Reproductive Behavior of the Gray Triggerfish, *Balistes capriscus*, in the Northeastern Gulf of Mexico

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ABSTRACT

Reproductive behaviors of gray triggerfish, *Balistes capriscus*, were recorded by SCUBA divers and remote video on artificial reefs in the northeastern Gulf of Mexico in June and July 2004-2006. Gray triggerfish showed elaborate courtship, demersal nests, and parental care of the eggs by both sexes. Individual fish were identified by size or natural scars and marks. A dominant male gray triggerfish established a territory on and around the reef, and built demersal nests in the surrounding sediment. The mean diameter of a nest was 0.53 m, depth was 0.24 m and distance from the reef 8.6 m. Male gray triggerfish courtship behavior was indicated by elaborate circling of a female, color changes, and leading the female to a nest. Within the nest both fish circled each other for a few minutes, before release of demersal gametes. After spawning the female stayed on the nest and guarded the eggs for 24-48 h. While on the nest, females showed the following behaviors: cleaning the nest, blowing on eggs, chasing other fish, and chasing other gray triggerfish. Male gray triggerfish also showed parental care by patrolling the reef and guarding the nests from other fish. Male behaviors while protecting the nest included: chasing other fish, chasing other gray triggerfish, revisiting the nest, and feeding. On several instances two females were observed on separate nests guarding eggs simultaneously around one reef with a dominant male.

KEY WORDS: Gray triggerfish, *Balistes capriscus*, behavior, parental care, artificial reefs

Comportamiento Reproductivo del Pejepuerco blanco, Balistes capriscus, en el Golfo Noreste de México

El comportamiento reproductivo del pejepuerco blanco, *Balistes capriscus*, fue grabado por buceadores y video aislado en arrecifes artificiales en el golfo noreste de México en junio y julio 2004-2006. *Balistes capriscus* mostró un elaborado cortejo, nidos demersales, y cuidado de los huevos por ambos padres. Cada pez, fue identificado con tamaño o cicatrices y marcas naturales. Un macho dominante estableció un territorio sobre y alrededor del arrecife, y construyó nidos demersales cercanos al sedimento. El diámetro promedio de un nido fue de 0.53 metros, la profundidad fue de 0.24 metros y la distancia desde el arrecife de 8.6 metros. El comportamiento de cortejo de los peces machos, fue indicado por un esmerado rodeo hacia la hembra, cambios de color, y dirigir a la hembra al nido. Dentro del nido, ambos peces circulaban el nido por unos minutos antes de soltar los gametos demersales. Después de que la hembra desova, ésta se queda en el nido y cuida los huevos de 24-48 horas. Mientras estaban en el nido las hembras mostraron el siguiente comportamiento: limpian el nido, soplan sobre los huevos, cazan otros peces de especies diversas, y persiguen otros *B. capriscus*. Los machos también mostraron cuidado paternal patrullando el arrecife y protegiendo el nido de otros peces. El comportamiento de los machos mientras protegían el nido incluyeron: cazar otros peces de especie diferente, perseguir otros *B. capriscus*, visitar y alimentar el nido constantemente. En varias ocasiones se observaron dos hembras de nidos diferentes cuidando de los huevos simultáneamente alrededor de un arrecife con un macho dominante.

PALABRAS CLAVES: pejepuerco blanco, *Balistes capriscus*, comportamiento, cuidado de los padres, arrecifes artificiales

INTRODUCTION

Triggerfish (Balistidae) have shown atypical spawning behavior, with elaborate harem groups, nest building, and parental care of eggs (Fricke 1980, Gladstone 1994, Ishihara and Kuwamura 1996, Kuwamura 1997). For example, the orange-lined triggerfish, *Balistapus undulates,* and yellowmargin triggerfish, *Pseudobalistes flavimarginatus,* were found to build nests 2 m in diameter, 0.7 m deep in 1-6 m of water on a sand substrate (Lobel and Johannes 1980). One to two fish guarded the demersal eggs in the nest and the surrounding territory from egg predation by other fish species (Lobel and Johannes 1980, Gladstone 1994, Kuwamura 1997).

In the Gulf of Mexico, gray triggerfish may show similar reproductive behaviors, but to our knowledge only information on reproductive biology has been reported. For example, gray triggerfish off the coast of Ghana, Africa showed peak spawning in the warmer months of November and December (Ofori-Danson 1990). In the Gulf of Mexico gray triggerfish were multiple batch spawners, peaked during June and July, and showed a 1:2 male to female ratio. Males and females both reached sexual maturity at 250 mm FL, but males were age 1 and females were age 2 (Wilson *et al.* 1995, Ingram 2001).

