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The culture of *Hoplosternum littorale*: state of the art and perspectives

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Abstract — ***Hoplosternum littorale*** *is a siluriform fish of very high commercial value in some countries of South America. Some biological characteristics as easy spawning in confinement and good tolerance of low oxygen level make it easy to cultivate.*

Aquatic oxygen uptake does not allow to sustain standard metabolism, so it is considered as an obligated air breather. Routine metabolism and growth cannot be completed without air access.

A circadian rythm for feeding behaviour is observed. Most voluntary food intake occurs during the night. The sunset is a directive factor even in case of time lag. So, a night feeding schedule should be used in practise.

Spawning occurs during the rainy seasons in nests built by the male on the water surface. The seasonal fecundity is very high with more than 25000 large size (1.4 mm in diameter) eggs for a hundred gram female. The larvae are quite large (6-7 mm length) and can be reared in standing water on complete diet with a good survival rate (70 %) but poor growth. Newly hatched fry transferred in ponds give a better growth — 12 g in one month — but with only few survivors.

As initial rearing conditions seem to be determinant for sex ratio, promising perspectives are open for a high proportion of male, if not monosex, culture. This is of interest because females reduce their growth rate early when they reach sexual maturity.

INTRODUCTION

Hoplosternum littorale is a Callichthyid armoured catfish of wide distribution in northern South America. Its preferential biotopes are swamps and marshes. As many fishes inhabit oxygen deficient biotopes, it is an air breather. A special adaptation of large intestine epithelia enables it to use atmospheric oxygen.

It has a very high commercial value in countries like French Guiana, Suriname, Guyana, and Trinidad. For some of the market the needs are covered by importations from Brazil and Venezuela where there are small scale fisheries on abundant floodplains.

The data on its biology, even scarce, and the success obtained on the first attempts in rearing (Singh, 1978; Machado-Allison, 1987), indicate that it should be able to be cultivated. Thus, there is an opportunity to develop its culture, even if its economical impact seems to be limited. The aim of this paper is to present the state of the art on this field, summarizing the works we have done during the last few years.

CULTURE PRACTISES

Age and season for spawning

Both male and female reach sexual maturity during the first year, and sometimes as early as 6 to 7 months if they are old enough at the rainy season which is the normal spawning season. Sexual dimorphism, other than size, becomes visible only just before or during spawning period (Winemiller, 1987). The most characteristic differences are the thickening of both fin and spiny ray of pectorals for males.

Spawning behaviour

Spawning occurs in floating nests built by the male on the water surface with froth and vegetals fragments. The different stages of reproductive behaviour : pair formation, nest building, egg laying, fertilisation, and care of the eggs have been well described by Gauthier et *al.* (1988). The most peculiar steps are the oral milt collection by the female and its transfer to the foam bed before laying. The male maintains the nest until hatching adding bubbles, and protects the eggs by vigorously attacking any intruder.

Fecundity

The number of eggs counted in nests collected from the wild or in ponds ranges from 3100 to 51500 (our observations), from 5600 to 55300 (Machado-Allison and Zaret, 1984), and from 2000 to 22800 (Singh, 1978), with respective average numbers 14700, 17100, and 10200. This indicates that there are multiple layings in a nest. Indeed, during a complete spawning sequence, a 100 g. female layes from 600 to 10000 eggs as observed in aquaria or in small tanks. This amount corresponds well to the observations of Machado-Allison and Zaret (1984) who counted an average of 4500 mature ovules in females ready to spawn. These authors noticed also the presence of non mature ovules. Successive spawnings — up to 9 — are effectively observed in tanks. In a 1000 m^2 pond stocked with 4 males and 12 females (97 g. body weight), we counted 290 000 eggs in the 17 nests controlled (total nest number : 21) during a 50 days period of observation. This indicates a seasonal fecundity higher than 250000 eggs per kg body weight. This is to be considered as very high taking into account the large size (1.4 mm in diameter, and 3.5 mg in weight) of the eggs.

Broodstock management

Due to multiple spawnings in a single nest, as well as the territorial behaviour of the males during the successive steps of nest care, spawning ponds can be stocked with more females than males. We use a satisfactory ratio of 3 to 1, even if we don't know the optimal value. Small ponds of 500 to 1000 m2 are used but at very low density (20 individuals) as, even if not quantified until now, it appears clearly that high stocking rates contraries both nest elaboration and egg number. There seems to be intraspecific disturbances since the presence of other species as *Myleus rhomboidalis* and young *Plagioscion squamossissimus* perturbs less the reproduction. The needs for space for all stages of spawning are not so large, as normal spawnings are observed in half m2 aquaria (200 litres). Such a method of reproduction in aquaria is very useful when one wants to get eggs on a precise date. If the fish are previously kept in separated tank, the nest building starts 24 hours after the partners are brought together.

Incubation and hatching

Nest building takes place during the night but laying is often delayed until the following night. So it is not easy to control how long the incubation lasts. But in most cases we observed hatching about 60 hours after laying, when the temperature averaged 30°C for water and ranged from 23 to 32°C for the air. Fertility is about 100 %, in the same way as hatching rate. For the ulterior easy management of the larvae, it is desirable to conduct the end of incubation out of the nest and then collect larvae free of grass fragments.

The most useful technology we found is to draw the aggregated egg cake from the nest early in the morning of the third day after the appearance of the nest, and to end incubation of the whole mass standing on nylon wires at a few centimetres above the surface of the water. This method runs well in more than 80 percent of the trials and draws more than 85 percent hatching rate.

