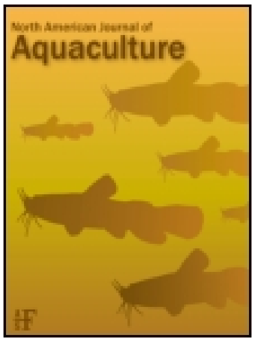

North American Journal of Aquaculture

ISSN: 1522-2055 (Print) 1548-8454 (Online) Journal homepage: http://www.tandfonline.com/loi/unaj20

Effect of Feed Pellet Characteristics on Growth and Feed Conversion Efficiency of Largemouth Bass Raised in Ponds

James Tidwell, Shawn Coyle & Leigh Anne Bright

To cite this article: James Tidwell, Shawn Coyle & Leigh Anne Bright (2015) Effect of Feed Pellet Characteristics on Growth and Feed Conversion Efficiency of Largemouth Bass Raised in Ponds, North American Journal of Aquaculture, 77:1, 55-58, DOI: 10.1080/15222055.2014.960116

To link to this article: http://dx.doi.org/10.1080/15222055.2014.960116

Published online: 16 Dec 2014.

North American Journal of Aquaculture 77:55–58, 2015

ISSN: 1522-2055 print / 1548-8454 online
DOI: 10.1080/15222055.2014.960116

COMMUNICATION

Effect of Feed Pellet Characteristics on Growth and Feed Conversion Efficiency of Largemouth Bass Raised in Ponds

James Tidwell,* Shawn Coyle, and Leigh Anne Bright
Aquaculture Research Center, Kentucky State University, 103 Athletic Road, Frankfort, Kentucky 40601, USA

Abstract
We investigated the growth, survival, and feed conversion of Largemouth Bass *Micropterus salmoides* fed one of two sizes of floating pellets or a sinking pellet for 151 d in 0.04-ha ponds. The floating and sinking pellets were made from almost identical formulas. The fish were fed once daily to apparent satiation based on observed feeding activity. There was no significant difference in survival, growth, or feed conversion of fish fed the larger floating pellet versus those fed the standard-size floating pellet or sinking pellet. Fish fed the sinking pellet were significantly larger at harvest than fish fed either size of floating pellet. The efficiency of feed utilization was not decreased with the sinking pellet. These results indicate the Largemouth Bass accept and utilize sinking pellets well. However, their use on commercial scale farms would probably require some management modifications.

The Largemouth Bass *Micropterus salmoides* is the largest member of the North American sunfish family, Centrarchidae, and shows promise as a commercial aquaculture species (Cochran et al. 2009). There have been a number of studies evaluating their nutritional requirements (Tidwell et al. 1996; Coyle et al. 2000; Bright et al. 2005) and the ability to utilize alternative feed ingredients (Tidwell et al. 2005, 2007; Subhadra et al. 2006). Fish diets must be formulated to meet the animals' nutritional requirements and must be manufactured into pellets that the fish will readily accept and utilize efficiently. The ability of fish to detect, ingest and utilize a feed can be affected by physical characteristics such as pellet density (floating, sinking, sinking rate), size (shape, diameter, and length), color (contrast), and texture (hardness; Jobling et al. 2001).

Early commercial fish diets were manufactured by steam pelleting into densely compressed particles that sink. Later, extrusion processed feeds that float on the water surface became more common. Floating feed is a valuable management tool because it allows the farmer to see how much, and how actively, the fish eat (Mgbenka and Lovell 1984). Extrusion can also increase the water stability of the pellet (Lovell 1989), as well as increase the digestibility of carbohydrates (Hardy and Barrows 2002) and potentially deactivate certain antinutrition factors (Sorensen 2012).

Cost is a disadvantage of extruded floating feeds compared with pelleted sinking. Extrusion requires more expensive equipment than pelleting (Mgbenka and Lovell 1984). Also, energy costs are higher because more steam is used (the ingredient mix is heated to a higher temperature, and extruded feeds require heat in drying, while pelleted feeds do not (Mgbenka and Lovell 1984). However, in some species the lower nutrient density and greater pellet stability of extruded diets prolonged gastric emptying time compared with steam pellets and consequently reduced feed intake (Hilton et al. 1981; Venou et al. 2009) and even growth (Booth et al. 2000, 2002; Honorato et al. 2010).