This study examined the reproductive behavior of gray triggerfish on artificial reefs in the northeast Gulf of

Mexico. If gray triggerfish show similar elaborate reproductive behavior this would be the first description in the northern Gulf of Mexico for this species.

METHODS

Study Area

The study sites were located 26-50 km south to southeast of Dauphin Island, Alabama. Artificial reefs were used for this study because natural reef habitats are rare in the northern Gulf (Parker *et al.* 1983) and the use of artificial sites allows size standardization. In October 2003, we deployed 16 artificial reefs, 50 m apart, consisting of steel cages (2.5 x 1.2 x 1.5 m) in the Hugh Swingle reef building zone (Chapin *et al.* In press). In April and May 2004, an additional 44 steel cages were deployed 1 km apart in the Hugh Swingle reef building zone. During the months of June and July 2004, we surveyed 45 of these habitats for spawning gray triggerfish. We completed 63 surveys on 18 army tanks (M60, 9.3 x 3.6 x 3.2 m) in June, July and August 2005, and 82 surveys on 28 army tanks and in June and July 2006 to quantify gray triggerfish behavior.

Spawning Behaviors

Divers recorded the number and length of all gray triggerfish on slates and also video tapped the fish on each reef. When courtship and pre-fertilization behaviors were observed, a video camera (Sony TR101 Hi-8 video camera) was placed 1-2 meters from the nest, facing the reef to remotely record gray triggerfish behavior in the absence of divers for 30 to 60 min. We also used the same method to remotely record post-fertilization behaviors of females on their nest and the associated dominant male. For all nests built around the reef, divers measured the two largest diameters of the nest, depth, distance from the reef, and compass bearing from the reef to the nest. Sediment samples and eggs were collected from active nests with a guarding female.

Egg Measurements

Eggs were collected and at least 10 eggs from each clutch (n = 9) were measured to the nearest 0.1 mm with an Olympus BH-2 compound microscope and a Flash Point Digitizing Board. Total egg clutch weights were measured to the nearest 0.1 g with an Ohaus balance.

Environmental Data

Temperature, salinity, dissolved oxygen, and depth were measured with a YSI 6920 meter at every site when spawning was observed. Mean values were estimated from the bottom 3 m.

Video Analysis

Behaviors were divided into pre and post-fertilization parental care for both the male and female gray triggerfish. The number of times a fish showed a particular behavior was divided by total minutes of recorded video.

Fish Collection

Gray triggerfish were collected with a spear gun from 19 army tanks in August, October, and November 2005 and June-September 2006. Two fish were collected while in an active nest with eggs for sex identification. In 2006, gray triggerfish were collected from an additional six artificial reef sites for sex ratio data. These reef sites included: steel cages, concrete pyramids, a barge, and a pipe with concrete mat. We measured weight (kg), lengths (SL, FL, and TL), sex, and gonad weight (nearest 0.1 g) from all gray triggerfish collected.

Data Analysis

Pre and post-fertilization behaviors for males and females were analyzed separately with an analysis of variance (ANOVA), if significant differences were detected we used a Student Newman Keuls test to show specific differences. We compared male and female lengths (FL) and weights (kg) for each year using a two-way ANOVA.

RESULTS

Fish Collection

Gray triggerfish males were significantly ($p < 0.001$) larger (297 $\pm$ 6.1 mm, 0.66 $\pm$ 0.04 kg compared to females (265 $\pm$ 3.8 mm, 0.47 $\pm$ 0.02 kg, Tables 1 and 2). Fish size differences were not detected between years or interactions (Tables 1 and 2). Mean sex ratios at sites taken outside the spawning season spawning were 1 male to 1.7 females (n =

Table 1. ANOVA table for total length (mm) of gray triggerfish collected from sites in 2005 and 2006.

Source	d.f.	S.S.	M. S.	F	Pr > F
Year	2	1716.2	858.1	0.55	0.58
Sex	1	32967.4	32967.4	21.1	< 0.0001
Year*sex	1	2554.3	2554.3	1.6	0.2
Error	124	193619.7	1561.5		
Total	128	230857.6			

Table 2. ANOVA table for weight (kg) of gray triggerfish collected from sites in 2005 and 2006

Source	d.f.	S.S.	M. S.	F	Pr > F
Year	2	0.06	0.03	0.53	0.59
Sex	1	1.22	1.22	21.1	< 0.0001
Year*sex	1	0.06	0.06	1.1	0.29
Error	124	7.2	0.06		
Total	128	8.5			

28 reefs). Sex ratios at sites with active spawning were 1:1, 1:4 and 2:4 males to females. Fish removed from active nests were identified as females.

