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A new cleaning system for rearing tanks in larval fish culture

by

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ABSTRACT

An automatic system for cleaning the bottom in larval rearing tanks has been developed and tested in a preliminary trial with Atlantic halibut. The system can be applied for a wide range of species and feeding regimes. A cleaning system is essential for keeping good hygienic conditions, particularly when formulated food is used during the larval stages. The present cleaning system consists of a draining arm fitted to a centrally placed rotating connection through the tank bottom. This rotating connection is powered by an electric motor with a gear mounted on the underside of the tank. The draining arm is a tube with downward holes at regular intervals, and it is covered with a shield resting on a squeegee. Water outlet of the tank is through the arm, which enables particulate organic material to be collected, concentrated under the draining holes, and flushed out at regular intervals either manually or automatically. Hence, labour and disturbance due to tending are substantially reduced, and accumulation of organic material as substrate for bacterial growth can be prevented. Description and function of the system are discussed in relation to a preliminary rearing trial with Atlantic halibut larvae fed *Artemia* for 10 days. In this experiment, mortality and ammonia levels in the automatically cleaned tank were substantially lower than with the traditional siphon tending, while larval growth rate in the automatic system was more than twice of that observed with traditional cleaning.

INTRODUCTION

Successfully development of highly intensive rearing techniques for marine fish larvae and fry may be dependent on that certain environmental factors in the tanks (e.g. oxygen saturation, ammonia concentration, and microbial growth) can be controlled. Mostly, the control of such factors will be interactions between stocking densities (total biomass of larval fish), food supply (amount and type of prey items), and water exchange. Water exchange rate may be limited to the mobility and fragility of the reared organism, but oxygen depletion due to high larval and food densities can be manipulated by aeration or direct injection of oxygen to the inlet water pipes. If the food requirements of the reared larvae are met, the next limiting factor may be microbial growth on the basis of accumulated organic material (faeces and food remains) in the tank. Blooming of potential fish pathogens may cause considerable losses among the reared larvae. In addition, the microbial activity may produce ammonia which together with the excreted ammonia from the larvae and live prey may exceed limits of harmful effects on larval growth, development and survival (Guillén *et al.*, 1993; 1994).

For Atlantic halibut (*Hippoglossus hippoglossus* L.) the high food demands through the larval stages (van der Meeren, 1995) may have a considerable effect on the above mentioned environmental factors. At stocking densities of 3-4 per litre, the halibut larvae produce a considerable daily amount of faeces which together with dead uningested prey (*Artemia*) have to be manually removed at least every second day by a siphon. Despite this tending procedure, oxygen has to be supplied and ammonia has showed to build up in the tanks. This has caused a need for development of more efficient tending systems, which enable frequent cleaning of the tank bottom without the disturbance made by the traditional siphon tending. Further, due to restricted availability and nutritional deficiencies of *Artemia*, research seems to concentrate on formulated feed for larval fish. Thus, development of efficient cleaning systems is even more accentuated when considering the needs for keeping good hygienic conditions when formulated food are used during the larval stages.

The current paper presents an automatic cleaning system for circular tanks. Description and function of the system are discussed in relation to a preliminary rearing trial with Atlantic halibut larvae fed *Artemia*.

MATERIALS AND METHODS

Description of the cleaning system

The present cleaning system is developed by Institute of Marine Research, Austevoll Aquaculture Research Station in coorporation with a local electro-mechanical company (Austevoll Rør og Elektromekaniske AS). It can be adapted to various tank sizes and placed in already existing tanks used for larval fish culture.

The cleaning system consists of a draining arm fitted to a centrally placed rotating connection through the tank bottom (Fig 1). This rotating connection is powered by an electric motor (12-24V DC) with a gear mounted on the underside of the tank. The draining arm is a tube with downward holes at regular intervals, and it is covered with a shield resting on a squeegee (Fig. 2) which compensates for unevenness or flexions of the tank bottom. The squeegee is pointed forward in the direction of the movement of the draining arm. Water outlet of the tank is through the arm, which enables particulate organic material to be collected, concentrated under the draining holes, and flushed out at regular intervals, either manually by hand or automatically by a magnetic valve.

The speed of the draining arm can be controlled by the DC voltage of the electric motor, and 24V DC gives a 360° turn in approximately 35 minutes. The frequency of cleaning turns per day is controlled by a timer, and the signal and period for automatic flushing are given by a combi recycler (Electromatic S-System S 1231).

