The Effect of Three Pelleted Diets on the Survival, Growth and Feed Conversion of Juvenile White Grunts (*Haemulon plumieri*)

W. M. COLE, J. E. RAKOCY, D. S. BAILEY and J. A. HARGREAVES
University of the Virgin Islands
Agricultural Experiment Station
RR 2, Box 10,000
Kingshill, St. Croix, U.S. Virgin Islands 00850

ABSTRACT

Juvenile white grunts (*Haemulon plumieri*) were cultured in flow-through tanks and fed three formulated diets and a control diet for ten weeks. The control diet was comprised of ground fish, shrimp and squid. Fish fed a 43% protein, 10% moisture salmonid diet had significantly ($P<0.05$) lower growth rates (0.20 g/d, 0.76 %/d) and significantly higher feed conversion (12.4) than the fish fed the control diet (0.26 g/d, 0.92 %/d, 10.2). There were no significant differences in growth rates and feed conversion between fish fed the control diet and a 43% protein, 18% moisture, semi-moist salmonid diet or a 55% protein, 7% moisture marine finfish diet. There were no significant differences in condition factor between fish fed the control and formulated diets. Survival was 100% for all treatments. Although no diseases were observed and the fish responded well to handling, relatively low growth rates and poor feed conversion with all diets indicate that white grunts are not desirable for foodfish aquaculture.

KEY WORDS: mariculture, nutrition, *Haemulon plumieri*, white grunt.

INTRODUCTION

Natural productivity in the Eastern Caribbean marine environment is relatively low due to limited available nutrients. Coralline shelf areas are typically narrow and thermal stratification of the surrounding deep water prevents upwelling of nutrient-rich layers. Munro (1983) estimated the productivity of the Caribbean coralline area to be 18-40 kg/ha/yr.

Landings of marine fish in the Caribbean fail to meet market demand (Ryther *et al.*, 1991; Sandifer, 1991). In spite of increased fishing effort, 16,700 mt of seafood products, valued at U.S. $56 million, were imported in 1987 (FAO, 1987). High value, nearshore species are at or exceed the maximum sustainable yield (Goodwin *et al.*, 1985).

Aquaculture, an alternative means of supplying seafood products, has been slow to develop in the Caribbean. Although the only economically successful aquaculture projects have involved fresh water species (Ryther *et al.*, 1991), commercial efforts are being made to culture tilapia (*Oreochromis* spp.) and red drum (*Sciaenops ocellata*) in sea water (Tucker and Jory, 1991).

Little information is available on the culture potential of indigenous Caribbean reef finfish. Researchers at Harbor Branch Oceanographic Institution in Fort Pierce, Florida have studied several species and have had success in spawning and rearing Nassau grouper (*Epinephelus striatus*). Based on a selection program for species suitable for culture in Martinique (F.W.I.), Thouard *et al.* (1990) suggested an indigenous species, the palometa (*Trachinotus goodei*), as having potential. Permit (*T. falcatus*), mutton snapper (*Lutjanus analis*) and gray snapper (*L. griseus*) were not selected due to lack of broodstock. Spawning success of yellowtail snapper (*Ocyurus chrysurus*) was inconsistent and growth rates for schoolmaster (*L. apodus*) and lane snapper (*L. synagris*) were relatively low. Two exotic species, red drum and red hybrid tilapia (*Oreochromis sp.*), were identified as having culture potential.

The University of the Virgin Islands Agricultural Experiment Station has initiated a program to evaluate the culture potential of selected near-shore Caribbean marine finfish. The program consists of three phases:

1. Juvenile feeding experiments. Culture potential of selected marine finfish are determined by growth performance, feed conversion efficiency and survival of juveniles fed formulated, high-protein diets.

2. Grow-out experiments. Two production systems (tanks and cages) will be evaluated for the grow-out to market-size of species selected from juvenile feeding experiments.

3. Spawning and larval rearing experiments. Spawning and larval rearing will be attempted for those species which perform best in the grow-out experiments.

METHODS

Juveniles of both white grunts (*Haemulon plumieri*) were collected from the south shore of St. Croix, U.S. Virgin Islands. Six 1.9-cm mesh, plastic traps (122 cm X 40 cm X 40 cm) were placed in 1-2 m of water near a rocky point for 12 days. The traps were baited with cut fish. Soak times ranged from 2-3 days, after which the captured fish were removed and additional bait added. The grunts were held in tanks until enough individuals of one species were captured for an experiment. During the holding period, the fish were fed a mixture of ground fish, shrimp and squid.

