A STUDY ON THE COMPETITION BETWEEN VARIOUS SPECIES AND STRAINS OF *ARTEMIA* IDENTIFIED IN SALT LAKES OF ALGERIA

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Abstract: The present study highlights the effect of competition between indigenous Algerian *Artemia* in a mesocosm during the winter - spring season. A number of 100 nauplii, aged 48h from pure cyst hatching of each population identified (*Artemia salina*, *A. parthenogenetica diploid* and *tetraploid*) were introduced into a medium consisting of a 65 g L^{-1} brine and a mixture of microalgae (*Tetraselmis sp.* and *Dunaliella sp.*). Seasonal variations cause changes in the competitive abilities of the three indigenous forms investigated. Sexual populations show their presence at low temperatures. A parthenogenetic strain comes into existence with an increase in temperature. At first, the tetraploid form is followed by the diploid one. In parallel, a loss of the sexual species is observed. As a result, parthenogenetic strains prefer to live at high temperatures. Parthenogenetic forms dominate and persist at the end of the season compared to other populations.

Keywords: *Artemia*, competition, crustacean, cyst, nauplius, Salt Lake.

Introduction:

The geographical distribution of the *Artemia* species of the old world has always revealed the coexistence of the populations of the sexual species *A. salina* and those of the parthenogenetic strain, which follow one another temporarily in several coastal saltworks (Amat 1981, 1983; Amat et al. 1995; Hontoria and Amat 1992a, 1992b). This situation confirms well the distinct behavior of this population vis-à-vis the environmental factors.

In general, for both species two types of adaptation can be noted. Sexual forms adapt to low temperatures and dominate during winter and at the beginning of spring, whereas the parthenogenetic populations prefer moderate temperatures and develop during summer when the temperature is higher (Amat 1981; Takami 1989; Barata et al. 1996a, 1996b).

The experiments of competitiveness carried out on *Artemia* show important differences between the sexual and the parthenogenetic stocks (Amat 1985; Browne and Halanych 1989; Barata et al. 1996a, 1996b). The American sexual species (*Artemia franciscana*) have a higher competitive capacity compared to the species of the Palearctic area. The populations of the parthenogenetic diploid strain eliminate the Mediterranean sexual populations in all the

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experiments. Browne and Halanych (1989) affirm that the competitive capacities of *Artemia* depend on their reproductive parameters and their life period as well as on the changes of these characteristics caused by the temperature affecting them.

This study has been carried out in laboratory under controlled temperature (24 ºC and more), where practically the parthenogenetic stocks and the American bisexual species exhibit a better capacity of reproduction and survival (Browne 1980b; Browne et al. 1988) and consequently of great competitive capacities.

In addition, the analysis of the competitive interactions between species shows that the exclusion of a species can be due to the behavior of certain critical age groups. Case studies carried out in cladoceran and Copepod species show that generally the larval and youthful stages are more vulnerable to the lack of food than adult ones. Threlkeld (1976) concludes that in conditions of fast development, age groups of small size are more fragile than old ones.

Sick (1976) shows that, from the physiological point of view, metanauplius and young *Artemia* have a low rate of assimilation, compared to the individuals of larger size. In addition, Masson (1963) observed that the stages with sizes between 2 and 7 mm are the most sensitive to the variation of the quality of food. These results indicate that the youthful stages can be a critical age group, one exclusively sensitive during interspecific competition for food.

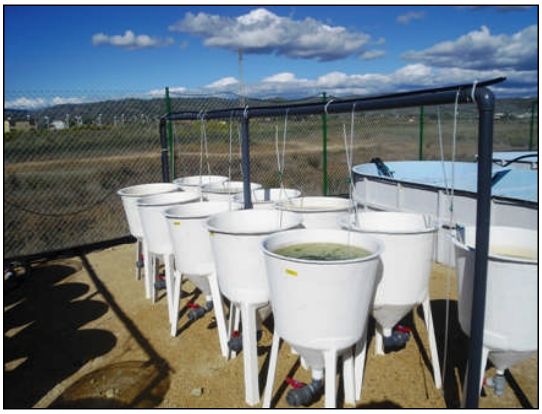
Also, during the fast period or the very reduced food mode, *Artemia* reproduces continuously to the detriment of its survival, but its longevity tends to shorten (Browne 1982).

Materials and methods:

The experiment of competitiveness was carried out in mesocosm with indigenous species or forms identified in Algeria saltworks (Ghomari et al. 2011) during two identical periods (from 07/04/2008 to 30/06/2008) and (from 03/04/2009 to 01/07/2009).

