

Ecological Impact of *Gambusia affinis* (Cyprinodontiform: Poeciliidae) on the Aquatic Environments

¹S. Hamouda and ²B. Samraoui

¹Laboratory of UMR 75 33 LADYSS, Department of Geography,
 University of Paris 8, France

Research Laboratory on Wetlands (L.R.Z.H),

²Department of Biochemistry, Faculty of Science,
 University of Badji Mokhtar Annaba 23 000, LP 12, Algeria

Abstract: We led an experimental study tending to evaluate the impact of two species introduced, *Gambusia affinis* and *Cyprinus carpio* on the wetlands of Numidia. Our results clearly state that the predation of fish is an important factor influencing the composition and the structure of the watery biocenoses and that the introduction of exotic fish represents a real threat for Algerian wetlands.

Key words: *Gambusia affinis*, aquatic environments, biodiversity, wetlands, Algeria

INTRODUCTION

The extreme North-East of Algeria shelters a complex of wetlands of international reputation, characterized by its diversity of mediums and its floristic and faunistic richnesses (Samraoui and De Belair, 1997, 1998). The management of this complex is a true challenge (considering the complexity of the problems) and a moral obligation, underlined by the urgency of the situation. Indeed, the wetlands are vulnerable mediums subjected to an intense anthropic pressure (Hollis, 1992).

Among the various factors of degradation of the wetlands, the introduction of exotic species is particularly frightening but potentially devastator on the ecosystems. The examples of the introduction of the rabbit *Oryctolagus cuniculus* or *Opuntia stricta* in Australia became the traditional ones in the works of ecology (Krebs, 1985). The examples of catastrophic consequences due to the exotic fish introduction do not miss unfortunately: The introduction of the pole of the Nile Lates niloticus to Lake Victoria caused the disappearance of several species of Ciclides (Payne, 1986) in the same way to the Lake Lanao (the Philippines), the introduction of the goby *Glossogobius giurus* led almost to the disappearance of several endemic species (Payne, 1986).

In Algeria, the consequences of the introduction of several species of carpi to the Lake Oubeira, could not be sufficiently shown well that their impact on the vegetation of the Lake Oubeira was unanimously regarded

as harmful. It is also the case for *Gambusia affinis* which is the subject of our study and is one of the exotic fish species most abundant in Algeria. Our purpose is to show its impact on the watery ecosystems.

Indeed, the work undertaken on *Gambusia affinis* was focused especially on biology (Cech *et al.*, 1985; Reznick and Braun, 1987; Zimmerman *et al.*, 1988; Gonzalez *et al.*, 1989; Drysdal and Bortone, 1989; Schöpf *et al.*, 2004; Pyke, 2005). There are relatively few studies, set apart those of Hulbert *et al.* (1972) Hulbert and Mulla (1981), Nagdali and Gupta (2002), Rogowski and Stochwell (2006) about the impact of *Gambusia affinis* on the structure of the watery communities.

Within the framework of our investigations, we were essentially interested in the study of the impact of this fish in certain ponds of Numidia in order to evaluate the specific richness and the structure of the biocenoses of the water levels with or without *Gambusia*.

MATERIALS AND METHODS

Choice of the sites: Our study was carried out in 2000 in the zone of the national park of El-Kala to the north-eastern extreme of Algeria.

The selected ponds are practically very of the same size, joined together in a surface of 500 m². They are thus subjected to the same climatic conditions and they share the same substrate. They are also accessible (close relations from the trunk road 44) and the fact that they are temporary prevents any involuntary propagation of

Gambusia towards other wetlands. Another asset of this choice is the fact that these ponds were the subject of a systematic study spread out over several hydrological cycles (1996-2000).

Sampling: The sampling carried out on the level of the fifteen ponds was carried out each 15 days, extending from December 1998 to June 1999. The techniques of harvest required the following material:

- A scoop of 1 mm of vacuum of mesh, to carry out two taking away for each pond; each taking away is done in two passages through the ponds (10 hauls).
- Bottles in figure labelled with dates and places of harvest.
- Formoldehyde to fix the samples obtained.
- A conductimeter to measure the electric conductivity of water.
- A disc of Secchi to measure the transparency of water.
- A thermometer to measure the temperature of water.
- Charts where the data are noted.

