

**GROWTH, SURVIVAL, AND CANNIBALISM RATES OF ALLIGATOR GAR
Atractosteus spatula IN RECIRCULATING AQUACULTURE SYSTEMS**

A Thesis

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Master of Science in Marine and Environmental Biology

By

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CERTIFICATE

This is to certify that the thesis entitled “Growth, survival, and cannibalism rates of alligator gar *Atractosteus spatula* in recirculating aquaculture systems” submitted for the award of Master of Science to Nicholls State University is a record of authentic, original research conducted by Mr. Timothy Allen Clay under our supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship, or other similar titles.

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ABSTRACT

Alligator gar *Atractosteus spatula* aquaculture methods are currently being developed to restore native populations and to potentially create a new commercial market. The goal of this project was to determine optimal levels of temperature regulation, feeding ration, and rearing density of larval and juvenile alligator gar based on growth, survival, and cannibalism rates. To determine the importance of live feed at first feeding, larval alligator gar fed floating feed were reared with or without an *Artemia* spp. supplement for the first 7 days of feeding. Fish supplemented with *Artemia* had higher growth rates, higher survival and lower cannibalism rates than fish not supplemented with *Artemia* spp. To determine the effect of stocking density and feed ration on culture of juvenile alligator gar, fish 15 days after hatching (DAH) were stocked at densities of 2.5, 5, 7.5, or 10 fish/L and fed 4 or 8% body weight daily. Fish stocked at 10 fish/L had higher condition than those stocked at 5 fish/L and individuals fed 8% had higher survival than fish fed 4% body weight. Juvenile alligator gar (52 DAH) were exposed to three experiments: (1) regulated and non-regulated temperatures; (2) fed 4% body weight daily split among 2 feedings or 3 feedings; (3) fed 1, 2, 4, 6, 8, 10, or 12% body weight daily split among 3 feedings. There was no effect detected for the regulated temperature trials. Juvenile alligator gar fed 3 times daily had a lower feed conversion ratio (FCR) than those fed 2 times daily. Highest growth rates occurred when fed 6% or higher feed rates and fish fed 4% had a lower FCR than those fed 1, 8, 10 or 12%. Alligator gar should be supplemented with *Artemia* spp. for the first 7 days of feeding, temperature does not need to be regulated, and juveniles should be fed 7.4% body weight divided equally 3 times per day.

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LIST OF SCIENTIFIC NAMES

Alligator gar	<i>Atractosteus spatula</i>
Atlantic sturgeon	<i>Acipenser oxyrinchus</i>
Bastard halibut	<i>Paralichthys olivaceus</i>
Bighead carp	<i>Hypophthalmichthys nobilis</i>
Bowfin	<i>Amia calva</i>
Brook trout	<i>Salvelinus fontinalis</i>
Brown trout	<i>Salmo trutta</i>
Channel catfish	<i>Ictalurus punctatus</i>
European sea bass	<i>Dicentrarchus labrax</i>
Fat snook	<i>Centropomus parallelus</i>
Gilthead sea bream	<i>Sparus aurata</i>
Longnose gar	<i>Lepisosteus osseus</i>
Nile tilapia	<i>Oreochromis niloticus</i>
Northern snakehead	<i>Channa striatus</i>
Orange-spotted grouper	<i>Epinephelus coioides</i>
Paddlefish	<i>Polyodon spathula</i>
Palmetto bass	<i>Morone saxatilis</i> X <i>M. chrysops</i>
Rabbitfish	<i>Siganus rivulatus</i>
Rainbow trout	<i>Onchorhynchus mykiss</i>
Senegalensis sole	<i>Solea senegalensis</i>
Silver perch	<i>Bidyanus bidyanus</i>
Spotted gar	<i>Lepisosteus oculatus</i>
Summer flounder	<i>Paralichthys dentatus</i>
Sunshine bass	<i>Morone chrysops</i> X <i>M. saxatilis</i>
Winter flounder	<i>Pseudopleuronectes americanus</i>

LIST OF ABBREVIATIONS

Analysis of covariance	ANCOVA
Analysis of variance	ANOVA
Centimeters	cm
Days after hatching	DAH
Dissolved oxygen	DO
Feed conversion rate	FCR
Gonadotropin releasing hormone	GnRH
Lutenizing hormone releasing hormone	LHRHa
Killigram	kg
Millimeters	mm
Milligram	mg
Parts per thousand	ppt
Specific growth rate	SGR
Total length	TL
Total ammonia-nitrogen	TAN

INTRODUCTION

Natural History

Alligator gar *Atractosteus spatula* are the largest species of lepisosteids, which are comprised of seven extant species belonging to two genera; *Atractosteus* and *Lepisosteus*. *Atractosteus* species differ in physical appearance from *Lepisosteus* species by having a double row of teeth in their upper jaw and large, ornate gill rakers (Suttkus 1963). All lepisosteids have armor-like ganoid scales, a characteristic they share with the family Polypteridae. Lepisosteidae belongs to the infraclass Holostei, which they share with the bowfin *Amia calva* in the family Amiidae. Holosteans possess a highly vascularized, physostomous swim bladder that allows them to derive oxygen from aerial respiration and survive in waters with low dissolved oxygen (DO; Landolt and Hill 1975).

Alligator gar usually spawn between April and June (Suttkus 1963). The spawning habitat of wild alligator gar is poorly documented but thought to occur primarily in seasonally inundated river floodplains (Simon and Wallus 1989). The spotted gar *Lepisosteus oculatus* and longnose gar *L. osseus* have been observed spawning in littoral zones among submerged vegetation (Echelle and Riggs 1972). Spawning behavior of alligator gar is similar to that of other lepisosteids and involves courtship with several males pursuing a female. Once courtship has been completed a single male and female broadcast eggs and sperm simultaneously with a final rush when genital regions are thrust together (personal observation).

Gar have large eggs (*L. oculatus* 2.5 ± 0.3 mm, *A. spatula* 2.0 ± 0.7 mm) comparable to that of bowfin *Amia calva* (2.0 ± 0.3 mm), paddlefish *Polyodon spathula*

(2.1-3.1 mm), and sturgeon *Acipenser* spp. (2.0-4.7 mm; Reed et al. 1992; Ferrara 2001; Davis 2006; Chapman 2007; Smith 2008). Lepisosteid eggs are adhesive (Simon and Wallus 1989) and are toxic to mammals, reptiles, and crustaceans (Brooks 1856; Fuhrman 1969; Goodger and Burns 1980; Burns 1981; Broussard 2009). Newly hatched alligator gar are approximately 7 mm long (total length; TL), have a terminal suctorial disk on the snout, and a visible yolk-sac (Simon and Wallus 1989; Mendoza et al. 2002a, Mendoza et al. 2002b). Larval alligator gar use the suctorial disk to adhere to vegetation or other substrate during their lecithotrophic stage, which lasts until they are approximately 13.5 mm TL (Mendoza et al. 2002b). Larval alligator gar lose the suctorial disk and begin exogenous feeding between 12.5 and 22.5 mm TL (Simon and Wallus 1989) during the transitional lecitho-exotrophic feeding stage where they simultaneously obtain nourishment from yolk reserves and active predation (Mendoza et al. 2002b). Complete exogenous feeding occurs at 22 mm TL based on experiments using fed and unfed alligator gar larvae (Mendoza et al. 2002b). Simon and Wallus (1989) noted the development of teeth in juvenile alligator gar between 32.5 and 65.0 mm TL. Larval alligator gar have the fastest growth rate of all lepisosteids, with rates of 1.5 mm/day until 10 days after hatching (DAH) and 5.6 mm/day after 10 DAH when reared at 28 °C (Mendoza et al. 2002b). Mendoza et al. (2002a) produced 300 mm alligator gar in 4 months fed only artificial diets.

All gar are carnivorous, but their diet varies with age, location, season, and prey availability (Goodyear 1967; Seidensticker 1987). Larval gar are opportunistic feeders with an increasing tendency towards piscivory with increasing body size (Echelle and Riggs 1972). Prey size is often determined by snout size, with adult snout proportions

reached when juvenile alligator gar are between 23 and 37 mm TL (Mendoza et al. 2002b). Cannibalism is common in cultured alligator gar because of a lack of appropriate sized feed and artificial rearing densities (Aguilera et al. 2002; Mendoza et al. 2002a; Mendoza et al. 2002b). Cannibalistic alligator gar quickly outgrow their culture cohorts and identified because of their larger sizes and faster growth rates (Aguilera et al. 2002; Mendoza et al. 2002a; Mendoza et al. 2002b). Stomach analyses of adult alligator gar usually contain greater quantities of benthic species than other lepisosteids (Goodyear 1967; Seidensticker 1987). Suttkus (1963) suggests that alligator gar scavenge more than other lepisosteids, which was supported by subsequent research (Goodyear 1967; Seidensticker 1987).

Lepisosteids are restricted to the Gulf of Mexico and Atlantic drainages of North and Central America. The native range of alligator gar is the Gulf of Mexico coast from Florida to central Mexico and as far north as southern Illinois (Weed 1923; Mendoza et al. 2002a). Alligator gar inhabit slow moving, large bodies of water (Goodyear 1966) and typical freshwater habitats include bayous, swamps, canals, reservoirs, rivers and oxbow lakes (Goodyear 1966, Mendoza et al. 2002a). Along the Gulf of Mexico coast, alligator gar inhabit saline bays and estuaries. Alligator gar have been found at salinities of 31ppt and may have the widest salinity tolerance among lepisosteids (Goodyear 1966; Suchy 2009).

Aquaculture

During the last century, habitat loss and fishing pressure have contributed to the decline of alligator gar populations throughout the species' historical range (Ferrara

2001; Aguilera et al. 2002; Mendoza et al. 2002a). Aquaculture can be a useful option to both reestablish natural populations and to commercially produce food fish, and can be a viable short-term method to restore natural populations of alligator gar (Aguilera et al. 2002; Mendoza et al. 2002a; Kelly and Kohler 2006). The establishment of efficient aquaculture practices that can produce market-size alligator gar may reduce fishing pressure on wild populations.

Alligator gar have several traits that are advantageous for aquaculture. Brood stock are easily maintained, are highly fecund, can be spawned in captivity and can tolerate poor water quality (Aguilera et al. 2002; Mendoza et al. 2002a, Mendoza et al. 2002b). Juvenile alligator gar can also tolerate poor water quality and can be reared completely on artificial feed (Mendoza et al. 2002a; Boudreaux et al. 2007a, 2007b). However, juvenile alligator gar larvae are highly cannibalistic and most studies end with release of individuals at 15 DAH to minimize cannibalism in captivity (Mendoza et al. 2002a). In order to develop successful culture of alligator gar, methods are needed to maximize larval and juvenile growth rates while minimizing cannibalism.

Induced Spawning

Development of any finfish aquaculture requires the ability to produce and rear larvae. Artificially spawning brood stock allows for controlled production of fertilized eggs. Spawning can be induced in spotted gar during their spawning season by intramuscular injections of the gonadotropin releasing hormone (GnRH; Boudreaux et al. 2007a). GnRH injections allow for coordination of spawning of many individuals by advancing synchronous maturation of gonads. To ensure good water quality when

rearing fish at high densities, a rapid turnover of culture tank water is often necessary. Larval alligator gar are sedentary and techniques used to rear larvae should maximize water quality with minimal water current.

Larval Feed

Newly hatched *Artemia* spp. nauplii (*Artemia* hereafter) are a common feed for many fish larvae (Wedemeyer 2001). Live feed is costly and requires intensive labor to produce and some fish can quickly outgrow the size of *Artemia* (Mendoza et al. 2008). Not all larvae require live feed to begin exogenous feeding. For example, larval alligator gar can be reared completely on artificial feed without a reduced survival rate compared to larvae fed only *Artemia* (Mendoza et al. 2002; Mendoza et al. 2008). Additionally, at 20 DAH larval alligator gar fed only *Artemia* were smaller than larval alligator gar fed exclusively floating pellets (Mendoza et al. 2008).

Quantification of optimal growing conditions is important for any new aquaculture candidate. Larval mortality can influence final production and is usually high during the transition from endogenous to exogenous feeding. Different larval feeding strategies have been developed to wean larvae from live feed, and results have depended on digestive tract development, feeding behavior, and mouth size (Dabrowski 1984). Atlantic sturgeon *Acipenser oxyrinchus* have a functional stomach and a well developed digestive tract at the beginning of exogenous feeding (Mohler et al. 2000). Atlantic sturgeon fed *Artemia* until minimum conversion size can easily be converted to artificial feed without weaning (Mohler et al. 2000). At 5 DAH (approximately 18 mm TL) larval alligator gar begin exogenous feeding and are capable of digesting artificial

feed (Mendoza et al. 2002a). However, supplementing an artificial diet with live feed may enhance nutritional condition, and pre-condition larvae to accepting artificial feed (Rosenlund et al. 1997).

Rearing Density

Optimum rearing density is important in aquaculture as both understocking and overstocking result in inefficient production (Leatherland and Cho 1985). Determination of optimum rearing density can optimize space use, feed consumption, growth, and survival (Leatherland and Cho 1985). Increasing rearing density may result in no effect (Rowland et al. 2004; Corrêa and Cerqueira 2007; Saoud et al. 2008) or a decrease in growth rate (Leatherland and Cho 1985; Siddiqui et al. 1989; Hengsawat et al. 1997; Rahman et al. 2006). Vijayan and Leatherland (1988) found that an increase in stocking density of juvenile brook trout leads to a decrease in growth, feed consumption, and feed efficiency. Correa and Cerqueira (2007) found that cannibalism was positively related to rearing density for juvenile fat snook *Centropomus parrellelus*. Water quality often deteriorates with increased rearing density because of increases in nitrogen from excreted wastes, which decrease DO levels. To increase culture efficiency of alligator gar production methods should optimize rearing density to minimize cannibalism and feed conversion rates, and maximize growth rates while efficiently using available space.

Temperature

Temperature influences fish growth rates, and determination of the optimum temperature for growth is important for efficient aquaculture practices. However, maintaining constant temperatures that are optimal for growth in a greenhouse or

outdoors can be costly and impractical. The effects of fluctuating temperature on growth rates vary among species. Brown trout *Salmo trutta* exposed to constant temperatures had increased growth (Flodmark et al. 2004) compared to trout exposed to fluctuating temperatures. However, Spigarelli et al. (1982) found that brown trout had decreased growth when reared at constant temperatures compared to fluctuating temperatures. Both brown trout and palmetto bass *Morone saxatilis* X *M. chrysops* had no differences in growth when reared at constant temperatures compared to fluctuating temperatures (Woiwode and Adelman 1991; Jobling 1997). To increase culture efficiency of alligator gar production methods should rear fish at temperatures that do not effect growth or survival.

Optimal Feeding Regime

The optimal amount of feed used in efficient aquaculture practices is determined by maximizing fish growth rate, reducing feed conversion rates, minimizing costs, and maintaining water quality. Overfeeding can lead to poor water quality and wasted feed; underfeeding can result in reduced growth rates. Amount of daily feed is either based upon a percentage of body weight or feeding to satiation (Kelly and Kohler 2006). Feed conversion ratio (FCR) is defined as the ratio of amount of feed given to the amount of weight gained, and is used to determine the efficiency of feeding practices.

Fish fed to satiation may experience higher growth rates as compared to fish fed a lesser amount, but feeding to satiation may also lead to a higher FCR (Figure 1; Barrows and Hardy 2001; Silverstein 2006). The minimal FCR occurs when feed is assimilated into body mass most efficiently. Fish fed at their minimal FCR use feed more efficiently,

resulting in improved water quality and cost savings; however at the lowest FCR, growth rates may not be the fastest (Figure 1; Barrows and Hardy 2001). FCR levels will increase from the minimal FCR with increasing and decreasing feed rations. Decreased feed levels allow less feed for body mass assimilation because energy for basic maintenance takes priority and increased feed levels waste feed because of inefficiency in digestion (Figure 1; Barrows and Hardy 2001). Specific growth rate (SGR) is an aquaculture standard for measuring weight gained daily over a specific time. Maximal SGR and minimal FCR do not occur at a single feed rate, but compromises can be made to maximize SGR while still minimizing FCR by determining the greatest difference between curves (Figure 1). In addition to the total amount of feed provided per day, the number of feedings per day may affect growth rates. Bolivar et al. (2006) found that reduced feeding frequency improves feed conversion rates in Nile tilapia *Oreochromis niloticus*. Minimal feeding frequency can reduce costs associated with labor. To increase culture efficiency for alligator gar production methods should maximize growth rates and minimize feed conversion rates while maintaining water quality.

Water Quality

The water quality of aquaculture systems can directly affect the growth and survival of fish being reared. Total ammonia-nitrogen (TAN) levels can build up in aquaculture systems from excreted wastes and decomposition of uneaten food. High levels of TAN cause toxicity at the cellular level and can reduce growth and decrease survival (Tomasso 1994). Based on results obtained from several species, TAN will not inhibit growth if maintained below 9% of each species' 96hr median lethal concentration of TAN (Tomasso 1994). Safe TAN levels for alligator gar aquaculture should remain

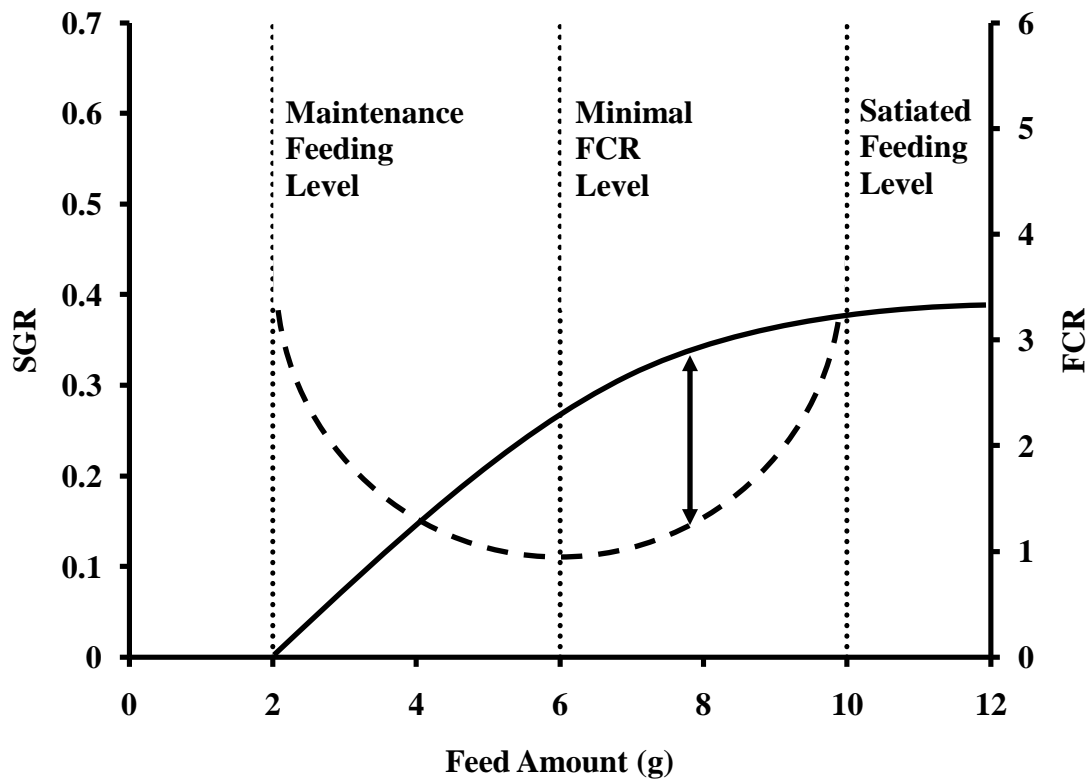


Figure 1. Relationship between feed level, fish growth rate (SGR; solid line), and feed conversion ratios (FCR; dashed line). Double pointed arrow represents feeding level where a minimal FCR and maximal SGR are optimized. Adapted and modified from Barrows and Hardy 2001.

below 12.15 mg/L (Boudreaux et al. 2007a). Through bacterial nitrification, ammonia is oxidized into nitrite, which can be further oxidized into nitrate. Nitrite is toxic to fish and actively enters through the chloride uptake mechanism of the gills (Tomasso 1994; Boudreaux et al. 2007b). Once in the blood, nitrite oxidizes hemoglobin to methemoglobin, reducing the ability of the blood to bind and carry oxygen (Tomasso 1994; Wedemeyer 2001). Nitrate, however, is not toxic to fish at levels found in most aquaculture systems; however, in high density recirculating aquaculture systems, the rate of ammonia nitrification can exceed the rate of nitrite nitrification (Wedemeyer 2001). The pH of water can adversely affect the physiology of fish, with a pH range of 6.5-9.0 preferred by most aquacultured fish (Wedemeyer 2001). Below 6.0, nitrite becomes nitrous acid and increasing pH beyond 7.0 increases the amount of un-ionized ammonia. Both nitrous acid and un-ionized ammonia freely diffuse across the gill membrane (Wedemeyer 2001) and can cause physiological problems (Tomasso 1994). While DO levels can limit production of most teleost fish, DO levels are less problematic for gar which are facultative air breathers. Low DO can reduce the number of nitrifying bacteria and hinder the nitrification of nitrite to nitrate. To increase the culture efficiency of alligator gar production methods should minimize ammonia and nitrite levels while maintaining appropriate pH and DO levels.

The goal of this project was to determine the effect of regulated temperatures, feeding regimes, and rearing density, on growth, survival, and cannibalism rates of larval and juvenile alligator gar reared in recirculating systems and fed commercially available artificial diets so that optimal culture conditions could be determined. The objectives included the following:

1. Compare growth, survival and cannibalism rates of larval alligator gar fed artificial feed or artificial feed supplemented with *Artemia*;
2. Compare growth, survival, and cannibalism rates for 15 DAH juvenile alligator gar fed 4 or 8 % body weight per day and reared at 2.5, 5, 7.5, or 10 fish/L;
3. Compare growth and survival rates for 52 DAH juvenile alligator gar reared at regulated or non-regulated temperatures;
4. Compare growth and survival rates for 52 DAH juvenile alligator gar fed a total of 4 % body weight per day divided into either 2 feedings/day or 3 feedings/day;
5. Compare growth and survival rates of juvenile alligator gar fed 1, 2, 4, 6, 8, 10 or 12% body weight of feed per day divided into 3 feedings/day;
6. Compare the water quality from the different treatment regimes.

METHODS

Experimental Systems

All experiments were conducted in 95 L circular, plastic tanks fitted with a center overflow drain in a greenhouse equipped with a misting system, shade cloth, and fans to reduce maximum daily temperatures. Each tank was either fitted with an individual filtration system or grouped with three or seven other tanks on a common filter system. Twelve individual systems were constructed with a single tank connected to a 20 L sump and a 946 L/hr pump (Figure 2). Four tank systems initially had a common 265.5 L sump (0.90 x 0.75 x 0.38 m) and a 3,085 L/hr pump (Figure 3) for the 2008 trials. Three eight-tank systems were constructed from a four tank system and 4 individual systems. A second sump with equal dimensions as the original sump was added to the eight tank system in 2009 to increase system volume and filtration capabilities (Figure 4). Eight tank systems were modular and could be reassembled into the starting systems with the caveat that the four tank systems contained two sumps (Figure 4). Ultra-violet sterilizers (4W; Lifeguard Aquatics, Cerritos, California) were installed on the four and eight tank systems prior to water returning to the tanks. All systems contained Bio-Spheres (Clearwater Inc., Apopka, Florida) in the sumps to facilitate filtration and flow was controlled by use of valves. Water salinity was maintained at 4 ppt and water was maintained by adding water from one of two reservoirs containing carbon filtered-chlorine free water at either 0 or 4 ppt.

Water Quality

Total ammonia-N (TAN; mg/L) was measured using the direct Nesslerization

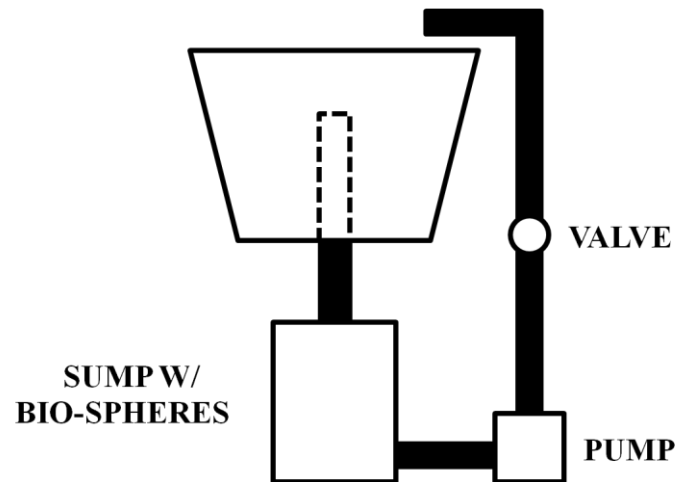


Figure 2. Schematic of single tank system. Systems consisted of a 95 L plastic tank containing 60 L of water. Tanks drained from a center mounted overflow into a 20 L sump containing bio-spheres. Water was returned with a 946 L/h pump regulated with a valve.