Larval rearing

The automatic cleaning system was compared with traditional tending (by siphon every second day) in a pilot larval rearing trial with Atlantic halibut. The experiment lasted for a period of 10 days after initiation of exogenous feeding. The larvae were hatched and stored through the yolk-sac stages as described by Harboe *et al.* (1994). Two black polyethylene tanks (1m diameter, 390 litre water volume) were stocked with approximately 3000 larvae each. At stocking, larval development corresponded to 285 daydegrees post-hatch. Frequency of gaping deformity (Blaxter *et al.*, 1983; Pittman *et al.*, 1990), commonly observed when transferred to the start-feeding system from the yolk-sac incubation silos, were as low as 11%. Temperature in the silos at transfer was 6.0°C, and water of 9.0°C was used to fill the two start-feeding tanks. The water was left stagnant for one to allow a gradual temperature increase to 12°C. One day after stocking the water flow was set to 0.28 litre per minute (100% of tank water volume per day). Illumination was continuous for 24 hours per day

(one 18W light tube for each tank). Green water was used to enhance larval feeding (Naas *et al.*, 1992), and algae (*Tetraselmis* sp.) were continuously supplied to the tanks to give a turbidity of 1.0-2.5NTU (HACH 2100P turbidimeter). *Artemia*, enriched for 18 hours with DHA Selco and vitamin premix, was used as food. The larvae received *Artemia* twice a day (morning and evening). Food densities were counted every morning before food supply, and additional *Artemia* was then administered to the larval tanks so that the final concentration reached approximately 1000 prey per litre. In the evening, additional *Artemia* up to 500 prey per litre tank volume was supplied. To circulate tank water and larval prey, and to distribute the halibut larvae toward the upper water layer in the tanks, continuously aeration was used in the centre of both tanks. Analyses of ammonia (salicylate-hypochlorite method: Bower & Holm-Hansen, 1980) was carried out on water samples of surface tank water.

In the tank with traditional tending, a siphon was used to remove organic material from the bottom every second day. The siphoned water and material were filtered through a 350µm sieve to recover the number of halibut larvae removed from the tank. In the other tank with the automatic cleaning system, one cleaning cycle consisted of a 460° clockwise turn lasting for 45 minutes, followed by a period of 35 seconds automatic flushing of the collected debris by a magnetic valve. Three such cycles were performed every 24 hour. Removed halibut larvae were collected on a 350µm sieve from the flushing outlet. Similarly, larvae removed though the ordinary drain pipe of both tanks were also collected.

At termination of the experiment on day 10, 25 larvae from each tank were fixed in a 0.5% glutaraldehyde + 2.5% paraformaldehyde solution buffered with cacodylate (Helvik & Karlsen, 1996). After 5 month storage, the larvae were dried 24 hours at 60°C and weighed on a Mettler 3M Microbalance (±1µg).

RESULTS AND DISCUSSION

Temperature in the rearing tanks was between 11.9 and 13.2°C. Oxygen concentration was slightly above 100%. Most halibut larvae remained in the upper half of the tank. Almost all larvae removed from the tanks were dead, and the number of larvae removed by traditional tending or automatic cleaning is shown as cumulative mortality in Fig.3. Mortality was highest in the beginning of the experiment, which is normally seen in rearing trials with larval halibut. However,

mortality persisted to day 6 in the tank with the traditional tending procedure, while mortality ceased in the automatically cleaned tank at day 3. The total mortality in the traditionally tended tank was more than twice of what was found in the tank with the automatic cleaning system. Tending every second day allows considerable amounts of organic material to sediment on the tank bottom. This was also observed, and probably provided a good substrate for microbial growth. Further, tending by siphon will disperse some of the sedimented material in the water column, including remains of decaying larvae. This is most unfortunate, because it may increase contact between larval pathogens and the viable larvae in the upper half of the water column. In contrast, the automatic cleaning system was observed to effectively remove debris from the tank bottom without dispersing any of the organic material in the tank water. This was due to the slow speed of the cleaning arm compared to the siphon, and that the squeegee and the shield of the draining arm locked the debris under the draining holes where water continuously is removed from the tank.

Larval dry weight at day 10 was 1.87 and 3.50 mg in the traditionally tended and automatically cleaned tanks, respectively (Fig.4). This corresponds to specific growth rates (SGR: exponential growth model of Ricker, 1958) of 5.1 and 11.3% daily increase in weight. With a constant supply of food, daily ration and growth rate were expected to be lowest in the automatically cleaned tank, which compared to the siphon-cleaned tank had the best survival. In fact, the observed difference in growth between the two tanks was opposite to this, and 11.3% SGR is among the highest values ever reported for such young halibut larvae.