Although sufficient numbers of both species were collected, caudal fin erosion was observed on some of the French grunts. White grunts were selected for this trial.

A flow-through system, comprised of 12 2-m^3 fiberglass tanks, was used for the study. Each tank was covered by 80% shade cloth. Water was pumped from the ocean using a one horse-power (hp) continuous-duty pump, and a 1/2-hp air blower supplied emergency aeration.

Ten white grunts (mean wt., 20 g) were placed into each tank and cultured for ten weeks (August 25 - November 2, 1992), including an initial two-week acclimation period. Four treatments consisting of three formulated diets and a control diet (Table 1) were replicated three times and were randomly assigned to the tanks. The formulated diets consisted of sinking pellets (4.0 mm). Two of the diets which contained 43% protein were formulated for salmonids (Moore-Clark Co., Inc., LaConner, WA). One of these diets (dry, salmonid) contained 10% moisture and the other (semi-moist, salmonid) contained 18% moisture. The third formulated diet (MFF), developed by John Tucker of Harbor Branch Oceanographic Institute, and manufactured by factured by Zeigler Brothers, Gardner, PA, was specifically formulated for warm water, marine finfish. The control diet was composed of 45% fish, 45% shrimp and 10% squid. The ingredients wereu ground, mixed and supplemented with vitamins and minerals. Proximate analysis of the control feed was determined by Woodson-Tenent Laboratories, Inc., Memphis, TN.

During the acclimation period, fish in the formulated diet treatments were trained to accept the assigned pelleted feed. In the first three days the fish received control feed only. Subsequently, after each three-day period, pelleted feed was increased by 25% of the daily ration until the feed ration consisted of 100% pelleted feed.

Throughout the experiment the fish were fed once daily at a rate of ten percent of their body weight. Growth was monitored by weighing each fish (±0.1 g) at two-week intervals. Daily feed rations were adjusted to reflect the new weight. Water quality was monitored weekly by measuring dissolved oxygen, temperature and flow rate for each tank while salinity and pH values were measured in the system influent.

At the termination of the experiment, individual fish were weighed and measured for total length (±1 mm), and length-weight relationships were determined by linear regression for each treatment. One fish from each replicate was preserved for stomach-content analyses. Absolute growth rate, AGR (g/d), was determined by dividing weight gain (g) by time (days), and feed conversion ratio, FCR, was determined by dividing total weight of feed administered during the feeding trial by total weight gain. Feed conversion based on the dry weight of each diet (dFCR) was determined by dividing the total dry weight of feed administered by total weight gain. Specific growth rate, SGR was calculated by the formula:

$$SGR\ (\%/d) = (Ln\ W_2 - Ln\ W_1 / T) \times 100$$

where W_1 was the initial weight (g), W_2 was the final weight (g) and T was time (days). Condition factor, K, was determined by the formula:

$$K = 105\ X\ W_2 / L3$$

where L was final total length (mm).

Table 1. Composition of diets fed to juvenile white grunts for ten weeks. Protein, fat, fiber and ash are expressed as a percent of dry weight.

DIET	%PROTEIN	%FAT	%FIBER	%ASH	%MOISTURE
Dry salmonid[a]	43	15	4	12	10
Semi-moist salmonid[a]	43	15	3	11	18
MFF[b]	55	11	2	11	7
Control[c]	82	8	27	80	

[a] Moore-Clark Co., Inc., LaConner, WA.

[b] Marine finfish diet, HB9210, was manufactured by Zeigler Brothers, Inc., Gardners, PA and formulated by John Tucker, Harbor Branch Oceanographic Institution, Fort Pierce, FL.

[c] Composed of 45% fish, 45% shrimp and 10% squid. The ingredients were ground, mixed and supplemented with vitamins and minerals.

AGR, SGR, FCR, K, dissolved oxygen, temperature and flow rate were compared by single-classification analysis of variance. Dunnett's two-tailed test was used in multiple comparisons of AGR, SGR, FCR and K. Treatment means were considered significant at the 0.05 level of probability. All statistical analyses were conducted using SAS (1985).

