ADVANCES IN TROPICAL AQUACULTURE. Tahiti Feb 20 - March 4, 1989
AQUACOP IFREMER Actes de Colloque 9 pp 699-709

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Problems related to the lack of functional swimbladder in intensive rearing of *Dicentrarchus labrax* and *Sparus auratus*.

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Abstract. — *The primordial inflation of swimbladder normally occurs at a size of 4 to 5 mm in sea bream Sparus auratus and 5 to 6 mm in sea bass* **Dicentrarchus labrax.** *However, in intensive larval rearing conditions, lack of inflation is often observed and leads to the production of up to 80 % of postlarvae whose swimbladder is not functional. They are, on the average, 20-30 % smaller in weight than normal fry. Their survival rate can also be reduced by any kind of stress such as weaning, handling or hypoxic conditions. It is suggested that the selective mortality which affects the abnormal fish results both from a decrease in predatory efficiency and an increase in energetic needs. The lack of a functional swimbladder in larvae will also lead to lordosis in older fish. This skeletal deformity appears at a size of roughly 20 mm and the lordosis angle increases afterwards. It is hypothesized that lordosis appears because those fish which cannot modulate their density, are continuously swimming in an oblique position to avoid sinking.*

Primordial inflation can be artificially inhibited by preventing the larvae from reaching the water surface, suggesting that air gulping is necessary to realize it. Systems which eliminate, from the surface, the naturally occuring oily film, significantly improve the inflation rate in reared sea bass and sea bream populations.

INTRODUCTION

Strong interest has been raised in recent years concerning the swimbladder of Teleosteans. This organ, which develops from the dorsal wall of the digestive tract, plays an important role in hydrostatic regulation, perception and sound production and respiration (for a detailed review see Harden-Jones, 1957; Steen, 1970; Love, 1981). Its morphology and physiology is well known in adult fish but little information is available on its post-embryonic development, especially in reared *Serranidae* and *Sparidae*.

The swimbladder primary inflation of the Japanese sea bream *Pagrus major* was studied by Yamashita (1966, 1982), Takashima et *al.* (1980), Kitajima et *al.* (1981) and Chatain (1982). Beside the morphological and biometrical aspects of the development, these authors also gave some indications on the relationship between the lack of inflation and fish development anomalies, in particular skeletal deformities. Doroshev and Cornacchia (1979), Bulak and Heidinger (1980), Doroshev et *al.* (1981) discussed similar results for the american sea bass *Morone saxatilis*, Giavenni and Doimi (1983), Weppe and Bonami (1983) and Johnson and Katavic (1984) for the european sea bass *Dicentrarchus labrax* and Paperna (1978) and Weppe and Bonami (1983) for the common sea bream *Sparus auratus.*

In 1982, larval rearing of *Dicentrarchus labrax* and *Sparus auratus* produced, in France, roughly 400 000 fry of which 70 to 95 % presented swimbladder anomalies. Research undertaken by IFREMER to significantly improve the larval rearing techniques of these two species led to the production, in 1988 of 6 millions normal fry. The aim of the present paper is to summarize the main steps of this research.

MORPHOLOGICAL ASPECTS OF THE DEVELOPMENT OF THE SWIMBLADDER

In sea bass and sea bream the primordial swimbladder can be observed *in vivo* by transparency as early as the third day after hatching. In both species, normal swimbladder development, from the initial vesicle, is characterized by two stages.

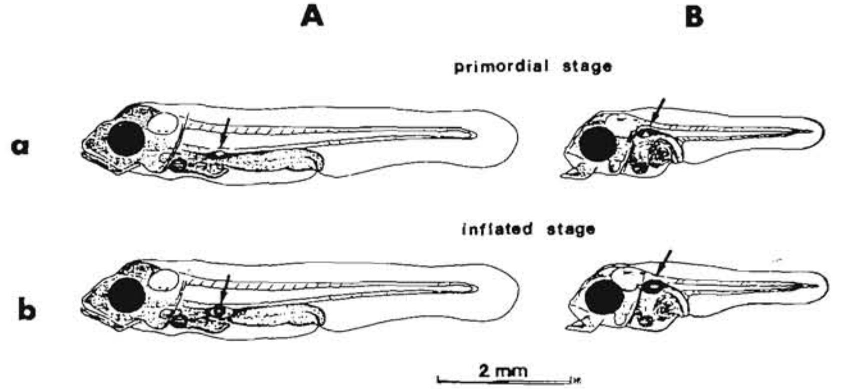

Fig. 1. — The two stages of the swimbladder (arrow) in (A) *Dicentrarchus labrax* and (B) *Sparus auratus* (a) prior and (b) after inflation (from Chatain, 1986).