The size and shape of the feed may also affect the amount eaten (Jobling et al. 2001). Particle size of fish feeds should be as large as possible to minimize nutrient leaching (Lovell 1989). Optimally, pellet size should be 25–50% of the species mouth width (Jobling et al. 2001). Kubitza and Lovshin (1997) fed age-1 Largemouth Bass (initial weight, 62 g) a 7-mm trout pellet and reported that pellet size may have been too small. They indicated that Largemouth Bass strike at individual pellets and many strikes would be required to satiate a fish. Kubitza and Lovshin (1997) proposed that by feeding a large pellet to Largemouth Bass, less feeding energy would be expended per meal and faster growth might be attained.

The objective of our study was to evaluate the relative performance of Largemouth Bass fed feeds with different pellet characteristics (sinking or floating and pellet size) under practical pond conditions.

*Corresponding author: james.tidwell@kysu.edu
Received May 5, 2014; accepted August 25, 2014

TABLE 1. Formulation of diets manufactured as two sizes of floating pellets or as sinking pellets and fed to juvenile Largemouth Bass in ponds.

	Ingredient or composition (%)	
Item	Floating	Sinking
Ingredient		
Soybean meal (48%)	20.85	18.58
Poultry by-product meal	16.00	15.00
Fish meal	10.00	10.00
Distillers dried grains	0.00	10.00
Rice bran–high fat	6.49	8.00
Corn	10.57	7.78
Poultry blood meal	7.50	7.35
Wheat flour	10.00	3.00
Fish–poultry oil blend	9.88	8.92
Mono/di-calcium phosphate	0.70	0.70
D-methionine	0.30	0.29
Vitamin premix	0.25	0.25
Trace mineral premix	0.05	0.05
Analyzed composition		
Moisture	9.0	9.1
Protein	43.4	43.6
Lipid	16.8	18.4
Fiber	2.7	2.6
Ash	7.8	7.4
Nitrogen-free extract	20.2	18.9

METHODS

Age-1 (subadult) feed-trained Largemouth Bass averaging 184.7 g (SD, 35.3) and 22.8 mm (SD, 1.3) were indiscriminately stocked into nine, 0.04-ha earthen ponds (volume $\approx 550\ m^3$) at a density of 10,000 bass/ha. New water was only added to replace evaporation. There were three replicate ponds per dietary treatment. Fish were fed once daily (0800 hours) to apparent satiation based on feeding response. Total amount of diet consumed was recorded daily. The three experimental diets were formulated to contain 43% protein and 17% lipid (Table 1). All formulations were similar, with only minor differences effected by pellet density, size, and ability to float. Pellets were manufactured by Burris Mill and Feed (Franklinton, Louisiana). Floating pellets were produced with diameters of 5.5 mm (control) and 13.0 mm (large); sinking pellets were 5.5 mm, as manipulated via pellet expansion during manufacture.

After 151 d of feeding each pond was seined three times and then drained to ensure that all fish were removed. Harvested fish were bulk weighed and counted into holding tanks. Once all fish were harvested from a pond, a indiscriminate sample of 40 fish from each pond were individually weighed and measured for total length.

Water quality.—In each pond, water temperature and dissolved oxygen were measured twice daily using an YSI 85 DO meter (YSI Company, Yellow Springs, Colorado). Total ammonia, nitrite, pH, and alkalinity were measured three times per week using a HACH DR/2500 spectrophotometer (HACH, Loveland, Colorado).

Statistics.—Various growth performance characteristics were calculated: condition factor (K = [average weight/average harvest length^3]100); specific growth rate (SGR) or percent body weight gain/day was calculated as SGR = $[(\log_e W_f - \log_e W_i)/t]\,100$, where W_f = final weight (g), W_i = initial weight (g), and t = time (d); feed conversion ratio or FCR = total diet fed (g)/total wet weight gain (g); and feed cost per unit of weight gain = manufactured diet cost/weight gain (kg), where cost (US$) was based on actual invoice amounts. Treatments were statistically compared using analysis of variance at $\alpha = 0.05$ via Statistix version 8.0 (Statistix Analytical Software, Tallahassee, Florida). If significant differences were found, treatment means were separated using Fisher's Least Significant Difference method (Steele and Torrie 1980). All percentage and ratio data were arcsine-transformed prior to analysis (Zar 1984). However, data are presented untransformed to facilitate comparisons.

RESULTS AND DISCUSSION

There were no significant treatment differences ($P > 0.05$) in any of the measured water quality variables over the study period (Table 2). Values for un-ionized ammonia nitrite were all at concentrations considered acceptable (Roseboom and Richey 1977; Palachek and Tomasso 1984).

