

Determination of the stomach emptying time of tilapia *Oreochromis* sp. using different weekly feeding frequencies and starvation

Determinación del tiempo del vaciado del estómago de la tilapia *Oreochromis* sp. mediante la utilización de diferentes frecuencias de alimentación semanal y ayuno

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Abstract

The study measured the time necessary to complete emptying of the stomach of tilapia (*Oreochromis* sp.) starting on the day subsequent to regular feeding a fasting period. Samples were collected from stomach contents in periods of 2 hours after feeding (9:30 and 15:30 h) until the first sign of emptying. The tilapia weighed 150 ± 10 g and was distributed in four treatments: (1) T5 = feed to satiation for 5 days and fasting for two days (T5), (2) T6 = feed to satiation for 6 days and fasting for one day, (3) T7 = feed to satiation for 7 days, and (4) TC = restricted feeding table recommended by the manufacturer, 7 days a week. Data analysis was performed using repeated measures ANOVA, using as factors the treatment and emptying time, with each repetition as the experimental unit. Unlike the T5 treatment, in others tilapia emptied its stomach contents during the time period between the first and the second ration of food and in the period after the second ration. Therefore, when the stomach content was higher due to a higher feed intake in the diet, as in the case of treatment (T5), the time required to empty the stomach of tilapia increased.

Key words: Evacuation, ingest, ration, satiety, starvation, tilapia.

Resumen

En el estudio se midió el tiempo necesario para el vaciado total del estómago de tilapias (*Oreochromis* sp.) en el día de comienzo regular de alimentación posterior a un periodo de ayuno. Se recolectaron muestras de contenido estomacal en periodos de 2 horas después del suministro de alimento (9:30 y 15:30 h) hasta el primer indicio de vaciado. Se utilizaron tilapias con un promedio de peso vivo de 150 ± 10 g dispuestas en cuatro tratamientos: (1) T5 = alimentación a saciedad durante 5 días y ayuno de 2 días (T5), (2) T6 = alimentación a saciedad durante 6 días y ayuno de 1 día, (3) T7 = alimentación a saciedad durante 7 días, y (4) TC = alimentación restringida mediante tabla recomendada por el fabricante, 7 días a la semana. El análisis de datos se realizó mediante Anova de medidas repetidas, empleando como factores el tratamiento y el tiempo de vaciado, siendo cada repetición la unidad experimental. Las tilapias en el tratamiento T5 presentaron mayor cantidad de alimento en el estómago después del primer periodo de muestreo y en los muestreos posteriores al suministro de la primera y segunda ración. A diferencia del tratamiento T5, en los demás las tilapias vaciaron su contenido del estómago durante el periodo comprendido entre la primera y la segunda ración de alimentación y en el periodo posterior a la segunda ración. Por tanto, cuando el contenido estomacal fue mayor, debido a un mayor consumo de alimento en la ración, como en el caso del tratamiento T5, el tiempo

necesario para vaciar el estómago de las tilapias se incrementó.

Palabras claves: Ayuno, evacuación, ingesta, ración, saciedad, tilapia.

Introduction

Studies on tendency and evacuation of stomach contents in fish are scarce due to the difference among species, food and feeding methods. Knutsen (1998) defines gastric evacuation as the product emptying from the stomach to the intestine through the pyloric sphincter, and the rhythm or rate for its occurrence as the speed measured in weight (g) or proportion (%) per unit of time (t). Feeding rhythm and time for gastric evacuation can be affected by temperature, consumption, diet quality, activity, body size, intestinal capacity, satiety and metabolic rhythm (Persson, 1981; Hofer *et al.*, 1982; Holmgren *et al.*, 1983; Grove *et al.*, 1985; Riche *et al.*, 2004).

Gastric evacuation rhythm generally declines in time in a consistent and exponential way, although sometimes it can be lineal (Smith, 1989). It is considered that the amount of food ingested voluntarily on a time interval is inverse to the filling of the stomach, however this does not entirely explains the appetite phenomenon. Huebner and Langton (1982) and Lee *et al.* (2000) observed that the emergence of appetite is closely related with the gastric evacuation rate. Direct comparison of the results from different studies on digestion is not possible, because the different species, food types and evaluation methods used (Marais and Kissil, 1979). It has been demonstrated that the amount of consumed food by a fish depends on the filling of its stomach, thus the intervals between feeding times are a function of the stomach emptying (Grove and Crawford 1980; Holmgren *et al.*, 1983; Grove *et al.*, 1985). Therefore, intervals between daily food supply are closely related with time of gastric evacuation (Lee *et al.*, 2000). Jobling (1980) studied the effect of the source and the daily energy level supplied on the diet over the gastric emptying in plaice (*Pleuronectes platessa*) and found that diets with low energy supply were evacuated from the stomach faster than those with a higher energetic content. Gwyther and Grove (1980) demonstrated that stomach emptying time in the common