The first stage, called « initial inflation », is characterized by the apparition of a light refractive bubble in the initial vesicle (Fig. 1). It occurs in 5 mm sea bass larvae (around 7 days old) and 4 mm sea bream larvae (around 5 days old). Inflation coincides with oil globule resorption (Fig. 2). When initial inflation fails, the swimbladder development is stopped at a stage ressembling that prior to inflation and is not functional. Its size is always inferior to the size of the inflated swimbladder.

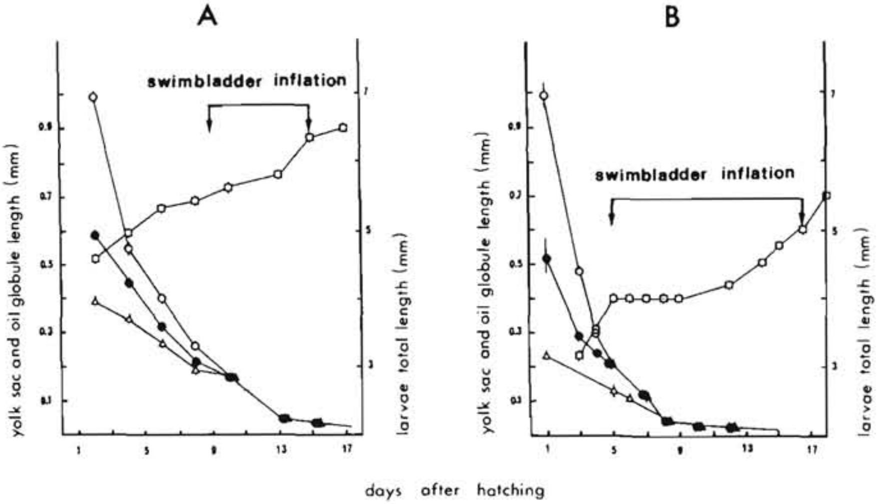

Fig. 2. — Resorption of the yolk sac [length (○) : width (●)] of the oil globule (△) and growth in length of larvae (□) of (A) *Dicentrarchus labrax* and (B) *Sparus auratus.* Mean values are represented with their confidence interval ($\alpha = 5\,\%$) (from Chatain, 1986).

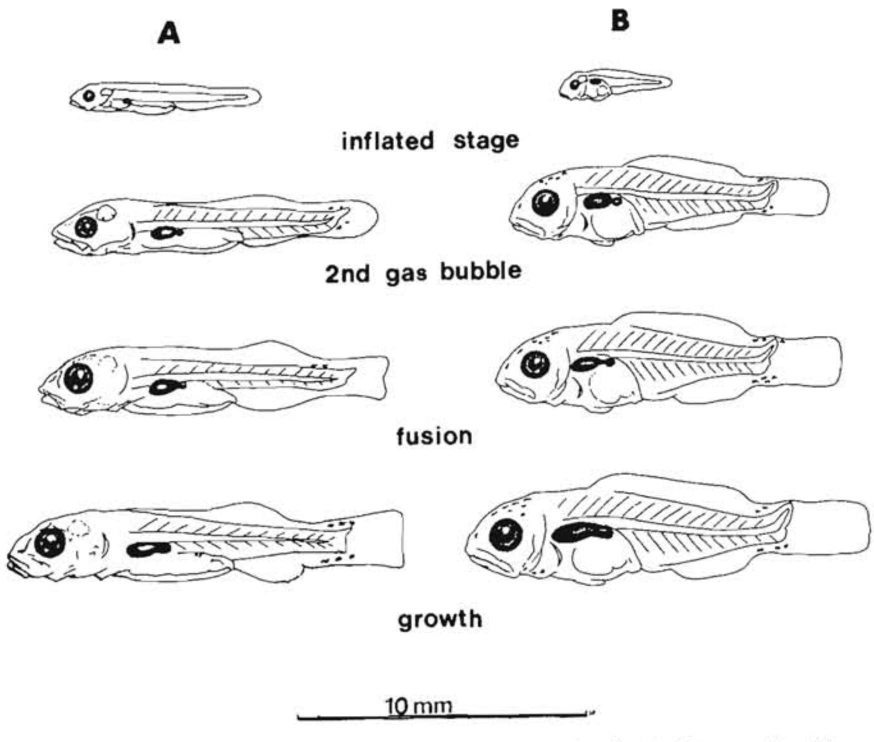

Fig. 3. — The different stages of the swimbladder expansion in (A) *Dicentrarchus labrax* and (B) *Sparus auratus* (from Chatain, 1986).