Examination and identification: At the laboratory we need:

- Limp of Petri, an entomological grip and brushes to strip and count the collected specimens.
- We preserved the larvae as well as other insects of small sizes such as: Planorbis, Asellus, etc in formol.
- The adult insects such as coleopters and hemipters are pinned on polystyrene and with each insect is mentioned the date and the place of harvest, the whole is preserved in limp of collection.
- To the end comes the most important stage which is the identification of the various specimens.
- We also used the collection of reference of the laboratory (L.R.Z.H).

Analyze data

Some characteristics of a settlement: Abundance = a total number sampled individuals.

The frequency = it is expressed by the number of statements containing the studied species, it can be expressed in the form of percentage from where:

$$C = (p/100)P$$

p : A number of statements containing the studied species.

P : The total number of taken readings.

The structure of a settlement: It expresses the mode of distribution of the individuals among the species which make the settlement, i.e. the organization of the table species-statements.

The study of this mode of distribution can be made:

- By analysis of the distributions of abundance (model of Preston, Motomura, Mac Arthur).
- By means of aggregative indexes of diversity (Southwood, 1978).
- The diversity of a settlement is also expressed by the number of species present (specific richness).

Among the indices of diversity allowing the comparison of the settlements in space and time, we have:

Index of SHANNON:

$$H = - \sum p_i (\log 2p_i)$$

n_i : Abundance of the species.

N : Total number of individuals.

p_i : Relative abundance of each species (n_i/N)

Equitability:

$$E = H / H_{max}$$

H : Maximum diversity.

H_{max} : $\log 2S$.

S : Specific richness.

Index of MARGALEF: it is expressed by:

$$mj = (S-1) \ln N$$

S : Specific richness.

N : Total number of individuals, all confused species.

Analyze statistical multivariate: It is a descriptive method of ordination where a correspondence is carried out between two typologies. The starting point of the analysis is the rough table of the data, where raised are represented by columns and species by lines or the reverse.

Each intersection statements-species indicates the presence, the absence or the abundance of the species. The cloud of the points represented either by the statements or by the species in original multidimensional space is characterized by privileged directions of

lengthening. They are factorial axes which contain a certain proposal of the total information of the data, the axes are thus extracted by the AFC (performed with Minitab 13.31).

RESULTS

Influence abiotic variables on the ecosystems

Hydroperiod: The complex of the ponds of El Feid went back out of water at put December and the hydroperiod lasted nearly 7 months.

Conductivity: Within the same pond, conductivity can vary from 0.49-1.08 ms cm⁻² (Feid). The abiotic data characterizing the studied ponds are summarized.

Fauna: The specimens collected on the level of the fifteen ponds are represented by taxas according to:

The invertebrates represent 94% of fauna, divided into 4 taxas. The invertebrates are primarily composed of introduced fish (Gambusias or Carpi) and Amphibians. The Shellfish are dominating in number and probably in biomass. These results differ from those obtained before on the level of several ponds of Eastern Numidia and of the dune depressions and they reflect primarily the abundance of two species on the level of El-Feid: *Chirocephalus diphanus* and *Asellus* sp.

Specific richness: The 4 ponds without fish (Feid 1-4) have at the beginning a similar richness specific to the other stations, at the beginning of the water handing-over. This specific richness increases with the wire of time and reached or exceeds 20 taxas for the first ponds whereas it is always lower than 16 for the remainder. The specific richness of El-Feid 3 decreases because its offsetting is rather advanced in May.

Index of shannon: It was calculated monthly for each pond and indicates that only Feid 1-2 (and Feid 4 in April, Feid 10 in a lesser degree) have a high index of diversity (3).

Phenology: The table delivers to us the data concerning phenology of the species met within El-Feid. Let us note the continuous presence of some taxas (*Berosus affinis*, *Helochaeres lividus*, *Planorbis planorbis*) and the late appearance of other taxas (Odonata, *Corixa* sp, *Hyphydrus aubei*). The hatching of eggs of the late species is probably regulated by the other factors (temperature, photoperiod) than water.