Spawning Behaviors

During the spawning season we were able to distinguish large male gray triggerfish by their charcoal coloration, black fins, and aggressive behavior towards divers and other fishes. Other gray triggerfish could usually be distinguished from one another by size, external parasites and scars. We observed spawning behavior during the months of June and July 2004-2006. Pre-fertilization and courtship behaviors were difficult to observe on the reef. We observed these behaviors once each year for 2h total recorded behavior over 3 spawning seasons. Nest building was the highest recorded male behavior with a mean count/min $\pm$ SE = 0.31 $\pm$ 0.12. This behavior included removing sediment by mouth and laying laterally while in the nest and fanning the nest with the dorsal and caudal fins. Other mean counts of male triggerfish behavior prior to spawning included: chasing other fish = 0.09 $\pm$ 0.04, attacking the camera = 0.13 $\pm$ 0.05, getting in the nest = 0.13 $\pm$ 0.09, and swimming near the nest = 0.11 $\pm$ 0.06. No significant differences were detected in counts of these behaviors. The male was also observed circling in the nest with the female. This behavior showed the lowest mean number/min = 0.05 $\pm$ 0.03. We feel that gamete release and egg fertilization occurred shortly after this circling behavior.

Prior to spawning the female spent most of her time near the nest, mean number/min $\pm$ SE = 0.09 $\pm$ 0.07 and swimming into the nest = 0.11 $\pm$ 0.06. Other mean counts of female gray triggerfish behavior prior to spawning included attacking the camera = 0.06 $\pm$ 0.02 and feeding = 0.04 $\pm$ 0.01. Females also showed two unexpected behaviors: two females circling in a nest prior to spawning = 0.01 $\pm$ 0.01, with one female subsequently chasing the other female out of the nest = 0.01 $\pm$ 0.01. However, no significant differences were detected among counts/min of female behaviors.

On most surveys during the spawning season when active nests were located with eggs, there was a female in the nest with a territorial male patrolling the area. Males showed four common behaviors around an active nest: chasing other species of fish, chasing other gray triggerfish, attacking the camera, and returning to the nest. Males showed significantly more times returning to the nest, mean counts/min $\pm$ SE = 0.22 $\pm$ 0.04, compared to all other recorded behaviors ($p < 0.001$, n=13). Females showed most of the same behaviors as males during the post-fertilization time period, behaviors included: chasing other fish, chasing gray triggerfish, attacking camera, feeding, swimming off the nest, and blowing/fanning the eggs. However, females differed greatly from males in that they stayed on the nest, with only rare movements off the nest. Fanning and blowing the eggs in the nest was the highest recorded behavior = 1.7 $\pm$ 0.23 and significantly different from the other female post-fertilization behaviors ($p < 0.001$, n=14).

Nest and Egg Measurements

Nests were randomly distributed around the reef. Mean $\pm$ SE nest diameter = 0.53 $\pm$ 0.01 m (n=304), depth = 0.24 $\pm$ 0.01 m (n=152), and distance from the reef = 8.6 $\pm$ 0.43 m (n=152). Eggs were deposited in a single cohesive mass at the bottom of the nest. Eggs were negatively buoyant, even if broken from the clutch. Large pieces of shell and sediment were attached to the bottom of the egg mass. Mean $\pm$ SE egg size = 0.62 $\pm$ 0.003 mm (n=90) from nine different clutches. Mean $\pm$ SE egg clutch wet weight = 173.6 $\pm$ 11.2 g (n=8). Based on clutches returned to the laboratory fish hatched in 24-48h.

Environmental Data

Gray triggerfish spawning was observed at a mean temperature $\pm$ SE of 23.0 $\pm$ 0.1 EC (range: 20.9 to 30.0), a mean salinity of 34.0 $\pm$ 0.1 ppt (range: 29.8 to 35.6), a mean dissolved oxygen of 6.0 $\pm$ 0.2 mg/L (range: 4.9 to 6.8), and a mean depth of 25.4 $\pm$ 0.17 m (range: 14.6 to 31.1).

DISCUSSION

Sexual dimorphism in length and weight was apparent off coastal Alabama as male gray triggerfish were significantly larger than females. Wilson *et al.* (1995) did not

detect a significant difference between male and female gray triggerfish fork lengths and weight. However, Ingram (2001) and Moore (2001) also showed males were significantly larger than females, and that both sexes were longer in fork length compared to the present study. These differences are probably due to collection methods. Most previous collections were from charter boats and tournaments, and fishers may bias catch by only keeping the largest sized fish.