The experimental device consists of 60 liter tanks equipped with an aeration system by air bubbles from the bottom. The assembly is placed in the open air under atmospheric conditions (Fig. 1).

Figure no. 1 The mesocosm setup for competitiveness study between *Artemia* forms.



The breeding medium was brine obtained with filtered seawater increased at a salinity of 65 ppt by addition of ordinary salt. A suspension of microalgae comprising a mixture of *Dunaliella sp.* and *Tetraselmis sp.* was added to the brine. The average initial concentration was 71 x 10^3 cells per milliliter. Breeding in the basins (in triplicate) was initiated with a number of 100 nauplius aged 48 hours coming from hatching pure cysts under standard laboratory conditions (Sorgeloos 1980).

Throughout the experiment environmental parameter measurements such as temperature and salinity were done in the breeding ponds. Once per week, the amount of food available was studied in the breeding medium by measuring the cell density of the microalgae. The measurements were performed using an atomic absorption spectrophotometer which gives an optical density convertible to the number of cells per milliliter (by applying the mathematical model developed in the laboratory of the IATS).

The population in each tank was evaluated based on the average count of three samples. For each basin the number of nauplius per liter, the number of metanauplius per liter, the number of juveniles per liter and the number of adults per liter were determined.

Results and discussion:

The average temperature of the breeding environment in the basins of mesocosm during the study periods (2008 and 2009) reached 13 ºC in April and rose above 20 ºC during the months of May and June (Fig. 2, Annexes).

Salinity during the experimental period in 2008 reached an average of 83 gl^{-1} with a maximum of 107 gl^{-1} and a minimum of 60 gl^{-1}. There is no large variability, as this year was wet and rainy. On the other hand, for the experimental period of 2009 salinity underwent significant variations with a minimum of 68 gl^{-1} at the beginning of the experiment and a maximum of 160 gl^{-1}.

The variation in the number of adults in the environment in the case of the two periods follows two phases: a first phase of growth proportional to the increasing proliferation of phytoplankton decreasing with the lack of food, then a second phase during which the number of individuals increases, and tends to stabilize (Fig. 3, Annexes).

The results of competitiveness experiments are shown in Figure 4 (Annexes) for the spring periods (2008 and 2009). In free environmental conditions, the populations of bisexual species *A. salina* were eliminated by the parthenogenetic strain. The populations of the bisexual species appear at first, in view of their thermal preference allowing them to adapt to low temperatures. Thereafter, the development of populations of parthenogenetic diploid strain immediately followed dominating over the tetraploid parthenogenetic strain since this latter manifests itself only above 12 ºC (Browne et al. 1988).

The extinction time of the sexual species does not exceed 4 months if we consider its appearance from February when environmental conditions begin to improve. Rare individuals which resist beyond the month of May are represented by males who survived the rising temperature and salinity.

The diploid parthenogenetic population persists in breeding until the end of the experiment. Its behavior appears to be similar during the two experimental periods.

During the spring period (2008-2009), nauplius and metanauplius species were emerging from April. Their number increases during the following months reaching high densities due to the development of the adult population. Towards the end of June, the fall of phytoplankton influenced directly the survival of the offspring (Fig. 5, Annexes).

Most experiments carried out in external temperature conditions (outdoors), indicate that the development of populations depends on two main factors: firstly, on the power of growth of the populations of different species or strains during certain periods of the year and on the effect of interspecific competition, and secondly, on the favorable or poor conditions of the breeding environment. The importance of these factors depends on the biological efficiency (fitness) of species or strains in competition and the period of year.

The role of temperature as an environmental factor is at least to regulate the competitive capacity of *Artemia* populations, like populations of sexual species *A. salina* which develops at first, given their ecological preference to live in conditions of low temperature (Vanhaecke et al. 1984; Browne et al. 1988; Hontoria 1990; Barata et al. 1996b). Parthenogenetic populations can show development only beyond above 12 ºC (Browne 1988; Amat et al. 1991; Barata 1996a, 1996b). Moreover, temperatures higher than 20 ºC favor the growth of parthenogenetic diploid populations (Browne et al. 1988; Amat 1983), but these temperatures do not seem favorable for polyploid strains. This thermal regime eventually reduces the competitive power of the tetraploid parthenogenetic strain.