Larvae and fry culture

When hatched in ponds, the fry resilience is very low : after a month only few fingerlings — some per thousand to some percent — can be recovered in the spawning pond. A predation by the parents cannot be implicated as we observe the same poor results when a fish free pond is stocked with a hatching nest. At that time we don't know the reasons of such a dramatic mortality. We can own to wide daily pH variations : in French Guiana the natural waters and the soil are demineralized so they do not have any buffer capacity, and pH can fluctuate 2.5 points according to photosynthesis intensity. Other aggression as predation should be suspected, for example there are in some ponds more than one Odonate larvae per mó and these predators can eat more than 30 fish larvae per day. A trophic deficiency can be also suspected due to water poorness in fertilizers, even if manure is added.

But, in all cases, direct pond transfer of newly hatched fry gives very good growth rates, reaching 12 g body weight in one month.

In order to avoid this problem of survival, and to screen responsible factors, rearing in tanks constitutes one way : predators are easy to control, and pH remains constant. More, this technique can be done easily as at hatching *H. littorale* weights 2 mg and is 6 to 7 mm long.

Singh (1978) succeeded for the first time to produce fingerlings indoor when using live food, mainly periphyton. In our trials, in standing water tanks of 300-500 litres capacity, with a half water renewal once a week, the survival rate at 30-40 days ranges from 28 to 80 percent using trout crumbles as only one food. At this time these values are very encouraging in terms of survival rate. Unfortunately, the concomitent growth is very low, as the mean weight does not exceed 500 mg. This do not constitute a redhibitory handicap, because the ulterior growth in ponds follows a similar pattern to that observed with a direct fry rearing in ponds.

Growth in ponds

Growth potentiality in ponds appears very high as the mean weight increases twofold every month. *H. littorale* reaches, in this way, 50 g at the end of third month. Beyond it is observed a differential growth rate according to the sex. It still goes on until 150 g for the males, whereas it goes slower for females which reach a ceiling of about 100 g. Early sexual maturity seems to explain one part of these limitations, and maximum sizes round about 300 and 200 g respectively.

This fish needs to be reared in very low density (0.2 fish/m2) to reveal such potentialities even when a feeding rate of 3.5 % body weight per day is used. We do not know the main responsible parameter for such a low growth rate in higher densities, a crowding factor as well as bad feeding practises can be suspected.

NICTHEMERAL CYCLES

Feeding behaviour

In the wild, *H. littorale* is known for its nocturnal behaviour. Thus some experiments have been conducted on nicthemeral cycles for feeding and respiration.

Voluntary feeding has been studied using demand feeders based on a mechanical push of a swich driving an electric feeder. A circadian cycle is observed with a pronounced peak of nocturnal trophic activity very pronounced from 2 to 5 am. During these 3 hours, fish feed themself 40 per cent of total daily intake which oscillates around 3.5 % body weight. A lighter feeding peak is also observed just after the light is turned off. The same behaviour is noticed when the dark-light cycle is advanced, and this is true for both the first and the last day of photophase changes. Then it appears that the light-dark change constitutes the synchronizer.

This night trophic behaviour seems to be suspected as one among explanatory factors for the weak growth observed both in aquaria and in ponds at high densities when we use the normal feeding schedule during day-light.

Respiratory balances

The obligatory nature of air breathing for this fish has been studied holding it in oxygen saturated water without any surfacing abitily. A total mortality is observed within the first month. It begins early as it reaches 40 % at the end of the first hour.

In such condition *H. littorale* cannot compensate the air oxygen respiration by increasing aquatic oxygen uptake which values are 230 mg/kg BW./hour in « normoxic » situation. Aquatic respiration is hardly exhausted as it only increases until 250 mg/kg BW./hour when fish is not able to surface. Metabolism becomes anaerobic as simultaneously carbon dioxide excretion (which in every case is always aquatic) stands at 450 mg/kg BW./hour. This corresponds to a respiratory coefficient of 1.23. Such a phenomenon is known on some other fishes held in anoxic conditions.

In normal conditions, aquatic oxygen uptake remains constant (230 mg/kg BW./hour) and does not show nor circadian nor postprandial variations. Air breathing appears to be the only way to cover oxygen requirements following on locomotory activity, food intake and metabolisation. According to this, surfacing intensities vary cyclicaly with two night peaks, the first at dusk following the increases of locomotory activity, and the second at the end of the night following the food intake.

Then air breathing appears to be not only an adaptative behaviour making life easier in low oxygen waters, but an obligatory mechanism.

SEX RATIO PROBLEM

In the wild, a normal (50/50) sex ratio is observed with *H. littorale* (Singh, 1978). The compilation of successive trials done in our laboratory for different purposes brings us to wonder about sex ratio flexibility in *H. littorale.* When the larvae are reared directly in ponds, with few days (1 to 5) maintenance in concrete tanks before pond stocking, the observed sex ratio is normal. The pond management consists of feeding it daily with trout starter meal on the basis of 2 to 6 kg per hectare; whether this food is used directly or as manure has to be checked.

When larvae are kept for 20 to 40 days in plastic or concrete tanks, with trout crumbles or starter meal as main food, the ulterior sex-ratio is very unbalanced. Recorded values range from few to 25 percent of males.

At the present this constitutes a major inconvenient as we produce a large proportion of low growing females instead of fast growing males. A reverse high percentage of males should be more advisable.

The question of sex determinism in this fish species arises. If there is a genetic determinism, this means that phenotipic sexes can be oriented by the initial rearing conditions. At this time we do not know if the main factors are the holding conditions or if there is a direct effect of the food or both.

But if the hypothesis of the production of neo-females genetically male fish is proved to be correct, some promising fields are open. One can hope for a high proportion, if not total, of males at the F2, when breeding such neo-females. Naturally the successive steps of this hypothesis still have to be tested.

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