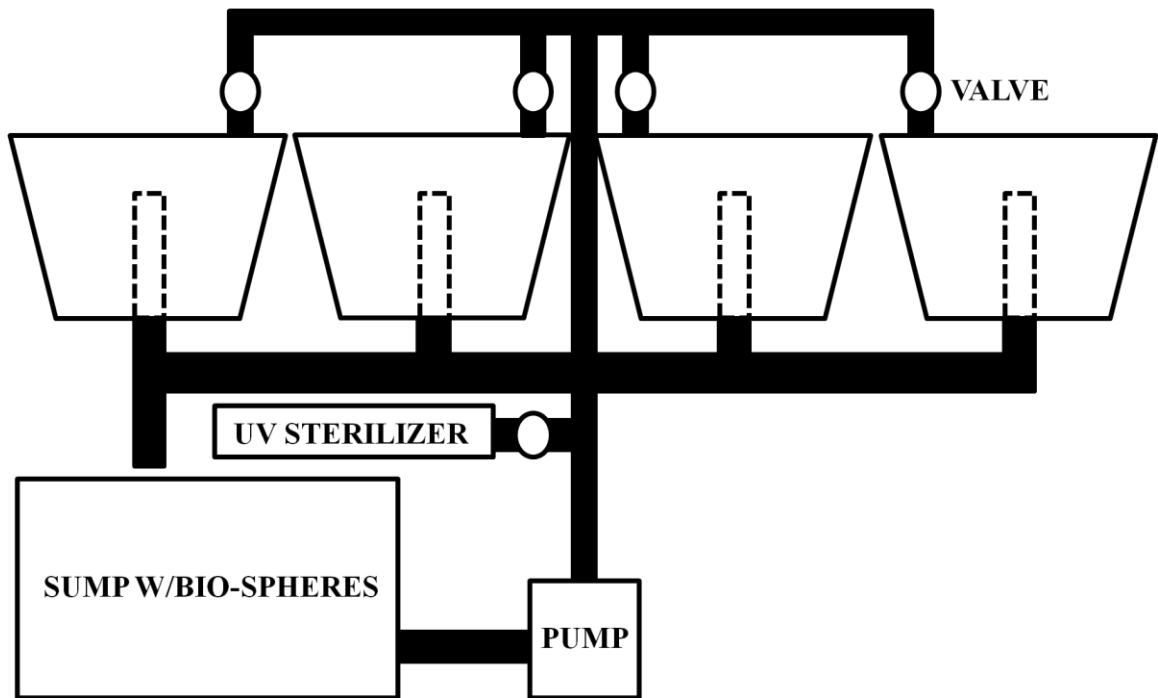


Figure 3. Schematic of the 4 tank system. Systems consisted of four 95 L plastic tanks containing 60 L of water. Tanks drained from a center mounted overflow to a common sump containing bioballs. A 3,085 L/h pump supplied water to the tanks and a 4W UV sterilizer. Water flow was controlled to the tanks and UV sterilizer with individual valves.

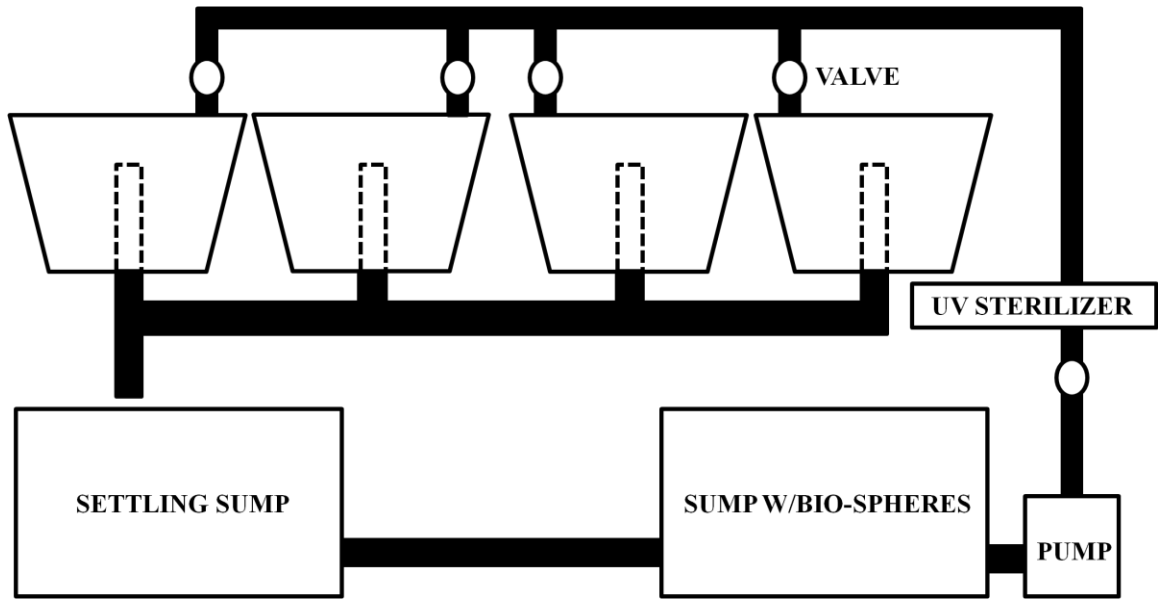


Figure 4. Schematic of the modified 4 and 8 tank systems. Systems consisted of 4 or 8-95 L plastic tanks containing 60 L of water. Tanks drained from a center mounted overflow to one of two common sumps containing bio-spheres. A 3,085 L/h pump supplied water to the tanks and a 4W UV sterilizer. Water flow was controlled to the tanks and UV sterilizer with individual valves.

method, nitrite-N (mg/L) was measured using the AZO dye method, and pH was measured using a Hannah Instruments pH meter. Dissolved oxygen (DO; mg/L), temperature (°C), and salinity (ppt) were measured with a Yellow Springs Instrument model #85 handheld temperature-oxygen-conductivity-salinity meter (Yellow Springs, Ohio). Temperature, DO, and salinity were measured and recorded each morning and evening for each treatment. TAN, nitrite-N, and pH were measured daily for each treatment. Temperature was also recorded hourly with continuous data loggers (Hobo; Bourne, Massachusetts) placed in the sumps of the four-tank systems. Water was added and exchanged as needed to maintain acceptable water quality (TAN 12.15 mg/L) for alligator gar (Boudreaux et al. 2007a; Boudreaux et al. 2007b).

Spawning and Rearing

Adult alligator gar were collected with multifilament gill nets (bar mesh of 7.6, 12.7, or 15.2 cm) from Golden Ranch Plantation (N=32) and Bayou Chevreuil (N=3) in southern Louisiana. Adult alligator gar were kept in an outdoor pond in pens either 48.4 m³ or 96.7 m². Each alligator gar was injected intramuscularly with 0.1 mg/kg luteinizing hormone releasing hormone (LHRHa) and immediately transferred to a 3.7 m diameter tank (Table 1). Sex of brood stock alligator gar was differentiated based on size and weight, with females being larger than males (Table 1). For the successful 12 May 2008 injection (Table 1) the tank was maintained at ambient temperature (26.4 ± 1.0 °C) and exposed to the natural photoperiod (approximately 14L:10D). Bundles of raffia, artificial material, were attached to 25.4 x 1219 mm PVC pipe and anchored to bricks and used as spawning substrate. Approximate date of spawn (15 May 2008) was determined based on presence of eggs. Spawning substrate with adhered eggs was transferred to four 454 L

Table 1. Injection dates with designated sexes, mean wt (kg \pm SE), mean TL (mm \pm SE) and estimated # of larvae produced in 2008 and 2009.

Date	Male			Female			#
	N	Wt	TL	N	Wt	TL	Larvae
12 May 2008	7	9 \pm 0.6	1247 \pm 23.4	3	12 \pm 0.7	1388 \pm 40.9	20,000
6 June 2008	5	17 \pm 1.8	1391 \pm 67.6	6	10 \pm 1.0	1154 \pm 56.9	0
16 June 2008	5	10 \pm 1.0	1154 \pm 56.9	1	20	1310	0
10 April 2009	6	11 \pm 0.4	1260 \pm 30.5	4	14 \pm 1.7	1278 \pm 52.0	1,000
1 May 2009	5	11 \pm 1.2	1276 \pm 46.7	1	27	1746	10
11 May 2009*	5	11 \pm 1.2	1276 \pm 46.7	1	27	1746	0
27 May 2009	7	10 \pm 1.3	1179 \pm 50.0	4	22 \pm 0.9	1479 \pm 59.6	100

*Fish from the previous spawning group were re-injected.

recirculating fiberglass raceways. The substrate was removed from PVC pipes and transferred to two 1.9 m diameter, aerated tanks. Temperature (23.0 ± 0.41 °C; mean \pm SE), pH (7.8 ± 0.41), DO (7.2 ± 0.97 mg/L), TAN (0.8 ± 0.78 mg/L), and nitrite-N (0.03 ± 0.04 mg/L) were measured daily. Hatching occurred approximately five days after LHRHa injection of adults, and larval alligator gar were transferred to a static, aerated raceway (2.1 x 0.7 x 0.1 m) supplied with raffia for larval attachment. The raceway was partitioned to increase the density of larval alligator gar, which allowed for more effective feeding. The partition was moved daily to increase holding area during development to accommodate growth (Figure 5). Larval alligator gar were fed to satiation three times daily and feed size increased with fish size (Table 2). Dead individuals were recorded and removed daily. Temperature (22.8 ± 0.73 °C), pH (7.7 ± 0.18), DO (5.6 ± 1.85 mg/L), TAN (4.4 ± 2.54 mg/L), nitrite-N (0.04 ± 0.03 mg/L), and water exchanges (34.2 ± 8.5 L/day) were recorded daily.

Artemia Supplemented Larvae

To determine the effect of supplementing *Artemia* spp. at first feeding for larval alligator gar, fertilized eggs were obtained from the 10 April 2009 injection of captive alligator gar and were transferred to and incubated in three 8-tank recirculating systems containing 30 L of water per tank (flow approximately 1 L/min; Figure 4). Water quality was measured daily and maintained at predetermined acceptable levels; temperature = 23.7 ± 0.07 °C, pH = 8.1 ± 0.03 , DO = 8.0 ± 0.13 mg/L, TAN = 0.5 ± 0.09 mg/L, and nitrite-N = 0.3 ± 0.04 mg/L.

Eggs hatched eight days after injection (18 April 2009) and larval gar were reared

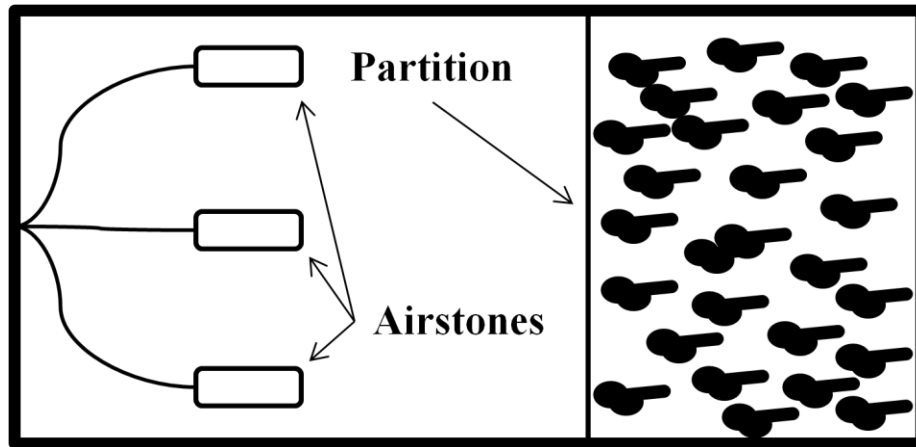


Figure 5. Schematic of larval rearing tank.

Table 2. Feeding schedule for larval alligator gar from the 15 May 2008 spawning reared from hatching to 17 days after hatching (DAH).

Feed	Size (mm)	%Protein/ %Lipid	Duration (DAH)
<i>Artemia</i> nauplii (newly hatched)			5-17
Zeigler AP100 floating larval fish feed	0.25-0.45	50/12	5-12
Silver Cup Trout fry artificial granulated crumble	0.59-0.84	48/14	9-17
Silver Cup Trout fry artificial granulated crumble	0.84-1.38	48/14	15-17

until 4 DAH without feed. Water quality was measured daily and maintained at: temperature = 23.6 ± 0.06 °C, TAN = 0.5 ± 0.09 mg/L, nitrite-N = 0.3 ± 0.04 mg/L, DO = 8.0 ± 0.13 mg/L, and pH = 8.1 ± 0.03 . At 5 DAH a subsample of 25 larvae was sacrificed to determine initial wet weight ($3.39 \pm 0.08 \times 10^{-2}$ g), and total length (TL; 15.4 ± 0.79 mm).

Five DAH alligator gar were stocked at 100 fish per tank in a single 8-tank system (Figure 4). Fish were fed to satiation three times daily with feed size increasing with fish size (Table 3). Four tanks received only floating feed (F-F) and four tanks were fed floating feed supplemented with *Artemia* (A-S; Table 3). *Artemia* (2.5 g cysts/L of hatching water) were hatched under constant light and aeration and were fed to the larval alligator gar 24 hr after being placed in the hatching jar. Larval mortalities were recorded daily and total # of surviving individuals were recorded at the end of the trial. Mortalities due to cannibalism were calculated as the difference between total (based on total survival) and observed (number removed during experiment) mortality. Water quality was maintained at predetermined acceptable levels (Boudreaux et al. 2007a, 2007b; temperature = 26.6 ± 0.04 °C, TAN = 0.8 ± 0.15 mg/L, nitrite-N = 0.6 ± 0.06 mg/L, DO = 6.8 ± 0.25 mg/L, pH = 7.8 ± 0.06 , and salinity = 4.0 ± 0.17 ppt).

For the A-S treatment, larval alligator gar received *Artemia* and floating feed from 5 DAH to 12 DAH, then only floating feed to 20 DAH. For the F-F treatment, larval alligator gar received only floating feed from 5 DAH to 20 DAH. Subsamples of five individuals per tank were sacrificed at 12 DAH (end of *Artemia* supplement) and 20 DAH (end of experiment) to measure weight (g) and TL (mm). Analysis of variance (ANOVA; $\alpha = 0.05$) was used to compare condition factor, SGR, wet weight, TL,

Table 3. Feeding schedule for larval alligator gar from the 10 April 2009 injection reared from hatching to 20 days after hatching (DAH).

Feed	Size (mm)	%Protein/ %Lipid	Duration (DAH)
<i>Artemia</i> nauplii (newly hatched)*			5-12
Ziegler AP100 floating larval fish feed	0.25-0.45	50/12	5-12
Silver Cup Trout fry artificial starter	0.44-0.59	48/14	9-15
Silver Cup Trout fry artificial granulated crumble	0.59-0.84	48/14	12-20

*Only for the *Artemia* supplemented treatment.

survival and percent cannibalism between treatments.

Stocking Density and Feeding Amount

To determine the effect of stocking density and feed amount on growth, a 16 day 4x2 factorial trial was conducted with 15 DAH alligator gar. Alligator gar were obtained from the Private John Allen National Fish Hatchery in Tupelo, Mississippi. Fish were stocked at densities of 2.5, 5, 7.5, or 10 fish per liter and fed a 1 mm granulated crumble (48% protein, 14% lipid; Silver Cup, Murray, Utah) at either 4 or 8% body weight daily divided among three feedings. Three eight-tank systems were used to allow for replication of all treatments (Figure 4). Initial wet weights (0.0901 ± 0.0047 g) and lengths (26.4 ± 0.60 mm) were measured from a subsample of individuals (N = 25). Feed amount was adjusted based on subsample wet weights (g) obtained every other day. At the conclusion of the trial individual wet weights (g) and lengths (mm) were measured for all individuals. Dead fish were counted, recorded and removed daily. ANOVA was used to compare condition factor, SGR, wet weight, TL, and survival among treatments.

Temperature Regime

To compare the effects of regulated and unregulated temperature on juvenile alligator gar growth, a 21 day trial was conducted in the single sump four-tank systems (Figure 3). Juvenile alligator gar were obtained from the 12 May 2008 spawning and stocked at 0.5 fish / L per tank (Table 1). Initial wet weight (8.8 ± 2.4 g) and total length (127.5 ± 10.2 mm) were measured for all individuals. One system was exposed to unregulated temperatures (28.7 ± 1.5 °C) inside the greenhouse. A heater and chiller were used to regulate the other system and maintain temperatures at 27.5 ± 0.5 °C. The

fixed temperature was based on the average temperature for 30 days prior to the start of the experiment. Alligator gar in both systems were fed a 2.4 mm extruded floating pellet (#4 Aquamax; 45% protein, 16% lipid, Purina Mills, Gray Summit, Missouri) at 4% body weight daily split evenly among three feedings. To adjust feed amounts, wet weights (g) were measured and recorded every other day for a subsample of randomly selected individuals (N=10) from each tank. Upon conclusion of the trial wet weight (g) and TL (mm) were measured for all individuals. Dead fish were counted, recorded and removed daily. ANOVA was used to compare condition factor, SGR, FCR, wet weight, TL, survival and water quality between treatments.

Feeding Frequency

To determine the effect of feeding frequency on juvenile alligator gar growth, a 21 day trial was conducted in 2-4 tank systems (Figure 3). Juvenile alligator gar were obtained from the 12 May 2008 spawning and stocked at 0.5 fish / L (Table 1). Initial wet weight (9.1 ± 2.4 g) and total length (128.5 ± 11.0 mm) were measured for all individuals. One system was fed a 2.4 mm extruded floating pellet (#4 Aquamax, 45% protein; 16% lipid) at 4% body weight daily split between two feedings. The other system was fed extruded pellet #4 at 4% body mass daily split among three feedings. To adjust feed amounts, wet weights (g) were measured every other day for a subsample of randomly selected individuals (N=10) from each tank. Upon conclusion of the trial wet weights (g) and total lengths (mm) were determined for all individuals. Dead fish were counted, recorded and removed daily. ANOVA was used to compare condition factor, SGR, FCR, wet weight, TL, and survival between treatments.

Feed Ration

Two 21 day trials were conducted to determine the effect of feed amount on growth of juvenile alligator gar. For the first trial, juvenile alligator gar were obtained from the 12 May 2008 spawning and stocked at 0.5 fish / L in single tank systems (Table 1; Figure 2). Initial wet weight (5.5 ± 1.3 g) and total length (111.4 ± 9.9 mm) were measured for all individuals. Fish were fed an extruded floating pellet (#4 Aquamax, 45% protein; 16% lipid) at rates of 1, 2, 4, or 8% body weight daily split among 3 feedings. Twelve individual tanks were used to provide three replications per feed rate. To adjust feed amounts, wet weights (g) were measured and recorded every other day for a subsample of randomly selected individuals (N=10) from each tank. Upon conclusion of the trial wet weights (g) and total lengths (mm) were determined for all individuals. Dead fish were counted, recorded and removed daily. ANOVA was used to compare condition factor, SGR, FCR, wet weight, TL, survival, and water quality among treatments.

For the second 21 day growth trial alligator gar were obtained from the Private John Allen National Fish Hatchery. Fish were stocked in the dual sump four tank systems at 0.5 fish/L (Figure 4). Initial wet weight (5.32 ± 0.03 g) and total length (103.6 ± 0.29 mm) were measured for all individuals. Initial dry weights were obtained from a subsample of 25 fish. Fish were fed an extruded floating pellet (#4 Aquamax, 45% protein; 16% lipid) at rates of 6, 8, 10, or 12% body mass daily split among three feedings. Three, four tank systems were used to provide three replications per feed rate. To adjust feed amounts, wet weights (g) were measured and recorded every other day for a subsample of randomly selected individuals (N=10) from each tank. Upon conclusion

of the trial wet weights (g) and total lengths (mm) were determined for all individuals. Final dry weights were obtained from a subsample (N=5) from each tank. Dead fish were counted, recorded and removed daily. ANOVA was used to compare condition factor, SGR, FCR, wet weight, TL, survival, and water quality among treatments.

Statistical Analyses

Dry weights were obtained by drying fish for 7 d at approximately 65 °C and were recorded to the nearest 0.0001 g. Total length was measured from the tip of the snout to the end of the caudal fin. Condition factor was determined as:

$$100,000 * [\text{wet weight} / (\text{TL})^3]$$

SGR was determined as:

$$[\text{Ln}(\text{final wet weight}) - \text{Ln}(\text{initial wet weight}) / (\text{final day} - \text{initial}) * 100].$$

FCR was determined as:

$$[\text{dry weight of feed} / \text{dry weight of fish}].$$

ANOVA was used followed by Tukeys *post hoc* analysis to compare condition factor, FCR, SGR, TL, wet weight, survival, temperature, DO, nitrite, ammonia, pH, and salinity among treatments. Analysis of covariance was used to determine the relationship between density and feed amount in the density and feed amount trials. ANOVA was used to determine the relationship between feed amounts and wet weight, TL, condition factor, and survival. ANOVA and regression analysis were used for FCR and SGR in the feed amount trials to determine the relationship between FCR and SGR.

RESULTS

Artemia Supplemented Larvae

Larval alligator gar for both the *Artemia* supplemented (A-S) and the floating feed only treatments (F-F) gained weight during the experiment (Figure 6). Alligator gar from the A-S treatment were heavier (0.030 ± 0.0016 g; $p = 0.0001$; Figure 6a) and longer (35.2 ± 0.59 mm; $p = 0.0001$; Figure 6b) by 12 DAH than were fish from the F-F treatment (0.012 ± 0.0010 g; 26.4 ± 0.47 mm). Although weights and lengths were different, condition factor was not different at 12 DAH (0.67 ± 0.007 ; $p = 0.7598$; Figure 7) or 20 DAH (0.80 ± 0.006 ; $p = 0.1797$; Figure 7). SGR was higher at both 12 (0.36 ± 0.024 ; $p = 0.0019$) and 20 DAH (1.21 ± 0.049 ; $p = 0.0297$) for alligator gar in the A-S than for alligator gar in the F-F treatment (0.12 ± 0.014 ; 0.58 ± 0.131 ; Figure 8). Although SGR increased between 12 and 20 DAH for the F-F treatment, the A-S treatment continued to outgrow the F-F treatment by 20 DAH (Figures 6 and 8).

Total mortality was lower ($p = 0.0066$) in the A-S treatment (29%) than in the F-F treatment (57%; Figure 9). Cannibalism was the primary cause of mortality for both treatments, and was higher ($p = 0.0091$) in the F-F treatment (44%) than the A-S treatment (19%; Figure 9). However, there was no difference ($p = 0.0863$) between treatments for mortalities not attributed to cannibalism (Figure 9).

Stocking Density and Feed Amount

There was no interaction between density (2.5, 5, 7.5, 10 fish/L) and feed ration (4 or 8%) for this experiment, allowing for separate analyses for densities and feed

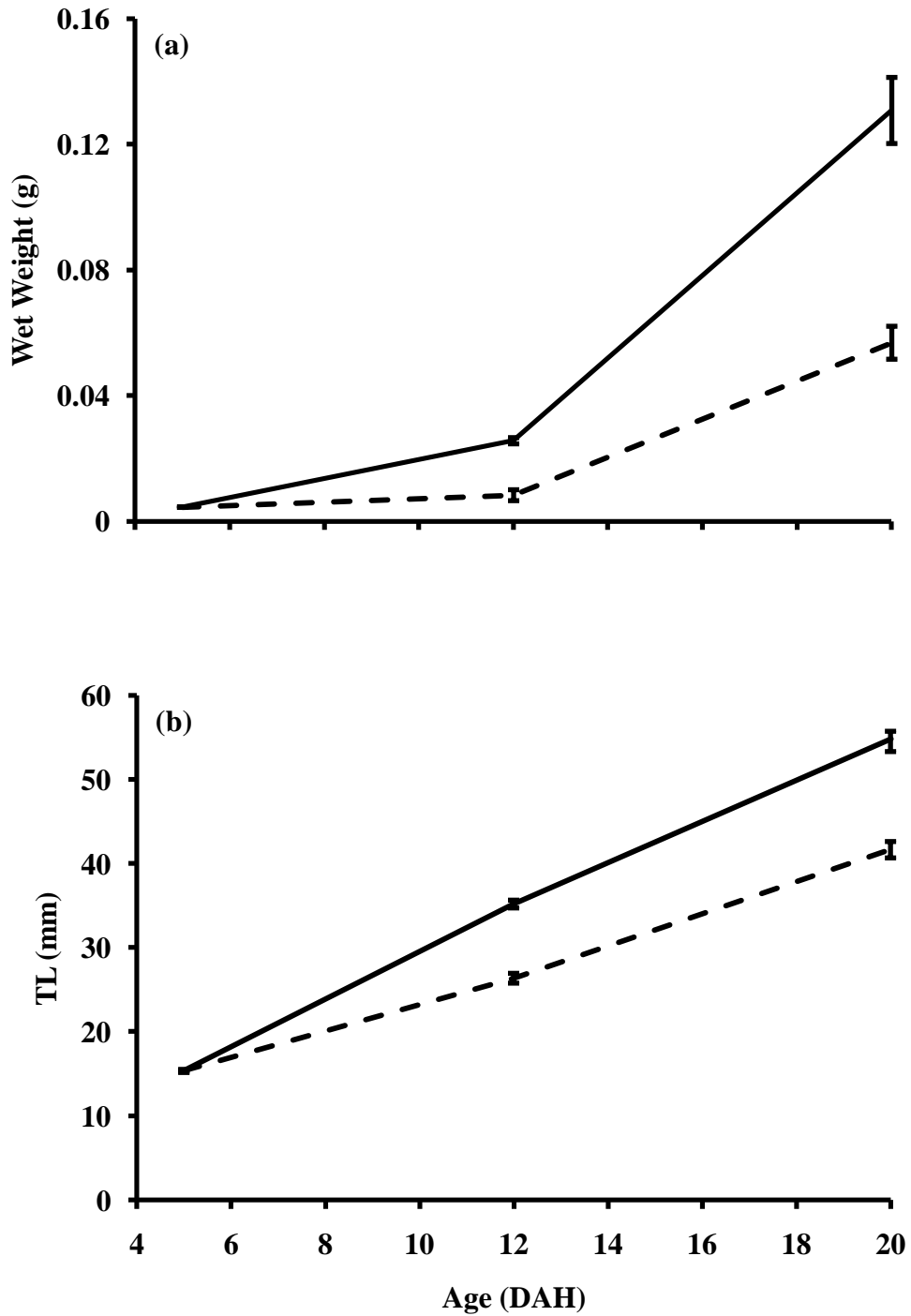


Figure 6. Mean (\pm SE) wet weight (a) and TL (b) at 12 DAH (end of *Artemia* supplement) and 20 DAH (end of experiment) for larval alligator gar fed a commercially available floating feed with (solid line) or without (dashed line) a live *Artemia* nauplii supplement for the first 7 days of exogenous feeding.