On the other hand, the competitive capacities of the populations seem to be related to their life cycle as already reported (Browne 1980a; Browne et al. 1984; Barata et al. 1996b; Amat et al. 2007). The reproductive behavior is one of the biological factors that most affect the ecological development of organisms. In *Artemia*, there is a great variability in the mode of reproduction and fertility, according to the changes in environmental conditions, particularly, food and temperature. In some cases, it has been observed that the interspecific competitiveness reduced fertility in females, and the lack of food affects much the most critical stages of development (Lenz and Dana 1987; Browne et al. 1988; Amat et al. 1991).

In the present work, we note that as soon as food becomes scarce, interspecific competitiveness affects well fertility, the size of offspring is affected and the number of adults is high at the end of the experiment (Figs. 3, 4 and 5, Annexes). Lenz and Dana (1987) reported that the population having reached a high density reduces its fertility to maintain equilibrium with the environment.

It follows that the response of the reproductive parameters of the diploid parthenogenetic strain differs from one population to another and even within the same population. Some populations are ovoviviparous throughout their life cycle, others are sometimes most oviparous when the temperature range is between 19 and 24 ºC (Ghomari 2013). The analysis of the reproductive parameters of tetraploid parthenogenetic strain shows that the first laying is ovoviviparous giving rise to nauplius, then immediately the female initiates the process of oviparity until the end of its life. Occasionally, nauplius exists at a very low rate in oviparous laying, due to instant cysts that hatch suddenly and which are responsible for the reappearance of the population which completely disappeared.

Conclusions:

From this study, it can be concluded that during the spring period, the sexual populations manifest their presence early in the season at low temperatures. When temperature rises the parthenogenetic strain occurs: at first, the tetraploid form appears followed by the diploid one. Meanwhile, the sexual species starts to disappear.

Rezumat:

STUDIU PRIVIND COMPETIȚIA DINTRE DIFERITE SPECII ȘI FORME DE *ARTEMIA* IDENTIFICATE ÎN LACURILE SĂRATE DIN ALGERIA

Acest studiu subliniază efectul competiției între indivizii speciei indigene *Artemia* din Algeria în condiții de laborator în timpul sezonului de iarnă – primăvară. Un număr de 100 de nauplii, în vârstă de 48 de ore, proveniți din incubația unui chist pur din fiecare populație (*A. salina, A. parthenogenetica diploid* și *tetraploid*) au fost introduși într-un mediu format din 65 g L^{-1} apă sărată și un amestec de microalge (*Tetraselmis* sp. și *Dunaliella* sp.). Variațiile sezoniere induc schimbări în abilitățile competitive la cele trei forme indigene cercetate. Populațiile sexuale au fost semnalate la temperaturi scăzute. O formă partenogenetică apare o dată cu creșterea temperaturii. La început, forma tetraploidă este urmată de una diploidă. În paralel, este observată o descreștere a speciilor sexuale. Ca o concluzie, formele partenogenetice preferă să trăiască la temperaturi înalte. Formele partenogenetice sunt dominante și sunt prezente până la sfârșitul sezonului în comparație cu alte populații.

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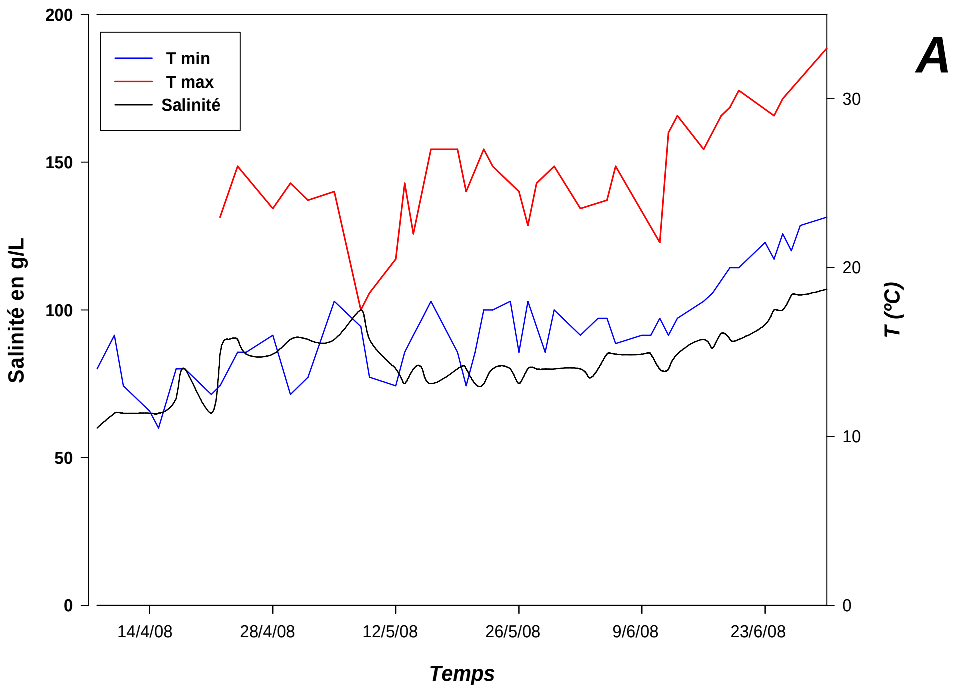
Annexes:

