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RESEARCHES REGARDING THE PRODUCTION OF AUTOMATED FISH FEEDING SYSTEMS USED IN SUPER INTENSIVE CULTURE FACILITIES

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INTRODUCTION

During the last few decades several fish feeding methods and techniques have been developed in part as a result of intense aquaculturing and increases in fish demands on the global market and in part for comparative studies to test the influence of certain feeding techniques on fish growth, feed efficiency and feed wastage (Pfeffer 1977, Thorpe *et al.* 1990, Alanärä 1992a, Kentouri *et al.* 1993, Paspatis *et al.* 1999).Generally 3 categories of feeding system or techniques are recognized: *hand-feeding*, *fixed feed ration systems* and *demand feeding systems*. In practice, the choice of feeding system or technique must be made following considerations of type and level of production and the cost of the feeding system. It may be necessary to change different feeding techniques during the production cycle and several techniques may be combined.Hand-feeding is the oldest and most simple feeding technique but it can be very efficient as the farmer has daily contact with the fish and it is possible to make direct observation on the individuals and, thus, a more efficient food distribution can be made. From the point of view of large scale commercial production hand feeding can not be considered a viable option due to high labour costs and as it is a time consuming practice.Electronically operated timer-controlled feeding systems appeared and became popular during the 1970s as a result of intensive fish farming, but were replaced by computer based control units at the end of the 1980s, which offered more options for the regulation and timing of feed delivery. Although the price for purchasing such a device is high, the operational costs are low. When timer or computer-controlled systems are used, the quantities of feed to be supplied are determined on the basis of either feed tables or mathematical models describing daily energy requirements. Demand feeding systems were developed during the 1980s and 1990s for use on commercial farms and are based on the principle that the supply of feed is regulated by the demand of the fish. Demand feeders work in one of the two ways: either by fish requesting feed themselves (self-feeders) or by automatic cessation or reduction of feed delivery when feeding activity declines (interactive feedback systems).The problem detected with self-feeders is that, with the exception of some salmonids (Alanärä 1996, Alanärä & Kiessling 1996) and sea bass (Boujard et al. 1996, Paspatis et al. 1999) most economically important species failed to learn to activate the trigger for the food dispenser or were not tested. Another problem arises on with species that manifest social hierarchies and agnostic behavior. The interactive feedback system requires the development of proper software, which leads to extensive costs regarding the usage of such a system. This may be proper for large scale industrial production units but is economically inefficient in smaller production farms.The aim of the current study is to test the response of a sample population of fish to the usage of an automatic feeding device and observe their development over the feeding trial period.

MATERIALS AND METHODS

The experiment was carried out over a period of 30 days, the fish being fed on a regular basis, as in normal conditions, the only implemented change being the use of the automated feeder instead of the manual feeding technique. At the end of the trial period fish were captured, measured, weighed, photographed and released.

The overall mortality during the experiment was 0%.*Automatic feeder*The automatic feeder is designed around a microcontroller (PIC16F648A) that allows automation of the feeding process or the demand feeding through specially designed software installed on a PC.

It is equipped with a LCD display, a keyboard that allows data input, a PC connection port and the feed loading device.*Species involved in the experiment*In order to obtain relevant results for aquaculture, some economically important species of fish were selected for the trial, with the main focus on sturgeon species: *Acipenser ruthenus*, A*cipenser stellatus*, *Acipenser guldenstaedti.* The animals were reared in large, concrete tanks using a continuous flow system to preserve their typical behavior so that any disturbance caused by the use of the automatic feeder can be observed.

Feeding

During the experiment the usual food was offered to the sturgeons, namely complete extruded pellets *Advanced Sturio,* to minimize the potential factors impacting the sturgeons' behavior.

The floatability percentage 1minute after administration was calculated at 0 % and the physical disaggregation start period at a working temperature of 14 ^{o}C was determined to be 10 hours, after which chemical disaggregation begins as well.

Feeding periods

Sturgeons 1-3 years of age were fed complete extruded feed 5 times a day, as often as with the normal manual feeding technique and those over 3 years of age were fed 7 times a day, as in usual conditions.

