Preliminary Results on Growth and Feeding of Wild-caught Red Grouper (*Epinephelus morio*) in Captivity

XIMENA RENÁN [1,2] *, JAIME SUÁREZ-BAUTISTA[1],
ADRIANA PAREDES-MEDINA[1] and XAVIER CHIAPPA-CARRARA[1]
[1]*UMDI- Sisal, Facultad de Ciencias UNAM- Universidad Nacional Autónoma de México, Puerto de Abrigo sin número Sisal, Yucatán México. C.P. 97355.*
[2]*Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional. Departamento de Recursos del Mar, Unidad Mérida, Antigua Carretera a Progreso Km 6. Cordemex. Mérida Yucatán, México. C.P. 97310.*
*ximenarenan@me.com; ximenarenan@hotmail.com.

ABSTRACT

Epinephelus morio (red grouper) commercial fishery is the most important in Yucatan. This study seeks to provide new information on rearing conditions for red grouper, which can serve as an alternative to fishing. Using hook and line, 141 red grouper juveniles were caught, from April 20th to August 22nd 2007, at Sisal Yucatan Mexico. All individuals were kept alive in an aerated 0,5 m^3 container, vented if needed, and carried to the UMDI-UNAM facility, where they were weighed and placed randomly in eight outside seawater tanks. Groupers were fed with trash fish for two months, until adapted to captivity. To minimize cannibalism and aggression groupers were graded into three size groups: small: 27.3 (± 3.06 cm); medium: 34.3 (± 1.74 cm) and large: 45.9 (± 3.42 cm), and reared in 19.63 m^2 tanks (5 m diameter and 0.85 m deep), with constant seawater influx and airflow. Fish densities varied from 15.47 to 83.03 g/m^2 depending on the size group. All individuals were fed a balanced humid pellet (55.6% protein, 4.9% lipids, 34.5% carbohydrates and approximately 4% vitamins and minerals, 3 times a week. In order to determine the individual growth rate each grouper was tagged using VIE (Visible Implant Elastomer tags), measured and weighed every 39 days and then sacrificed gradually throughout a year (until August 2008). Mean individual weight at the beginning of the study was 0.57 kg attaining a mean weight of 1.9 kg per fish, a year later. Daily growth rate was 3.64 g/fish. There were significant differences in weight between sampling (*Kruskal- Wallis;* H= 143.111; $p < 0.05$), between growth rate in time (*Kruskal- Wallis*; H = 46.39, $p < 0.05$) and between the food consumption rate ($t = 2.58006$; $p < 0.05$).

KEY WORDS: Red grouper, growth rate, reared conditions

Resultados Preliminares de la Tasa de Crecimiento y Alimentación de *Epinephelus morio* en Confinamiento

La pesquería del *Epinephelus morio* (mero rojo o mero) es la actividad económica más importante para el estado de Yucatán. Este estudio provee de información sobre las condiciones necesarias para el cultivo del mero rojo, que podría ser una alternativa a la pesca. Se capturaron 141 meros rojos con anzuelos, entre abril 20 a agosto 22 del 2001, en aguas cercanas a la costa de Sisal Yucatán, México. Todos los individuos se mantuvieron con vida en un contenedor de 0.5 m^3 con aireación constante, y llevados a ocho estanques al aire libre, ubicados en la UMDI- UNAM donde fueron colocados de manera aleatoria. Los meros fueron alimentados durante los primeros dos meses con sardinas frescas, hasta que se adaptaron a las condiciones de manejo. Para minimizar el canibalismo y la agresión entre individuos, los meros se separaron según su tamaño en tres grupos, pequeños: 27.3 (± 3.06 cm); medianos: 34.3 (± 1.74 cm) y grandes: 45.9 (± 3.42 cm), y colocados en tanques de 19.63 m^2 (5 m diámetro y 0.85 m profundidad) abiertos, con aireación e intercambio de agua de mar constantes. Las densidades iniciales variaron entre 15.47 a 83.03 g/m^2 dependiendo del tamaño de los individuos. Todos los meros fueron alimentados con un pellet semi húmedo (55.6% proteínas, 4.9% lípidos, 34.5% carbohidratos y aproximadamente 4% de vitaminas y minerales), tres veces por semana. Para poder determinar la tasa de crecimiento individual, cada mero fue marcado con elastómeros de colores (VIE), medidos y pesados cada 39 días y sacrificados gradualmente a lo largo de un año (hasta agosto 2008). El peso promedio al inicio del estudio fue de 0.57 kg alcanzando pesos promedio finales de 1.9 kg un año después. La tasa diaria de crecimiento fue de 3.64 g/pez. Se registraron diferencias estadísticas significativas en el peso de los individuos entre muestreos (*Kruskal- Wallis;* H= 143.111; $p < 0.05$), en la tasa de crecimiento (*Kruskal- Wallis*; H = 46.39, $p < 0.05$) a lo largo del año y en la tasa de ingestión ($t = 2.58006$; $p < 0.05$).

