*Note*

# Can turbot, *Psetta maxima*, be fed with self-feeders ?

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**Abstract**

The capability of turbots to use self-feeders was studied using 3 groups of 100 juveniles. Feeding activity reached a plateau after 20 days. Almost all feeding activity was observed during the photophase, and the acrophase was associated with dawn. The proportion of nocturnal demands was the highest in the replicate with the lowest feed efficiency, suggesting that feed waste was mainly occurring during nocturnal feeding activity. During the last 30 days of the experiment, demands were only rewarded during two periods of 2.5 $h.day^{-1}$. Feed efficiency was improved and was homogeneous between the three tanks, but the voluntary feed intake was reduced. It is concluded that turbots are able to use self-feeders but they do not adapt quickly, and they are not able to compensate a reduction of feed access by increasing demand activity during the access period.

**Keywords:** Turbot, self-feeders, feeding behaviour, feeding rhythms.

## INTRODUCTION

Haralson and Bitterman (1950) were probably the first authors to report the ability of fish to press a lever to obtain food. Since then, there have been numerous studies of feeding behaviour and growth of fish fed by means of self-feeders. Fish species belonging to the salmonid (*see* review by Alanärä, 1996), siluriform (*see* review by Boujard and Luquet, 1996) and centrarchid (Anthouard *et al.*, 1993; Sanchez-Vazquez *et al.*, 1995) families are among the most studied using this feeding technique. Nevertheless, there is still little information about the ability of several commercially cultured species to use a self-feeder. To the best of our knowledge, this is the case for the turbot (*Psetta maxima*).

One might expect that when fish are fed using self-feeders, growth and feed conversion are improved because the fish can regulate feed distribution in relation to their energy needs (Kaushik and Médale, 1994), and their feeding rhythms (Boujard and Leatherland, 1992). In some species such as the rainbow trout, self-feeding can lead to feed waste if self-feeding activity is high (Alanärä, 1992*a*; Boujard and Leatherland, 1992; Brännäs and Alanärä, 1994). Nevertheless, a restriction of the time during which feed is made available (two feeding periods per day) may lead to reduced feed waste without any alteration of growth performance (Alanärä, 1992*b*) provided that the feeding periods are in phase with the feeding rhythms of the fish.

The aim of this study was to test the ability of turbot to use a self-feeder, to compare their growth performance and feed efficiency under unrestricted and time-restricted access to the feeders, and to describe the feeding rhythm of this species.

## MATERIAL AND METHODS

### Experimental fish and maintenance conditions

The fish used in the study were hatched at the "Laboratoire de Ressources aquacoles" (IFREMER, Brest) and were raised according to the methodology described by Person-Le-Ruyet *et al.* (1991). They were adapted to commercial diets for juvenile turbot, and feeding was carried out using belt-feeders. Twenty days before the start of the experiment, 300 fish weighing approximately 20 g were selected. The fish were randomly divided into 3 groups, with 100 fish in each. Each group was maintained in a 370 l tank (1 $m^2$) supplied with 9 $l.min^{-1}$ of aerated, thermoregulated sea water (16-17 °C, salinity 35). An artificial photoperiod of 12L:12D (lights on at 8:00 h, 160 lux at the water surface) was maintained using 18 W neon tubes, and an artificial dawn and dusk was created (during the first and last half-hour of the photophase, using only 25 W bulbs, 20 lux at the water surface).

### Feeding protocol

During the experiment, an electronic self-feeder (Boujard *et al.*, 1992) which delivered approximately 1 g of feed (extruded, 54 % protein and 18 % lipids) each time a fish activated the trigger was installed in each tank. The trigger, located 1 cm below the water surface, could pivot freely around its axis. It consisted of a simple 10 cm long and 0.4 cm thick stainless steel rod with a 2 cm diameter ring fixed at its end. When the rod moves, a proximity switch positioned at the apex closes a logical 5 Volt direct current (Boujard *et al.*, 1992). During the initial 20 day acclimatisation phase, the feeders were rarely triggered by the turbot, so they were activated by hand at regular intervals during the photophase. From $D_1$ to $D_{63}$, the feeders were connected to a computer that recorded the time, the date and the tank from which each feed demand originated (Boujard *et al.*, 1992). From $D_{65}$ to $D_{90}$, the electronic self-feeders were programmed to deliver feed during only two periods each day, 5:30-9:30 h and 13:30-16:30 h, and the photoperiod was advanced by 3 h. The dim lights were switched on between 5:00 and 17:00 h, and the main lights were only switched on during the feeding periods in an attempt to make it easier for the fish to distinguish between feeding times and non-feeding times.

### Sampling and analytical procedure

The amount of feed distributed was calculated by regularly weighing the feed remaining in the feed hoppers between $D_0$ and $D_{91}$; and the three groups of fish were weighed on $D_0$, $D_{21}$, $D_{43}$, $D_{64}$ and $D_{91}$. The overall mortality was 0 % during the whole experiment.