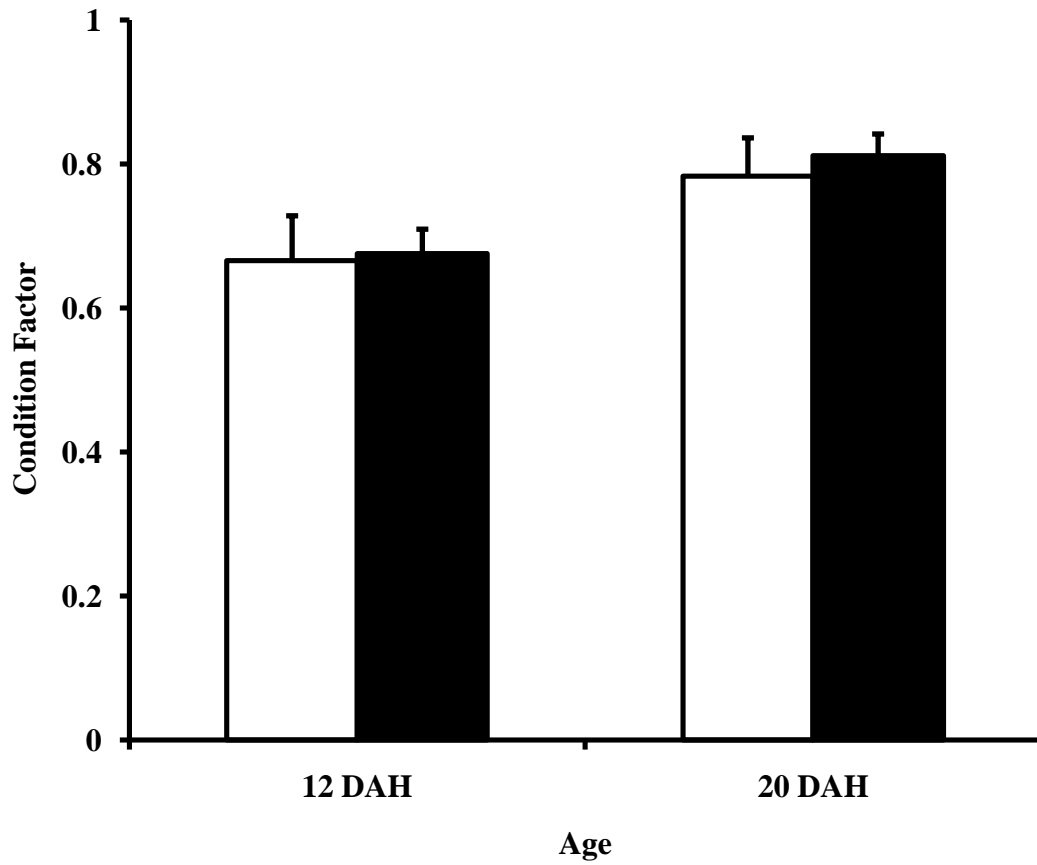


Figure 7. Mean (\pm SE) condition factor at 12 and 20 DAH for larval alligator gar fed a commercially available floating feed with (empty boxes) or without (solid boxes) a live *Artemia* nauplii supplement for the first 7 days of exogenous feeding.

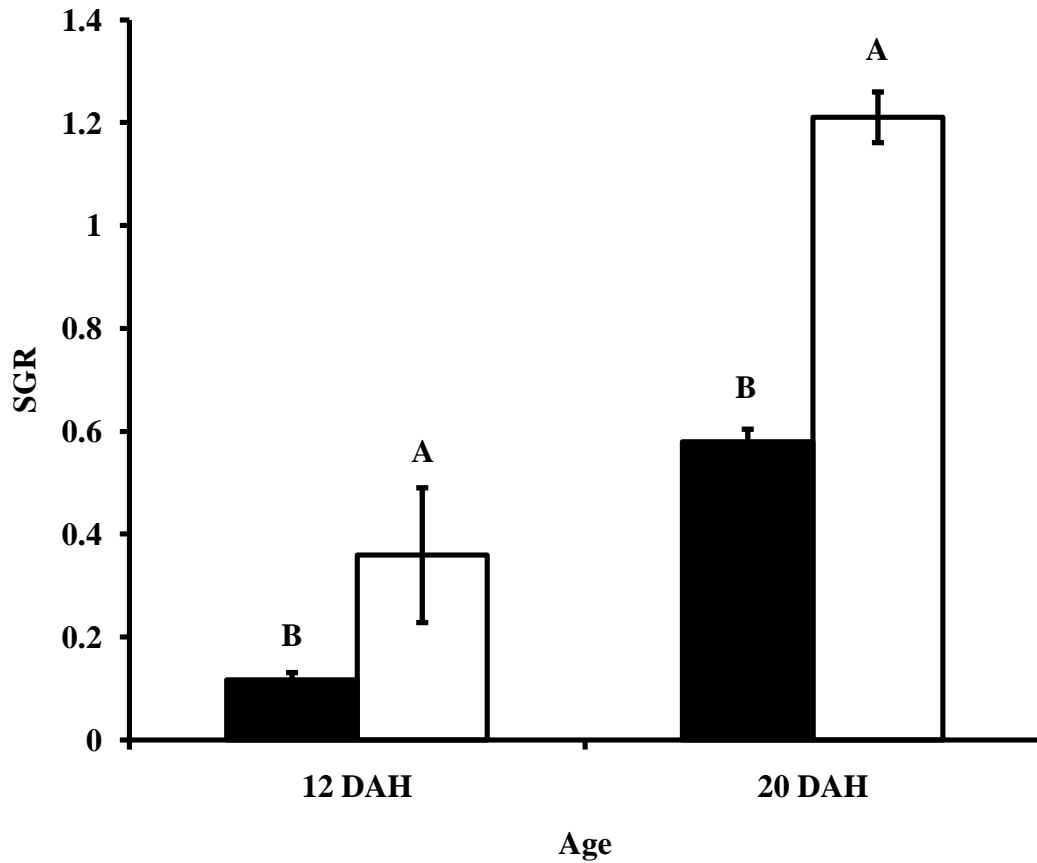


Figure 8. Mean (\pm SE) SGR at 12 and 20 DAH for larval alligator gar fed a commercially available floating feed with (empty boxes) or without (solid boxes) a live *Artemia* nauplii supplement for the first 7 days of exogenous feeding. Letters above samples represent Tukey groupings based on ANOVA results and denote differences among samples.

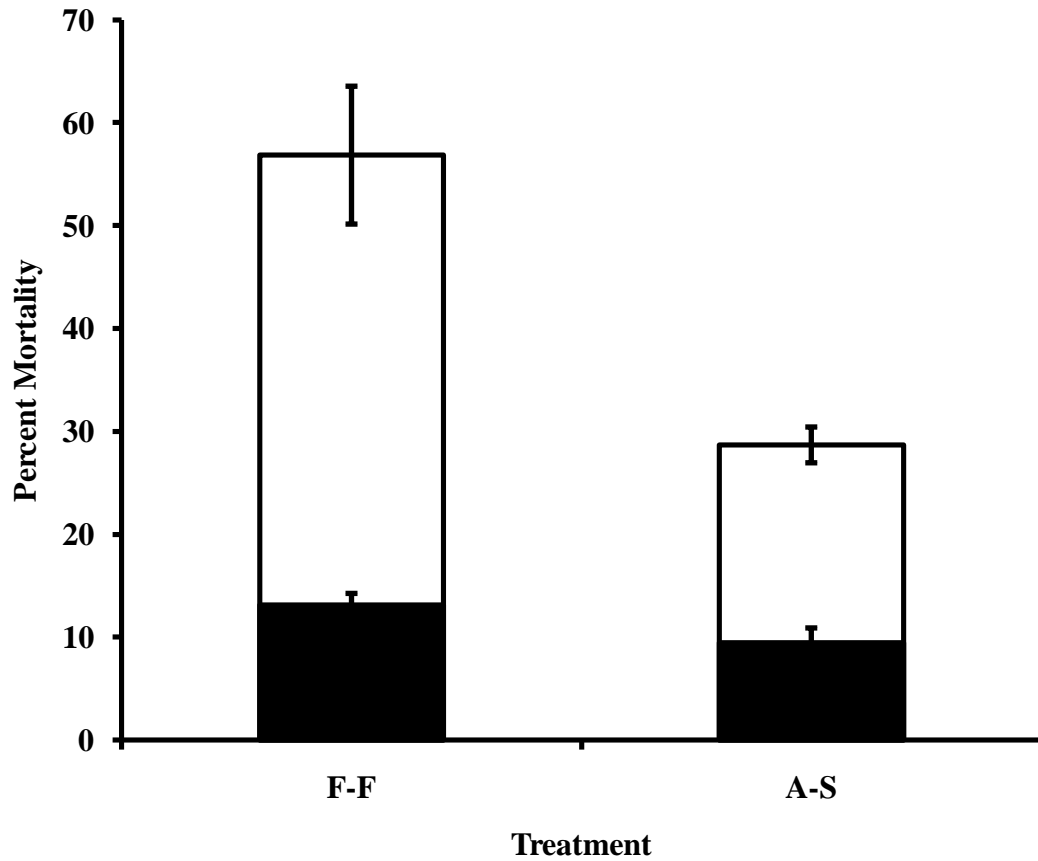


Figure 9. Mean (\pm SE) percent total mortalities (open boxes) and observed mortalities (solid boxes) at 20 DAH for larval alligator gar fed a commercially available floating feed with (A-S) or without (F-F) a live *Artemia* nauplii supplement for the first 7 days of exogenous feeding.

percentages for comparisons. Final weights ($p = 0.6256$) and TL ($p = 0.6975$) were not different among the density treatments (Figure 10). Final weights ($p = 0.1367$) and TL ($p = 0.6878$) were not different between feed rations (Figure 10). Fish stocked at 10 fish/L (0.45 ± 0.009) had higher condition factor than fish stocked at 5 fish/L (0.42 ± 0.005 ; $p = 0.0067$; Figure 11a). Condition factor was not different between feed rations ($p = 0.4299$; Figure 11b). SGR was not different among density treatments ($p = 0.6089$; Figure 12a) or between feed percentage treatments ($p = 0.8804$; Figure 12b). Total survival was not different among density treatments ($p = 0.1829$; Figure 13a). Fish fed 8% body mass (24%) had a higher survival rate than fish fed 4% body mass (17%; $p = 0.0491$; Figure 13b). Mortality not attributed to cannibalism was lowest for fish at densities of 5 and 7.5% fish/L ($p = 0.0132$; Figure 13a). However, mortality was not different among feed rations ($p = 0.8172$; Figure 13b). Cannibalism was not different among density treatments ($p = 0.0797$; Figure 13a) and between feed rations ($p = 0.0555$; Figure 13b).

Temperature ($p = 0.7070$), DO ($p = 0.4170$), and salinity ($p = 0.4980$) did not differ among experimental systems (Table 4). TAN ($p = 0.0003$), pH ($p = 0.0058$), and nitrite-N ($p = 0.0001$) were higher in system three than in the other two systems (Table 4).

Temperature Regime

Alligator gar in both the regulated and unregulated temperature treatments increased in size during the experiment (Figure 14) and did not differ in weight ($p = 0.4090$; Figure 14), TL ($p = 0.4111$; Figure 15) or final condition factor ($p = 0.6886$; Figure 16). FCR ($p = 0.1790$; Figure 17) and SGR ($p = 0.0729$; Figure 18) were not

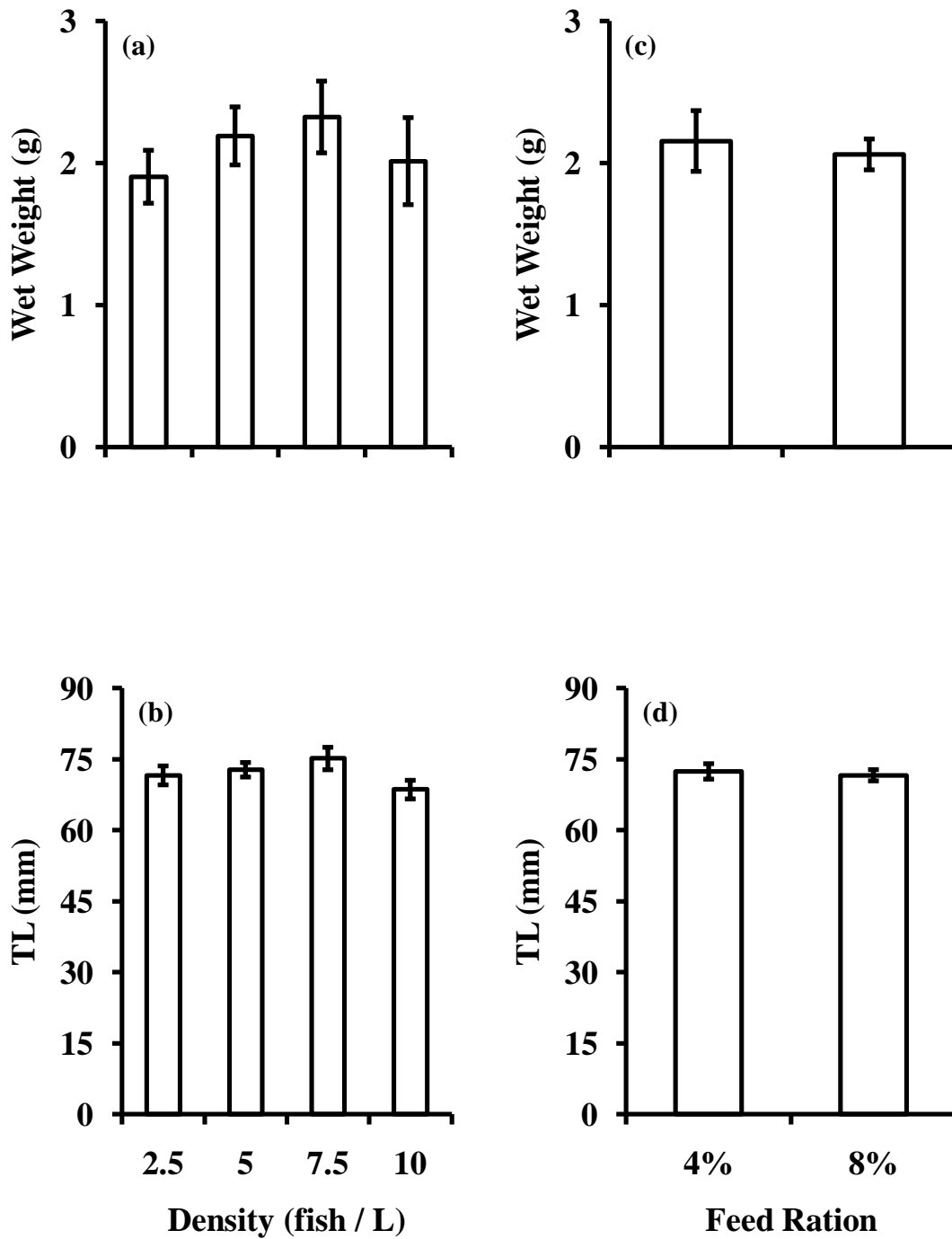


Figure 10. Final mean (\pm SE) wet weight and TL of juvenile alligator initially stocked at different densities (a,b) and fed either 4 to 8 percent body weight split among three daily feedings (c,d) for 16 days.

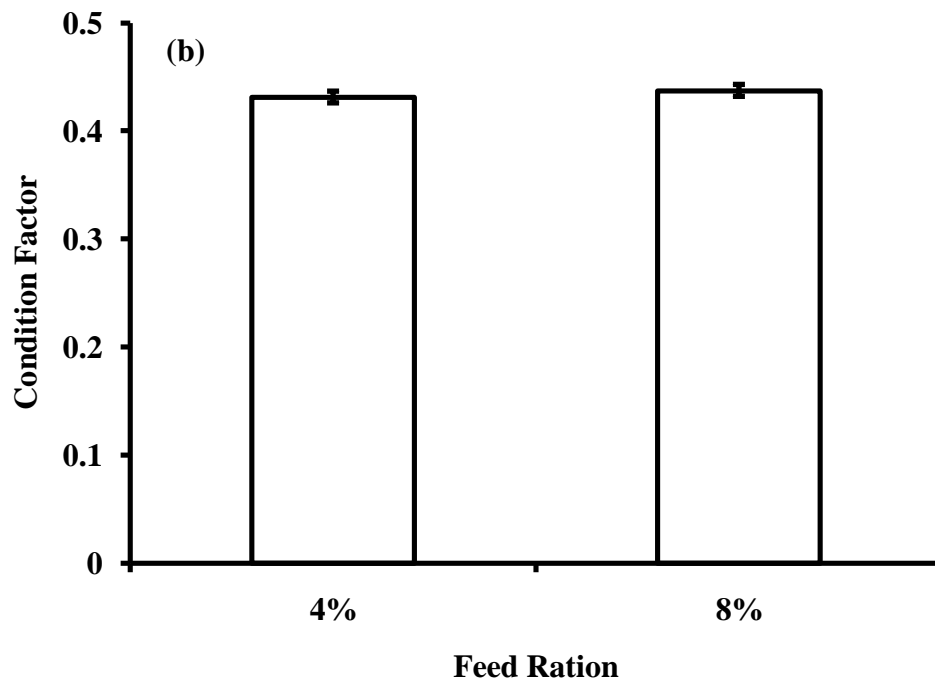
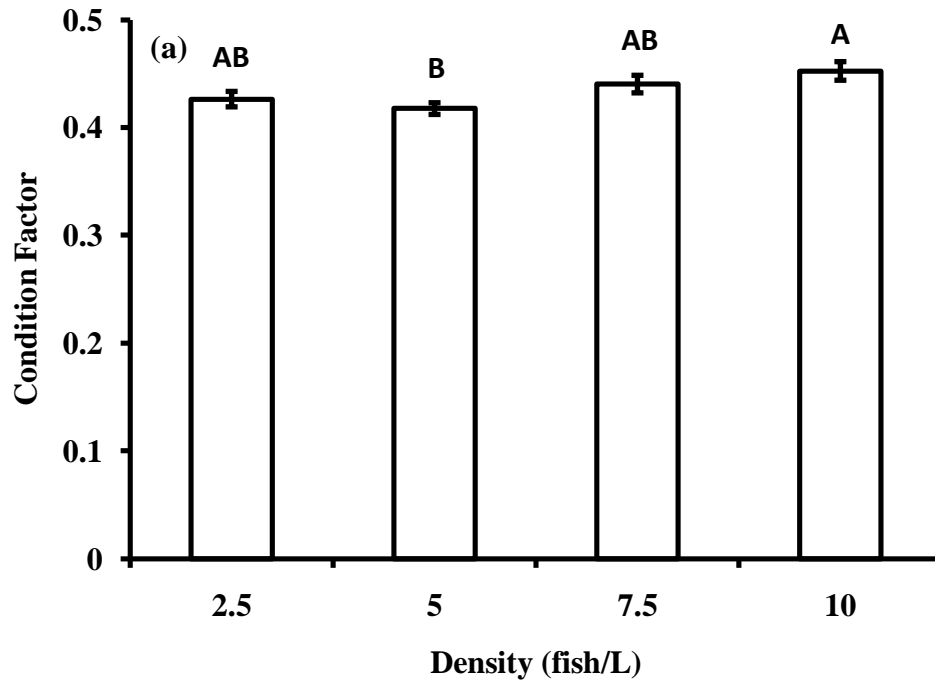


Figure 11. Final mean (\pm SE) condition factor at of juvenile alligator initially stocked at different densities (a) and fed either 4 or 8 percent body weight split among three daily feedings (b) for 16 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

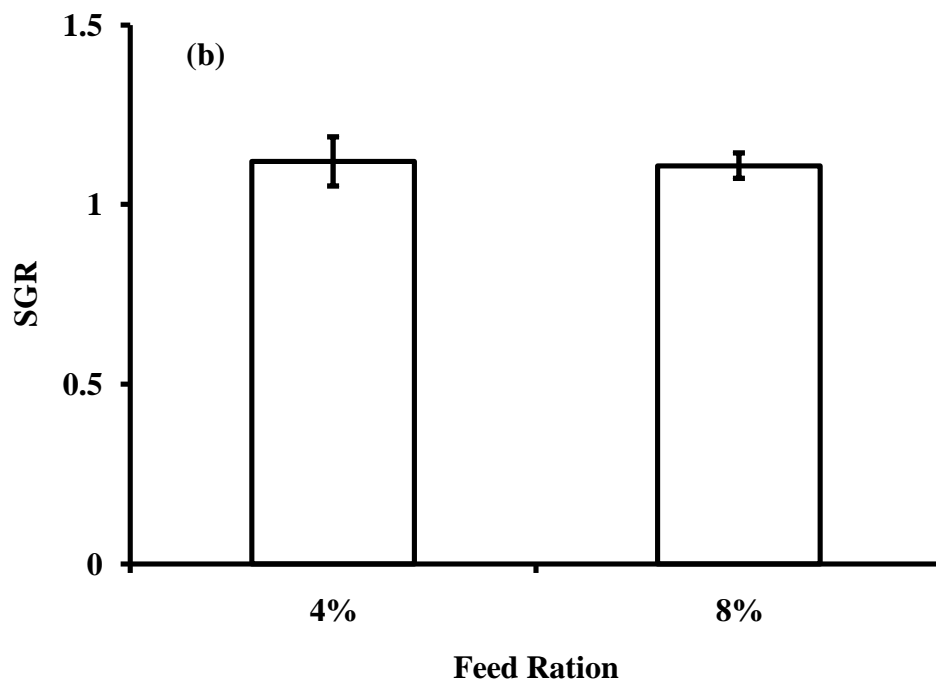
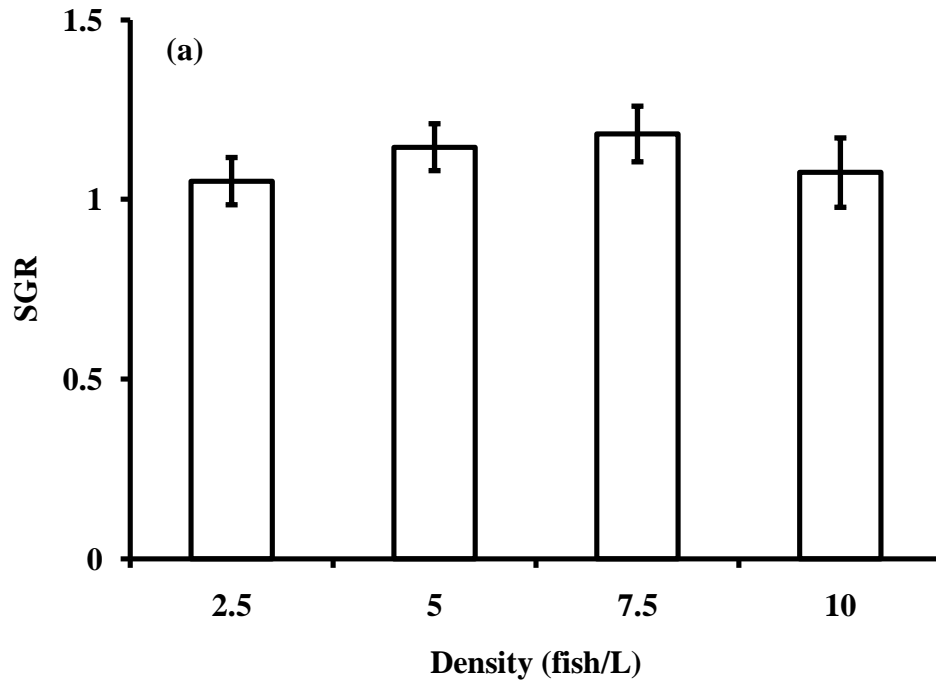


Figure 12. Final mean (\pm SE) SGR of juvenile alligator initially stocked at different densities (a) and fed either 4 or 8 percent body weight split among three daily feedings (b) for 16 days.