dab (*Limanda limanda*) varied in a direct and significant proportion with the ration size. Paul *et al.* (1990), on the other hand, suggest that ration size significantly affects evacuation rate; and De Silva and Anderson (1995) found that when ration size is larger, the evacuation time required increments, although not on a proportional way.

Fishes are poikilotherms and therefore, temperature affects food speed through the intestine. Temperature influence has been one of the most studied aspects on gastric evacuation rate (De Silva and Anderson, 1995). Jobling (1980) and De Silva and Anderson (1995) observed that this rate increments with temperature in plaice (*P. platessa*) and in grass carp (*Ctenopharyngodon idella*). De Silva and Weerakoon (1981) revealed that evacuation time of grass carp decreases with the live body weight increment. Jobling (1980) found that the daily food evacuation of European plaice increases in proportion to the live body weight increment. Santos and Jobling (1991) found that different sizes of cod (*Gadus morhua*) feed with concentrated food on a fixed ration in relation to the body weight presented constant evacuation times that were independent of body size.

There are several methods to measure gastric evacuation in fishes. One of the most frequent is the slaughter of animals at different intervals in order to measure the amount of food contained in the stomach (De Silva and Anderson, 1995). Gastric evacuation rate (GER) and stomach evacuation time (GET) can be used to develop suitable strategies on a feeding plan for fishes (Santos and Jobling, 1991). The estimation of the digestion rate and its relation with GER allows predicting the appetite degree of fishes and feeding efficiency (Lee *et al.*, 2000); therefore, knowing the stomach emptying time of tilapias helps adjusting the food supply intervals ensuring a more efficient consumption.

The goal of this study was to determine the stomach emptying time of tilapias (*Oreochromis* sp.) subjected to four weekly feeding frequen-

cies and starvation.

Materials and methods

120 tilapias were used with an average weight of 150 ± 10 g distributed in 12 experimental tanks of 500 l each, for a total of 10 fishes per replicate. In the experimental area the photoperiod artificially maintained was (12/12). Water conditions on the tanks were optimal for fish growth (28 °C, 6 ppm of dissolved oxygen and total refill of water each 4 h). This work was done in the experimental lab Mario González Aranda of the Universidad Nacional de Colombia - Palmira.

Treatments (food supply frequencies) were randomly distributed and replicated three times. These consisted in: T5 = feed to satiety during 5 days/week and starvation the other days (Saturday and Sunday); T6 = feed to satiety for 6 days/week and starvation the last day (Sunday); T7 = feed to satiety for 7 days/week; TC = restricted feed during all the week based on concentrated supplier's recommendation. Experimental period was 45 days.

As food source it was used a commercial concentrate produced by Itacol S.A., containing protein 30%, fat 6%, fiber 8%, ashes 12% and humidity 6%, this was manually supplied in two rations at 9:30 and 15:30 h. Samples were taken after each food supply. In order to estimate the stomach emptying time, the day of regular feed after starving was used to collect samples of stomach contents, in periods of 2 h after supply of each food ration till the first occurrences of complete emptying. Fishes were slaughtered and dissected to remove the stomach, extract its contents and determine the weight before and after emptying. Results were expressed as live weight percentage values (%/fish) for gastric evacuation rate (GER) of stomach food contents at different hours (Table 1) and in percentage of stomach emptying (GET) during sampling times (Figure 1).

$$GER = \frac{\text{weight of the filled stomach (g)} - \text{weight of the empty stomach (g)}}{\text{fish weight (g)}}$$

Data analysis was performed by repeated measures ANOVA using as factors treatments and emptying time, and each replicate was an experimental unit. Statistical software used was SAS® (Statistical Analysis System Institute, 2006).

Results and discussion

Gastric evacuation rate at different hours is shown on Table 1. Tilapias in the T5 treatment consumed larger amount of food in both daily supplies in comparison with the fishes in the other treatments, therefore the stomach content was larger after starvation in the first ones. Tilapias of T6, T7 and TC treatments showed a similar behavior for all measurements, although differences ($P < 0.05$) were found in the measurement after the supply of the first daily ration.