PALABRAS CLAVE: *Epinephelus morio*, tasa de crecimiento, condiciones de cultivo.

Les Résultats Préliminaires sur la Croissance et L'alimentation des *Epinephelus morio* en Captivité

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MOTS CLÉS: Mérou rouge, taux de croissance, conditions d'élevage

INTRODUCTION

Epinephelus morio (red grouper) is the most fished grouper specie in Yucatan. Total red grouper landings accounted for as much as 35 - 79% of the total grouper catches (from 1995 to 2000) and up to 87% total weight landings (Giménez- Hurtado et al. 2005, Brulé et al. 2009). Nevertheless, there is a slow decline in commercial grouper- catch biomass of 50%, since 1972 (19,886 T) to 2008 (9,762 T) and in CPUE from 2,400 kg (1980) to 1,150 (2002) of fish/catch per day (SAGARPA 2008). Furthermore, estimates based on population dynamic models indicate that red grouper stocks from the southern Gulf of Mexico are over- exploited (Giménez-Hurtado et al. 2005, Albañez-Lucero and Arreguín-Sánchez 2009) and overfished (Burgos and Defeo 2000 2004). However, Mexican fishery regulations are restricted only to limiting fishing license, a closed season from February 15 to March 15 since 2003, and an annual catch quota of 1,200 MT for the Cuban fleet (Garcia-Moliner and Eklund 2004).

Several grouper species (especially *Epinephelus coloides* and *Epinephelus malabaricus*) have been raised on commercial scale in Asia, Taiwan, Hong Kong and Indonesia (Ottolenghi et al. 2004). For farming in the southeastern U.S. and Caribbean, Nassau (*Epinephelus striatus*), gag (*Mycteroperca microlepis*) and black groupers (*Mycteroperca bonaci*) seem to have good potential (Tucker 1999). In America, some studies that involved grouper confinement included: induced spawning, sex inversion, egg and larval development, growth rate and efficiency in food utilization (Levin and Hay 2003, Strelcheck et al. 2003, Tucker 1999, Ellis et al. 1997, Roberts and Schlieder 1983). In Mexico, only Brulé et al. (1996) studied the juvenile red grouper growth performance in a re-circulating water system.

Capture-based grouper studies could be useful to obtain information regarding its life history, bioenergetics, recruitment dynamics or habitat requirements. This is important since groupers are particularly vulnerable to intensive fishing due to their longevity, slow growth, delayed reproduction, and aggregate spawning. The objective of this study is to determine the growth and feeding rate of red grouper for Yucatan in order to generate new information that could be useful for the development of aquaculture in the specie.

METHODS

Red grouper juveniles were captured on the northwestern coast of Yucatan, Sisal from April 20th to August 22nd, 2007, using conventional hook and line, and maintained in confinement throughout a year.

All individuals were kept alive in an aerated 0,5 m^3 container, vented if needed (following St. John, 2003 procedure), and carried to the UMDI-UNAM facility, where they were weighed and placed randomly in eight outside seawater tanks. Red groupers were fed with trash fish for two months, three times per week, until they adapted to captivity and handling.

After acclimation, each individual was weighed, measured and tagged using VIE (Visible Implant Elastomer tags). Specimens were reared in eight open 19.63 m^2 tanks (5 m diameter and 0.85 m deep), with a 16,680 l volume and constant seawater influx and airflow. Taking into account the red grouper's cryptic preferences, PVC shelters were provided in each tank. Physical and chemical water parameters were measured in each tank at 800 and 1800 hrs every day, using a YSI model 556 multiparameter Meter (Cole-Parmer®).

In order to minimize cannibalism and aggressive behavior, specimens were graded into three size-groups: small (3 tanks), medium (3 tanks) and large (2 tanks). During the confinement year, all individuals were fed "*ad libitum*" with a balanced humid pellet three times per week at 1200 hours. The diet was adapted from a previously developed marine-fish diet, containing 55.6% protein, 4.9% lipids, 34.5 % carbohydrates and approximately 4% vitamins and minerals. Food was weighed before and after fish were fed in order to calculate the daily intake.