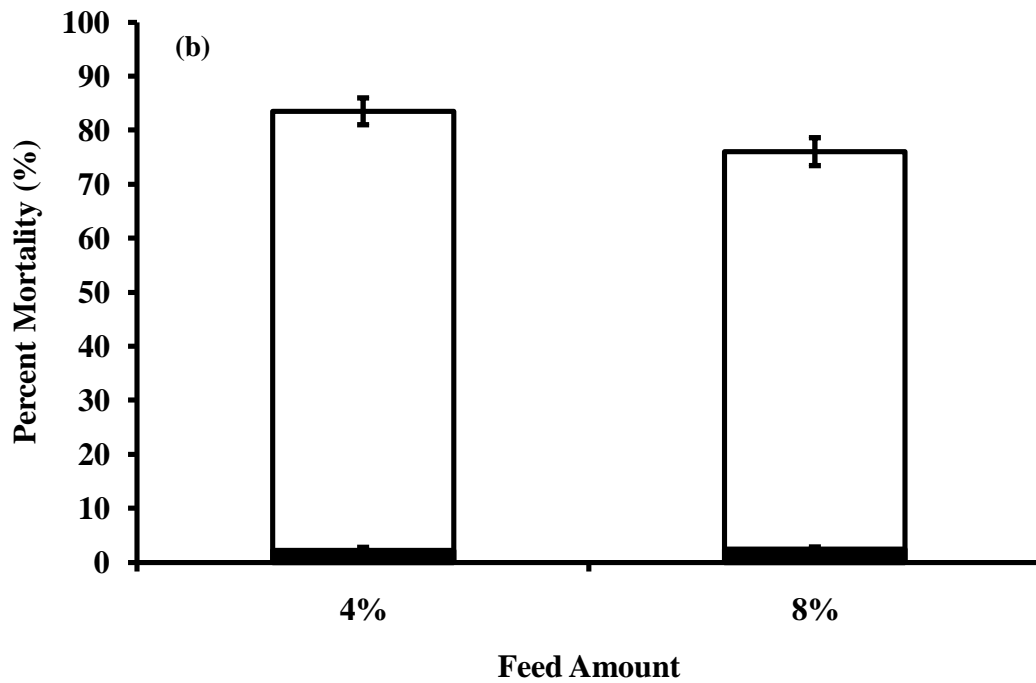
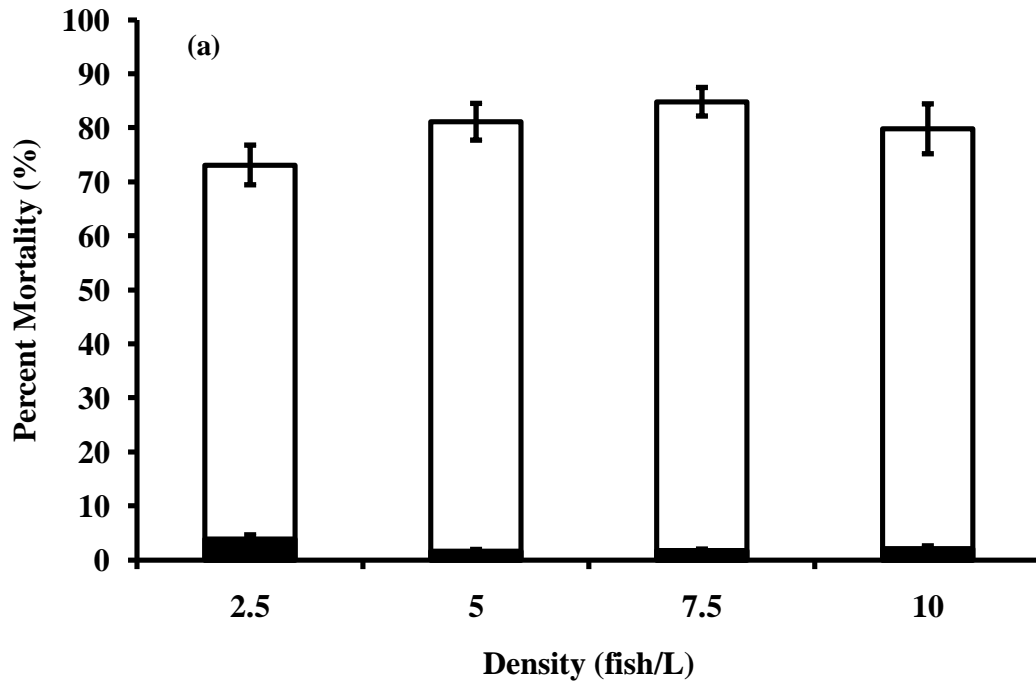


Figure 13. Final mean (\pm SE) percent cannibalism (empty boxes) and natural mortality (solid boxes) of juvenile alligator initially stocked at different densities (a) and fed either 4 or 8 percent body weight split among three daily feedings (b) for 16 days.

Table 4. Mean (\pm SE) temperature, salinity, DO, pH, TAN, and nitrite-N for each system used in the juvenile alligator gar density and feed ration experiments. Different lower case letters denote Tukey groupings.

Variable	System			<i>p</i> value
	1	2	3	
Temperature ($^{\circ}$ C)	26.7 \pm 0.35	26.6 \pm 0.32	26.3 \pm 0.34	0.7070
Salinity (ppt)	4.1 \pm 0.02	4.2 \pm 0.02	4.1 \pm 0.03	0.4980
DO (mg/L)	6.3 \pm 0.21	6.5 \pm 0.23	6.8 \pm 0.25	0.4170
pH	7.7 \pm 0.03 ^b	7.8 \pm 0.04 ^{ab}	7.9 \pm 0.05 ^a	0.0058
TAN(mg/L)	0.7 \pm 0.07 ^b	0.7 \pm 0.08 ^b	1.6 \pm 0.26 ^a	0.0003
Nitrite-N (mg/L)	0.5 \pm 0.08 ^b	0.2 \pm 0.03 ^b	1.6 \pm 0.14 ^a	<0.0001

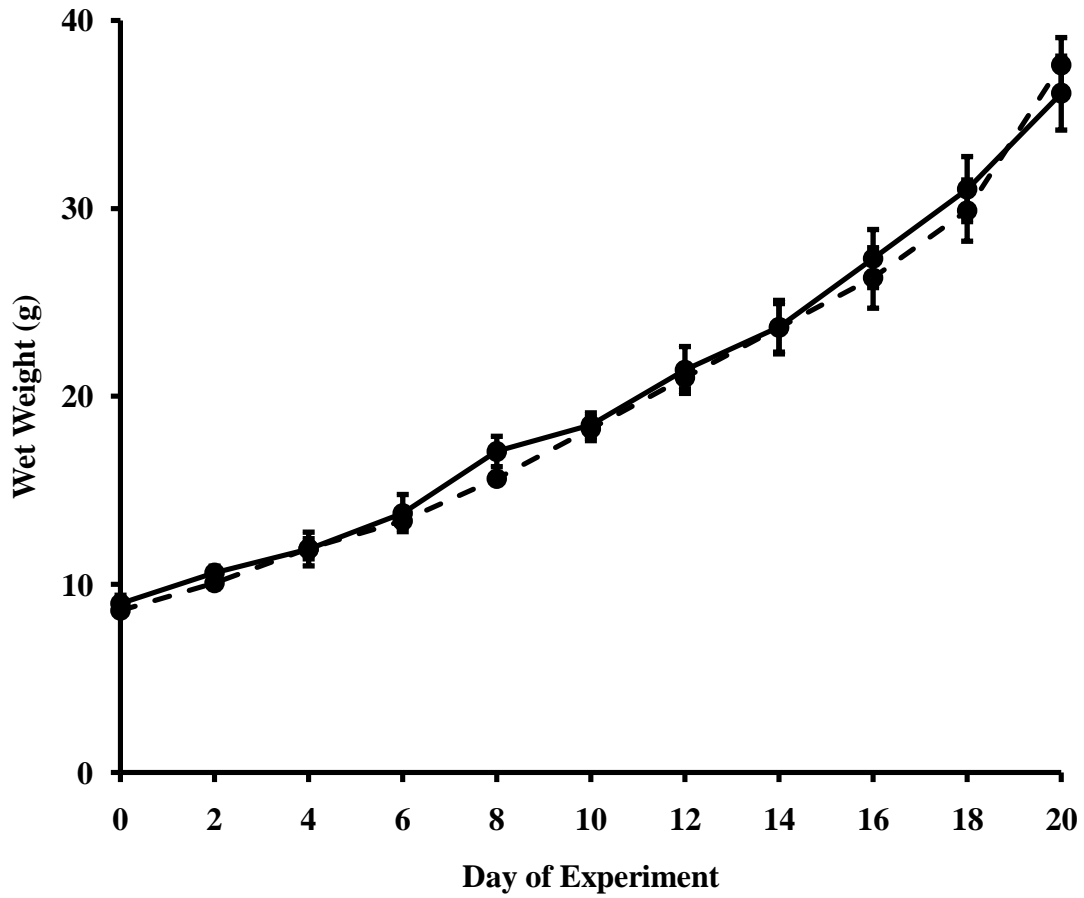


Figure 14. Mean (\pm SE) wet weight for subsamples (N = 10) of juvenile alligator gar exposed to regulated temperatures (solid line) and fluctuating temperatures (dashed line) for 21 days.

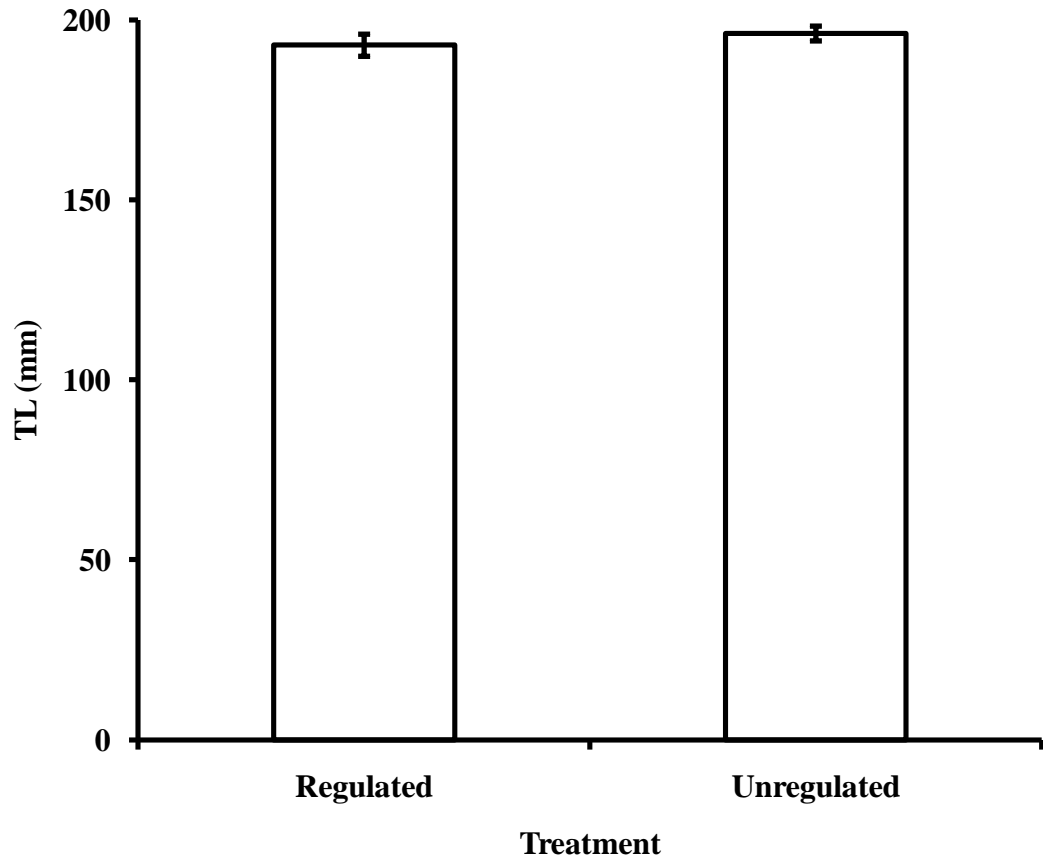


Figure 15. Final mean (\pm SE) TL of juvenile alligator gar exposed to regulated or unregulated temperatures for 21 days.

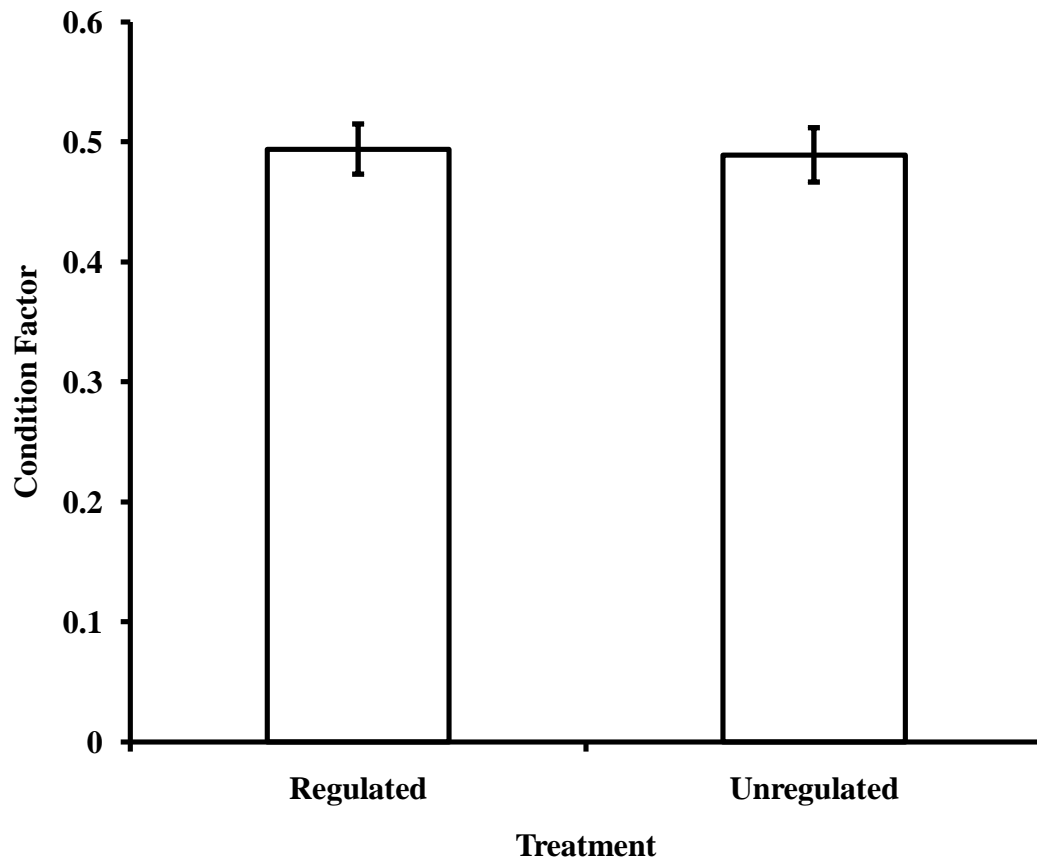


Figure 16. Final mean (\pm SE) condition factor of juvenile alligator gar exposed to regulated or unregulated temperatures for 21 days.

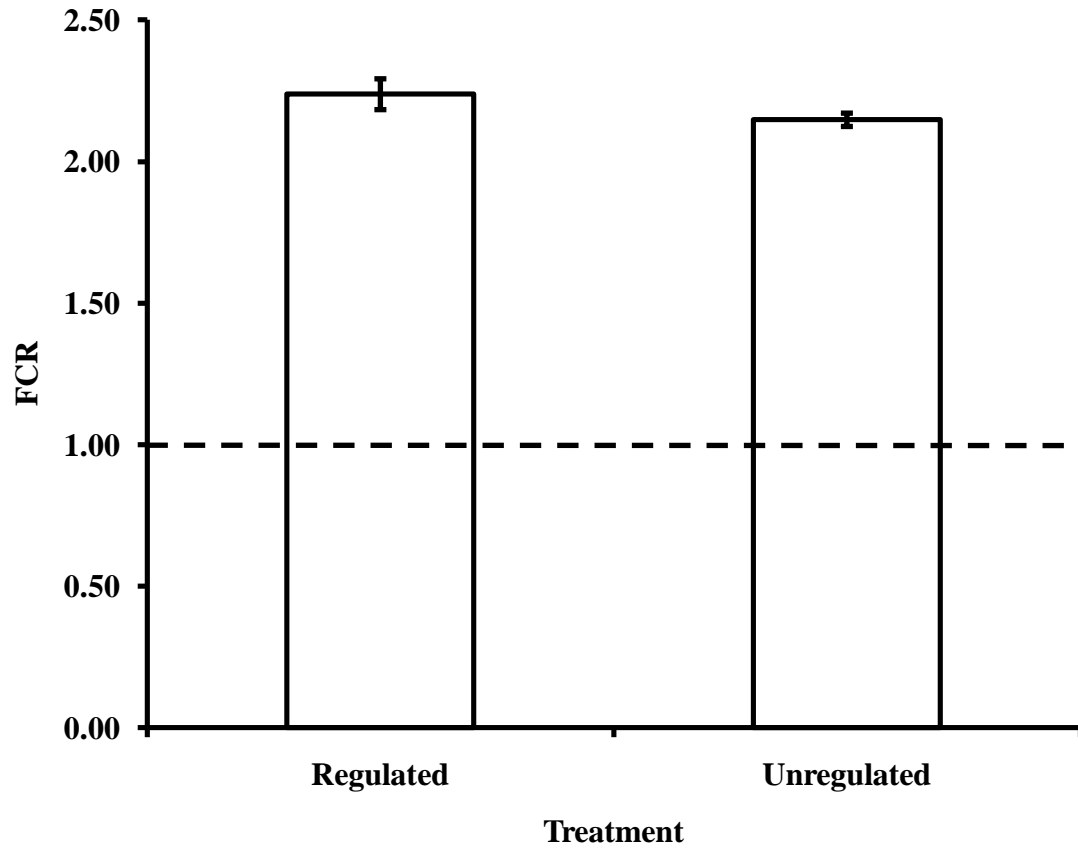


Figure 17. Final mean (\pm SE) FCR of juvenile alligator gar exposed to regulated or unregulated temperatures for 21 days.

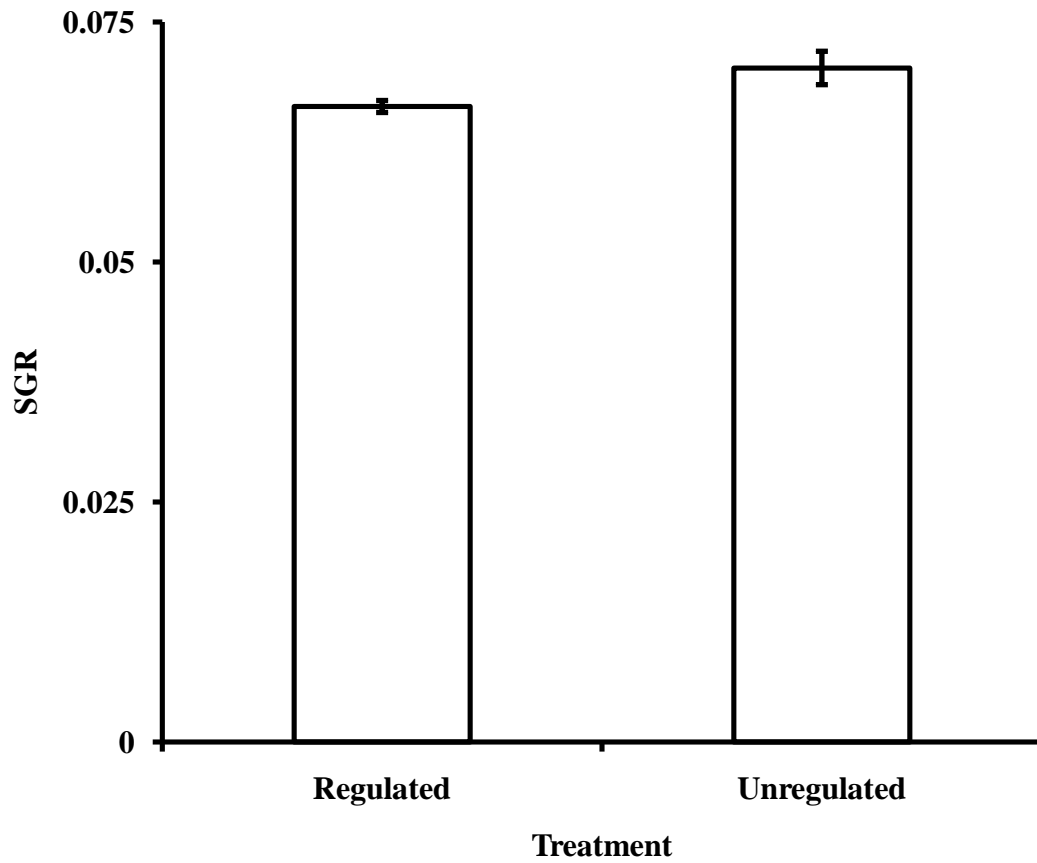


Figure 18. Final mean (\pm SE) SGR of juvenile alligator gar exposed to regulated or unregulated temperatures for 21 days.

different between regulated and unregulated treatments. Survival was similar between regulated and unregulated treatments with no mortalities associated with cannibalism ($p = 0.2148$, Figure 19).

Mean temperature was higher in the unregulated treatment than the regulated treatment ($p = 0.0001$; Figure 20, Table 5). DO, pH, and nitrite-N were all higher in the unregulated temperature treatment than the regulated treatment (Table 5). TAN was higher in the regulated treatment than the unregulated treatment (Table 5.)

Feeding Frequency

Alligator gar in both treatments increased in size during the experiment (Figure 21). Final weights were similar between the two treatments ($p = 0.0800$; Figure 21). Final TL was longer in the 2 feedings per day treatment (204.7 ± 1.97 mm) than the 3 feedings daily treatment (196.2 ± 2.05 mm; $p = 0.0010$; Figure 22), although the difference was 8.5 mm. Final condition factor was similar between the two treatments ($p = 0.7457$; Figure 23). FCR was higher in alligator gar exposed to 2 feedings daily (2.3 ± 0.04) than those exposed to 3 feedings daily (2.2 ± 0.02 ; $p = 0.0110$; Figure 24). SGR was similar between the two treatments ($p = 0.8394$; Figure 25). Survival was not different between the two treatments and there were no mortalities associated with cannibalism ($p = 0.2599$; Figure 26).

Temperature and salinity were not different between treatments (Table 6). DO, pH, and TAN were higher in the 2 feedings per day treatment than the 3 feedings per day treatment (Table 6). Nitrite-N levels were higher in the 3 feedings per day treatment than the 2 feedings per day treatment (Table 6).

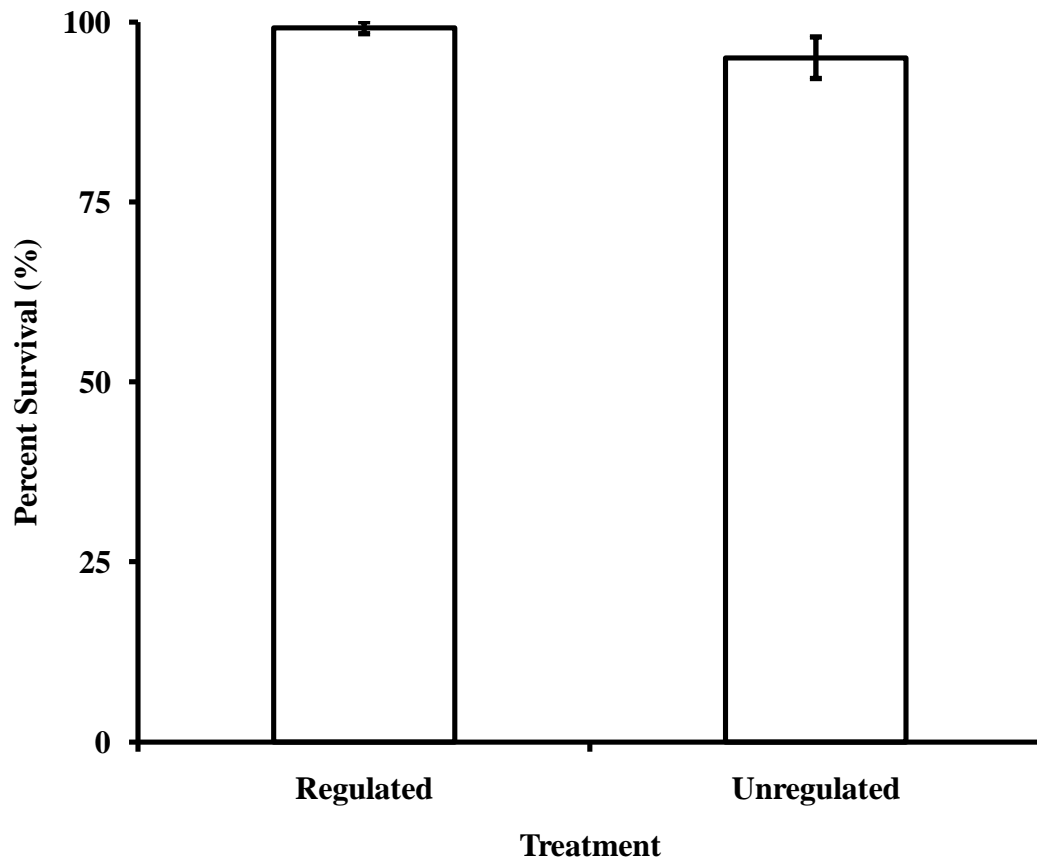


Figure 19. Final mean (\pm SE) percent survival of juvenile alligator gar exposed to regulated or unregulated temperatures for 21 days.