Besides the microbial exposure, larval feeding behaviour is probably also affected by the traditional siphoning method. The visual and mechanical disturbance (tubulent shear) of the moving siphon through the water column produces escape responses among the larvae. It is most likely that such stress will reduce daily food ingestion, which may partly explain the observed differences in larval growth. In addition, monitoring of ammonia showed increased levels in the traditionally tended tanks (Fig. 5). Although ammonia was low in the experiment, very little is known of how sub-lethal levels of ammonia may affect development and growth in fish larvae. Guillén *et al.* (1993) observed effects of ammonia on growth in red sea bream at concentrations that was not very much higher than found in the present experiment.

The new cleaning system has so far only been tested with halibut larvae in a single pilot experiment. More testing is needed to verify possible biological effects of the system, and this will be done in the near future in larval rearing trials of both halibut

and other commercially interesting fish species, e.g. turbot. The system will also be tested in experiments with formulated feed. Such experiments will be of particular importance because early weaning or initial start-feeding on formulated feeds in most cases will produce a heavy organic load in the tank system. A good cleaning system is therefore essential for keeping good hygienic conditions with the use of formulated feeds.

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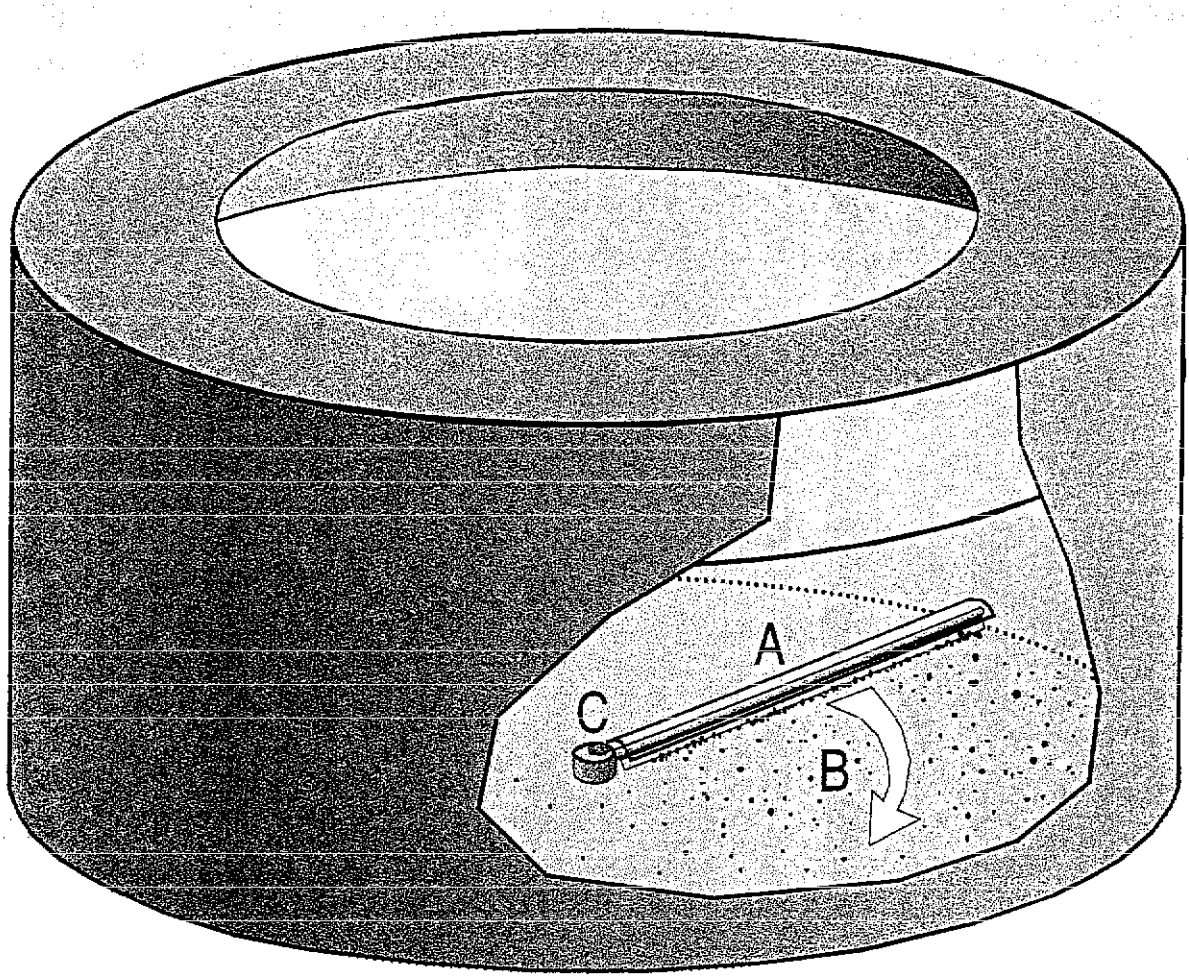