RESULTS

Final mean weights, total lengths and length/weight equations are given in Table 2. Fish fed the MFF diet had the highest growth rate (0.29 g/d, 1.02 %/d) and the lowest FCR (9.0) (Table 3). The fish fed the semi-moist salmonid diet had an AGR of 0.27 g/d, a SGR of 0.94 %/d and a FCR of 10.4. Growth rate and feed conversion values for the fish fed the MFF and semi-moist salmonid diets were not significantly different from those fed the control diet, which were 0.26 g/d, 0.92 %/d and 10.2. Fish fed the dry salmonid diet had significantly lower growth rates (0.20 g/d, 0.76 %/d) and a significantly higher FCR (12.4) than the fish fed the control diet. Fish fed the control diet had a significantly lower dFCR (2.0) than fish fed the dry salmonid (10.9), semi-moist salmonid (8.6) and MFF (8.4) diets. There were no significant differences in condition factor (K) between the fish fed the control diet and those fed the formulated diets. Survival for all

Table 2. Mean values for initial weight, final weight, final total length and final length/weight equations for juvenile white grunts fed three formulated diets and a control diet for ten weeks.

Diet	Initial Weight (g)	Final Weight (g)	Final Total Length (mm)	Length/weight Equation[a]
Dry salmonid	19.9 ±0.2	33.9 ±0.7	122.6 ±1.2	y=0.81x-65.60 r=0.985
Semi-moist salmonid	20.0 ±0.1	38.6 ±0.8	126.0 ±1.4	y=0.88x-73.67 r=0.983
MFF	19.7 ±0.1	40.2 ±0.6	127.9 ±1.9	y=0.97x-84.18 r=0.974
Control	19.8 ±0.3	37.8 ±0.2	121.1 ±1.9	y=0.94x-81.12 r=0.993

[a] y = weight(g), x = length(mm)

Table 3. Mean values (±SEM) for absolute growth rate, specific growth rate, feed conversion ratio (FCR), feed conversion ratio based on dry weight of feed (dFCR) and condition factor of juvenile white grunts fed three formulated diets and a control diet for ten weeks. Values followed by an asterisk are significantly different ($p<0.05$) from the control.

Diet	Absolute Growth Rate (g/d)	Specific Growth Rate (%/d)[a]	FCR	dFCR	Condition Factor[b]
Dry salmonid	0.20 ±0.0*	0.76 ±0.1*	12.4 ±0.8*	10.9 ±0.1*	1.84 ±0.1
Semi-moist salmonid	0.27 ±0.0	0.94 ±0.1	10.4 ±0.6	8.6 ±0.1*	1.93 ±0.0
MFF	0.29 ±0.0	1.0 ±0.0	9.0 ±0.3	8.4 ±0.1*	1.92 ±0.0
Control	0.26 ±0.0	0.92 ±0.0	10.2 ±0.2	2.0 ±0.1*	2.13 ±0.1*

[a] Specific growth rate (%/d) = (Ln W2 - Ln W1 / T) X 100
Where:
W_1 = initial mean weight (g)
W_2= final mean weight (g)
T = time (days)

[b] Condition factor (K) = 105 X final mean weight (g) / final total length $(mm)^3$