Table 1. Species, age groups and number of individuals / age group used in the experiments

No	Species	Age group	No. of individuals
1.	*Acipenser ruthenus*	1 year	5
		2 years	6
		3 years	4
		4 years	3
		5 years	1
		6 years	1
		Total:	20
2.	*Acipenser stellatus*	1 year	19
		2 years	18
		3 years	1
		Total:	38
3.	*Acipenser guldenstaedti*	1 year	5
		2 years	8
		3 years	5
		Total:	18

The quantity of offered food was calculated at an optimal 1 – 1,25 % of the body mass of the fish (ratios were calculated for the entire lot in a rearing tank, representing 1 – 1,25 of the biomass of the respective stock).

Data analysis

Obtained data was introduced into the computer using Microsoft Office Excel and processed using Statistica 6.0 analysis pack.

Table 2. Composition of the extruded feed used during the trial

Ingredient	%
Crude protein	48.0
Crude fat	16.0
Crude fiber	1.3
Ash	8.1
Phosphorus	1.3

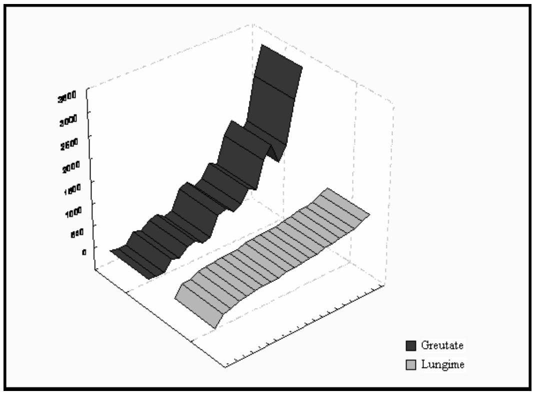
RESULTS AND DISCUSSIONS

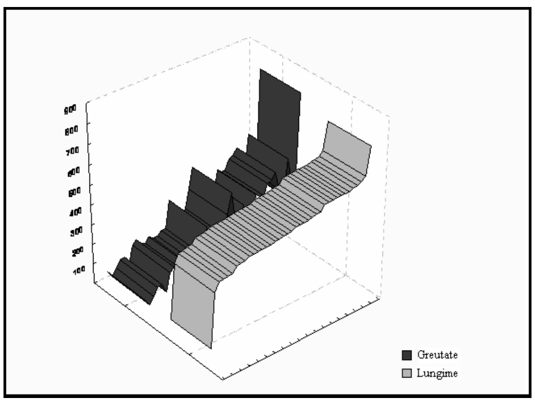
*Ethological response of fish to the presence of the automatic feeder*Analysis of the behavior during feeding trials using manual feeding technique revealed that the sturgeons will move rapidly when detecting the presence of food in the water, typical for the exploratory – feeding behavior of the group.Still, earlier introduced individuals seemed to respond more rapidly than individuals introduced later, the possible explanations being the adaptation period needed after moving from one tank to another, the response to abiotic factors or the lack of needed adaptation period to a social network with earlier established hierarchies.

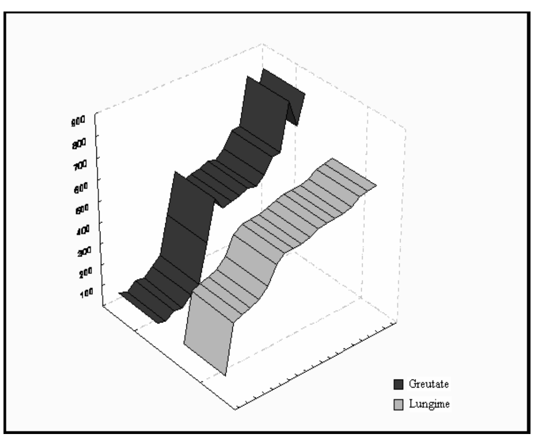
During the experiment different placement models of the automatic feeders were used, taking into account the water delivery pumps and a variable number of devices. No ethological response to the presence of the automatic feeder was observed, the sturgeons pending their exploratory – feeding behavior as normal.In the case of placing the automatic feeder out of the range of the water delivery pumps the pellets, having a limited floatability, sank to the bottom of the tank, where access was granted to the older fish or to the ones with a higher fitness, creating a feeding area to which smaller individuals had restricted access. An interesting case consisted in placing more automatic feeders in different areas around the basin and synchronizing them to dispense feed at the same time.