Figure 1: Schematic drawing of the cleaning system viewed inside the tank. The draining arm (A) is a tube covered by a shield and resting on a squeegee. The arm moves slowly clockwise (arrow) to collect sedimented organic material (B) which is concentrated underneath the draining holes of the draining arm. The arm can easily be detached (lifted) from the centrally placed rotating connection (C) through the tank bottom.

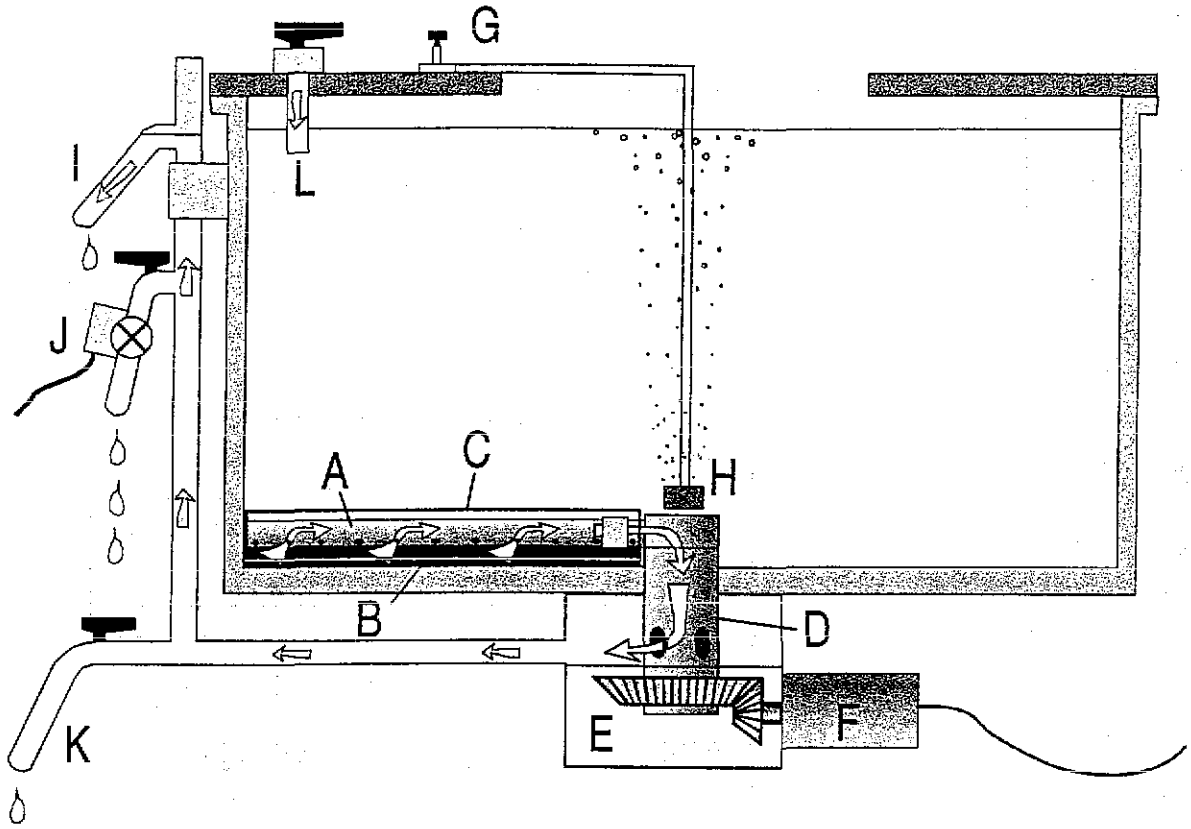

Figure 2: Sketch of the different components of the cleaning system mounted in the rearing tank. Arrows show draining of water from the system. The electric motor and magnetic valve are connected to a control unit (see text for further details).