Pellet Sizes

Both pellet sizes of the floating diet were well utilized by the fish throughout the experiment. Harvest data indicated that standard size (control, 5.5 mm) versus large (13.0) floating pellets produced no significant ($P > 0.05$) impact on production characteristics during second year growth of Largemouth Bass in ponds (Table 3). However, fish fed the 5.5-mm sinking pellets had significantly greater ($P \leq 0.05$) growth (average weight gain and SGR) than fish fed either size of floating pellet.

Although Kubitza and Lovshin (1997) proposed that Largemouth Bass might benefit from increased pellet sizes, they did not conduct a controlled comparison. While our data, however, showed larger pellets of no benefit, Nortvedt and Tuene (1995) reported that feeding larger pellets improved feed conversion efficiencies in Atlantic Halibut *Hippoglossus hippoglossus*. Linner and Brannas (1994) reported that in Arctic Char *Salvelinus alpinus* responded more rapidly to larger pellets, but pellet consumption was better at intermediate sizes. That is agrees with our study; i.e., bass actively accepted the larger pellets, but that did not subsequently result in improved production.

Floating Versus Sinking Pellets

The Largemouth Bass fed the 5.5-mm sinking pellets were significantly larger ($P \leq 0.05$) at harvest (629 g) than those

TABLE 2. Mean ± SE water quality results from ponds containing Largemouth Bass fed two sizes of floating pellets or sinking pellets tested in three replicate ponds per diet. There were no significant differences ($P > 0.05$) among treatments.

		Feed type	
Variable	Standard floating	Large floating	Sinking
Morning temperature (°C)	21.1 ± 0.6	20.3 ± 0.1	20.9 ± 0.1
Afternoon temperature (°C)	22.4 ± 0.0	22.1 ± 0.2	22.6 ± 0.1
Morning dissolved oxygen (mg/L)	7.3 ± 0.1	7.3 ± 0.0	7.0 ± 0.2
Afternoon dissolved oxygen (mg/L)	12.4 ± 0.9	1 0.9 ± 0.2	10.9 ± 0.4
Total ammonia (mg/L)	0.67 ± 0.13	0.69 ± 0.04	0.89 ± 0.04
Un-ionized ammonia (mg/L)	0.132 ± 0.01	0.115 ± 0.01	0.124 ± 0.01
Nitrite (mg/L)	0.017 ± 0.01	0.041 ± 0.01	0.029 ± 0.02
pH	8.7 ± 0.1	8.5 ± 0.0	8.5 ± 0.1
Alkalinity (mg/L)	97.8 ± 2.6	101.7 ± 4.4	101.4 ± 2.8

fed a similar size floating pellet (566 g). Specific growth rate was also significantly higher ($P \leq 0.05$) in fish fed the sinking pellet (2.6 g/d) than in those fed the floating pellet (2.2 g/d). There was no significant difference ($P > 0.05$) in survival (> 90%), total yield, condition factor, FCR, or average daily feed consumption among fish fed the similar size floating or sinking diets. Total yields in our study were higher than for the Largemouth Bass reported by Cochran et al. (2009), who compared diets containing different fish meal levels, but stocked at a lower density (8,650/ha versus 10,000/ha). The fish we fed the 5.5-mm sinking pellets, compared with those fed the large (13 mm) floating pellets, had production metric differences similar to the differences between the 5.5-mm sinking versus floating pellets.

The larger average size at harvest and higher SGR, of Largemouth Bass fed sinking pellets are in agreement with findings of Booth et al. (2000, 2002) for Silver Perch *Bidyanus bidyanus* and with Honorato et al. (2010) for Pacú *Piaractus mesopotamicus*. According to Sorensen (2012), the lower bulk density (less weight per unit volume) of floating pellets compared with sinking pellets would result in fish fed floating pellets becoming physically satiated at a lower energy intake. This is supported by Mgbenka and Lovell (1984), who reported that sinking feeds had less bulk per unit of weight (i.e., were more dense) and less digestible energy. Dense pellets with low energy concentrations would allow fish to consume more of the nutrients essential to growth before becoming satiated by energy intake or stomach fullness.

There are also behavioral aspects associated with feeding sinking pellets versus floating. Kubitza and Lovshin (1997) proposed that use of sinking pellets might result in more wasted feed (i.e., higher FCR) because Largemouth Bass were not likely to pick up pellets off the bottom. However, we found FCR was not different among fish fed floating or sinking pellets, indicating the efficient use of sinking pellets. Both studies utilized satiation feeding. Other behavioral traits might also be affect the suitability of different pellet characteristics. Kubitza and Lovshin (1997) also observed that, when using floating pellets, Largemouth Bass were reluctantly forced into surface waters with high light levels and temperatures (≥30°C). Cochran et al. (2009) also observed that Largemouth Bass were hesitant to feed on floating pellets at the surface on bright sunny days, but would readily consume pellets that would "slow-sink" through the water column.