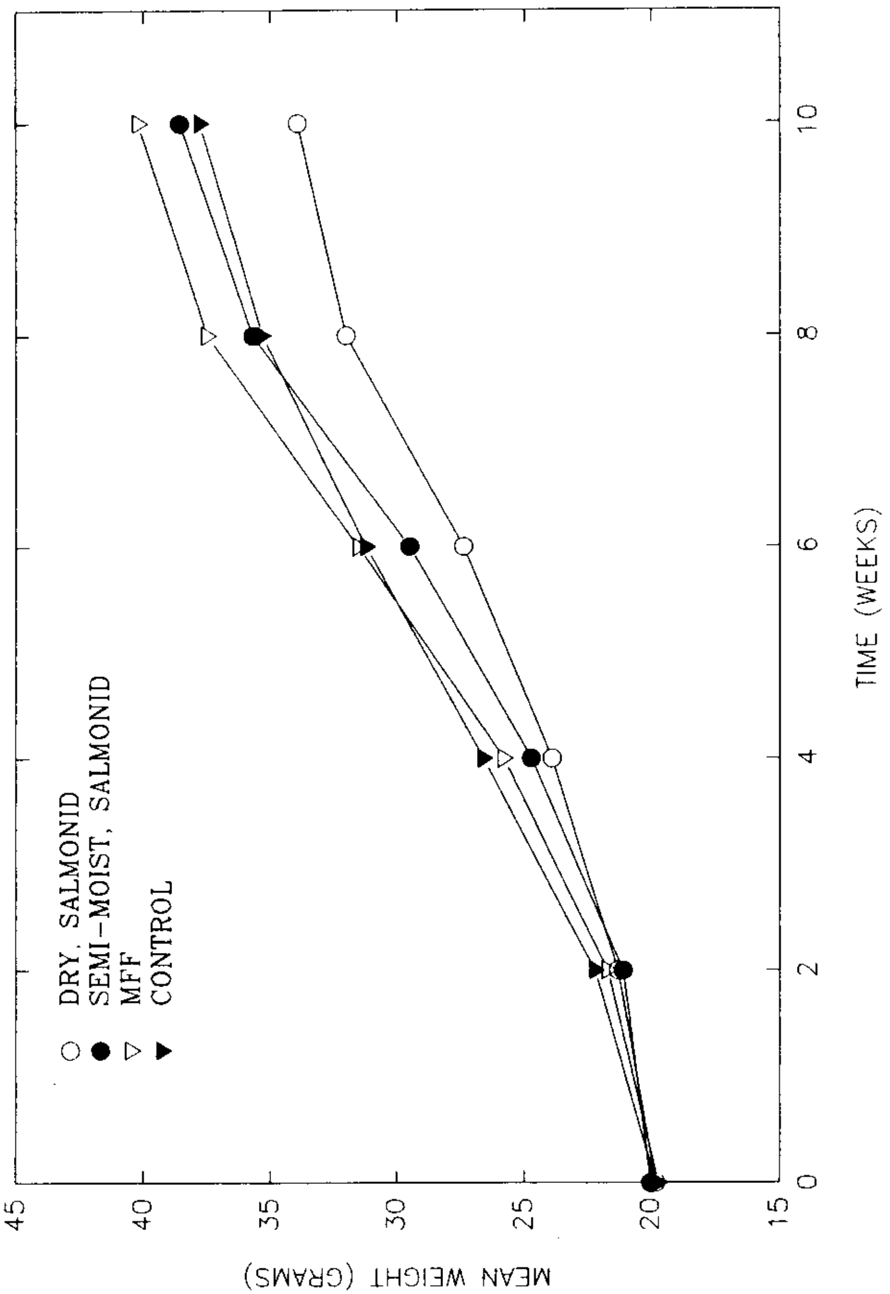

Figure 1. Mean weights of juvenile white grunts fed three formulated diets and a control over a 10-week period.

treatments was 100%. Growth curves for fish in each treatment are illustrated in Figure 1. All the fish taken for dissection had empty stomachs.

There were no significant differences among treatment means for dissolved oxygen, temperature and flow rate (Table 4). Dissolved oxygen remained above 5.6 mg/L through the entire experiment. Temperatures ranged between 29.1°C and 30.4°C, and the mean flow rate for all treatments was 23 L/min. Mean values for salinity and pH of the influent were 35 ppt (range, 35 - 36 ppt) and 8.3 (range, 8.3 - 8.4).

DISCUSSION

Several studies indicate that white grunts feed primarily on benthic invertebrates (Randall, 1967; Manooch, 1978; Robblee, 1987) at night as solitary individuals (McFarland *et al.*, 1979; Randall, 1983).

During the two-week acclimation period, the fish in all treatments readily accepted the control diet. However, none of the fish in the formulated diet treatments initially accepted the pellets. Fish fed the MFF diet were the first to consume the pellets, followed by the fish fed the semi-moist salmonid diet. Despite their nocturnal feeding habits, the fish consumed these diets during day-light hours.

Although it did not have the lowest moisture content, the dry salmonid diet had the highest density of the formulated diets. Fish fed this diet were never observed eating the pellets. These fish grew, and so it was assumed that they eventually consumed the pellets from the tank bottom, fed on materials brought into the tank, or fed on organisms growing in the tank. However, stomach-content analyses indicated that the fish had not eaten recently and were probably not feeding on supplemental feed sources.