All specimens were measured and weighed every 39 days (± 2 days) for a total of 9 samplings, after being given a clove oil bath (0.1/ml) to induce anesthesia. Since each specimen was given a particular tag, increase in individual total length (TL), standard length (SL) and total body weight (W) were recorded during the entire year. Specimens were sacrificed gradually.

RESULTS

Red groupers were resistant to handling and transportation procedure, and only 20% needed venting. All individuals were weighed, bathed in a methylene blue solution and placed in eight outside seawater tanks, where they rapidly used the PVC shelters. Physical and chemical water parameters ranged for cold months from 5.2 to 7.9

mg^{-1} dissolved oxygen and 22.0 to 27.8 °C temperatures; and from 5.1 to 7.4 mg^{-1} dissolved oxygen and 25.5 to 29.3 °C temperatures for warm months (Table 1). A Mann-Whitney (Wilcoxon) test displayed statistical differences between dissolved oxygen ($W = 429.5$, $p < 0.05$, $\propto = 95\%$) and between temperature ($W = 2133.5$, $p < 0.05$, $\propto = 95\%$) for cold and warm months.

Large individuals began to eat trash fish approximately at day 2, which triggered smaller individuals to eating. Once all the individuals feed consistently, a balanced humid pellet was gradually introduced. Finally, all the individuals accepted the balanced diet displaying a voracious appetite throughout the study. There were no problems concerning individuals' health during husbandry. Nevertheless, in some fishes the parasitic protozoan-causing itch was identified. In order to avoid propagation, all individuals were given a monthly freshwater bath with formalin methylene blue (200 - 250 ppm).

To reduce aggressive behavior, individuals were graded into three size-groups, small 27.3 (± 3.06 cm TL; 3 tanks); medium: 34.3 (± 1.74 cm TL; 3 tanks) and large: 45.9 (± 3.42 cm TL; 2 tanks). Mean TL and W per tank were recorded and stocked at initial densities of ± 15 g/m^2 (for small), ± 32 g/m^2(for medium), ± 54 g/m^2 and 83.03 g/m^2 (for large individuals) (Table 2).

Initial mean weight was 0.57 kg attaining a mean individual weight of 1.9 kg at the end of the study. A Kruskal-Wallis analysis displayed statistical differences between the median weights of the individuals throughout the year of confinement ($H = 143.11$; $p < 0.05$) where the major differences were recorded during May, June and August 2008 (Figure 1).

Food consumption rate between cold (March- August; Samplings 2 to 5) and warm months (September- February; Sampling 6 to 9) were statistically different ($t = 2.58$, $p < 0.05$, $\propto = 95\%$), increasing during the warm months. Nevertheless, the daily intake ($t = 1.35$, $p > 0.05$, $\propto = 95\%$) and the amount of food consumed per fish ($t = 1.56$; $p > 0.05$, $\propto = 95\%$) did not show statistical differences between seasons (Table 3).

Daily growth rate for red grouper was 3.64 g/fish,

Table 1. Mean water physical and chemical parameters registered in each seawater tank throughout the year study (April 2007 to August 2008). Oxygen units in mg^{-1} and temperature units in °C. Parameters in columns in grey correspond to cold months, whereas white columns to warm months.

Tank No.		Sept. 07	Oct. 07	Nov. 07	Dec. 07	Jan 08	Feb. 08	Mar. 08	Apr. 08	May. 08	Jun. 08	Jul. 08	Aug. 08
1	O_2	6.1	6.5	7.4	6.6	6.7	6.7	6.4	7.2	7.4	6.6	6.7	6.6
	Temp	26	24.8	23.9	22.7	24.7	22.6	26	27.2	27.9	29	29	27.8
2	O_2	5.2	6.3	7.4	7.5	7.0	7.4	6.2	5.8	5.2	5.8	5.4	5.9
	Temp	27.2	26.2	24.3	23.7	22.4	24.8	26.3	27.6	27.9	29	29.3	27.6
3	O_2	5.6	6.6	7.6	6.7	6.8	7.9	7.3	6.2	5.6	5.2	5.8	6.1
	Temp	27.3	27.3	24.6	24.6	22.2	25.5	25.9	27.0	27.8	29.0	29.1	27.9
4	O_2	5.8	6.2	7.9	7.2	7.0	6.13	6.1	6.3	5.8	5.4	5.8	6.1
	Temp	26.6	25.7	24.6	23.7	22.8	25.1	25.6	26.8	27.9	28.8	28.6	27.4
5	O_2	5.7	6.1	7.64	7.2	6.5	6.8	6.3	6.2	5.8	5.6	5.2	5.7
	Temp	26.8	25.7	24.8	23.7	22.0	25.2	26.2	27.3	27.4	27.9	28.8	27.6
6	O_2	6.03	6.4	7.9	7.1	6.9	6.1	6.0	5.8	5.6	5.2	5.1	6.2
	Temp	27.8	25.6	24.6	22.7	22.8	25.0	25.7	26.8	27.5	27.8	28.9	28.1
7	O_2	6.1	6.4	8.02	7.2	6.9	6.6	6.3	6.4	6.2	5.6	5.3	5.8
	Temp	27.8	25.9	24.7	23.6	22.3	25.1	25.5	26.8	27.9	28.1	28.6	27.6
8	O_2	5.4	6.5	7.3	7.1	6.5	6.4	6.3	6.1	5.8	5.7	5.8	5.3
	Temp	26.9	25.7	37.6	24.0	25.9	25.3	26.0	26.8	27.7	27.9	28.3	28.6