DISCUSSION

The impact of the exotic fish introduction within the Algerian wetlands remains essentially badly known. The dissemination of *Gambusia affinis* and the carp *Cyprinus carpio* during this century does not seem to worry the authorities or the managers of the wetlands. The role of fish in the trophic networks of the watery ecosystems was neglected a long time by the limnologists (Hulbert *et al.*, 1972) and it is only relatively recently that this phenomenon held the attention of the biologists, in spite of the innovative studies of Hrbacek (1962), Brooks and Dodson (1965) and Macan (1965a,b, 1966).

During the last twenty years, *Gambusia affinis* gradually became a sort widely spread in the Algerian wetlands and following the Chinese carp introduction to the Lake Oubeira in 1986 and 1991, *Cyprinus carpio* could gain other sites within the complex of the wetlands of Numidia. In comparison with the potential effects of *Gambusia affinis* (Hulbert *et al.*, 1972; Hulbert and Mulla, 1981) it had become urgent to evaluate the impact of these two species on the lakeside and palustre ecosystems of the area.

Since 1995, the L.R.Z.H. initiated a series of studies intended for better knowing the ecology of *Gambusia affinis* and *Cyprinus carpio*. The data cumulated to date state clearly that *Gambusia affinis* can enter in competition and exclude the autochthons like *Aphanius fasciatus*. *Gambusia affinis* and probably in a lesser degree *Cyprinus carpio* can also exclude several species of Amphibians and invertebrates. These results suit to those obtained in the U.S.A (Hulbert *et al.*, 1972; Hulbert and Mulla, 1981).

Our research, the first experimental study carried out on natural environments, confirms that the predation of fish is a significant factor controlling the richness and the structure of the aquatic environments (Fig.1). The preliminary results of the L.R.Z.H. indicate that the predation of the autochthones (*Pseudophoxinus callensis* and *Aphanius fasciatus*) does not have the same effect of impoverishment of the mediums that the predation of the exotic species and that this predation (fruit probably of a long co-evolution) has even an opposed effect, stimulating the diversity of the mediums.

The impact of *Cyprinus carpio* on the wetlands remains badly encircled and it is important to study its effect combined (or not combined) with that of *Gambusia affinis* on the biocenoses watery buildings. We know that *Cyprinus carpio* is able to colonize and to reproduce in the temporary mediums of Numidia, his survival depends then on sites refuges serving as source.

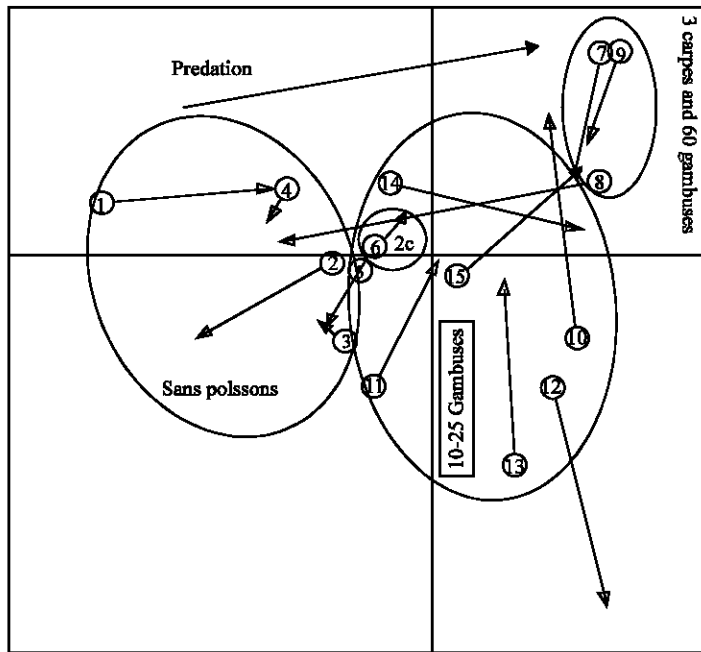


Fig 1: Gradient of predation

On the level of El-Feid, the reproduction was checked. It is thus important to study in priority these two species (*Gambusia affinis* and *Cyprinus carpio*) and to integrate the data with regard to them in any management of the wetlands of the area.

CONCLUSION

Our results as those obtained by the Research Laboratory of the Wetlands indicate that *Gambusia affinis* can negatively influence the abundance and the distribution of vertebrates (Amphibians and fish) and invertebrates. The fast extension of this species within the temporary mediums puts them directly in contact with species unsuited to the presence of fish.

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