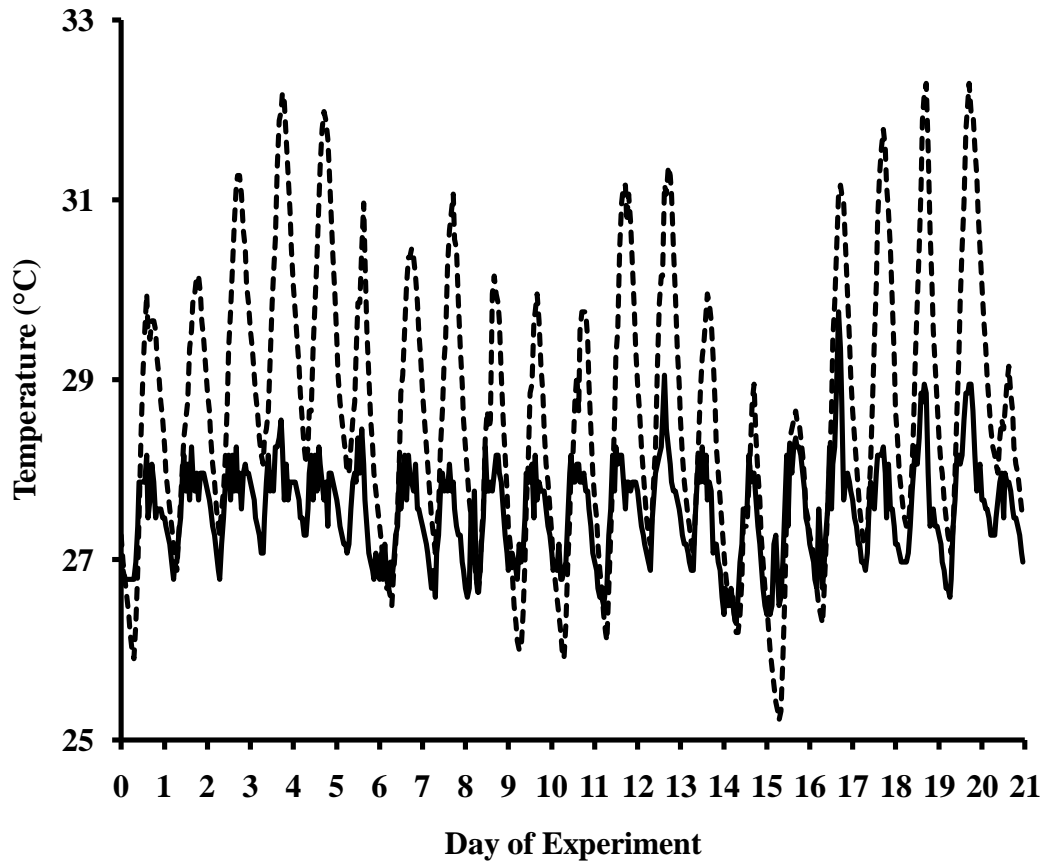


Figure 20. Hourly temperatures for regulated temperature (solid line) and unregulated temperature (dashed line) treatments for the duration of the experiment.

Table 5. Mean (\pm SE) temperature, salinity, DO, pH, TAN, and nitrite-N for juvenile alligator gar exposed to regulated and unregulated treatments for 21 days.

Variable	Treatment		<i>p</i> value
	Regulated	Unregulated	
Temperature ($^{\circ}$C)	27.6 \pm 0.02	28.7 \pm 0.07	<0.0001
Salinity (ppt)	4.0 \pm 0.01	4.0 \pm 0.01	0.5038
DO (mg/L)	5.2 \pm 0.07	5.4 \pm 0.07	0.0421
pH	7.1 \pm 0.05	7.4 \pm 0.05	0.0009
TAN(mg/L)	6.2 \pm 1.49	1.7 \pm 0.27	0.0056
Nitrite-N (mg/L)	2.1 \pm 0.33	7.6 \pm 0.58	<0.0001

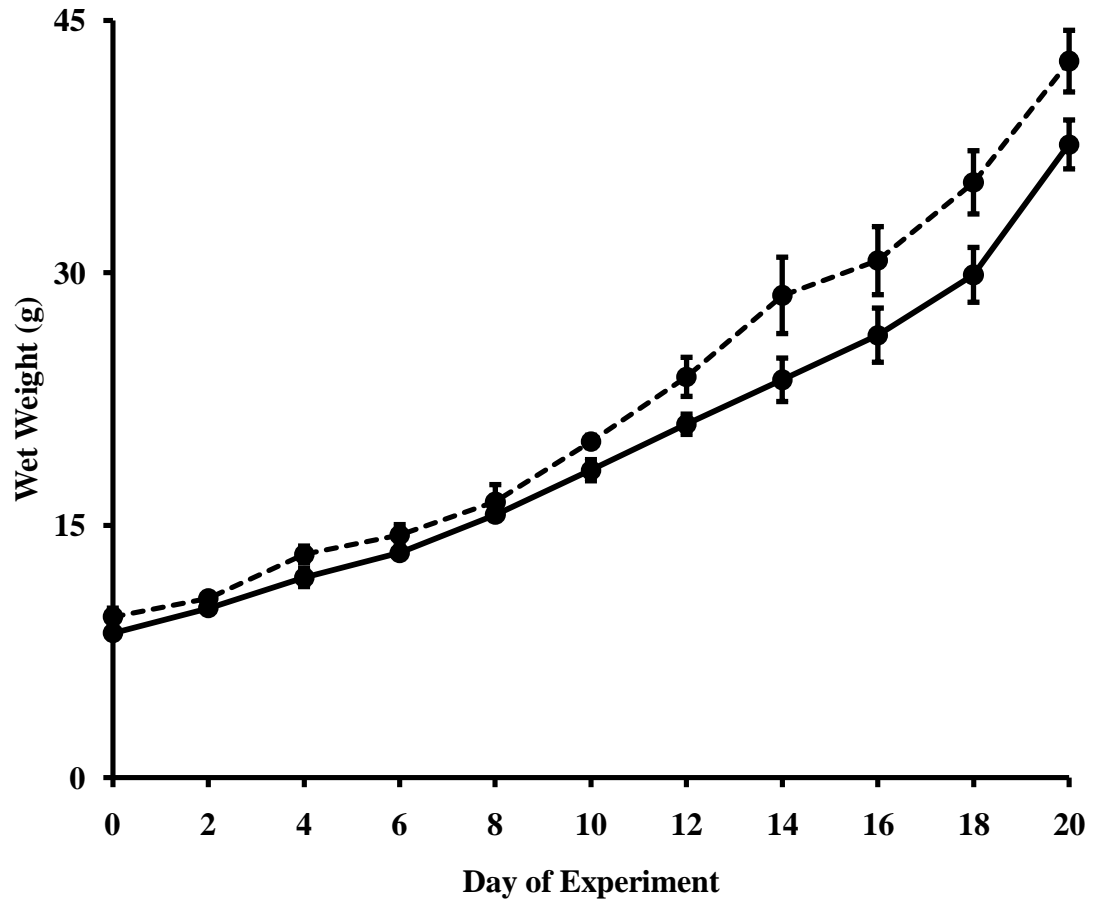


Figure 21. Mean (\pm SE) wet weight for subsamples (N = 10) of juvenile alligator gar fed 4% body weight split between 2 feedings per day (dashed line) or among 3 feedings per day (solid line) for 21 days.

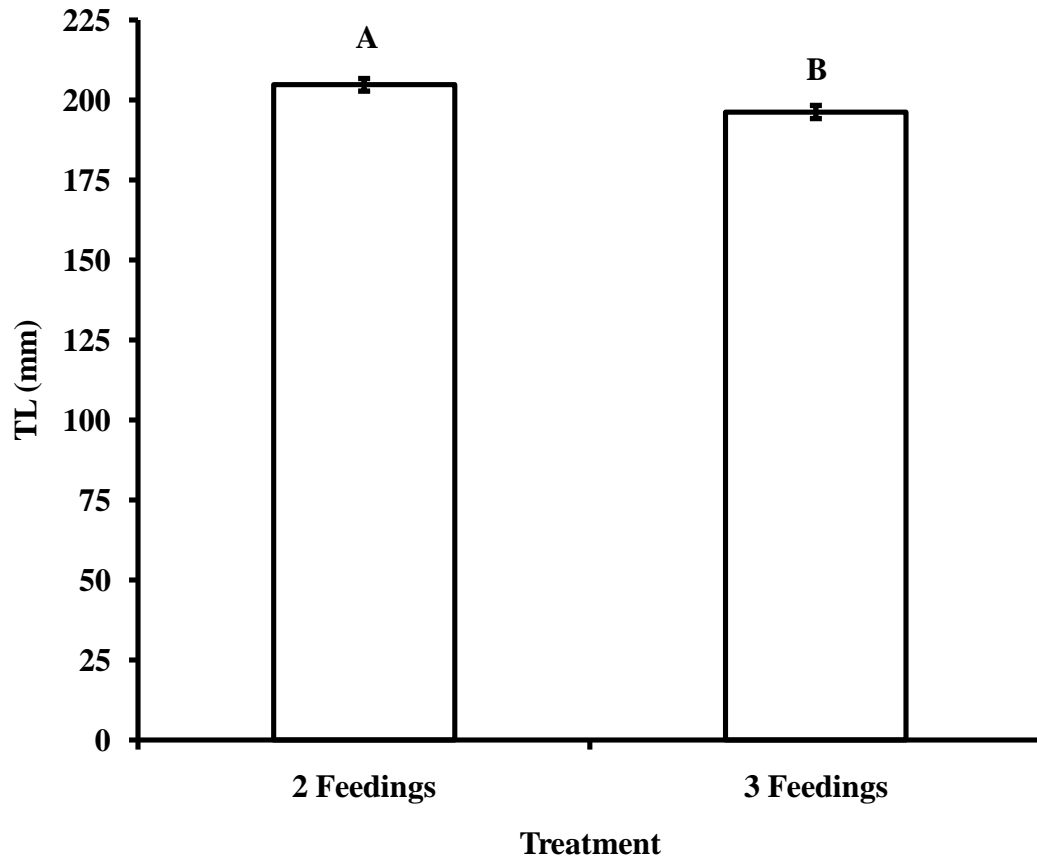


Figure 22. Final mean (\pm SE) TL of juvenile alligator gar fed 4% body weight split into 2 feedings per day or 3 feedings per day for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

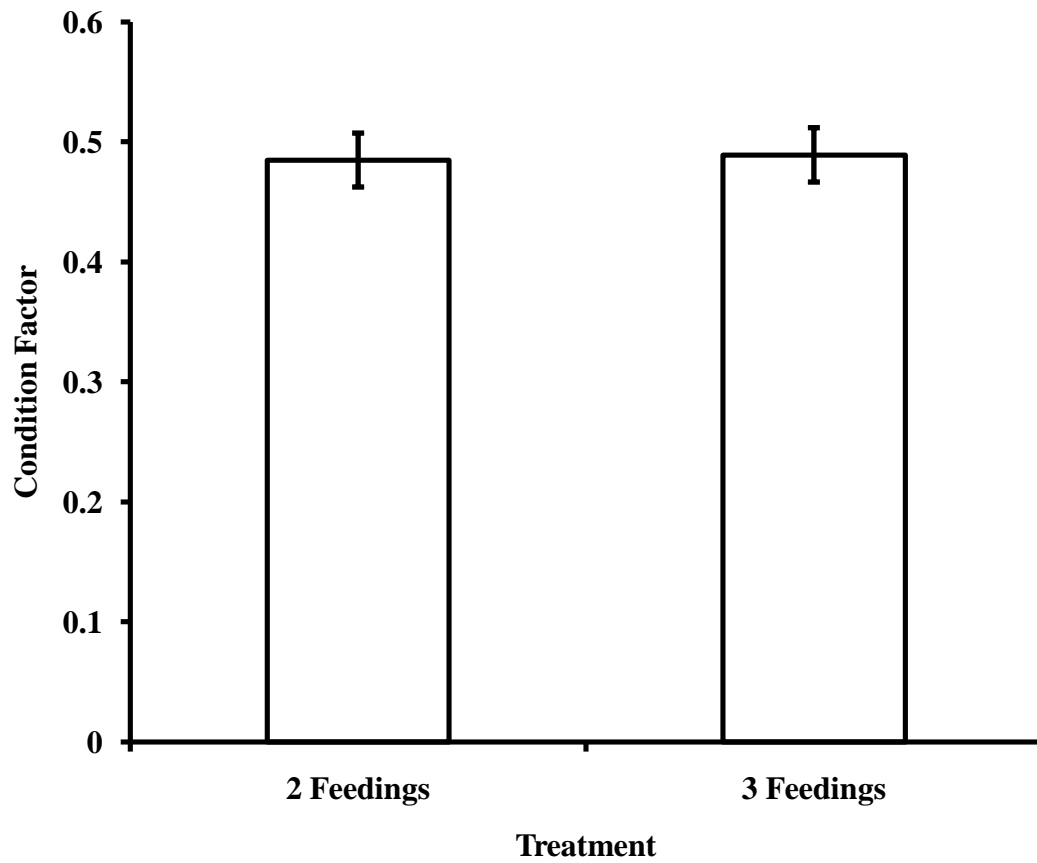


Figure 23. Final mean (\pm SE) condition factor of juvenile alligator gar fed 4% body weight split into 2 feedings per day or 3 feedings per day for 21 days.

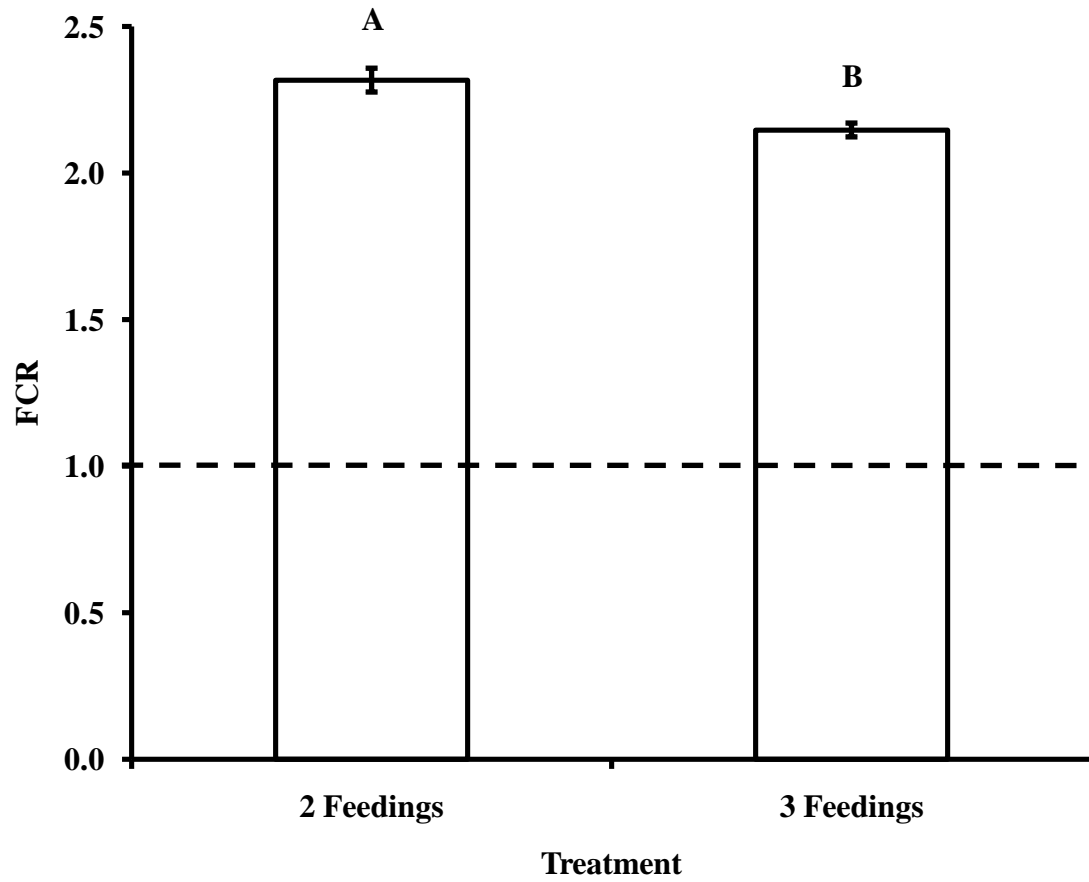


Figure 24. Final mean (\pm SE) FCR of juvenile alligator gar fed 4% body weight split into 2 feedings per day or 3 feedings per day for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

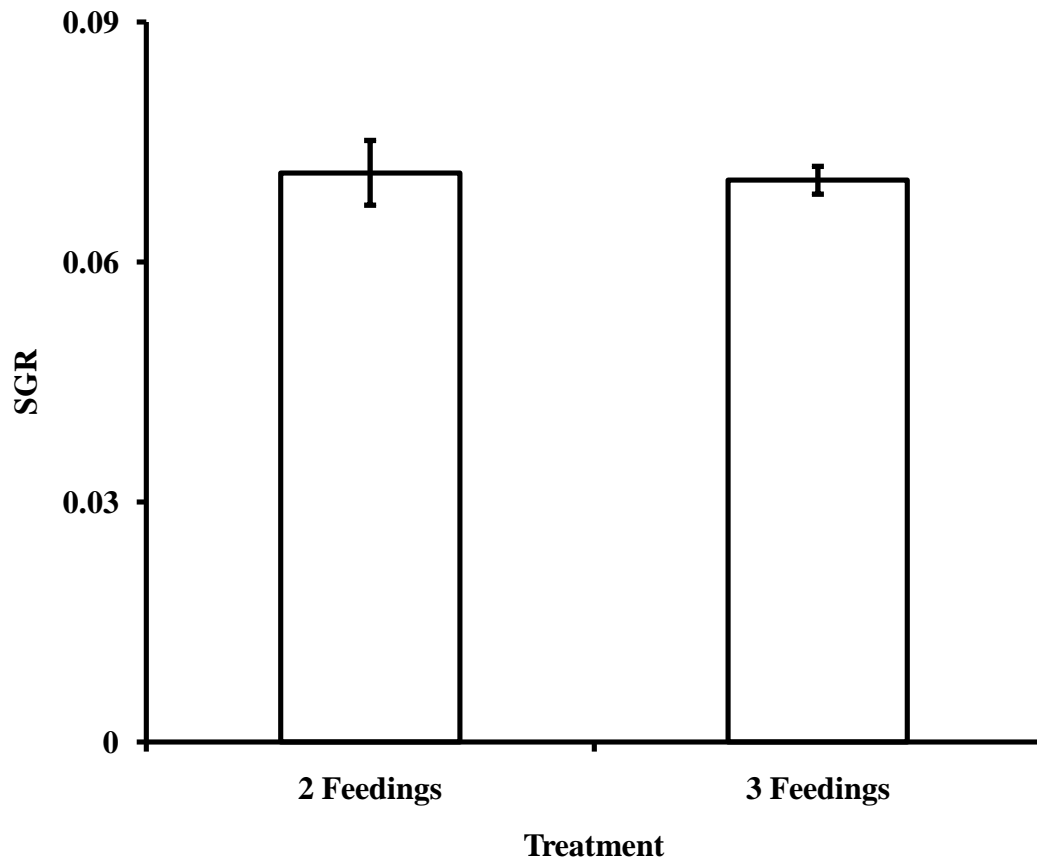


Figure 25. Final mean (\pm SE) SGR of juvenile alligator gar fed 4% body weight split into 2 feedings per day or 3 feedings per day for 21 days.

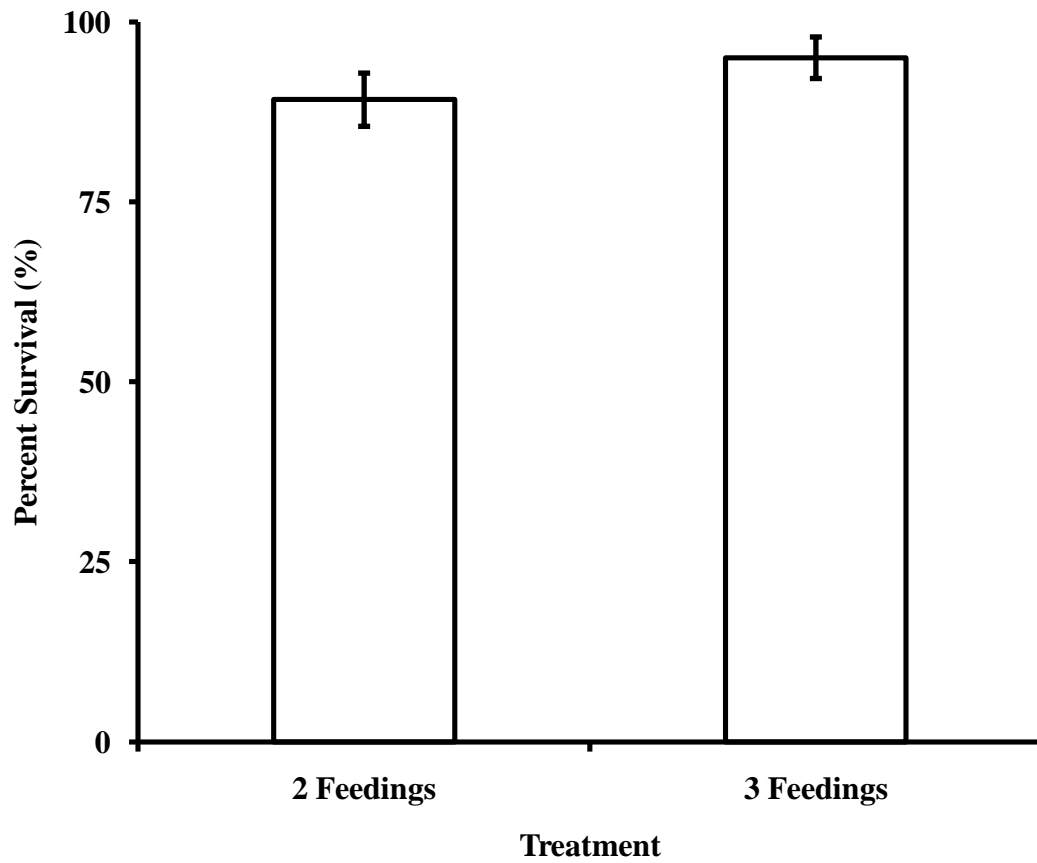


Figure 26. Final mean (\pm SE) percent survival of juvenile alligator gar fed 4% body weight split into 2 feedings per day or 3 feedings per day for 21 days.

Feed Ration

Alligator gar in all treatments (1, 2, 4, 6, 8, 10, and 12% feed based on body mass) increased in size during both the 2008 and 2009 feed ration experiments (Figure 27). Alligator gar weight was heavier in the 12% treatment (37.1 ± 1.69 g) compared to 1% (9.3 ± 0.45 g), 2% (15.4 ± 1.10 g), and 4% treatments (26.7 ± 1.08 g) but was not different from the 6% (28.7 ± 0.89 g), 8% (32.4 ± 2.10 g), and 10% treatments (32.6 ± 1.94 g; $p = 0.0001$; Figure 28). Final TL was longer for alligator gar in the 4% (173.4 ± 1.38 mm), 6% (179.0 ± 0.63 mm), 8% (184.5 ± 4.42 mm), 10% (184.2 ± 3.90 mm), 12% treatments (189.7 ± 2.61 mm) compared to the 1% (131.0 ± 2.49 mm) and 2% treatments (149.0 ± 2.49 mm; $p = 0.0001$; Figure 29). Condition factor was higher for alligator gar in the 4% (0.50 ± 0.018), 6% (0.50 ± 0.009), 8% (0.51 ± 0.020), 10% (0.50 ± 0.001), and 12% treatments (0.51 ± 0.011) compared to the 1% treatment (0.41 ± 0.01) but was not different from the 2% treatment (0.46 ± 0.014 ; $p = 0.0052$; Figure 30). FCR was lowest for alligator gar in the 4% treatment (2.6 ± 0.24) compared to the 1% (3.3 ± 0.33), 8% (3.6 ± 0.10), 10% (4.9 ± 0.07), and 12% (5.5 ± 0.26) treatments but was not different from the 2% (2.2 ± 0.44) and 6% treatments (3.3 ± 0.34 ; $p = 0.0001$; Figure 31). SGR was higher for alligator gar in the 12% treatment (0.09 ± 0.003) compared to the 1% (0.03 ± 0.003), 2% (0.05 ± 0.004), and 4% treatments (0.07 ± 0.002) but was not different from the 6% (0.08 ± 0.0003), 8% (0.08 ± 0.002), or 10% treatments (0.09 ± 0.003 ; $p = 0.0001$; Figure 32). SGR [$0.0256\ln(\text{feed}) + 0.1493$; $R^2 = 0.92673$; Figure 33] and FCR [$392.84(\text{feed})^2 - 23.561(\text{feed}) + 2.9799$; $R^2 = 0.8040$; Figure 33] were regressed on feed rations. Lowest estimate for FCR was 3% feed and greatest difference between FCR and SGR was at 7.4% feed. Survival (83%) was not effected by feed percentages

Table 6. Mean (\pm SE) temperature, salinity, DO, pH, TAN, and nitrite-N for juvenile alligator gar fed 4% body weight split into 2 feedings or 3 feedings for 21 days.