A: Draining arm with holes underneath
B: Rubber squeegee pointing forward in the direction of movement
C: Shield covering the draining arm
D: Centrally placed rotating connection through the tank bottom
E: Gear
F: Electric motor (12-24V DC)
G: Valve for control of air flow
H: Air stone
I: Ordinary drain pipe
J: Flushing pipe with magnetic valve
K: Drain pipe for emptying the tank
L: Water inlet

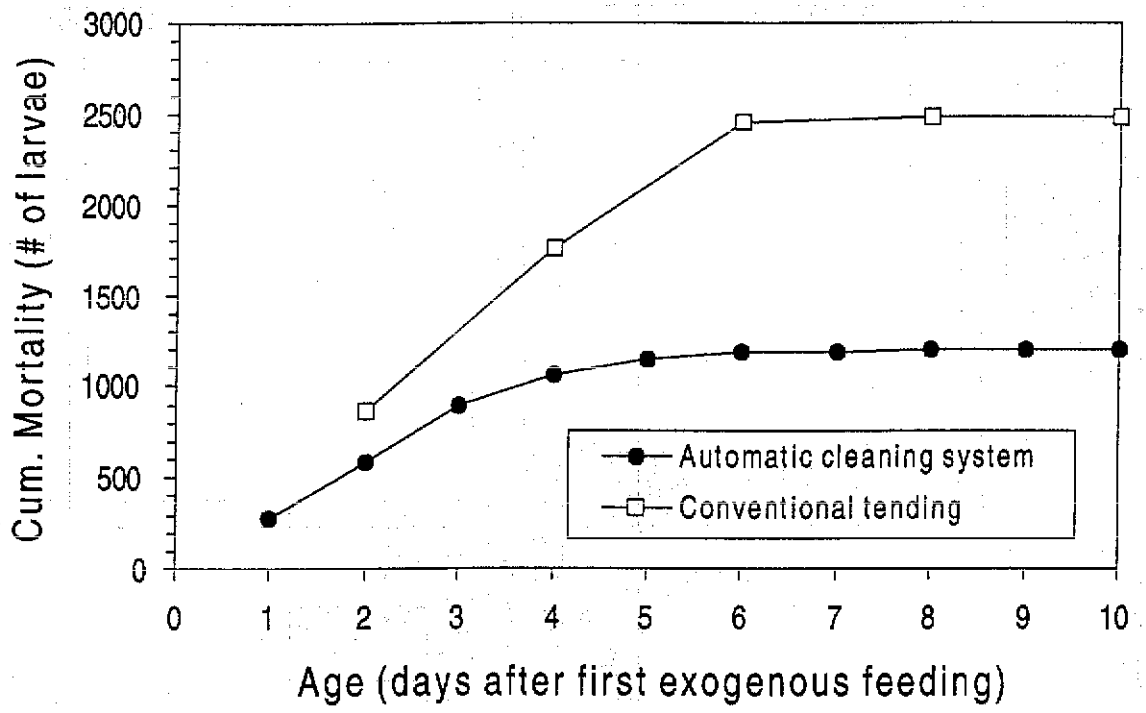

Figure 3: Cumulative numbers of dead larvae removed from each of the tanks.