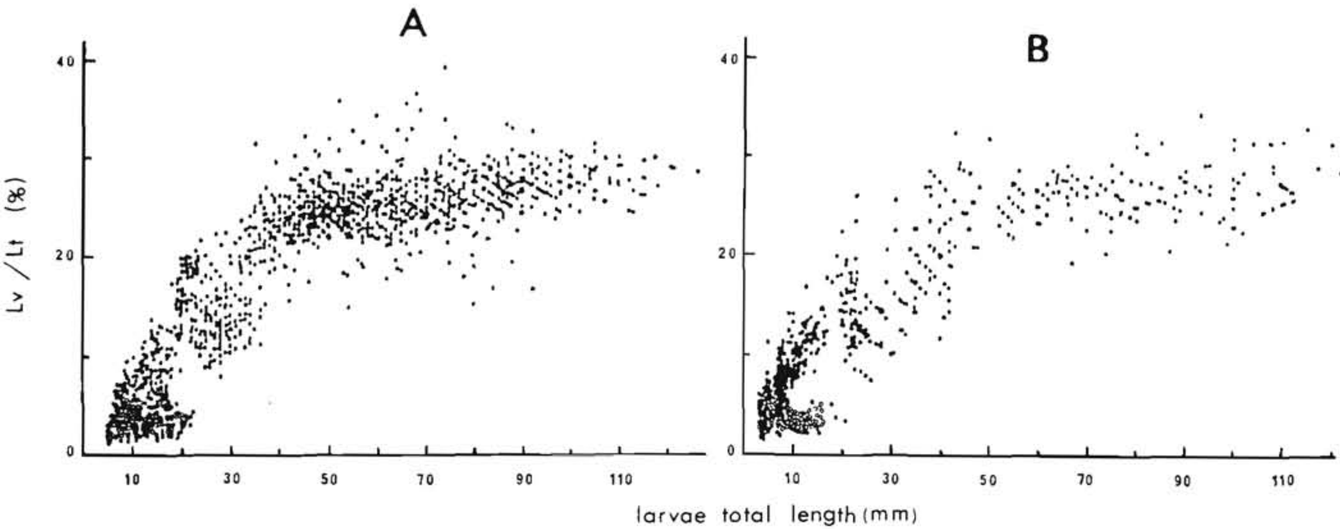

Fig. 4. — Evolution of the ratio of swimbladder length (Lv) to fish total length (Lt) versus growth in (A) *Dicentrarchus labrax* and (B) *Sparus auratus*. Individuals with (●) or without (○ a functional swimbladder (from Chatain, 1986).

The second stage corresponds to an expansion phenomenon. In larvae greater than 12 mm long, the swimbladder looks like an ellipsoidal vesicle which progressively stretches backwards during growth (Fig. 3). It becomes stable in 40-50 mm fish reaching 20 to 30 % of the total length (Fig. 4). Among larvae which fail to inflate, the swimbladder development stops and the bladder never exceeds 3-5 % of the fish length.

INFLUENCE OF THE SWIMBLADDER DEVELOPMENT ANOMALIES ON LARVAL GROWTH

In intensive larval rearing conditions, lack of inflation is often observed and leads to the production of up to 80 % of postlarvae whose swimbladder is not functional. It was showed that such postlarvae were smaller in size and weight than normal ones (Fig. 5).