## RESULTS

The change in the daily distribution of feed, with the passage of time (Fig. 1), provides evidence of three distinct phases in the experiment. During the earliest phase (phase A), feeding activity increased steadily. A plateau was then seen in two of the three replicates (phase B), but the amount of daily distributed feed remained unstable for the third replicate tank of fish. The amount of feed distributed to this third tank were almost always higher than in the two other replicates. When feed access was restricted to two periods per day (phase C), feeding activity was more homogeneous between the three replicates, but amounts of feed distributed were also reduced.

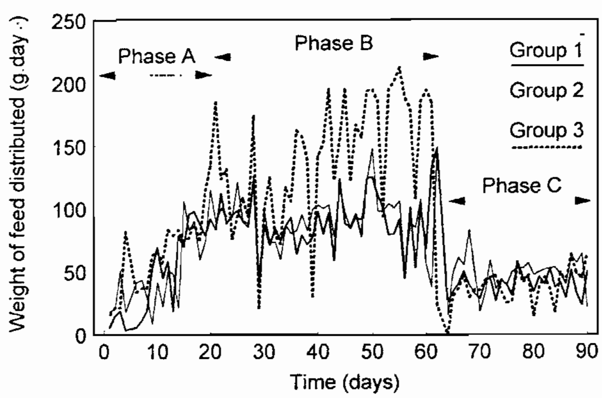


**Figure 1.** – Change in daily self-feeding demands (expressed in g.day [1]) of groups of juvenile turbot with time. Phase A : conditioning; phase B : free access to the self feeders; phase C : time restricted access to the self feeders.

The fish increased in weight by approximately 25 g during phase B (Table 1), and there was a low between-tanks coefficient of variation of mean live body weight at the end of this phase (C.V. = 3 %). Feed efficiency (FE) was low, and coefficient of variation was high due to an especially low value in group 3 (0.34). This result may indicate that a large part of the distributed feed was not eaten by this group of fish. During phase C, when the access to feed was time restricted, FE improved significantly, and was more homogeneous. SGR was, however, also significantly reduced, indicating that with such restrictive feeding protocol the turbot could not achieve maximum growth potential.

The daily profile of feeding activity during phase B is presented Figure 2: feeding activity was rhythmic with a period of 24 h [periodogram analysis, Sokolove and Bushell (1978)], the acrophase being between

**Table 1.** – Growth characteristics of groups of 100 juvenile turbot fed by means of self feeders, during phases A (conditioning, 21 days), B (free access to the self feeder, 42 days) and C (time restricted access to the self feeder, 27 days). Initial mean weight was 32.0 ± 0.5 g (mean ± SD); C.V. = 1.5 %. Data are expressed as mean ± SD and the coefficients of variation are given in brackets.

| Phase | Final Weight[1] (g) | | Specific Growth Rate[2] ($\%.d^{-1}$) | | Feed Efficiency[3] (%) | |
|---|---|---|---|---|---|---|
| A | 41 ± 2 | (5) | 1.27 ± 0.30[a] | (24) | 0.91 ± 0.19[ab] | (20) |
| B | 67 ± 2 | (3) | 1.15 ± 0.21[a] | (18) | 0.56 ± 0.19[b] | (34) |
| C | 79 ± 4 | (4) | 0.63 ± 0.08[b] | (13) | 1.08 ± 0.09[a] | (8) |

Means within columns with different superscripts are significantly different ($p < 0.05$). Data were analysed for normality of variance, and by ANOVA with the Splus package (MathSoft Inc., Seattle, USA). Individual means were compared using Duncan multiple range test ($p < 0.05$).
[1] Final weight = Total final fish weight/number of fish.
[2] Specific growth rate = 100 × [ln(final weight)-ln(initial weight)]/number of days.
[3] Feed efficiency = gain (g, wet weight)/total feed demanded (g, dry weight).

dawn and dawn + 2 h. The proportion of nocturnal demands was 15, 6 and 50 % in groups 1, 2 and 3, respectively, indicating a clear tendency for diurnalism in feeding activity in groups 1 and 2 but not in group 3.

Despite the fact that the lighting protocol was designed in an attempt to make it easier for the fish to distinguish between feeding times and non-feeding times during phase C, the proportion of trigger activation that occurred during time-restricted access (% of successful demands) was only 40 % on average during almost all the phase C (% activation at random would expect a 30 % to be successful). Nevertheless, for the last 8 days of the experiment this proportion reached 80 % (Fig. 3).

