to global warming.

One can thus deduce that the major finding is that which denotes the reality that zooplankton is particularly sensitive to any rise in temperature and given the fact that it constitutes the second link in the food chain, one of the most important links, the disappearance of zooplankton due to The global increase in temperatures could, unfortunately in the short term, lead to the disappearance of the fish that feed on them resulting in an interruption of the entire food chain and its disappearance too. The consequences of such a situation are incalculable as everything is tied together, a link jumps and the whole chain is broken. Thus, when the temperature increases the amount of zooplankton decreases and reaches almost extinction. Most prolific Months are the coldest ones while May constitutes a notable exception to this rule. This month is the most productive although its average temperature is nearly the average of the year, neither too cold nor too hot. When the temperature increases the propensity is to fall and as already as in June the zooplankton number has literally collapsed to very low quantity levels, as shown in figure 6. This study shows that as the temperature remains under the average temperature zooplankton quotas are quite substantial but once they raise upon this fatidic average temperature which appears to be a physical barrier, these populations diminish and weaken very quickly. These observations have already been made by other authors but concerned only the marine plankton and it is, to our knowledge, the only study that has considered the development of zooplankton populations in relation to seasonal temperature variations.

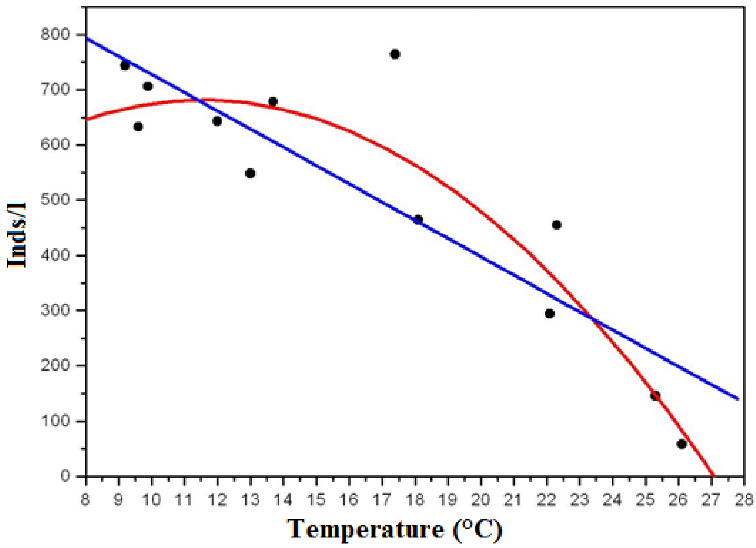

Figure 6: Quadratic evolution of the plankton.

Our results thus corroborate those found internationally and shows, if needed, that the limnic zooplankton is also subject to temperature variations like marine zooplankton and that these variations are of the same kind and trends. Nevertheless, the major finding is that which denotes that the zooplankton is particularly allergic to any temperature rise and the fact that because it is the second link in the food chain, one of the most important link, the disappearance of zooplankton caused by the increase in global temperatures could, and regrettably at short-term, lead to loss of fish that feed on them leading to an interruption of the entire food chain and its disappearance as well. The consequences of such a situation are incalculable because everything is linked, a link jumps and the whole chain is broken. This brings us finally to ask a crucial question, which unfortunately remains unanswered: with global warming, are we going to the disappearance of plankton, so the extinction of whole animal life? Are we on the threshold of another great extinction in the image of the Permian one or worse than of the Cretaceous?

References

1. Barnett T.P., Pierce D.W. and Schnur R., Detection of anthropogenic climate change in the world's oceans, Science, 292: 270-274 **(2001)**
2. Edwards M. and Richardson A.J., Impact of climate change on marine pelagic phenology and trophic mismatch. Nature, 430: 881-884 **(2004)**
3. Barnett T.P., Pierce D.W., Achutarao K.M., Gleckler P.J., Santer B.D., Gregory J.M. and Washington W.M., Penetration of human-induced warming into the world's oceans. Sci., 309: 284-287 **(2005)**
4. Deque Michel, Temperature et precipitations extremes sur la france dans un scenario de changement climatique. Clim. Dyn, 11: 321-339 **(2005)**
5. Planton S., Déque M., Douville H., Spagnoli B., Impact du réchauffement climatique sur le cycle hydrologique. *Géosci*., 337, 193-202. **(2005)**
6. Harley C.D.G., The impacts of climate change in coastal marine systems. Ecol. Lett., 9: 228-241 **(2006)**
7. Meunier Francis, Energies et changement climatique. Dunod. 45-60 **(2008)**
8. Beaugrand G., Decadal changes in climate and ecosystems in the North Atlantic Ocean and adjacent seas. Deep-Sea Research II, 56: 656-673 **(2009)**
9. Stenseth G., Ottersen J.W. Hurrell and Belgrano A., Marine ecosystems and climate variation. Oxford University Press. Chippenham,15-32 **(2005)**
10. Hegerl G.C., Zwiers F.W., Kharin V.V. and Stott P.A., Detectability of anthropogenic changes in temperature and precipitation extremes. J. Clim., 17: 3683-3700 **(2004)**
11. Musat O. and Planton L., Simulation du climat récent et futur par les modèles du CNRM et de l'IPSL. La Météorol., 55: 45-59 **(2004)**
12. Caperon J., Population growth in micro-organisms limited by food supply, Ecology, 49: 715–721 **(1968)**