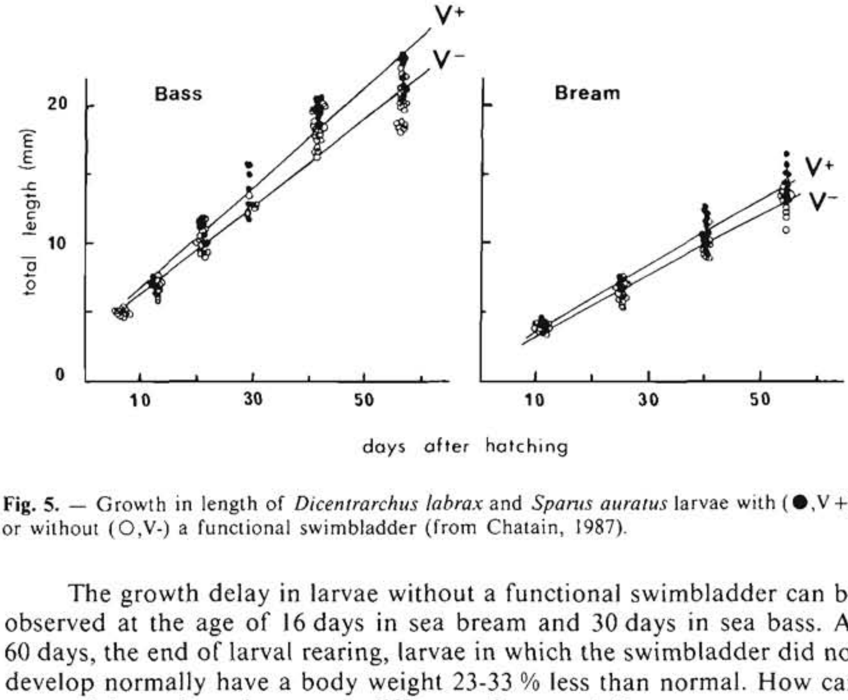

Fig. 5. — Growth in length of *Dicentrarchus labrax* and *Sparus auratus* larvae with (●,V+) or without (O,V-) a functional swimbladder (from Chatain, 1987).

The growth delay in larvae without a functional swimbladder can be observed at the age of 16 days in sea bream and 30 days in sea bass. At 60 days, the end of larval rearing, larvae in which the swimbladder did not develop normally have a body weight 23-33 % less than normal. How can we explain such an important difference in growth ?

Competition for food seems unlikely because in intensive rearing conditions, larvae are always fed in excess. The growth difference most probably lies in the higher energetic needs of abnormal larvae which present buoyancy anomalies. Such anomalies affect the swimming behaviour of the larvae as soon as the yolk sac resorbtion is completed. The development of a functional swimbladder provides the capability for hydrostatic regulation and thus the ability to overcome increasing specific gravity. The achievement of neutral buoyancy probably reduces the energetic cost of swimming and improves predatory efficiency.

INFLUENCE OF THE SWIWBLADDER DEVELOPMENT ANOMALIES ON LARVAL REARING

The larvae which have no functional swimbladder are viable but show a strongly reduced resistance to any kind of stress like handling, hypoxic conditions or weaning. In the case of weaning, the survival rate could be directly related to the proportion of normal fish initially present in the group (Fig. 6).

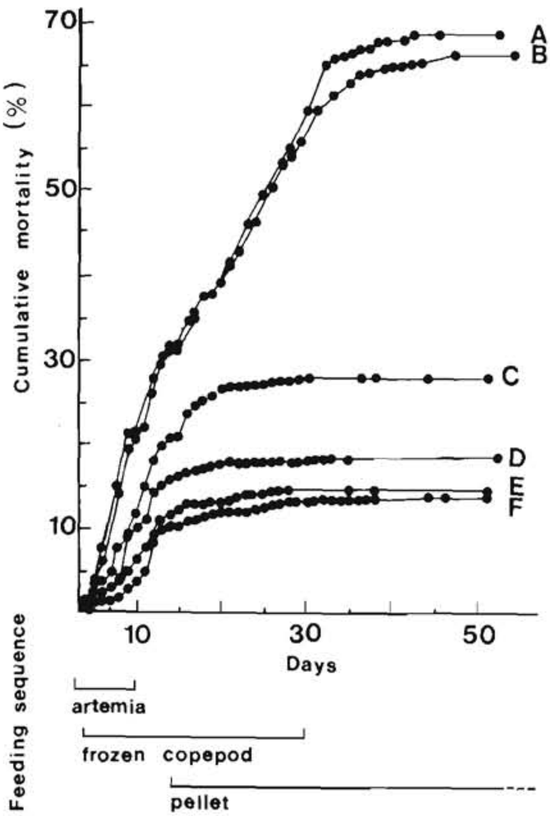

Fig. 6. — Weaning mortality in 6 groups of seabass, *Dicentrarchus labrax*, presenting, at begining of experiment, different functional swimbladder proportions: group A : 1 %; group B : 1 %; group C : 51 %; group D : 61 %; group E : 80 %; group F : 82 % (from Chatain and Dewavrin, *Aquaculture*, in press).