Table 2. Initial densities; mean total length (cm) and mean weight (g) per tank (standard deviation in parenthesis) of 141 red groupers reared in an open seawater tank- system, for one year (April 2007 to August 2008).

No. Tank (size-group)	No. individuals	Mean TL (cm)	Mean W (g)	Densities (g^{-m3})
1 (Small)	22	27.1 (± 2.92)	313.8 (± 92.8)	15.98
2 (Small)	18	27.1 (± 2.66)	309.4 (± 91.7)	15.72
3 (Small)	17	27.3 (± 3.06)	303.8 (± 91.4)	15.47
4 (Medium)	14	34.3 (± 1.74)	634.7 (± 89.5)	32.33
5 (Medium)	25	30.6 (± 2.06)	642.3 (± 89.0)	32.72
6 (Medium)	17	35.1 (± 1.22)	642.7 (± 99.3)	32.74
7 (Large)	12	42.0 (± 3.15)	1070.5 (± 123.6)	54.63
8 (Large)	16	45.9 (± 3.42)	1629.9 (± 277.2)	83.03

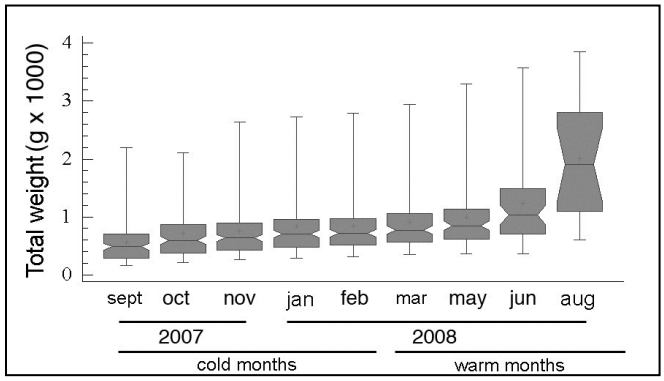

Figure 1. Median weight comparison of *E. morio*, throughout a year of confinement in an outside seawater tank-system. Weight statistical differences, occurred between cold months (September 2007- February 2008) and warm months (March 2008- August 2008), when the median weight was higher. Data in boxes showed 50% of the total weight registered whereas whiskers the lower and upper quartiles. The median is represented by the notch.

varying throughout the study and showing statistical differences in time (*Kruskal-Wallis*; $H = 46.39$ $p < 0.05$) (Figure 2), but not between the median growth rate per tank (*Kruskal-Wallis*; $H = 11.81$ $p < 0.05$).

DISCUSION

Reared red groupers were resistant to confinement, adapted easily to handling procedures, were very sociable, and quickly accepted the artificial feed. Nevertheless, they displayed aggressive and hierarchical behavior, which was minimized, by grading the individuals and providing several artificial shelters in each tank.

Individuals withstood changes in temperature (from 30 °C to - 21°C) and fresh water baths (to control parasites). Dissolved oxygen was maintained at the recommended level (< 5 mg/L) as stated by Tucker (1999), in effect, avoiding diseases related to oxygen suppression such as SBSS (swim bladder stress syndrome) or gas bubble disease (Brulé et al. 1996).