Variable	Treatment		<i>p</i> value
	2 Feedings	3 Feedings	
Temperature ($^{\circ}$C)	28.1 \pm 0.06	28.7 \pm 0.07	<0.0001
Salinity (ppt)	4.0 \pm 0.01	3.9 \pm 0.01	<0.0001
DO (mg/L)	5.3 \pm 0.08	5.4 \pm 0.07	0.5026
pH	7.5 \pm 0.04	7.4 \pm 0.05	0.1211
TAN (mg/L)	2.9 \pm 0.57	1.7 \pm 0.27	0.0718
Nitrite-N (mg/L)	5.3 \pm 0.66	7.6 \pm 0.58	0.0139

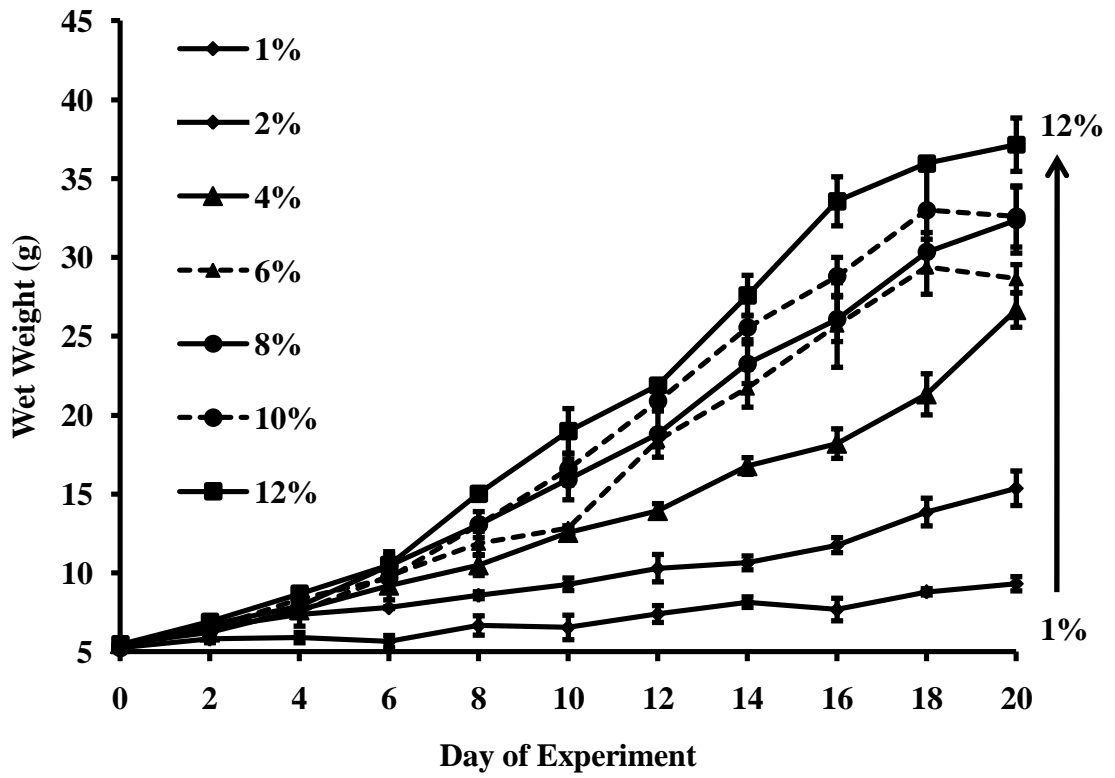


Figure 27. Mean (\pm SE) wet weight for subsamples (N = 10) of juvenile alligator gar fed different rations based on body weight split among three daily feedings for 21 days.

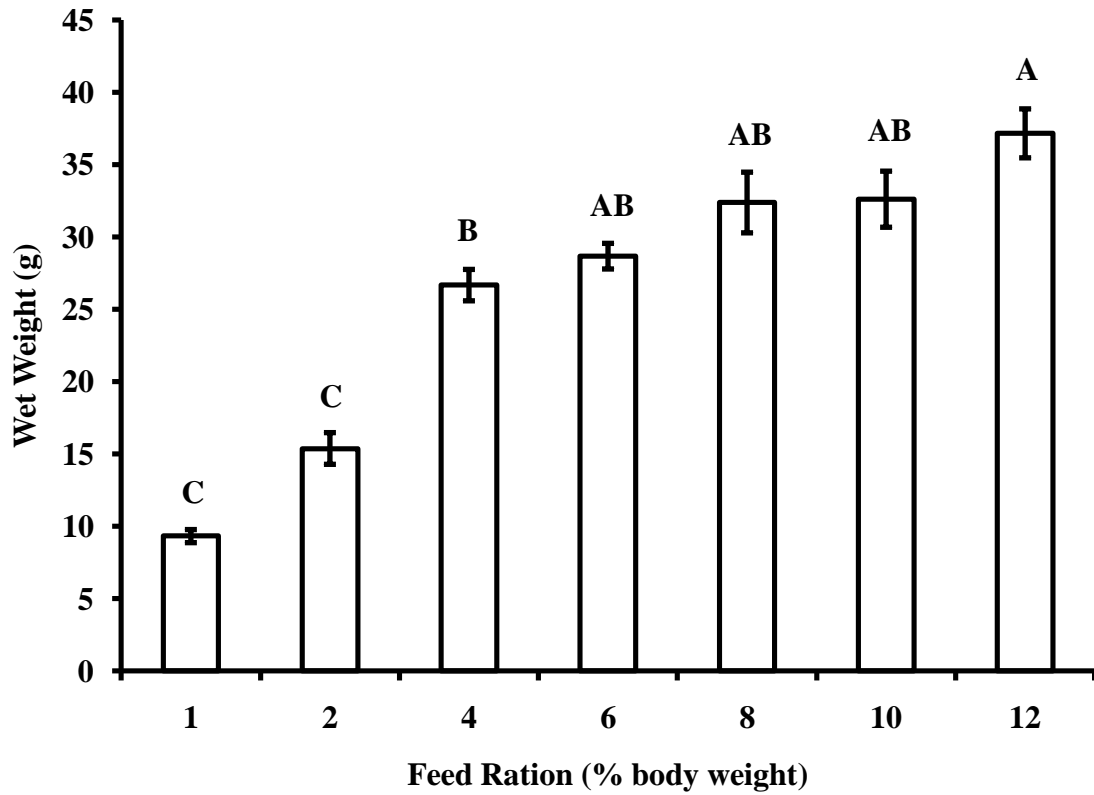


Figure 28. Final mean (\pm SE) wet weight of juvenile alligator gar fed different ratios based on body weight split among three daily feedings for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

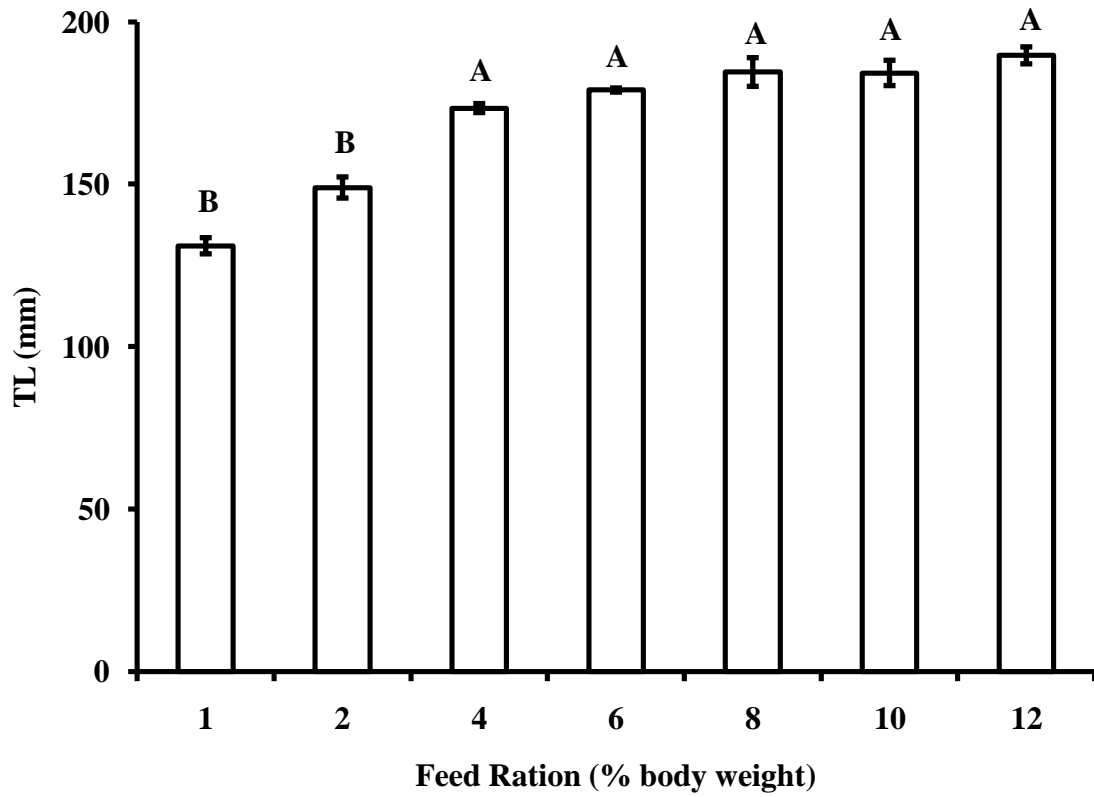


Figure 29. Final mean (\pm SE) TL of juvenile alligator gar fed different feed ratios based on body weight split among three daily feedings for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

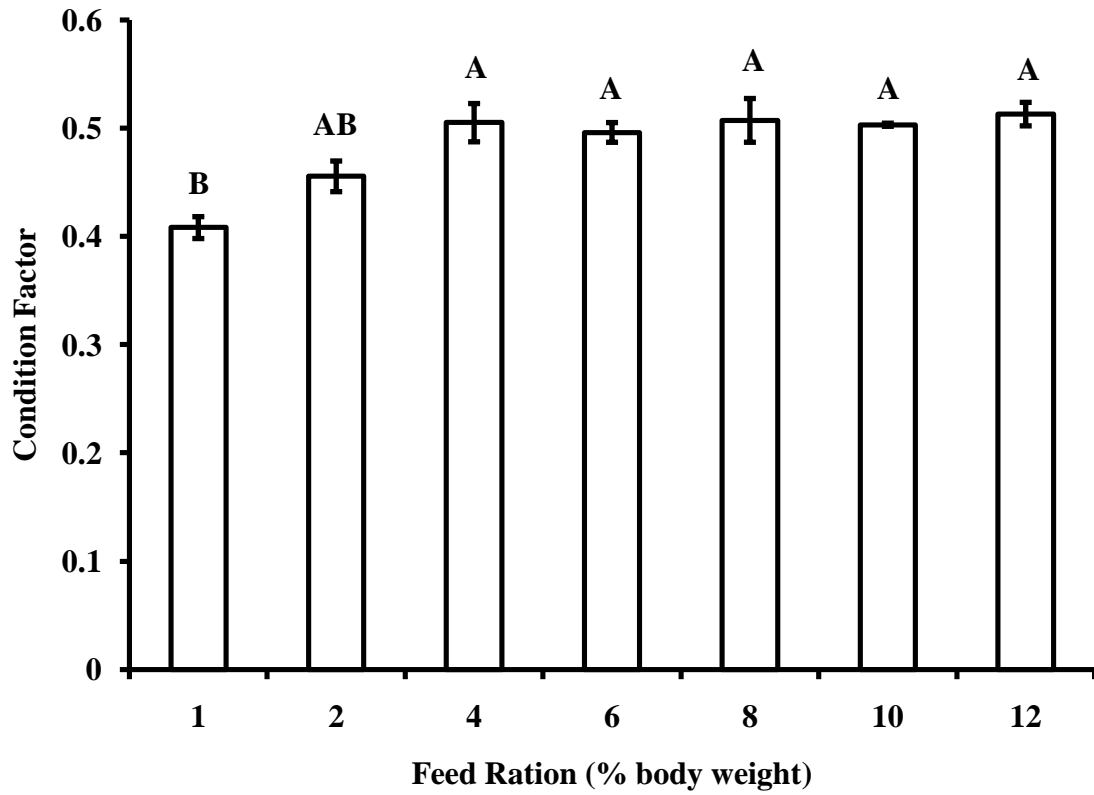


Figure 30. Final mean (\pm SE) condition factor at the conclusion of the experiment for juvenile alligator gar fed different feed rations based on body weight split among three daily feedings for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

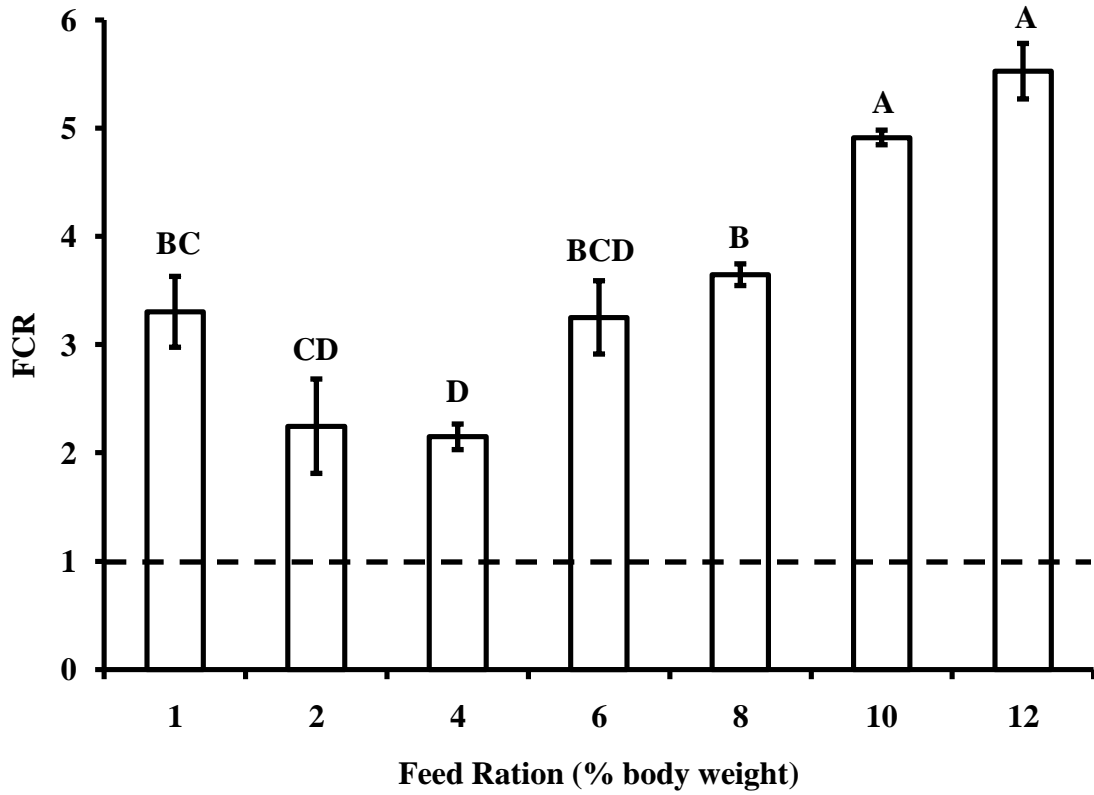


Figure 31. Final mean (\pm SE) FCR of juvenile alligator gar fed different feed rations based on body weight split among three daily feedings for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

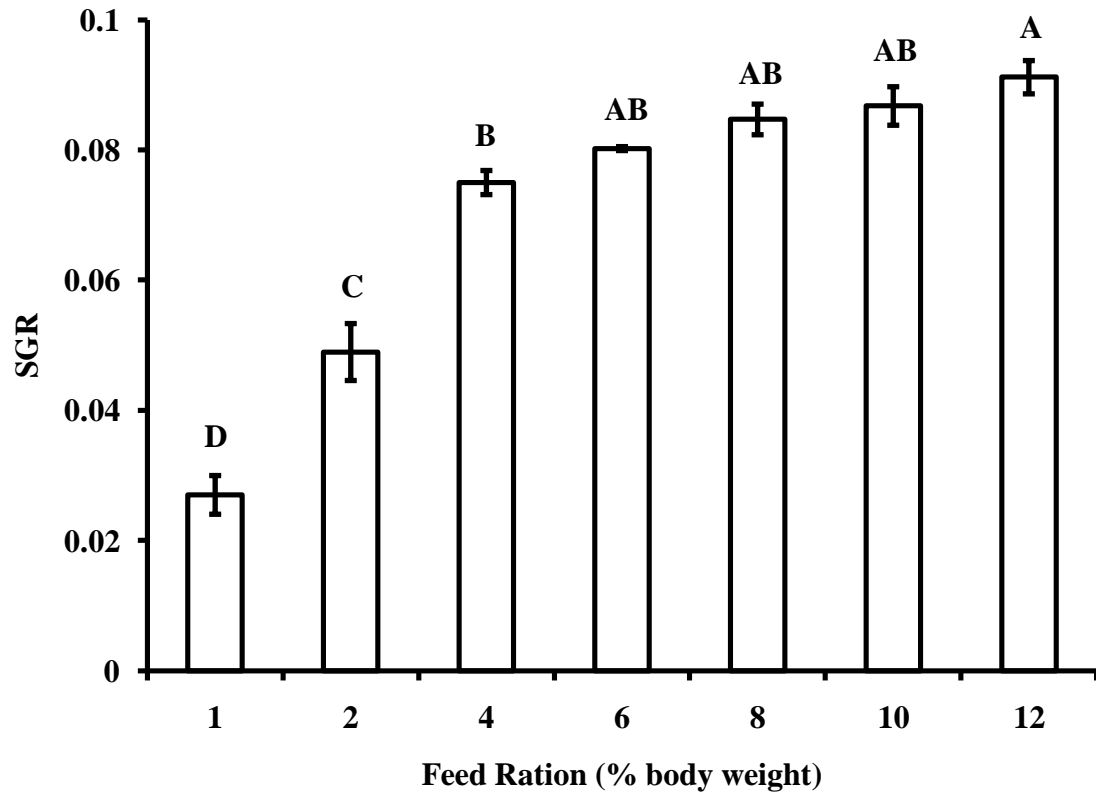


Figure 32. Final mean (\pm SE) SGR of juvenile alligator gar fed different feed rations based on body weight split among three daily feedings for 21 days. Letters above samples represent Tukey groupings based on ANOVA results and denote differences between samples.

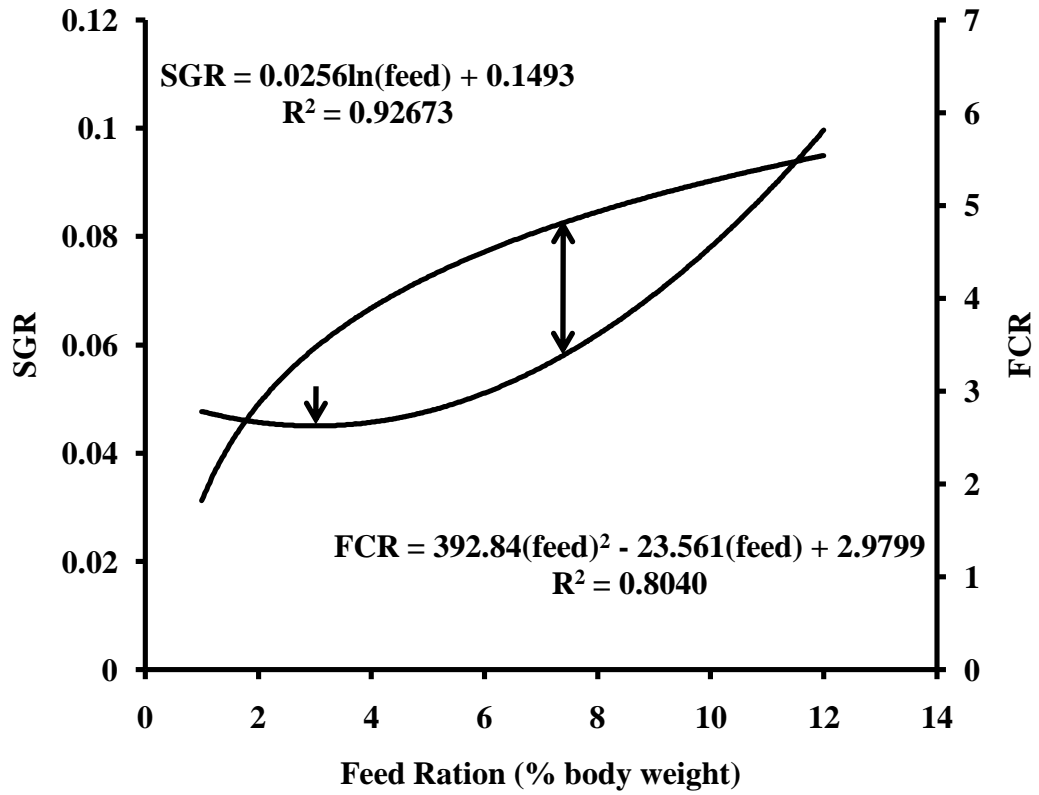


Figure 33. Regression curves of SGR and FCR for juvenile alligator gar fed 1, 2, 4, 6, 8, 10, or 12% body weight daily split among 3 feedings. Single point arrow indicates minimum FCR (3% feed) and double arrow indicates greatest difference between SGR and FCR (7.4% feed).

during this experiment and there were no mortalities associated with cannibalism ($p = 0.3141$; Figure 34).

Temperature and TAN were not different between 2008 and 2009 (Table 7). DO, salinity, pH, and nitrite-N were different between 2008 and 2009 (Table 7).

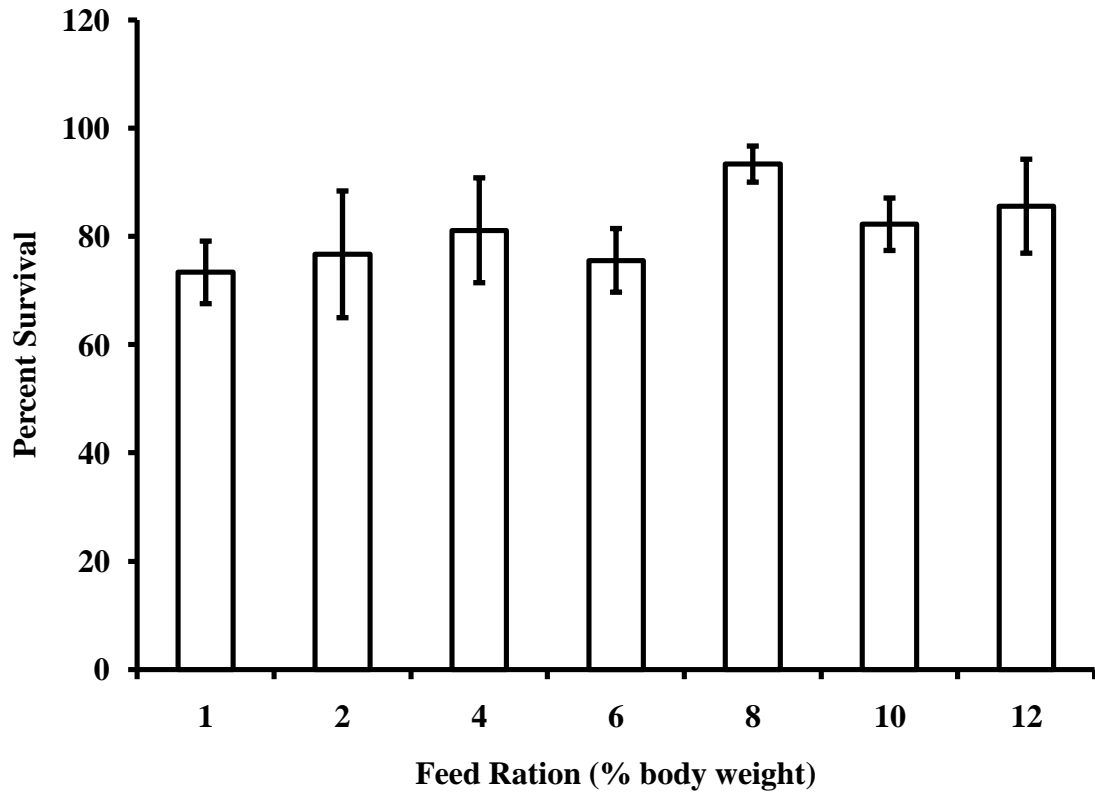


Figure 34. Final mean (\pm SE) percent survival of juvenile alligator gar fed different feed rations split among three feedings daily for 21 days.

Table 7. Mean (\pm SE) temperature, salinity, DO, pH, TAN, and nitrite-N for juvenile alligator gar fed different feed rations split among three daily feedings for 21 days.

Variable	Year		<i>p</i> value
	2008	2009	
Temperature ($^{\circ}$ C)	29.3 \pm 0.32	29.2 \pm 0.16	0.9291
Salinity (ppt)	4.0 \pm 0.00	3.9 \pm 0.06	<0.0001
DO (mg/L)	5.3 \pm 0.05	3.1 \pm 0.10	<0.0001
pH	7.6 \pm 0.03	7.3 \pm 0.02	<0.0001
TAN (mg/L)	3.6 \pm 0.68	7.3 \pm 1.20	0.0054
Nitrite-N (mg/L)	5.1 \pm 0.46	0.5 \pm 0.02	<0.0001

DISCUSSION

Artemia Supplemented Larvae

Five DAH larval alligator gar supplemented with *Artemia* had faster growth rates than did larvae not supplemented with *Artemia*. Visual cues are important in the first feeding of larval fish, followed by size, texture, and taste (Dabrowski 1984; Person-Le Ruyet 1989). The presence of *Artemia* may elicit a stronger feeding response and acceptance of artificial feed than only floating feed. Larval gar supplemented with *Artemia* had higher growth rates after the *Artemia* supplement ceased than did fish not supplemented with *Artemia*. Senegalensis sole *Solea senegalensis* fed *Artemia* and artificial feed during first feeding had higher growth rates after weaning from live feed than Senegalensis sole fed only *Artemia* prior to weaning (Cañavate and Fernández-Díaz 1991). Supplementing larval alligator gar with *Artemia* for the first seven days of exogenous feeding increased growth rates.