The radiography of dead fry revealed that 86 to 100 % of these animals had no functional swimbladder (Fig. 7). It is again suggested that the observed selective mortality results both from a decrease of predatory efficiency and higher energetic needs in abnormal fry.

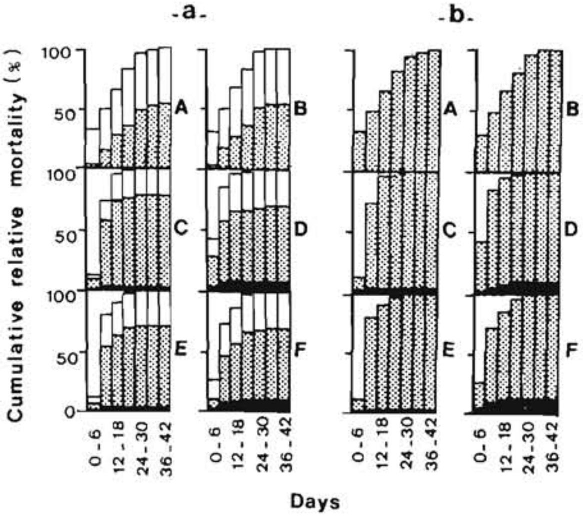

Fig. 7. — Relative cumulative mortality during the weaning of *Dicentrarchus labrax* fry with (■) and without (▭ ...) functional swimbladder ▭ : fry whose state does not allow classification. a - gross results; b - corrected results by inclusion of undetermined fish in the two others categories (from Chatain and Dewavrin, *Aquaculture*, in press).

RELATIONSHIP BETWEEN UNINFLATED SWIWBLADDER AND LORDOTIC DEFORMITIES

In mass rearing conditions, various types of deformations commonly occur but skeletal abnormalities and especially the V shaped lordosis, are the most important (Fig. 8).

In lordotic individuals, two or three vertebrae are deformed at the curving point of the spine. They are always located behind the digestive mass. Such a skeletal deformity appears on larvae measuring roughly 20 mm both in sea bass and sea bream. At this size, the lordosis angle is small. The occurence and the angle of the lordosis will increase as the fish grow.

It was found that there was a close relationship between the occurence of lordosis and the rate of uninflated swimbladder. It is hypothesized that lordosis appears because the fish which cannot modulate their density are continuously swimming in an oblique position to avoid sinking.

IMPROVEMENT OF THE PRIMARY INFLATION RATE OF THE SWIWBLADDER

Primordial inflation can be artificially inhibited by preventing the larvae from reaching the water surface (covering the water surface with a liquid paraffin layer) suggesting that air gulping is necessary to realize it.

The low inflation rates (< 30 %) observed to date in those species under intensive rearing conditions, could therefore eventually be related to the presence of a superficial oily film which usually develops from the feed. Three systems intended to remove this natural layer were tested (Fig. 9) : a hydrojet (a) and a sprinker (b), connected to the sea water arrival, which concentrated the oily layer on the tank walls and a blower (c and d) concentrating the film in a floating trap.