In this case the population divided in a number of groups corresponding to the number of feeders and the hierarchical pressure was diminished, all individuals having access to feeding areas. If the feeders are not correctly synchronized a migration path can be traced to each of the feeders, again favoring larger or healthier individuals. Nevertheless, a large quantity of food offered on a large surface of water increases the perspective that certain amounts of food would remain unconsumed, affecting thus the water quality throughout degradation processes.

Figure 1. Growth of the 3 sturgeon species over the trial period: *Acipenser ruthenus* (left up), *Acipenser stellatus* (right up), *Acipenser guldenstaedti* (middle down)







The best option seems to be the use of 1 - 3 automatic feeders, depending on the size and surface of the rearing tank, placed close to the water rejection pumps which ensured best dispersion of the extruded pellets and a wider area of feeding in which access was granted to almost all individuals of the population.*Growth rate of the study population*Wastage of feed was observed in all study tanks, same case being observed for other species of fish as well (Landless 1976, Alanärä 1992a, Boujard & Leatherland 1992, Burel et al. 1997). Wastage was reduced when the time during which food was available from feeder was restricted (Alanärä 1992b).

This type of time-restricted feeding protocol was also successfully used with sea bass (*Dicentrarchus labrax*) (Boujard et al. 1996) and turbot (*Psetta maxima*) (Burel et al. 1997). Length growth of the sturgeon species continued normally over the feeding trial period, with no direct influence from the automatic feeder.

This is what would be expected of normal sturgeons and similar results have been obtained for other species of sturgeons reared in alternative pond culture (*Acipenser baerii*, Adámek et al. 2007).

Weight gain was not uniform in the study population, but we cannot imply that the automatic feeding system is the reason for the differential weight gain, as there are many other factors that need to be discussed. Sturgeons generally have different hierarchical status, larger or healthier individuals benefiting from more food or better feeding places, leaving smaller or weaker individuals with less or no feed.Although placing one feeder in the tank, close to the water pumps seems to be the most reasonable solution, widening the feeding area as much as possible and within normal limits of feed loss, this does not a guarantee that every individual will have access to enough feed supplies.

Overall, the trial period shows an increase in body mass for all sturgeon species, leading to the conclusion that an inexpensive automatic feeding system easily makes a good replacement for manual feeding in small production farms, increasing the production rate and, from an economical point of view, diminishing production and personnel costs.

CONCLUSIONS

- Juvenile sturgeons adapt well to usage of automatic feeding, developing explorative – exploitative behavioral patterns that allow larger and more active individuals to take advantage of various features of the automated feeding process;

- In terms of feeding efficiency, automated feeding does not involve in growth rate modifications, thus providing the same values as obtained in experiments involving manual feeding; the advantages of the system, nevertheless, become obvious when dealing with large scale fish farms, where manual, human assisted feeding is more expensive and proves inappropriate as personnel involvement;
- Unlike other fish species, sturgeons have not yet proven to learn the utilization of feeding systems that administrate food when the fish employs certain devices; experiments using devices that administrate food when fishes gather to the feeding place are needed;
- Automatic systems prove efficient in controlling food quantity in order to diminish food loss, which, by disaggregation, leads to damaging the water quality.

ABSTRACT

Several techniques for fish feeding have been developed over the past decades and some comparative studies have been performed to test the influence of a certain feeding technique on fish growth, feed efficiency and feed wastage (Pfeffer 1977, Thorpe *et al.* 1990, Alanärä 1992a, Kentouri *et al.* 1993, Paspatis *et al.* 1999). All feeding methods, either manual or automatic have proven to have their advantages or disadvantages. While manual feeding seem to be the best choice in terms of correct dosages and observations, it is considered impractical in industrial-scale farms (intensive and super intensive systems) as it is time and money consuming, the best option here being automated feeding. The aim of the current paper is to evaluate the effect of such a device on economically important fish species in terms of ethological response and growth rates of the test individuals

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