Figure no. 2 Evolution of temperature as a function of salinity (2008-2009).

(A) period 2008



(B) period 2009

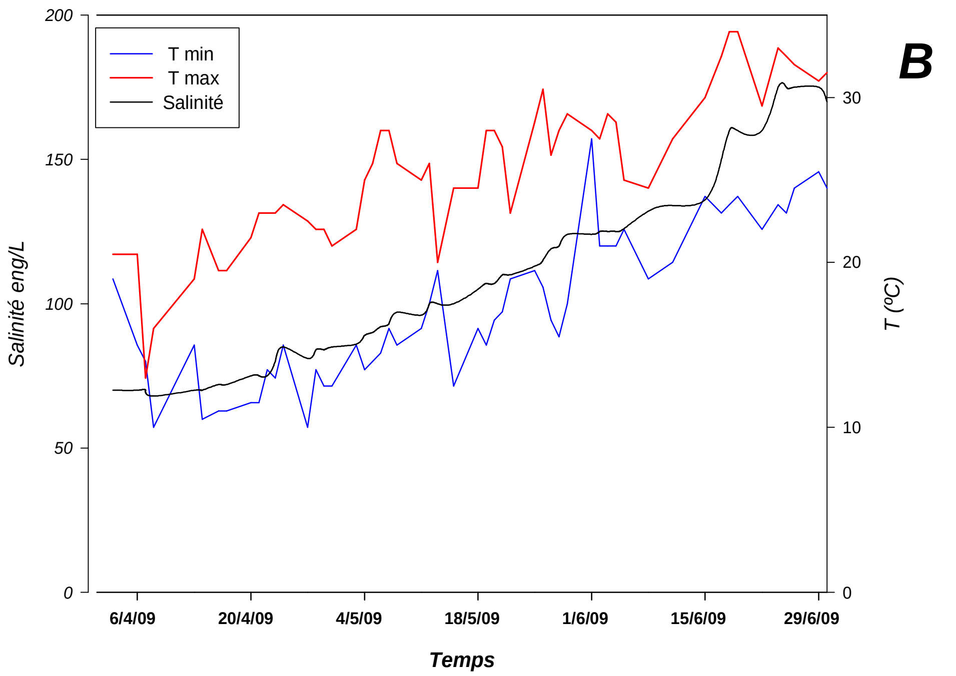
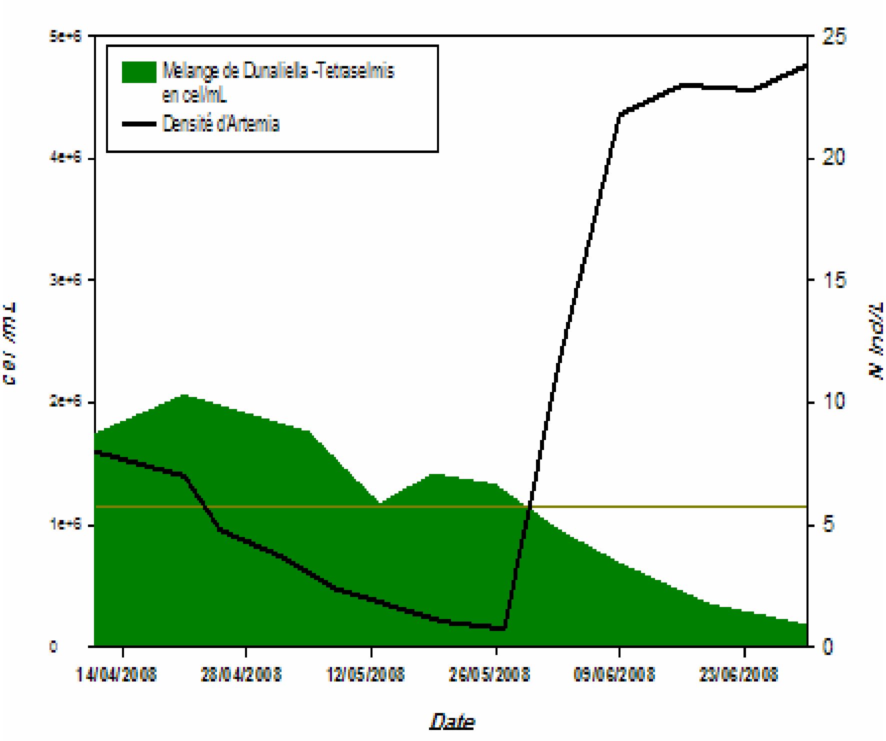