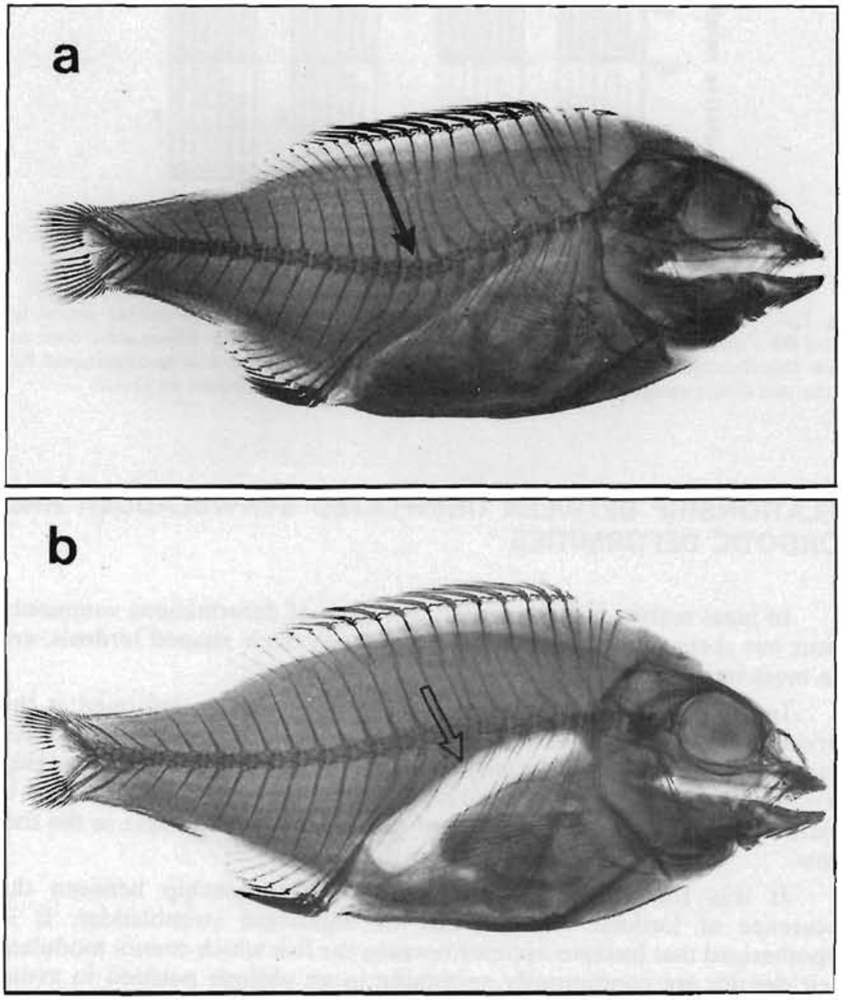

Fig. 8. — - a - sea bream juvenile without a functional swimbladder and with a lordosis (→); - b - normal juvenile with a functional swimbladder (⇒) (from Chatain, 1982).

The only system which significantly improves the inflation rate (80 %) without disturbing the growth (Fig. 10) is the blower. The two other systems have either little (sprinkler) or no effect (hydrojets) on the inflation rate (Table 1). Although they are efficient in removing the surface film, they create strong water turbulences and these probably prevent the larvae from reaching the surface in due time.