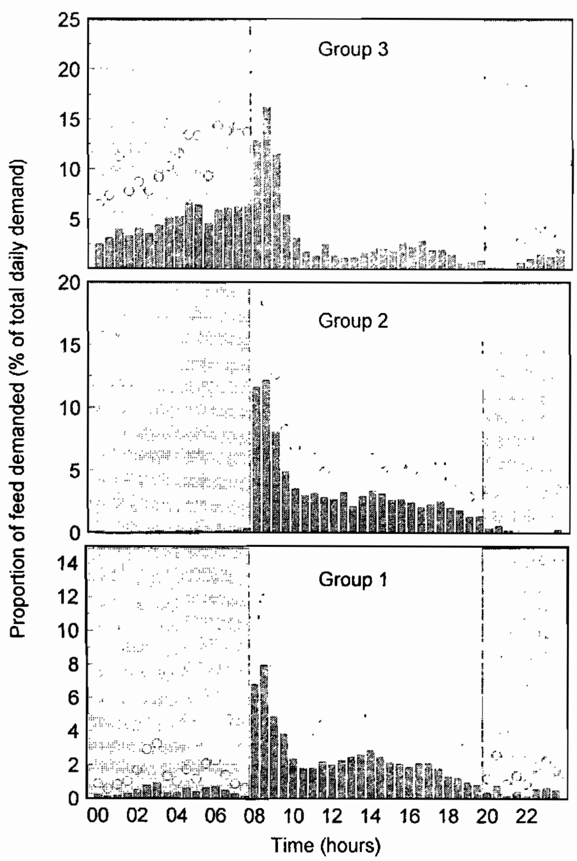


**Figure 2.** – Diel profile of feeding activity, (% of total daily demands per half-hour), for the three groups of juvenile turbot fed by means of self-feeders during phase B. Dashed areas indicate scotophase, and open circle = 1 Standard Deviation.

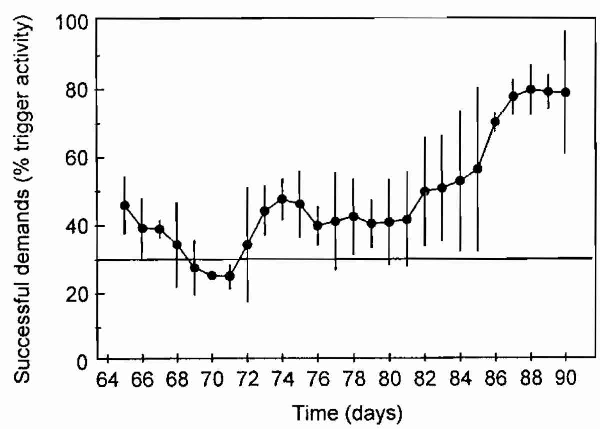


**Figure 3.** – Mean temporal change in the proportion of demands that occurred when turbot were fed according to the time-restricted access regime. Feeders were programmed to deliver feed during two periods per day (phase C). Activation at random would expect 30 % of activation to be successful. Vertical bar = 1 Standard deviation.

## DISCUSSION

It appears from our results that turbot learn to operate self-feeders more slowly than species such as rainbow trout (*Oncorhynchus mykiss*, Adron *et al.*, 1973) and goldfish (*Carassius auratus*, Sanchez-Vazquez *et al.*, 1996). In addition, one of the three groups of turbot obviously did not consume all the food delivered (Fig. 1, Table 1). Landless (1976), and later Alanärä (1992*a*) and Boujard and Leatherland (1992*b*) noted some wastage of food by rainbow trout held either singly or in groups. This wastage was reduced when the time during which food is available from the feeders was restricted (Alanärä, 1992*b*). This type of time restricted feeding protocol was also successfully used with sea bass (*Dicentrarchus labrax*), (Boujard *et al.*, 1996). Similarly, in the present experiment, when turbot were exposed to a time restricted feed access protocol, wastage appeared to be markedly reduced. However, the fish seemed to be slow to learn to restrict their feed demands to the time during which food was available (Fig. 3) and growth performance was reduced (Table 1).

In our experimental conditions (160 lux at the water surface), feeding activity of turbot appears to be mainly diurnal. This result is in accordance with the study of Huse (1994) with larvae of turbots exposed to planktonic feed organisms at seven illumination levels ranging from darkness to 10 800 lux reached a threshold level at 860 lux. It is also interesting to note that low feed efficiency was found in the replicate showing a high proportion of nocturnal demands. Therefore, one might speculate that our time-restricted protocol was too severe, and that feed waste could have been reduced with less effect on growth, by restricting the time during which food was available to the photophase.

It is concluded that turbot are able to use self-feeders. Nevertheless, they do not adapt very quickly to this type of feeding device, and they are not able to compensate for a reduction in the time of feed access (4+3 hours) by increasing demand during the access periods. Additional trials with the aim reducing the amount of time needed to learn to operate self-feeders, and programmed to deliver feed during the photophase only, are necessary to fully assess the value of using this feeding technique in culture of this fish species.

**Aknowledgements**

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