Figure no. 3 Evolution of phytoplankton as function of *Artemia* density (2008-2009).

(A) period 2008



(B) 2009 period

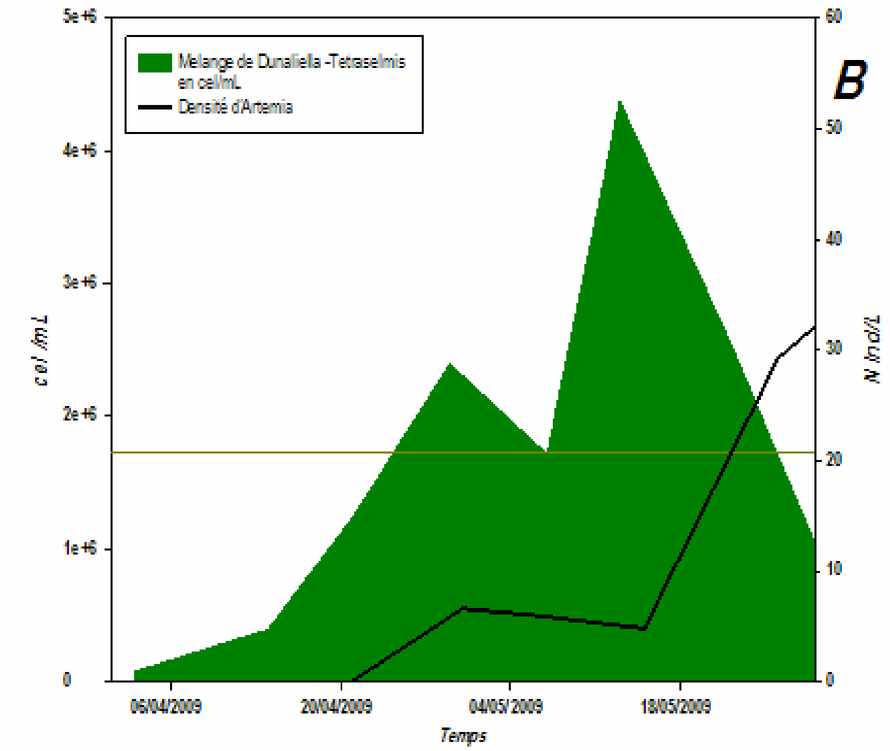
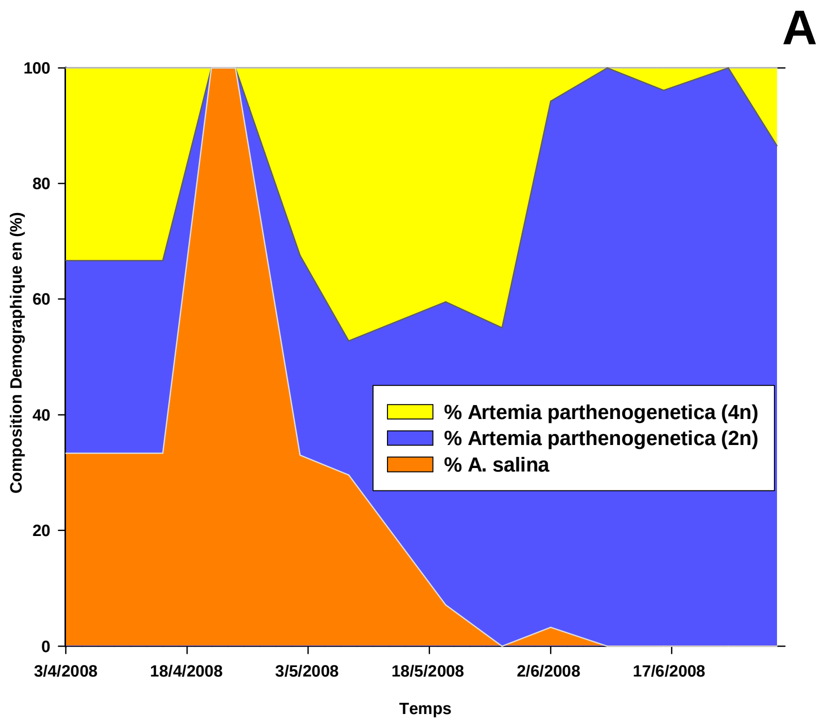