13. Chisholm S.W., Costello J.C., Influence of environmental factors and population composition of *Thalassiosira fluviatilis* (bacillariophyceae) grown on light/dark cycles. J. Phycol., 16: 375-383 **(1980)**
14. Quero J.C., Du Buit M.H. and Vayne J.J., Les observations de poissons tropicaux et le réchauffement des eaux dans l'Atlantique européen. Oceanol. Acta., 21: 345-351 **(1998)**
15. Bertolo A., Lacroix G., Lescher-Moutoue F. and Cardinal-Legrand C., Plankton dynamics in planktivore and piscivore-dominated mesocosms, Arch. Hydrobiol., 147: 327-349 **(2000)**
16. Behrenfeld M.J., Marañon E., Siegel A. and Hooker S.B., Photoacclimatation and nutrient-based model of light-saturated photosynthesis for quantifying primary production. Mar. Ecol. Prog. Ser., 228: 103-107 **(2002)**
17. Beaugrand G., Long-term changes in copepod abundance and diversity in the north-east Atlantic in relation to fluctuations in the hydro-climatic environment, Fish. Ocean, 12: 270-283 **(2003)**
18. Arhonditsis G.B. and Brett M.T., Evaluation of the current state of mechanistic aquatic biogeochemical modelling, Mar. Eco. Progr. Ser., 271:13-26 **(2004)**
19. Worm B., Impacts of biodiversity loss on ocean ecosystem services. Sci., 314: 787-790 **(2006)**
20. Blackford J.C., Predicting the impacts of ocean acidification: challenges from an ecosystem perspective. J. of Mar. Syst., 81: 12-18 **(2010)**
21. Testard P., Pourriot R., Rougier C. et Miquelis A. Fonctionnement de l'écosystème fluvial: organisation et rôle du zooplancton. Rapport de synthèse PIRENSeine. 3-38 **(1993)**
22. Milliman J.D., Farnsworth K.L., Jones P.D., Xu K.H. and Smith L.C., Climatic and anthropogenic factors affecting river discharge to the global ocean, 1951–2000. Glob. and Planet. Chan., 62: 187–194 **(2008)**
23. Balvay G., Long-term changes in zooplankton abundance and water transparency in Lake Geneva, Arch. Hydrobiology, 207: 31-36 **(1990)**
24. Haberman J., Zooplankton of lake Vörtjäv. Limnol., 28: 49-65 **(1998)**
25. Samraoui B., Sergers H., Maas S., Baribwengure D., Dumont H.J., Rotifera, Cladocera, Copepoda and Ostracoda from costal wet lands in northeast Algeria. *Arch. Hydrobiol*., 386:183-193 **(1998)**
26. Cherbi M., Lek-Ang S., Lek S. and Arab A., Distribution du zooplancton dans les lacs à climat méditerranéen. Comptes rendus de Biologie., 331(9): 692-702 **(2008)**
27. Lebid S., Amar Y., Djahed B., Mouedden K., Anani M. and Mathieu C., Sidi Bel Abbes Temperature Variations during the last Three Decades. J. of Environ. Sci. and Eng., 5B: 358-361 **(2012)**
28. Lebid S., Anani F., Allam M., Anani M. and Mathieu C., Rainfalls modeling during the last 35 years in Sidi Bel Abbes. Int. J. of Geol., Agri. and Environ. Sci., 33: 3-6 **(2015)**
29. Dussart B.H., Les Copépodes des eaux continentales d'Europe occidentale. 2. Cyclopoïdes et Biologie quantitative. Boubée & Cie. Paris, 292 **(1969)**
30. Amoros C., Introduction pratique à la systématique des organismes des eaux continentales françaises. *5 – Crustacés Cladocères*. Edit. Assoc. Franc. LimnoL. Paris. 63 **(1994)**