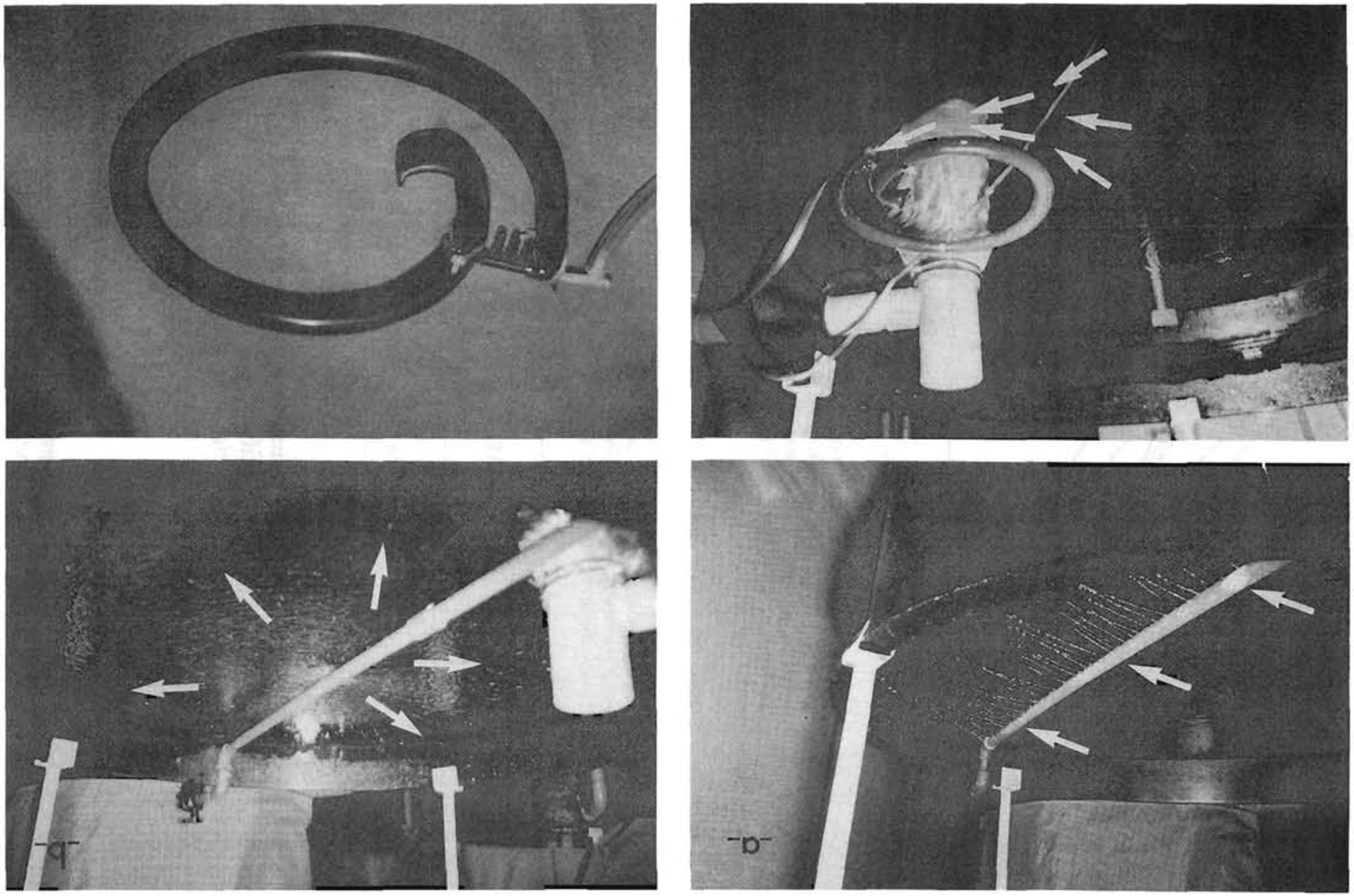

Fig. 9. — The three systems tested to remove the oily superficial layer which develops at the water surface of the rearing tanks. a : hydrojets; b : sprinkler; c and d : blower.
→ Movement of the superficial layer (from Chatain and Ounais-Guschemann, submitted to *Aquaculture*).

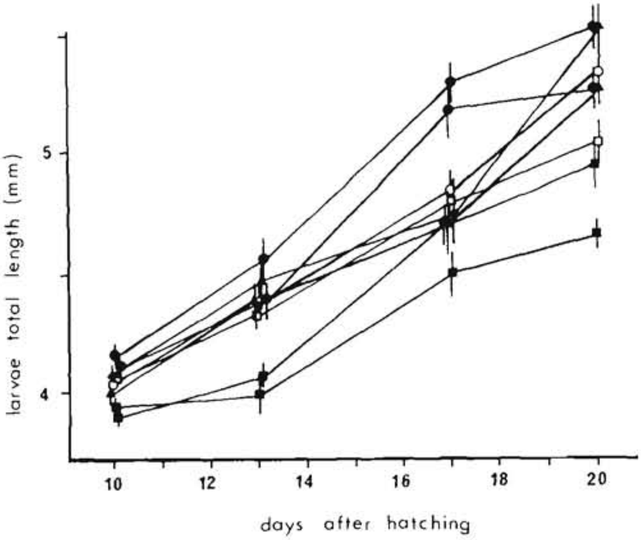

Fig. 10. — Growth in length of *Sparus auratus* larvae, within groups differing by the water surface treatment. Surface cleaned by hydrojets (■); sprinker (▲); blower (●); surface sealed by a liquid paraffin layer (□); control with uncleaned surface (○). The mean values are represented with their confidence interval ($\alpha = 5\,\%$) (from Chatain and Ounais-Guschemann, submitted to *Aquaculture*).

Table 1. Comparison between the functional swimbladder rate (V+) obtained, 20 days after hatching, in tanks whose surface was cleaned and in the uncleaned control. U test, standard error method with angular transformation (Dagnelie, 1975). NS : not significant; * : significant at the 5 % level; ** : significant at the 1 % level (from Chatain and Ounais-Guschemann, submitted to *Aquaculture*).

CLEANING SYSTEM	HYDROJET		SPRINKLER		BLOWER		CONTROL
REPETITION	1	2	1	2	1	2	1
V+ (%)	0	13	36	44	80	81	28
U test	2.341*	2.254*	0.969NS	1.870NS	5.682**	5.769**	—

By the use of this simple system, which greatly enhanced the swimbladder inflation rate, it was possible to significantly improve the growth and survival rates of the two species and to suppress the occurence of lordosis.

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