Survival by 20 DAH averaged 71% for individuals supplemented with *Artemia* compared to 43% for individuals not supplemented with *Artemia* (Figure 10). This contrasts with results from Mendoza et al. (2008) which had survival rates of near 60% for alligator gar larvae fed either artificial feed or *Artemia*, and Mendoza et al. (2002a) which had survival rates near 95% for alligator gar larvae fed *Artemia* and survival rates near 80% for alligator gar larvae fed only floating artificial feed. Senegalese sole had higher survival after weaning when co-fed live feed (rotifers and *Artemia*) with pelleted feed when compared to Senegalese sole fed only live feed (Cañavate and Fernández-Díaz 1999). *Artemia* supplement for the first seven days of exogenous feeding increased survival rates in larval alligator gar.

Dead fish were counted and removed daily during the trials, which allowed for precise determination of total number of individuals cannibalized. Cannibalism was the main cause of mortalities within both treatments. Cannibalistic rates were not different for larval summer flounder *Paralichthys dentatus* fed either *Artemia* or artificial feed (Francis and Bengston 1999). However, cannibalism was higher for larval alligator gar that were not supplemented with *Artemia*. Feed size was increased and overlapped during the trial to accommodate for variation in size and increasing body size, which allowed the larval gar to maximize energy gain while minimizing the chances of cannibalism (Echelle and Riggs 1972; Mendoza et al. 2008). The gar exposed to *Artemia* may have been stimulated to begin exogenous feeding earlier and were thus able to consume larger feed sizes.

Stocking Density and Feed Amount

Stocking densities did not affect the growth of juvenile alligator gar. Growth rates in other aquaculture species are unaffected by density; for example, juvenile winter flounder *Pseudopleuronectes americanus*, bighead carp *Hypophthalmichthys nobilis*, fat snook *Centropomus parrellelus*, silver perch *Bidyanus bidyanus*, and rabbitfish *Siganus rivulatus* growth rates were unaffected when reared at different densities (Engle and Brown 1999; Fairchild and Howell 2001; Rowland et al. 2004; Corrêa and Cerqueira 2007; Saoud et al. 2008). However, increasing stocking density inversely affects growth rates in brook trout (Vijayan and Leatherland 1988) and rainbow trout *Onchorhynchus mykiss* (Leatherland and Cho 1985). King et al. (2000) found no differences in growth of summer flounder reared at 10, 20, and 30 fish/L but growth was lower for fish reared at

60 fish/L. Stocking densities in this experiment may have been too low to result in differences in growth rates and overall survival.

Cannibalism was the main cause of mortality (77%). Juvenile alligator gar were 15 DAH at the start of this experiment, the stage in their development where Mendoza et al. (2002a) noted an increase in cannibalism rates. The lack of a difference in growth rates between the two feed percentages and high level of cannibalism suggest that any deficiencies in feed may have been made up through cannibalism. This theory is further supported by the feed percentage trial where there was no cannibalism and juvenile alligator gar fed 8% body mass had higher SGR than juvenile alligator gar fed 4% body mass.

Temperature Regime

Outdoor culture of alligator gar involves exposure to natural fluctuations in daily temperatures. There were no differences in weight, TL, SGR, FCR, condition factor, and survival between fish reared at a regulated temperature and fish reared at unregulated temperatures. This result is similar to Woiwode and Adelman (1991) where palmetto bass *Morone saxatilis* X *M. chrysops* exposed to a constant 21 °C or diel oscillations of ± 4 , ± 6 , or ± 8 °C resulted in no differences in SGR and FCR. Adaption to temperature fluctuations would be advantageous for juvenile alligator gar, which may inhabit shallow floodplains that can have rapid changes in daily temperatures. Adaptation to fluctuating temperatures is also advantageous for aquaculture. Developing aquaculture with fish that can tolerate fluctuating temperatures, such as alligator gar, would reduce expenses by avoiding manipulation of temperatures through the use of heaters and chillers.

Feed Frequency

Alligator gar fed twice daily had a final TL longer than alligator gar fed 3 times a day; however, final weight and SGR were not different between treatments. Feeding frequency does not affect channel catfish *Ictalurus punctatus* weight gain and SGR (Jarboe and Grant 1996). FCR was lower for alligator gar fed three times daily when compared to alligator gar fed twice daily. The relationship between FCR and feeding frequency varies among aquaculture species. In channel catfish fed once daily 3% body weight or 3 times daily 1% body weight the FCR was unaffected (Jarboe and Grant 1996). With channel catfish and sunshine bass *M. chrysops* X *M. saxatilis* fed to satiation, FCR increased with increased feeding frequency (Webster et al. 2001; Peterson and Small 2006). However, feeding to satiation can result in a FCR higher than if fed a lower amount (Barrows and Hardy 2001; Mihelakakis et al. 2002; Luo et al. 2006). Rainbow trout fed to satiation have a higher FCR than fish fed less feed (Silverstein 2006). As with channel catfish and sunshine bass fed at different frequencies (Jarboe and Grant 1996; Webster et al. 2001), feeding frequency did not affect alligator gar FCR.

Feed Ration

Different feed rations produced differences in weight, TL, condition factor, FCR, and SGR. Feed ration is an important factor in fish culture and governs the amount of growth. Feed ration and growth rate are positively correlated until plateauing at a satiation feeding level (Métailler et al. 1980; Clark et al. 1990; Mihelakakis et al. 2002; Luo et al. 2006; Kim et al. 2007). Growth rate increased with increasing feed amounts with maximum growth attained at 6% body weight, which was not different from 8, 10,

or 12% body weight. Alligator gar in the 10 and 12% body weight treatments were overfed with noticeable amounts of uneaten feed remaining between feedings, suggesting that juvenile alligator gar fed 10 % body weight were satiated. FCR values for the 10 and 12% treatments were high and were probably a result of the combination of the uneaten feed and inefficiency in digestion. FCR can be decreased by reducing feed rations below satiation levels without a reduction in growth rates. Juvenile alligator gar fed 6, 8, and 10% body weight had similar SGRs, however, alligator gar fed 6 and 8% had lower FCRs than alligator gar fed 10% body weight. The lowest FCRs in this study (2.1, 2.2, and 3.3) were higher than the lowest FCRs reported for rabbitfish (0.87; El-Sayed et al. 1995), snakehead *Channa striatus* (0.99; Qin and Fast 1996), orange-spotted grouper *Epinephelus coioides* (1.3; Luo et al. 2006), and channel catfish (1.6; Robinson and Li 1999). However, FCRs in the previously cited studies were calculated using wet weights, which results in lower FCRs because of moisture content, as compared to this study which used dry weights, which more accurately reflect feed conversion efficiency.

SGR and FCR are important tools for determining optimum feed amounts, minimizing waste production, and preventing water quality deterioration. Maximum SGR and minimal FCR cannot be attained simultaneously. Depending on culture goals, a level of feed that maximizes SGR or minimizes FCR can be pursued individually or an optimal compromise between SGR and FCR can be pursued. The minimal FCR for juvenile alligator gar was estimated to be 3% body weight. However, based on SGR regression this feed ration will result in a sub-optimal specific growth rate of 0.06. Based on ANOVA and regression analysis of SGR, optimum growth can be attained when fed between 6-12% body mass. Combining SGR and FCR regression curves, the optimal

compromise between FCR and SGR was determined to be 7.4% body weight. At 7.4% body weight juvenile alligator gar would be expected to have a FCR of 3.4 and a SGR of 0.08. Juvenile alligator gar fed 1% body weight gained mass, but had reduced SGR, increased FCR, and no reduction in survival compared to other treatments suggesting that the maintenance feeding level is below 1% body weight.

FUTURE RECOMMENDATIONS

Aquaculture of alligator gar in recirculating systems can be a practical and efficient method for producing individuals for market and re-stocking. According to the previous experiments the following recommendations should be followed to maximize efficiency of alligator gar production: Mature alligator gar should be spawned in the spring using LHRHa at 0.1mg/kg during the natural spawning period. Larval alligator gar should be fed floating feed supplemented with *Artemia* at first feeding to increase growth and survival. Juvenile alligator gar (15 DAH) should be reared at 10 fish/L, however more studies should be conducted at higher densities to determine at what density growth and survival is hindered. For maximal survival juvenile alligator gar should be fed floating pelleted feed at a rate of 8% body weight daily. To reduce expenses associated with regulating temperatures juvenile alligator gar may be reared without temperature regulation. To minimize FCR, juvenile alligator gar should be fed floating pelleted feed at 3% body weight split among three daily feedings. To maximize growth while maintaining minimal FCR, juvenile alligator gar should be fed floating pelleted feed at 7.4% body weight split among three daily feedings. In each individual situation, cost benefit analysis should be conducted and integrated with FCR and SGR for juvenile to more accurately determine the optimal feed rate for production.

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Appendix I. Initial replicates, TL (mm), wet weight (g), and dry weight (g) for 5 DAH larval alligator gar exposed to the *Artemia* supplement experiment.

Replicate	TL	Wet Weight	Dry Weight
1	13.4	0.0337	0.0039
2	15.1	0.0281	0.0043
3	14.7	0.0336	0.0050
4	15.7	0.0311	0.0040
5	14.8	0.0316	0.0038
6	15.3	0.0349	0.0041
7	15.8	0.0333	0.0043
8	16.5	0.0443	0.0044
9	15.7	0.0367	0.0045
10	15.5	0.0349	0.0042
11	15.0	0.0347	0.0044
12	14.4	0.0317	0.0044
13	15.7	0.0342	0.0041
14	16.3	0.0333	0.0044
15	14.7	0.0296	0.0045
16	16.5	0.0363	0.0044
17	16.0	0.0397	0.0048
18	13.9	0.0267	0.0049
19	15.0	0.0290	0.0047
20	15.6	0.0315	0.0050
21	14.9	0.0328	0.0047
22	15.7	0.0343	0.0051
23	15.9	0.0377	0.0037
24	16.6	0.0395	0.0048
25	15.1	0.0364	0.0052

Appendix II. Treatment, tank, replicate, TL (mm), wet weight (g), and dry weight (g) for 12 DAH and 20 DAH larval alligator gar fed floating feed supplemented with *Artemia* for 7 days (A-S) or fed only floating feed (F-F).

Treatment	Tank	DAH	Replicate	TL	Wet Weight	Dry Weight
A-S	A1	12	1	22.5	0.0527	0.0061
A-S	A1	12	2	26.8	0.0944	0.0135
A-S	A1	12	3	22.4	0.0543	0.0068
A-S	A1	12	4	28.0	0.1124	0.0171
A-S	A1	12	5	24.3	0.0572	0.0076
A-S	A2	12	1	21.8	0.0532	0.0070
A-S	A2	12	2	27.4	0.1013	0.0161
A-S	A2	12	3	27.0	0.0840	0.0112
A-S	A2	12	4	25.3	0.0993	0.0144
A-S	A2	12	5	25.7	0.0834	0.0115
A-S	A3	12	1	27.2	0.1143	0.0182
A-S	A3	12	2	26.3	0.0728	0.0096
A-S	A3	12	3	26.1	0.0757	0.0107
A-S	A3	12	4	25.3	0.0611	0.0072
A-S	A3	12	5	31.3	0.1468	0.0255
A-S	A4	12	1	27.7	0.0797	0.0107
A-S	A4	12	2	27.6	0.0895	0.0129
A-S	A4	12	3	27.6	0.1041	0.0146
A-S	A4	12	4	28.4	0.1174	0.0193
A-S	A4	12	5	28.8	0.1019	0.0145
F-F	B1	12	1	36.8	0.2318	0.0368
F-F	B1	12	2	33.8	0.1504	0.0222
F-F	B1	12	3	38.0	0.2223	0.0346
F-F	B1	12	4	33.2	0.1348	0.0196
F-F	B1	12	5	32.4	0.1322	0.0195
F-F	B2	12	1	22.5	0.0527	0.0061
F-F	B2	12	2	26.8	0.0944	0.0135
F-F	B2	12	3	22.4	0.0543	0.0068
F-F	B2	12	4	28.0	0.1124	0.0171
F-F	B2	12	5	24.3	0.0572	0.0076
F-F	B3	12	1	26.6	0.1022	0.0141
F-F	B3	12	2	33.7	0.1911	0.0302
F-F	B3	12	3	36.2	0.1976	0.0289
F-F	B3	12	4	35.6	0.2224	0.0353
F-F	B3	12	5	36.9	0.2186	0.0344
F-F	B4	12	1	35.3	0.1781	0.0272
F-F	B4	12	2	35.7	0.2045	0.0317
F-F	B4	12	3	35.8	0.2088	0.0330
F-F	B4	12	4	39.2	0.2578	0.0441
F-F	B4	12	5	39.1	0.2376	0.0376

Treatment	Tank	DAH	Replicate	TL	Wet Weight	Dry Weight
A-S	A1	20	1	47.8	0.4325	0.0649
A-S	A1	20	2	39.1	0.2569	0.0392
A-S	A1	20	3	46.9	0.6994	0.1063
A-S	A1	20	4	48.3	0.5658	0.0823
A-S	A1	20	5	37.1	0.2531	0.0400
A-S	A2	20	1	47.8	0.6477	0.0939
A-S	A2	20	2	43.9	0.4550	0.0771
A-S	A2	20	3	52.4	0.6124	0.1057
A-S	A2	20	4	58.3	0.8763	0.1332
A-S	A2	20	5	33.9	0.2005	0.0301
A-S	A3	20	1	38.8	0.2949	0.0493
A-S	A3	20	2	36.5	0.2000	0.0307
A-S	A3	20	3	37.3	0.2442	0.0387
A-S	A3	20	4	38.1	0.3034	0.0517
A-S	A3	20	5	32.8	0.1660	0.0254
A-S	A4	20	1	36.4	0.2165	0.0343
A-S	A4	20	2	32.7	0.1835	0.0270
A-S	A4	20	3	38.1	0.3426	0.0527
A-S	A4	20	4	36.9	0.2572	0.0392
A-S	A4	20	5	50.0	0.5937	0.1034
F-F	B1	20	1	53.4	0.7217	0.1316
F-F	B1	20	2	54.8	0.7734	0.1371
F-F	B1	20	3	59.7	0.8068	0.1445
F-F	B1	20	4	51.1	0.6494	0.1155
F-F	B1	20	5	47.1	0.4339	0.0727
F-F	B2	20	1	47.8	0.4325	0.0649
F-F	B2	20	2	39.1	0.2569	0.0392
F-F	B2	20	3	46.9	0.6994	0.1063
F-F	B2	20	4	48.3	0.5658	0.0823
F-F	B2	20	5	37.1	0.2531	0.0400
F-F	B3	20	1	45.6	0.4729	0.0783
F-F	B3	20	2	56.9	0.7947	0.1407
F-F	B3	20	3	55.9	0.7598	0.1347
F-F	B3	20	4	59.5	0.8722	0.1583
F-F	B3	20	5	60.7	0.9671	0.1797
F-F	B4	20	1	47.9	0.5994	0.1060
F-F	B4	20	2	56.1	0.8088	0.1522
F-F	B4	20	3	55.0	0.7174	0.1298
F-F	B4	20	4	51.5	0.6294	0.1100
F-F	B4	20	5	62.0	1.0734	0.1881

Appendix III. Treatment, replicate, total dead, observed mortalities, and cannibalized mortalities for larval alligator gar fed floating feed supplemented *Artemia* (A-S) or fed only floating feed (F-F) for 15 days.

Treatment	Replicate	Total Dead	Natural Dead	Cannibalized
A-S	1	70	15	55
A-S	2	52	10	42
A-S	3	39	13	26
A-S	4	55	12	43
F-F	1	25	11	14
F-F	2	29	10	19
F-F	3	24	5	19
F-F	4	31	10	21

Appendix IV. Initial replicates, TL (mm), wet weights (g), and dry weights (g) for juvenile alligator gar fed 4 or 8% feed based on body mass split evenly among 3 daily feedings and reared at 2.5, 5, 7.5, or 10 fish/L for 16 days.

Replicate	TL	Wet Weight	Dry Weight
1	22.0	0.0702	0.0082
2	29.3	0.1180	0.0174
3	23.8	0.0559	0.0076
4	25.6	0.0826	0.0123
5	22.7	0.0597	0.0079
6	23.0	0.0810	0.0120
7	27.7	0.0959	0.0137
8	22.9	0.0681	0.0104
9	30.6	0.1312	0.0212
10	29.7	0.1072	0.0173
11	32.4	0.1310	0.0200
12	30.6	0.1182	0.0179
13	21.8	0.0589	0.0087
14	26.7	0.1055	0.0170
15	29.8	0.1012	0.0159
16	25.9	0.0790	0.0116
17	25.7	0.0884	0.0134
18	25.5	0.0800	0.0131
19	24.9	0.0630	0.0096
20	29.9	0.1370	0.0204
21	24.7	0.0840	0.0125
22	26.3	0.0840	0.0135
23	24.7	0.0811	0.0128
24	25.5	0.0799	0.0127
25	27.3	0.0926	0.0136

Appendix V. Feed amount (%), density (fish/L), replicate, TL (mm; \pm SE), wet weight (mm), and total dead for juvenile alligator gar fed 4 or 8% feed based on body mass split evenly among 3 daily feedings and reared at 2.5, 5, 7.5, or 10 fish/L after 16 days.

Feed Amount	Density	Replicate	TL	Wet Weight	Dead
4	2.5	1	64.48 \pm 3.83	1.52	117
4	2.5	2	77.64 \pm 5.42	2.48	129
4	2.5	3	65.20 \pm 4.72	1.28	100
4	5	1	75.58 \pm 3.39	2.65	269
4	5	2	75.86 \pm 4.83	2.44	264
4	5	3	70.90 \pm 5.68	1.52	237
4	7.5	1	74.12 \pm 4.33	2.59	409
4	7.5	2	74.06 \pm 4.30	3.25	410
4	7.5	3	70.44 \pm 5.31	1.48	354
4	10	1	76.46 \pm 2.15	2.14	527
4	10	2	72.96 \pm 1.41	3.31	565
4	10	3	68.76 \pm 4.58	1.23	428
8	2.5	1	80.54 \pm 7.98	2.10	111
8	2.5	2	80.62 \pm 6.74	2.26	111
8	2.5	3	73.16 \pm 7.53	1.80	90
8	5	1	72.84 \pm 2.12	2.77	261
8	5	2	73.68 \pm 2.59	1.98	218
8	5	3	70.20 \pm 6.58	1.80	211
8	7.5	1	65.42 \pm 0.91	2.35	388
8	7.5	2	84.38 \pm 2.85	2.47	390
8	7.5	3	59.40 \pm 1.33	1.82	339
8	10	1	64.00 \pm 6.79	1.54	444
8	10	2	70.26 \pm 2.76	2.30	519
8	10	3	68.20 \pm 3.40	1.57	390

Appendix VI. Day, replicate, temperature regime, feed frequency, TL (mm; \pm SE), and wet weights (g; \pm SE) for juvenile alligator gar fed 4% feed based on body mass split evenly among 2 or 3 feedings daily for 21 days.

Day	Replicate	Temperature	Feed Frequency	TL	Wet Weights
0	1	Regulated	3	132.6 \pm 1.85	10.3 \pm 0.53
0	2	Regulated	3	129.6 \pm 1.71	9.3 \pm 0.36
0	3	Regulated	3	125.2 \pm 1.59	8.5 \pm 0.38
0	4	Regulated	3	131.9 \pm 1.72	8.1 \pm 0.32
0	1	Fluctuating	3	124.3 \pm 1.61	8.6 \pm 0.35
0	2	Fluctuating	3	125.0 \pm 2.27	8.8 \pm 0.54
0	3	Fluctuating	3	125.1 \pm 1.61	8.6 \pm 0.37
0	4	Fluctuating	3	126.2 \pm 1.87	8.6 \pm 0.38
0	1	Fluctuating	2	128.0 \pm 1.85	11.0 \pm 2.08
0	2	Fluctuating	2	126.0 \pm 1.86	8.6 \pm 0.37
0	3	Fluctuating	2	129.3 \pm 2.35	9.1 \pm 0.59
0	4	Fluctuating	2	130.7 \pm 1.93	9.6 \pm 0.39
2	1	Regulated	3	-	11.3 \pm 1.48
2	2	Regulated	3	-	11.1 \pm 0.66
2	3	Regulated	3	-	10.4 \pm 0.84
2	4	Regulated	3	-	9.7 \pm 0.48
2	1	Fluctuating	3	-	9.6 \pm 0.59
2	2	Fluctuating	3	-	9.6 \pm 0.72
2	3	Fluctuating	3	-	10.3 \pm 0.82
2	4	Fluctuating	3	-	10.8 \pm 1.11
2	1	Fluctuating	2	-	11.1 \pm 0.75
2	2	Fluctuating	2	-	10.2 \pm 0.80
2	3	Fluctuating	2	-	10.7 \pm 1.40
2	4	Fluctuating	2	-	10.8 \pm 0.67
4	1	Regulated	3	-	14.3 \pm 1.25
4	2	Regulated	3	-	12.2 \pm 0.87
4	3	Regulated	3	-	10.3 \pm 0.60
4	4	Regulated	3	-	10.8 \pm 0.80
4	1	Fluctuating	3	-	11.2 \pm 0.68
4	2	Fluctuating	3	-	12.9 \pm 1.42
4	3	Fluctuating	3	-	10.7 \pm 0.63
4	4	Fluctuating	3	-	12.7 \pm 0.93
4	1	Fluctuating	2	-	12.1 \pm 0.54
4	2	Fluctuating	2	-	13.4 \pm 0.83
4	3	Fluctuating	2	-	14.5 \pm 1.92
4	4	Fluctuating	2	-	13.1 \pm 1.06
6	1	Regulated	3	-	16.3 \pm 1.25
6	2	Regulated	3	-	14.5 \pm 0.81
6	3	Regulated	3	-	12.5 \pm 1.09
6	4	Regulated	3	-	11.9 \pm 0.98
6	1	Fluctuating	3	-	13.4 \pm 1.27
6	2	Fluctuating	3	-	14.0 \pm 1.57

Day	Replicate	Temperature	Feed Frequency	TL	Wet Weights
6	3	Fluctuating	3	-	12.6 ± 0.82
6	4	Fluctuating	3	-	13.5 ± 1.67
6	1	Fluctuating	2	-	13.3 ± 0.73
6	2	Fluctuating	2	-	15.8 ± 1.28
6	3	Fluctuating	2	-	13.4 ± 0.56
6	4	Fluctuating	2	-	15.2 ± 1.02
8	1	Regulated	3	-	19.1 ± 1.19
8	2	Regulated	3	-	17.3 ± 0.93
8	3	Regulated	3	-	16.6 ± 1.45
8	4	Regulated	3	-	15.2 ± 1.65
8	1	Fluctuating	3	-	15.9 ± 1.15
8	2	Fluctuating	3	-	15.4 ± 1.86
8	3	Fluctuating	3	-	15.6 ± 1.00
8	4	Fluctuating	3	-	15.7 ± 1.09
8	1	Fluctuating	2	-	15.9 ± 0.87
8	2	Fluctuating	2	-	19.4 ± 1.22
8	3	Fluctuating	2	-	15.2 ± 1.28
8	4	Fluctuating	2	-	15.0 ± 2.00
10	1	Regulated	3	-	20.4 ± 1.86
10	2	Regulated	3	-	18.3 ± 1.32
10	3	Regulated	3	-	17.7 ± 0.74
10	4	Regulated	3	-	17.6 ± 1.81
10	1	Fluctuating	3	-	18.5 ± 1.49
10	2	Fluctuating	3	-	20.0 ± 2.51
10	3	Fluctuating	3	-	17.1 ± 1.51
10	4	Fluctuating	3	-	17.6 ± 1.72
10	1	Fluctuating	2	-	19.8 ± 1.76
10	2	Fluctuating	2	-	19.7 ± 1.53
10	3	Fluctuating	2	-	21.1 ± 3.20
10	4	Fluctuating	2	-	19.4 ± 1.31
12	1	Regulated	3	-	24.1 ± 2.16
12	2	Regulated	3	-	22.2 ± 1.82
12	3	Regulated	3	-	18.1 ± 0.89
12	4	Regulated	3	-	21.3 ± 1.71
12	1	Fluctuating	3	-	21.3 ± 1.69
12	2	Fluctuating	3	-	21.2 ± 2.36
12	3	Fluctuating	3	-	22.5 ± 1.62
12	4	Fluctuating	3	-	19.6 ± 1.33
12	1	Fluctuating	2	-	25.8 ± 2.78
12	2	Fluctuating	2	-	20.7 ± 2.13
12	3	Fluctuating	2	-	25.4 ± 3.88
12	4	Fluctuating	2	-	23.3 ± 1.90
14	1	Regulated	3	-	27.8 ± 2.51
14	2	Regulated	3	-	23.1 ± 1.40
14	3	Regulated	3	-	22.4 ± 1.93

Day	Replicate	Temperature	Feed Frequency	TL	Wet Weights
14	4	Regulated	3	-	21.4 ± 1.92
14	1	Fluctuating	3	-	20.6 ± 0.96
14	2	Fluctuating	3	-	22.9 ± 1.87
14	3	Fluctuating	3	-	26.7 ± 1.98
14	4	Fluctuating	3	-	24.5 ± 2.14
14	1	Fluctuating	2	-	24.4 ± 2.59
14	2	Fluctuating	2	-	27.8 ± 2.84
14	3	Fluctuating	2	-	35.1 ± 3.91
14	4	Fluctuating	2	-	27.4 ± 1.91
16	1	Regulated	3	-	31.0 ± 2.15
16	2	Regulated	3	-	27.9 ± 2.00
16	3	Regulated	3	-	26.9 ± 3.27
16	4	Regulated	3	-	23.5 ± 2.10
16	1	Fluctuating	3	-	25.1 ± 1.98
16	2	Fluctuating	3	-	27.0 ± 2.61
16	3	Fluctuating	3	-	30.3 ± 2.13
16	4	Fluctuating	3	-	22.7 ± 1.90
16	1	Fluctuating	2	-	29.5 ± 1.73
16	2	Fluctuating	2	-	26.4 ± 2.25
16	3	Fluctuating	2	-	36.0 ± 3.90
16	4	Fluctuating	2	-	31.1 ± 2.21
18	1	Regulated	3	-	36.0 ± 2.68
18	2	Regulated	3	-	30.8 ± 2.82
18	3	Regulated	3	-	28.7 ± 2.31
18	4	Regulated	3	-	28.6 ± 1.89
18	1	Fluctuating	3	-	27.1 ± 2.09
18	2	Fluctuating	3	-	32.1 ± 2.27
18	3	Fluctuating	3	-	33.3 ± 3.04
18	4	Fluctuating	3	-	27.1 ± 2.65
18	1	Fluctuating	2	-	31.3 ± 1.97
18	2	Fluctuating	2	-	36.8 ± 3.87
18	3	Fluctuating	2	-	39.9 ± 4.35
18	4	Fluctuating	2	-	33.6 ± 3.01
20	1	Regulated	3	200.8 ± 2.78	40.7 ± 1.83
20	2	Regulated	3	194.3 ± 2.50	37.4 ± 1.41
20	3	Regulated	3	189.8 ± 2.60	35.2 ± 1.55
20	4	Regulated	3	186.7 ± 2.91	31.3 ± 1.53
20	1	Fluctuating	3	192.0 ± 3.34	34.2 ± 1.51
20	2	Fluctuating	3	201.8 ± 4.13	40.8 ± 2.58
20	3	Fluctuating	3	195.3 ± 3.04	39.0 ± 1.84
20	4	Fluctuating	3	195.5 ± 2.94	36.5 ± 1.68
20	1	Fluctuating	2	201.0 ± 3.58	39.6 ± 1.96
20	2	Fluctuating	2	204.5 ± 4.35	43.2 ± 2.62
20	3	Fluctuating	2	210.2 ± 4.31	47.5 ± 3.21
20	4	Fluctuating	2	203.0 ± 3.19	39.9 ± 1.79

Appendix VII. Day, replicate, feed percentage, TL (mm; \pm SE), and wet weights (g; \pm SE) for juvenile alligator gar fed 1, 2, 4, or 8% feed based on body mass split evenly among 3 feedings daily for 21 days.