Stomach contents emptying rates during the first hours after each ration are shown in Figure 1. After the supply of the first ration (9:30 h), with exception of the T5 fishes that had 55% of their stomach contents, all the other fishes had a total emptying before the afternoon food supply (15:30 h). This behavior improved the food consumption by fishes in the T6, T7 and TC groups. Stomach emptying after the second ration supply happened in the next 6 h, although the T5 treatment had emptied not more than 40% of the stomach contents, in contrast, the other treatments emptied between 85 and 90% of the contents.

According to the results of this study, in tilapias, apparently, stomach contents emptying is conditioned by the supply ration size, as it is demonstrated by the hyperphagic response in the first day after starving. Tilapias feed during five consecutive days and starved for 2 days showed a higher amount of residual food in the stomach in the first measurement and were the ones that did not evacuate all the stomach contents before the second ration. This indicates that when the stomach contents were larger, the needed time to evacuate is incremented.

Results on other studies on the effect of ration size in the stomach evacuation time of fishes are contrasting. Riche *et al.* (2004) and

Table 1. Post-starving gastric evacuation rate (GER) in tilapias (%/fish) subjected to different hours of diet supply.

Hour	Treatments				±ES
	T5	T6	T7	T8	
Ration 1 (09:00 h)					
09:30	0.65	0.43 b	0.21 c	0.28	0.05
11:30	0.62	0.19 b	0.16 b	0.15	0.79
13:30	0.28	0.12 b	0.11 b	0.07	0.05
15:30	0.32	0.08 ab	0.01 b	0.02	0.01
Ration 2 (15:30 h)					
16:00	0.60	0.55	0.51	0.49	0.16
18:00	0.51	0.41	0.33	0.38	0.05
20:00	0.42	0.18 b	0.15 b	0.10	0.07
22:00	0.40	0.07 b	0.10 b	0.08	0.04
00:00	0.36	0.06 b	0.05 b	0.02	0.03

* Different letters indicate statistical differences between means ($P < 0.05$). Covariable: fish weight.

Azaza *et al.* (2010) found that in *O. niloticus* the gastric evacuation has an exponential trend and the evacuation rate is proportional to the food intake which is increased when the food particles are smaller. Gwyther and Grove (1980) found that the evacuation time in dab fish significantly varied with the size of the particles in the food ration. Paul *et al.* (1990) and De Silva and Anderson (1995), similarly,

found that the particle size in the ration can affect inversely the time of gastric evacuation.

Conclusions

- In this work was observed that when the stomach contents in *Tilapia Oreochromis* sp. are large, as a result of higher food intake, the time required for emptying

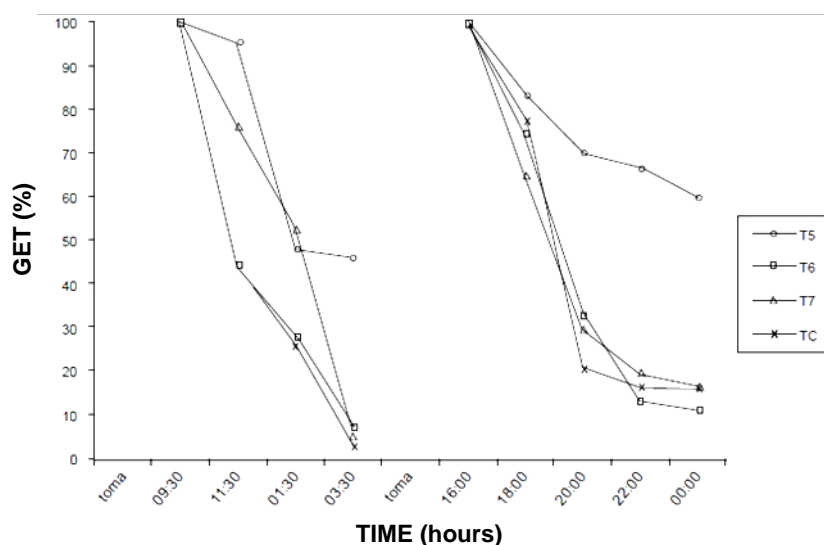


Figure 1. Emptying time of stomach contents (GET) of tilapias, in post-starving feed. T5 = feed to satiety and starving for 2 days; T6 = feed to satiety for 6 days and starving for 1 day; T7 = feed to satiety for 7 days; TC = restricted feed by supplier's recommendation table 7 days per week.

increases, suggesting that this is conditioned by the daily food intake.

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