Another potential positive aspect of the use of sinking feeds for Largemouth Bass is that the manufacture of sinking pellets

TABLE 3. Mean ± SD of production metrics for age-1 pond-cultured (151 d) Largemouth Bass fed two different floating pellet sizes (5.5 and 13 mm) or a sinking pellet (5.5 mm) of similar diet formulations. Different lowercase letters indicate statistical significance ($P < 0.05$).

Production variable	Standard floating	Large floating	Sinking
Average weight (g)	565.6 ± 11.0 y	580.6 ± 6.5 y	629.0 ± 9.8 z
Survival (%)	94.2 ± 2.2 z	94.6 ± 0.4 z	90.1 ± 2.3 z
Total yield (kg/ha)	5,321.1 ± 28.0 z	5,491.8 ± 59.3 z	5,669.5 ± 220.5 z
Specific growth rate (g/d)	2.2 ± 0.1 y	2.3 ± 0.0 y	2.6 ± 0.1 z
Condition factor	1.8 ± 0.0 z	1.9 ± 0.0 z	1.9 ± 0.0 z
Feed conversion ratio	1.7 ± 0.1 z	1.7 ± 0.1 z	1.5 ± 0.0 z
Feed consumption (kg/ha/d)	34.1 ± 0.9 z	36.2 ± 0.7 z	33.7 ± 1.3 z
Feed cost per unit of weight gain (US$/kg)	1.4 ± 0.0 z	1.4 ± 0.1 z	1.3 ± 0.0 z

allows lower dietary carbohydrate levels. To produce floating pellets a formulation must contain ≥20% carbohydrate for proper expansion (Lovell 1989). However, as a strict carnivore, Largemouth Bass have been found to be negatively impacted by carbohydrate levels of 20% (Goodwin et al. 2002; Amoah et al. 2008). Use of sinking pellets would allow more flexibility in feed formulation and reduction of carbohydrate content. Also, it would increase the potential of more localized feed production because steam pelleting facilities are more common and less complex than extruders.

A potential approach to capitalize on the positive results of sinking pellets, without sacrificing the positive feed management characteristics of floating pellets, could be to feed primarily sinking feed but to mix in some floating pellets as "indicator pellets" to assist in monitoring feeding activity and consumption, as evaluated by Mgbenka and Lovell (1984) in Channel Catfish *Ictalurus punctatus*. They proposed the feeding of a 15:85 ratio of extruded to pelleted diets to reduce costs while providing the same management benefits of feeding observation.

In summary, we found no benefit from increased pellet sizes of floating diets for feeding Largemouth Bass. We also found that Largemouth Bass fed sinking pellets had higher growth rates than those fed similar-seized floating pellets.

ACKNOWLEDGMENTS

We would like to thank Russell Neal for assistance in the daily care of the culture system. This research was partially funded by a U.S. Department of Agriculture/Cooperative State Research, Education, and Extension Service grant to Kentucky State University (KSU) under agreement KYX-80-91-04A. Additional support was provided by Kentucky's Regional University Trust Fund to the Aquaculture Program as KSU's Program of Distinction.

REFERENCES

Amoah, A., S. D. Coyle, C. D. Webster, R. M. Durborow, L. A. Bright, and J. H. Tidwell. 2008. Effects of graded levels of carbohydrate on growth and survival of Largemouth Bass, *Micropterus salmoides*. Journal of the World Aquaculture Society 39:397–405.

Booth, M., G. Allan, A. Evans, and V. Gleeson. 2002. Effects of steam pelleting or extrusion on digestibility and performance of Silver Perch *Bidyanus bidyanus*. Aquaculture Research 33:1163–1173.

Booth, M. A., G. L. Allen, and R. Warner-Smith. 2000. Effects of grinding, steam conditioning and extrusion of a practical diet on digestibility and weight gain of Silver Perch, *Bidyanus bidyanus*. Aquaculture 182:287–299.

Bright, L. A., S. D. Coyle, and J. H. Tidwell. 2005. Effect of dietary lipid level and protein energy ratio on growth and body composition of Largemouth Bass *Micropterus salmoides*. Journal of the World Aquaculture Society 36:129–134.

Cochran, N. J., S. D. Coyle, and J. H. Tidwell. 2009. Evaluation of reduced fish meal diets for second year growth of the Largemouth Bass, *Micropterus salmoides*. Journal of the World Aquaculture Society 40:735–743.