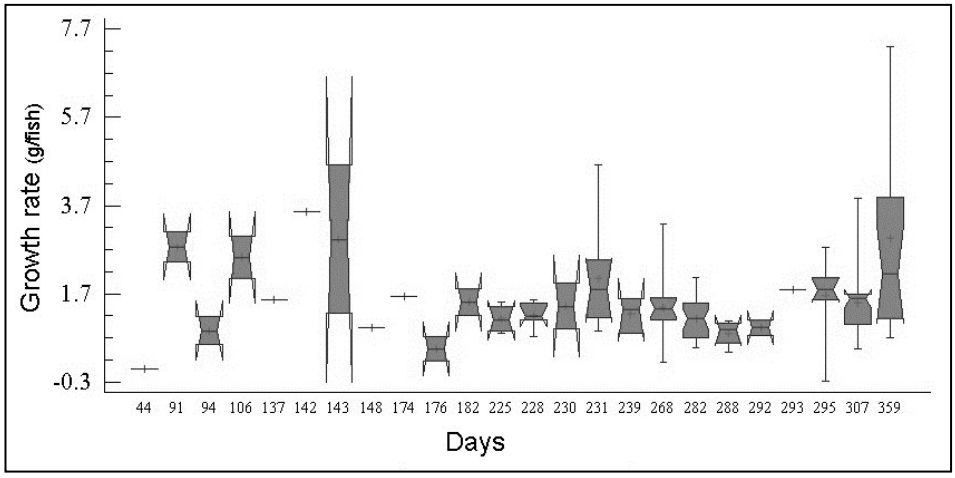

Figure 2. Median growth rate comparison of *E. morio*, throughout a year of confinement in an outside seawater tank-system. Boxes showed 50% of the growth rate data whereas whiskers stand for the lower and upper quartiles. The median is represented by the notch.

Table 3. Mean individual weight (kg), total food consumed (kg), daily intake and food consumption rate calculated from April 2007 to August 2008, and registered per sampling (each 39 ± 2 days). Results in columns in grey correspond to cold months (September 2007- February 2008), whereas white columns to warm months (March 2008- August 2008).

Sampling	N	Mean individual weight (kg)	Total food (kg)	Daily intake	Food kg/ fish	Food consumption rate
1	141	0.57	15.72	0	0	0
2	140	0.71	13.62	0.34	19.18	1.81
3	139	0.76	17.90	0.45	23.55	0.91
4	134	0.84	17.06	0.43	20.30	0.52
5	83	0.81	15.42	0.45	19.01	0.55
6	52	0.96	15.42	0.34	16.04	0.35
7	48	1.06	18.64	0.39	17.63	0.36
8	40	1.42	18.61	0.47	13.15	0.32
9	20	1.90	16.55	0.33	8.72	0.17

Individuals accepted the humid pellet feed and were accustom to feeding procedures (time and frequency) displaying the same feeding behavior as other reared grouper species such as *E. akaara* and *E. tauvina* (Boonyaratpalin 2002). Since red groupers are carnivorous their dietary protein requirements should be higher than 50% (Luo et al. 2005, Boonyaratpalin 2002, Shiau and Lan 1996). During this study, the mean weight gained by fish was 1.33 kg when fed with a 55.6% protein content diet and a feeding frequency to satiation once every two days. Shiau and Lan (1996) reported that protein could be lowered from 50 % to 44 % while the energy level of diet was maintained, which will make the diet more cost effective. Some individuals displayed signs of vitamin C deficiency (loss of appetite, erosion of the opercula and fins and exophthalmia) (Boonyaratpalin 2002) and were given supplementary vitamin C and E boosters, for one month.

Red grouper daily growth rate (3.64 g/fish) was higher than those observed for the same specie by Brulé et al. (1996) in a re-circulating water system. The differences may be due to experimental procedures, diet or feeding frequency. The growth rate recorded during this study was smaller to growth rates described by (Tucker 1999) for *E. striatus* (6.1 g/fish), similar to growth rates achieved by Chua and Teng (1980) for *E. salmoides* (3.08 to 5.44 g/ fish), and higher to growth rates registered by Chou and Wong (1985) for *E. tauvina* (2.33 g/fish), all cultured in floating net cages and fed with a pellet diet.

Since red grouper is the most important commercial specie in Yucatan, the generation of biological information that may help to its correct management, is essential. Alternatives to fishing such as aquaculture activities would also be desirable. Nevertheless, non-regulated capture-based aquaculture will only increase fishing pressure because of the extraction of juveniles to supply farming. Therefore, more studies on the growth performance, nutritional requirements and health husbandry must be carried out before a red grouper aquaculture in Yucatan could be developed.

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