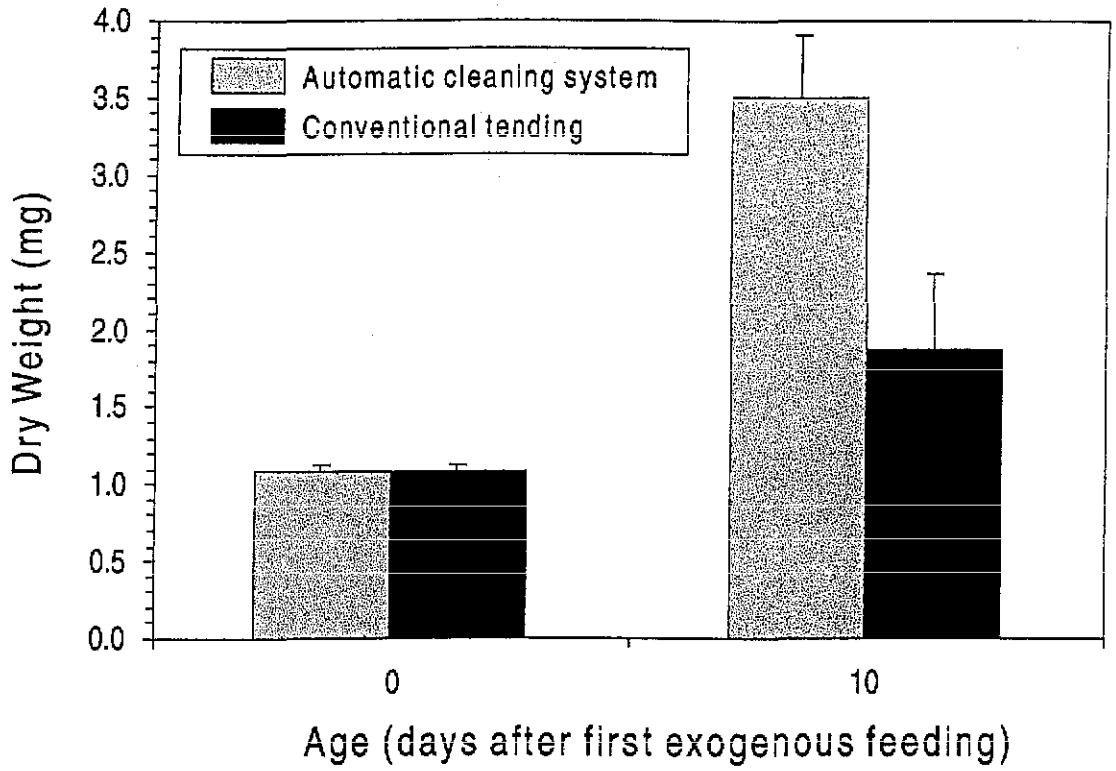

Figure 4: Dry weights of the larvae at initiation and termination of the experiment.

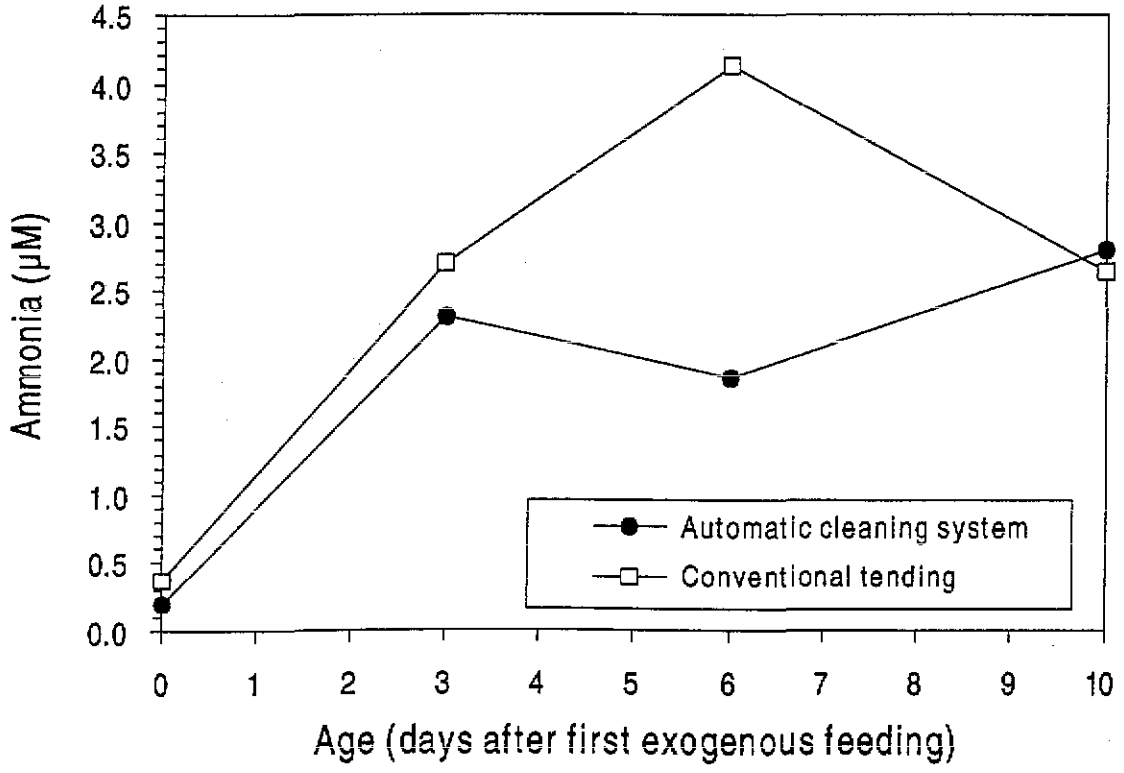

Figure 5: Concentration of ammonia in the rearing tanks.