Day	Replicate	Feed Percentage	TL	Wet Weight
0	1	8	118.7 \pm 1.52	5.4 \pm 0.25
0	2	8	110.1 \pm 1.50	5.8 \pm 0.24
0	3	8	108.5 \pm 1.51	5.5 \pm 0.23
0	1	4	118.5 \pm 1.46	5.5 \pm 0.19
0	2	4	108.6 \pm 1.36	5.3 \pm 0.21
0	3	4	111.3 \pm 1.66	5.8 \pm 0.25
0	1	2	119.3 \pm 1.58	5.6 \pm 0.25
0	2	2	108.8 \pm 1.47	5.7 \pm 0.23
0	3	2	105.2 \pm 2.34	5.2 \pm 0.31
0	1	1	111.0 \pm 1.67	5.0 \pm 0.22
0	2	1	108.9 \pm 1.40	5.5 \pm 0.20
0	3	1	107.9 \pm 1.88	5.4 \pm 0.28
2	1	8	-	7.1 \pm 0.45
2	2	8	-	7.2 \pm 0.45
2	3	8	-	7.1 \pm 0.57
2	1	4	-	6.1 \pm 0.39
2	2	4	-	5.6 \pm 0.23
2	3	4	-	7.0 \pm 0.51
2	1	2	-	5.4 \pm 0.48
2	2	2	-	7.2 \pm 0.39
2	3	2	-	7.0 \pm 0.81
2	1	1	-	5.4 \pm 0.22
2	2	1	-	5.9 \pm 0.38
2	3	1	-	6.1 \pm 0.46
4	1	8	-	8.1 \pm 0.65
4	2	8	-	9.1 \pm 0.62
4	3	8	-	8.3 \pm 0.58
4	1	4	-	6.9 \pm 0.49
4	2	4	-	7.8 \pm 0.67
4	3	4	-	8.3 \pm 0.68
4	1	2	-	6.5 \pm 0.50
4	2	2	-	6.9 \pm 0.45
4	3	2	-	8.9 \pm 0.78
4	1	1	-	5.5 \pm 0.36
4	2	1	-	5.7 \pm 0.32
4	3	1	-	6.5 \pm 0.56
6	1	8	-	11.7 \pm 1.24
6	2	8	-	12.3 \pm 1.11
6	3	8	-	11.7 \pm 0.81
6	1	4	-	7.9 \pm 0.54
6	2	4	-	11.0 \pm 0.78
6	3	4	-	8.8 \pm 0.58

Day	Replicate	Feed Percentage	TL	Wet Weight
6	1	2	-	7.7 ± 0.42
6	2	2	-	7.9 ± 0.68
6	3	2	-	7.8 ± 0.71
6	1	1	-	4.9 ± 0.25
6	2	1	-	6.1 ± 0.42
6	3	1	-	5.9 ± 0.40
8	1	8	-	12.9 ± 1.02
8	2	8	-	16.4 ± 1.38
8	3	8	-	14.3 ± 0.77
8	1	4	-	9.2 ± 0.80
8	2	4	-	11.4 ± 0.96
8	3	4	-	10.9 ± 0.94
8	1	2	-	8.5 ± 0.48
8	2	2	-	9.0 ± 0.51
8	3	2	-	8.3 ± 0.68
8	1	1	-	5.9 ± 0.50
8	2	1	-	7.9 ± 0.47
8	3	1	-	6.3 ± 0.49
10	1	8	-	18.5 ± 1.64
10	2	8	-	18.9 ± 1.09
10	3	8	-	18.1 ± 1.41
10	1	4	-	12.0 ± 1.06
10	2	4	-	12.7 ± 1.00
10	3	4	-	12.9 ± 1.00
10	1	2	-	9.4 ± 0.58
10	2	2	-	9.9 ± 1.21
10	3	2	-	8.5 ± 0.31
10	1	1	-	6.1 ± 0.41
10	2	1	-	8.1 ± 0.45
10	3	1	-	5.5 ± 0.42
12	1	8	-	20.3 ± 1.66
12	2	8	-	20.7 ± 1.55
12	3	8	-	24.1 ± 1.03
12	1	4	-	13.1 ± 1.21
12	2	4	-	14.1 ± 1.21
12	3	4	-	14.6 ± 1.23
12	1	2	-	8.8 ± 0.54
12	2	2	-	10.7 ± 0.50
12	3	2	-	11.5 ± 1.22
12	1	1	-	6.1 ± 0.32
12	2	1	-	7.9 ± 0.42
12	3	1	-	6.3 ± 0.29
14	1	8	-	25.4 ± 2.45
14	2	8	-	25.5 ± 1.43
14	3	8	-	26.8 ± 1.84

Day	Replicate	Feed Percentage	TL	Wet Weight
14	1	4	-	16.4 ± 0.68
14	2	4	-	16.1 ± 1.02
14	3	4	-	17.8 ± 1.61
14	1	2	-	9.8 ± 0.71
14	2	2	-	10.9 ± 0.82
14	3	2	-	11.2 ± 0.84
14	1	1	-	7.9 ± 0.79
14	2	1	-	8.8 ± 0.47
14	3	1	-	7.7 ± 0.71
16	1	8	-	28.1 ± 2.94
16	2	8	-	24.2 ± 1.80
16	3	8	-	30.5 ± 1.94
16	1	4	-	19.2 ± 1.51
16	2	4	-	16.3 ± 0.99
16	3	4	-	19.0 ± 1.36
16	1	2	-	10.9 ± 0.85
16	2	2	-	11.9 ± 1.02
16	3	2	-	12.5 ± 1.64
16	1	1	-	7.0 ± 0.43
16	2	1	-	9.1 ± 0.67
16	3	1	-	7.0 ± 0.42
18	1	8	-	32.6 ± 3.30
18	2	8	-	31.0 ± 3.37
18	3	8	-	32.9 ± 2.35
18	1	4	-	19.0 ± 1.29
18	2	4	-	21.5 ± 1.84
18	3	4	-	23.5 ± 2.06
18	1	2	-	13.1 ± 1.28
18	2	2	-	12.9 ± 0.69
18	3	2	-	15.6 ± 2.07
18	1	1	-	9.1 ± 0.57
18	2	1	-	8.4 ± 0.56
18	3	1	-	8.8 ± 0.78
20	1	8	192.0 ± 3.36	34.6 ± 1.86
20	2	8	196.1 ± 3.29	39.4 ± 2.11
20	3	8	194.3 ± 2.74	36.1 ± 1.54
20	1	4	171.9 ± 2.90	24.5 ± 1.05
20	2	4	172.2 ± 3.29	27.6 ± 1.76
20	3	4	176.2 ± 3.63	27.9 ± 1.57
20	1	2	143.4 ± 2.59	13.3 ± 0.69
20	2	2	148.8 ± 2.33	15.9 ± 0.56
20	3	2	154.7 ± 4.60	17.0 ± 1.74
20	1	1	130.2 ± 2.70	9.6 ± 0.62
20	2	1	135.7 ± 1.85	9.9 ± 0.38
20	3	1	127.2 ± 2.26	8.4 ± 0.45

Appendix VIII. Initial replicates, TL (mm), wet weights (g), and dry weights (g) for juvenile alligator gar fed 6, 8, 10 or 12% feed based on body mass split evenly among 3 daily feedings 21 days.

Replicate	TL	Wet Weight	Dry Weight
1	98.0	4.2658	0.7842
2	115.5	6.5520	1.1948
3	82.7	2.6787	0.4771
4	105.9	5.6632	1.0196
5	116.1	6.6961	1.2780
6	98.1	3.6015	0.6436
7	123.1	8.1044	1.4761
8	89.2	2.7986	0.5127
9	88.3	3.1412	0.5740
10	106.8	5.4777	1.0472
11	112.5	5.9304	1.1359
12	128.6	8.9364	1.7707
13	103.2	5.6149	1.0392
14	82.7	2.8717	0.5105
15	97.9	3.2395	0.5779
16	93.7	3.5976	0.6715
17	86.8	2.8984	0.5076
18	82.0	2.4970	0.4427
19	88.6	3.2773	0.5865
20	89.4	2.9279	0.5142
21	113.4	6.2608	1.1235
22	93.6	3.5347	0.5252
23	99.0	3.3120	0.5762
24	90.8	3.0097	0.5303
25	90.7	2.4976	0.4476

Appendix IV. Day, replicate, feed percentage, TL (mm; \pm SE), and wet weights (g; \pm SE) for juvenile alligator gar fed 6, 8, 10 or 12% feed based on body mass split evenly among 3 feedings daily for 21 days.

Day	Replicate	Feed Percentage	TL	Wet Weight
2	1	6	-	6.7 \pm 0.56
2	2	6	-	6.5 \pm 0.29
2	3	6	-	2.4 \pm 0.37
2	1	8	-	6.4 \pm 0.29
2	2	8	-	6.0 \pm 0.37
2	3	8	-	6.5 \pm 0.34
2	1	10	-	6.0 \pm 0.26
2	2	10	-	6.9 \pm 0.27
2	3	10	-	6.6 \pm 0.33
2	1	12	-	6.7 \pm 0.33
2	2	12	-	7.0 \pm 0.23
2	3	12	-	7.1 \pm 0.50
4	1	6	-	7.4 \pm 0.79
4	2	6	-	7.2 \pm 0.36
4	3	6	-	8.0 \pm 0.57
4	1	8	-	6.9 \pm 0.51
4	2	8	-	7.0 \pm 0.45
4	3	8	-	7.9 \pm 0.40
4	1	10	-	7.7 \pm 0.34
4	2	10	-	8.7 \pm 0.47
4	3	10	-	8.6 \pm 0.75
4	1	12	-	8.2 \pm 0.71
4	2	12	-	9.4 \pm 0.44
4	3	12	-	8.4 \pm 0.62
6	1	6	-	9.3 \pm 0.87
6	2	6	-	10.1 \pm 0.71
6	3	6	-	10.0 \pm 0.96
6	1	8	-	8.9 \pm 0.75
6	2	8	-	8.3 \pm 0.54
6	3	8	-	9.9 \pm 0.46
6	1	10	-	9.2 \pm 0.56
6	2	10	-	9.6 \pm 0.86
6	3	10	-	10.2 \pm 1.10
6	1	12	-	9.1 \pm 0.86
6	2	12	-	12.0 \pm 0.48
6	3	12	-	10.4 \pm 1.27
8	1	6	-	10.9 \pm 0.88
8	2	6	-	11.4 \pm 1.22
8	3	6	-	13.4 \pm 1.05
8	1	8	-	12.0 \pm 0.86
8	2	8	-	10.6 \pm 1.03
8	3	8	-	12.2 \pm 0.85

Day	Replicate	Feed Percentage	TL	Wet Weight
8	1	10	-	13.0 ± 0.90
8	2	10	-	12.9 ± 1.24
8	3	10	-	13.3 ± 1.75
8	1	12	-	14.5 ± 1.28
8	2	12	-	14.8 ± 1.29
8	3	12	-	15.7 ± 1.23
10	1	6	-	12.8 ± 1.07
10	2	6	-	12.6 ± 1.16
10	3	6	-	13.1 ± 1.08
10	1	8	-	13.3 ± 1.37
10	2	8	-	11.2 ± 0.68
10	3	8	-	15.6 ± 1.26
10	1	10	-	14.9 ± 0.94
10	2	10	-	16.5 ± 1.36
10	3	10	-	18.4 ± 1.49
10	1	12	-	16.4 ± 1.41
10	2	12	-	19.2 ± 1.12
10	3	12	-	21.4 ± 2.03
12	1	6	-	19.1 ± 2.16
12	2	6	-	17.8 ± 1.89
12	3	6	-	18.3 ± 1.83
12	1	8	-	15.9 ± 1.00
12	2	8	-	14.2 ± 0.81
12	3	8	-	17.6 ± 1.45
12	1	10	-	19.9 ± 1.31
12	2	10	-	20.8 ± 1.81
12	3	10	-	22.0 ± 2.62
12	1	12	-	22.0 ± 2.49
12	2	12	-	21.8 ± 1.29
12	3	12	-	21.8 ± 1.86
14	1	6	-	22.8 ± 2.61
14	2	6	-	23.1 ± 1.88
14	3	6	-	19.3 ± 1.17
14	1	8	-	22.4 ± 1.54
14	2	8	-	19.1 ± 2.32
14	3	8	-	20.5 ± 0.90
14	1	10	-	24.3 ± 1.49
14	2	10	-	25.4 ± 1.91
14	3	10	-	27.0 ± 2.75
14	1	12	-	28.5 ± 2.12
14	2	12	-	25.1 ± 2.18
14	3	12	-	29.2 ± 2.77
16	1	6	-	21.0 ± 1.89
16	2	6	-	26.0 ± 2.23
16	3	6	-	30.2 ± 2.56

Day	Replicate	Feed Percentage	TL	Wet Weight
16	1	8	-	27.0 ± 1.91
16	2	8	-	26.5 ± 2.31
16	3	8	-	20.4 ± 1.63
16	1	10	-	26.8 ± 1.85
16	2	10	-	30.9 ± 2.27
16	3	10	-	28.7 ± 1.29
16	1	12	-	31.2 ± 2.85
16	2	12	-	32.9 ± 2.79
16	3	12	-	36.5 ± 3.18
18	1	6	-	31.7 ± 2.30
18	2	6	-	30.6 ± 2.59
18	3	6	-	26.0 ± 2.31
18	1	8	-	29.6 ± 2.27
18	2	8	-	31.3 ± 2.81
18	3	8	-	24.6 ± 1.60
18	1	10	-	29.5 ± 2.92
18	2	10	-	38.2 ± 3.61
18	3	10	-	31.3 ± 2.84
18	1	12	-	36.4 ± 2.93
18	2	12	-	35.5 ± 3.09
18	3	12	-	36.0 ± 3.27
20	1	6	177.8 ± 4.27	30.4 ± 2.68
20	2	6	175.6 ± 3.84	28.1 ± 2.28
20	3	6	177.2 ± 3.24	27.5 ± 1.60
20	1	8	171.2 ± 4.40	28.7 ± 2.03
20	2	8	176.0 ± 3.08	27.8 ± 1.51
20	3	8	177.8 ± 2.53	27.2 ± 1.63
20	1	10	177.0 ± 2.90	28.8 ± 1.67
20	2	10	190.5 ± 3.10	35.3 ± 1.93
20	3	10	185.8 ± 4.13	33.7 ± 2.16
20	1	12	191.3 ± 3.24	37.7 ± 2.32
20	2	12	189.1 ± 2.69	34.0 ± 1.59
20	3	12	195.3 ± 3.87	39.8 ± 2.44

Appendix X. Final replicates, treatment, TL (mm), wet weights (g), and dry weights (g) for juvenile alligator gar fed 6, 8, 10 or 12% feed based on body mass split evenly among 3 feedings daily for 21 days.

Replicate	Feed Percentage	TL	Wet Weight	Dry Weight
1	6	184	29.93	6.66
2	6	166	19.82	4.39
3	6	195	39.56	9.37
4	6	191	36.86	8.46
5	6	172	21.61	4.96
6	6	201	38.15	8.75
7	6	179	26.35	5.90
8	6	156	13.32	2.92
9	6	175	24.87	5.88
10	6	159	19.93	4.41
11	6	202	39.88	8.76
12	6	187	32.40	6.99
13	6	174	23.61	5.12
14	6	194	33.73	7.43
15	6	181	28.45	6.24
1	8	162	18.60	4.06
2	8	171	25.12	5.63
3	8	179	30.22	6.97
4	8	167	18.70	4.00
5	8	166	21.27	4.63
6	8	178	25.70	6.05
7	8	198	43.71	10.05
8	8	151	16.17	3.34
9	8	168	25.39	5.70
10	8	158	19.23	4.08
11	8	185	29.88	6.31
12	8	184	31.20	6.79
13	8	192	36.66	7.95
14	8	174	26.04	5.34
15	8	172	28.32	5.95
1	10	199	40.35	9.63
2	10	181	35.48	8.37
3	10	196	36.69	8.55
4	10	165	21.89	4.98
5	10	181	29.48	6.68
6	10	193	36.94	8.40
7	10	201	46.67	10.91
8	10	175	25.48	5.82
9	10	209	47.11	10.74
10	10	216	53.40	12.61
11	10	205	40.39	8.94
12	10	221	59.46	13.09

Replicate	Feed Percentage	TL	Wet Weight	Dry Weight
13	10	192	38.57	8.78
14	10	183	31.54	7.09
15	10	195	37.42	7.90
1	12	214	54.77	12.93
2	12	181	32.23	7.45
3	12	168	22.18	4.84
4	12	175	27.92	6.17
5	12	175	26.66	6.20
6	12	195	32.51	7.42
7	12	202	42.09	9.81
8	12	176	25.43	5.92
9	12	179	26.22	5.98
10	12	178	23.86	5.38
11	12	193	37.19	8.12
12	12	201	41.6	9.08
13	12	184	32.37	7.02
14	12	194	35.41	7.72
15	12	208	34.08	10.00

BIOGRAPHICAL SKETCH

Timothy Allen Clay was born on 4 July 1982, in the District of Columbia. Tim graduated from Long Reach High School in May of 2000. Tim furthered his education at the University of Maryland Baltimore County by earning a Bachelors of Science degree in Biology in December of 2004. Upon graduating from UMBC Tim worked a multitude of different wildlife jobs. In the winter of 2008 Tim enrolled in the graduate program in Marine and Environmental Biology at Nicholls State University. Tim conducted research through the Bayosphere towards the aquaculture of alligator gar *Atractosteus spatula*. At Nicholls State University Tim was a research assistant and manager for the Bayosphere laboratory. After graduation in December 2009, Tim plans to pursue further research and education through a Ph.D. position.

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EXPERIENCE

Masters Student, Nicholls State University, January 2008 – Present

Conducted research focused on developing culture techniques for all life stages of alligator gar. Thesis focused on maximizing efficiency of spawning alligator gar and the rearing of larvae and juveniles. Research assistantship involved helping fellow graduate students in their research in the areas of sturgeon plasma osmolality, oyster recruitment, yellow bass and zebra mussel population assessment, and spotted gar ageing. Maintained juvenile lake sturgeon, paddlefish, spotted gar and alligator gar in recirculating systems.

Intern, National Wetlands Research Center, USGS, February 2009 – April 2009

Participated for 80hrs in the Amphibian Research and Monitoring Initiative (ARMI). Through this internship I learned how to recognize the native frogs of southern Louisiana by call and by sight. We sampled sites at night with a presence/absence approach throughout the Atchafalaya River basin.

Fisheries Technician, University of Georgia, February 2007 – December 2007

Conducted research on shortnose and atlantic sturgeon in the both the Altamaha and Ogeechee river systems. Typical duties included the use of gill and drift nets, radio telemetry, data entry, maintaining boats and repairing fishing equipment. Developed new methods in the field of sturgeon research to find spawning grounds of Atlantic and shortnose sturgeon. This job required good physical condition as well as working in adverse conditions at potentially all hours of the day. The ability to work on your own or with peers without direct supervision is a key part of this job.

Animal Keeper, Catoctin Wildlife Preserve and Zoo, March 2006 – August 2006

General care and maintenance of a variety of mammals, large birds and fish. Duties included preparation of diets, feeding of animals, cleaning of enclosures, setting up and breaking down of enclosures, administering of medications. Also provided assistance to a fish hatchery working with koi and goldfish.

Seasonal Fisheries Technician, USGS and USFWS, June 2005 – September 2005

Conducted research on shortnose sturgeon and yellow perch in the Chesapeake bay. Duties included setting and retrieving gill nets, deploying and retrieving drift nets, and testing and recording water quality. This job required good physical condition as well as working in adverse conditions.

Volunteer, National Zoo, September 2002 – August 2004

General care and maintenance of a variety of tropical animals of the Amazon. Responsibilities included cleaning of enclosures and aquariums, setup and

breakdown of enclosures and aquariums, preparation of diets, feeding of animals, maintaining live food cultures, maintaining breeding populations of amphibians.

PUBLICATIONS

Early Growth and Survival of Larval Alligator Gar *Atractosteus spatula* Reared on Artificial Floating Feed With or Without a Live *Artemia* spp. Supplement. Current status:

Submitted and waiting review to The Journal of the World Aquaculture Society

PROFESSIONAL PRESENTATIONS

2009 Southern Division American Fisheries Society, Oral presentation.

Title – Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems
Timothy Clay, Mark Suchy, Wendell Lorio, Allyse Ferrara, Quenton Fontenot and Gary LaFleur

2009 Southern Division American Fisheries Society Annual Spring Meeting, Oral Presentation.

Title – Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. Mark Suchy, **Timothy Clay**, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot

2009 Aquaculture America, Annual Meeting, Poster Presentation.

Title – Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems.
Timothy Clay, Mark Suchy, Wendell Lorio, Allyse Ferrara, Quenton Fontenot and Gary LaFleur

2009 Aquaculture America, Annual Meeting, Poster Presentation.

Title – Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. Mark Suchy, **Timothy Clay**, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot

2009 Louisiana Academy of Sciences, Oral Presentation.

Title – Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems.
Timothy Clay, Mark Suchy, Wendell Lorio, Allyse Ferrara, Quenton Fontenot and Gary LaFleur

2009 Louisiana Academy of Sciences, Oral Presentation.

Title – Effects of salinity on growth and plasma osmolality of juvenile alligator gar *Atractosteus spatula*. Mark Suchy, **Timothy Clay**, Wendell Lorio, Allyse Ferrara, and Quenton Fontenot

2009 Nicholls State Research Week, Poster Presentation, **2nd Place in Graduate Student Competition.**

Title – Aquaculture of alligator gar *Atractosteus spatula* in recirculating systems
Timothy Clay, Mark Suchy, Wendell Lorio, Allyse Ferrara, Quenton Fontenot
and Gary LaFleur

2009 Nicholls State Research Week, Poster Presentation.

Title – Effects of salinity on growth and plasma osmolality of juvenile alligator
gar *Atractosteus spatula*. Mark Suchy, **Timothy Clay**, Wendell Lorio, Allyse
Ferrara, and Quenton Fontenot