Manooch (1978) examined scales and otoliths of white grunts from the North Carolina and South Carolina headboat fishery in order to determine age and growth. An equation ($W=0.00001426L^{3.0229}$) was calculated to describe the relationship of weight to length. From this equation a market-size fish (452 g) would be 303 mm long. Using growth rates obtained from scale readings, Manooch estimated that, in North Carolina and South Carolina waters, a white grunt that is 303 mm in length would be approximately five years old. The absolute growth rate for the first five years would then be 0.25 g/d. Although direct comparisons cannot be made, it is interesting that Manooch's absolute growth rates are similar to those obtained for the fish fed the control diet (0.26 g/d) in this study.

The fish exhibited preference for some unmeasured feed quality such as taste or texture. Although several characteristics of the formulated diets varied, it appeared the grunts preferred the softer feeds (MFF and semi-moist salmonid) while the moisture content of the pellets did not influence feed consumption.

Unfortunately, due to the remote location of the facility, the fish were only fed once daily. Higher growth rates may have been achieved by multiple daily feedings. No apparent diseases were observed and the fish responded well to handling. However, low growth rates and poor feed conversion with all the diets indicate that this species does not have culture potential.

ACKNOWLEDGMENTS

We thank Tony and Maggie Collins for their support and the use of their property for our facility. We also thank Terry Shoemaker and Von Anderson for their assistance in capturing the fish.

LITERATURE CITED

FAO. 1987. FAO Yearbook of Fisheries Statistics. Vol. **65**. Food and Agriculture Organization, Rome.

Goodwin, M., M. Orbach, P.A. Sandifer and E. Towle. 1985. Fisheries sector assessment for the Eastern Caribbean: Antigua/Barbuda, Dominica, Grenada, Montserrat, St. Christopher/Nevis, St. Lucia, St. Vincent and Grenadines. U.S. Agency for International Development, Regional Development Office, Caribbean. 141 pp.

Manooch, C.S. III. 1978. Age, growth and mortality of the white grunt, *Haemulon plumieri* Lacepede (Pisces: Pomadasyidae), from North Carolina and South Carolina. *Proc. 30th Anna.Conf.* SC Assoc. Game and Fish. Jackson, MS.

McFarland, W.N., J.C. Ogden and J.N. Lythgoe. 1979. The influence of light on the twilight migrations of grunts. *Environ.Biol. Fish.* **4**:9-22.

Munro, J.L. 1983. Caribbean coral reef fishery resources. ICLARM Studies and Reviews 7, International Center for Living Aquatic Resources Management, Manila, Philippines.

Randall, J.E. 1967. Food habits of reef fishes of the West Indies. *Studies in Tropical Oceanography*. **5**:665-847.

Randall, J.E. 1983. Caribbean reef fishes. T.F.H. Publications, Neptune City, NJ. 350 pp.

Robblee, M. 1987. The spatial organization of the nocturnal fish fauna of a tropical seagrass feeding ground. University of Virginia, Charlottesville, VA. Unpubl. Ph.D. Dissertation.

Ryther, J.H., R.L. Creswell and D.E. Alston. 1991. Historical overview: aquaculture in the Caribbean. Pages 9-29 in J.A. Hargreaves and D.E. Alston, eds., *Status and Potential of Aquaculture in the Caribbean*, World Aquaculture Society, Baton Rouge, LA.

SAS Institute, Inc. 1987. *SAS user»s guide: statistics*, version 6 edition. Cary, North Carolina, USA.

Sandifer, P.A. 1991. Species with aquaculture potential for the Caribbean. Pages 30-60 in J.A. Hargreaves and D.E. Alston, eds., *Status and Potential of Aquaculture in the Caribbean*. World Aquaculture Society, Baton Rouge, LA.

Thouard, E., P. Soletchnik and J.-P. Marion. 1990. Selection of finfish species for aquaculture development in Martinique (F.W.I.). *Aquaculture*. **89**:193-197.

Tucker, J.W. and D.E. Jory. 1991. Marine fish culture in the Caribbean region. *World Aquaculture* **22(1)**:10-27.