Figure no. 4 Variation in the composition of the adult *Artemia* population (2008-2009).

(A) period 2008



(B) period 2009

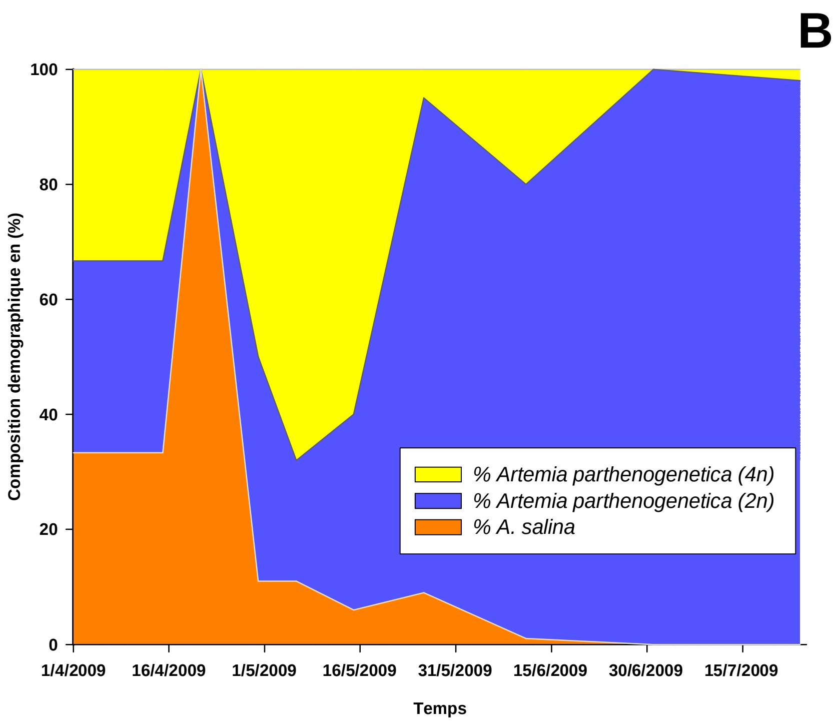
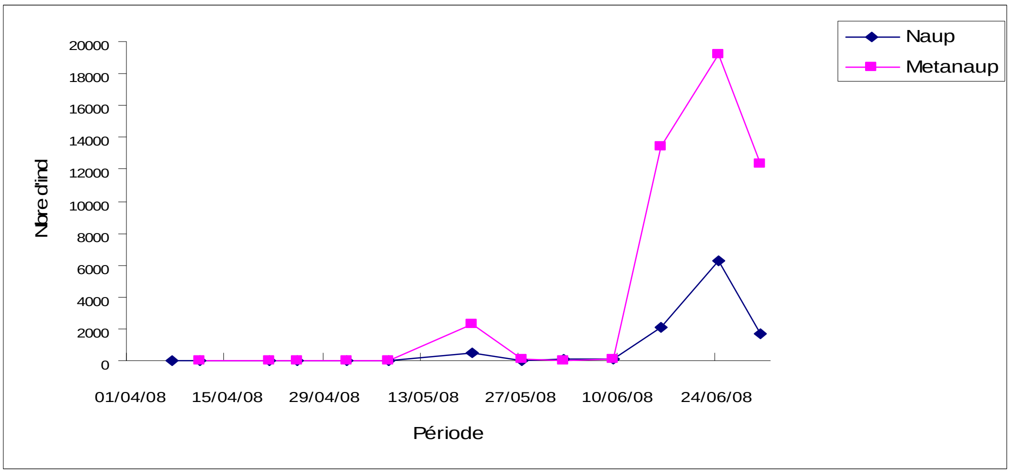


Figure no. 5 Evolution of the number of nauplius and metanauplius during the period of study (2008-2009).

(A) period 2008



(B) period 2009