We identified dominant males by coloration and behaviors. A single male gray triggerfish established a territory around a reef during the spawning season of June and July. We observed the male gray triggerfish chasing other species of fish away from the nest including other gray triggerfish. Similar territorial male dominance has been observed in the halfmoon triggerfish, *Sufflamen chrysopterum,* and the yellowmargin triggerfish, *Pseudobalistes flavimarginatus* (Kawase and Nakazo 1992, Gladstone 1994). We observed male gray triggerfish during courtship building demersal nests in the substrate, as shown in male orange-line triggerfish, *Balistapus undulatus* (Lobel and Johannes 1980). We observed the male gray triggerfish repeatedly returning to the nest, especially when the female was in the nest. New behaviors not reported for any Balistidae included the male and female tightly circling in a nest and rapidly changing colors. We expect that circling behavior might also be present in other triggerfish considering the similarities of the other spawning behaviors.

Female gray triggerfish courtship included chasing other fish away from the nest, similar to female halfmoon triggerfish during the spawning season (Kawase and Nakazono 1992). Also during pre-fertilization behavior we often observed the female gray triggerfish return and enter the nest, similar to "nest inspection" behavior shown by yellowmargin triggerfish (Gladstone 1994). A new behavior observed in the present study was a female gray triggerfish circling in the nest with another female gray triggerfish. We believe this behavior was to identify the sex of the other fish, because later the same female was observed chasing the second female off the nest.

Active nests with a guarding female and male were observed 15 times, on nine different reef sites in June and July 2004-2006. Information from gonadal somatic indexes (GSI) for males and females matched present behavioral observations, where GSI increased in May, and peaked during June and July (Ingram 2001). Gray triggerfish nest size was smaller compared to other species of Balistidae such as the yellowmargin triggerfish (Lobel and Johannes 1980, Gladstone 1994). This was expected because gray triggerfish are smaller sized fish compared to yellowmargin triggerfish with a maximum size of 60 cm (Lobel and Johannes 1980, Gladstone 1994).

Parental care of the eggs was displayed by both male and female gray triggerfish. The dominant male triggerfish continually patrolled around the reef and revisited the nest. We observed males in close proximity or directly over the nest with the female on the eggs, chasing other species of fish, chasing other gray triggerfish, and attacking the camera. Sometimes the female would rapidly swim off the nest up to the male and turn at the last minute after what appeared to be recognition. Diver observations confirmed that males protecting an active nest with a female would build more nests and court other females. After spawning the male would patrol both active nests. With some differences, the behaviors of the male gray triggerfish most closely parallel the behaviors of the yellowmargin triggerfish (Gladstone 1994).

Only the female gray triggerfish was observed blowing and fanning the eggs in the nest. On rare occasions, females moved off the nest. Most of the time this movement was to chase other species of fish, chase other gray triggerfish, or attack the camera, but females always quickly returned to the nest. Female gray triggerfish were observed chasing away several potential egg predators from the following families: Labridae, Haemulidae, Serranidae, and Lutjanidae. We rarely observed the female gray triggerfish leaving the nest due to competition or potential predators, except on one occasion the female quickly left the nest for the shelter provided by the army tank, when a 2 m sandbar shark, *Carcharhinus plumbeus*, pasted directly over the nest. The female halfmoon triggerfish displayed similar egg defense behaviors except the females spent less time on the nest and more time feeding on the reef about 2 m from the nest (Kawase and Nakazono 1992). We rarely observed female gray triggerfish feeding while guarding the eggs, and if so it was always close to the nest (< 0.5 m).

In a study of gray triggerfish off Ghana Africa, Ofori-Danson (1990) found significantly more females compared to males during spawning season from October to December. We expect that similar skewed ratios will be shown for gray triggerfish in the Gulf of Mexico based on our present behavioral observations. There may be other male gray triggerfish that attempt to enter the spawning area but we observed the dominant male repeatedly chasing a particular smaller gray triggerfish from the reef, but not showing any aggression toward several other gray triggerfish on the reef. After being driven off the reefs these individuals were observed returning to the reefs only to be attacked again and driven off the reef by the dominant male. This process was repeated over and over again and we suggest that these other fish were subordinate males.

In summary, this study showed that gray triggerfish in the Gulf of Mexico display harem like reproductive behavior. We observed substantial involvement in pre-fertilization and courtship and parental care by this marine species that is rare among most other marine fish species. Such elaborate reproductive behavior in gray triggerfish are consistent with other species of Balistidae.

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