Coyle, S. D., J. H. Tidwell, and C. D. Webster. 2000. Response of Largemouth Bass *Micropterus salmoides* to dietary supplementation of lysine, methionine, and highly unsaturated fatty acids. Journal of the World Aquaculture Society 31:89–95.

Goodwin, A. E., R. L. Lochmann, D. M. Tieman, and A. J. Mitchell. 2002. Massive hepatic necrosis and nodular regeneration in Largemouth Bass fed diets high in available carbohydrate. Journal of the World Aquaculture Society 33:466–477.

Hardy, R. W., and F. T. Barrows. 2002. Diet formulation and manufacture. Pages 506–600 in J. E. Halver and R. W. Hardy, editors. Fish nutrition. Academic Press, London.

Hilton, J. W., C. Y. Cho, and S. J. Slinger. 1981. Effect of extrusion processing and steam pelleting diets on pellet durability, pellet water absorption and the physiological response of Rainbow Trout *Salmo gairdneri*. Aquaculture 25:185–194.

Honorato, C. A., L. C. Almeida, C. Da Silva Nunes, D. J. Carneiro, and G. Moraes. 2010. Effects of processing on physical characteristics of diets with distinct levels of carbohydrates and lipids: the outcomes on the growth of Pacu (*Piaractus mesopotamicus*). Aquaculture Nutrition 16:91–99.

Jobling, M., E. Gomes, and J. Dias. 2001. Feed types, manufacture and ingredients. Pages 25–48 *in* D. Houlihan, T. Boujard, and M. Jobling, editors. Food intake in fish. Blackwell Scientific Publications, Oxford, UK.

Kubitza, F., and L. L. Lovshin. 1997. Pond production of pellet-fed advanced juvenile and food-size Largemouth Bass. Aquaculture 149(3-4):253–262.

Linner, J., and E. Brannas. 1994. Behavioral response to commercial food of different sizes and self-initiated food size selection by Arctic Char. Transactions of the American Fisheries Society 123:416–422.

Lovell, T. 1989. Feed formulation and processing. Pages 107–128 in T. Lovell, editor. Nutrition and feeding of fish. Van Nostrand Reinhold, New York.

Mgbenka, B. O., and R. T. Lovell. 1984. Feeding combinations of extruded and pelleted diets to Channel Catfish in ponds. Progressive Fish-Culturist 46:245–248.

Nortvedt, R, and S. Tuene. 1995. Multivariate evaluation of feed for Atlantic Halibut. Chemometrics and Intelligent Laboratory Systems 29:271–282.

Palachek, R. M., and J. R. Tomasso. 1984. Toxicity of nitrite to Channel Catfish (*Ictalurus punctatus*), tilapia (*Tilapia aurea*), and Largemouth Bass (*Micropterus salmoides*): evidence for a nitrite exclusion mechanism. Canadian Journal of Fisheries and Aquatic Sciences 41:1739–1744.

Roseboom, D. P., and D. L. Richey. 1977. Acute toxicity of residual chlorine and ammonia to some native Illinois fishes. Illinois State Water Survey Report of Investigation 85.

Sorensen, M. 2012. A review of the effects of ingredient composition and processing conditions on the physical qualities of extruded high-energy fish feed as measured by prevailing methods. Aquaculture Nutrition 18: 233–248.

Steele, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach, 2nd edition. McGraw-Hill, New York.

Subhadra, B., R. Lochmann, S. Rawles, and R. Chen. 2006. Effect of dietary lipid source on the growth, tissue composition, and hematological parameters of Largemouth Bass *Micropterus salmoides*. Aquaculture 255:210–222.

Tidwell, J. H., S. D. Coyle, and L. A. Bright. 2007. Effects of different types of dietary lipids on growth and fatty acid composition of Largemouth Bass. North American Journal of Aquaculture 69:257–264.

Tidwell, J. H., S. D. Coyle, L. A. Bright, and D. K. Yasharian. 2005. Evaluation of plant and animal source proteins for replacement of fish meal in practical diets for the Largemouth Bass *Micropterus salmoides*. Journal of the World Aquaculture Society 36:454–463.

Tidwell, J. H., C. D. Webster, and S. D. Coyle. 1996. Effects of dietary protein level on second year growth and water quality for Largemouth Bass (*Micropterus salmoides*) raised in ponds. Aquaculture 145(1-4): 213–223.

Venou, B., M. N. Alexis, E. Fountoulaki, and J. Haralabous. 2009. Performance factors, body composition and digestion characteristics of Gilthead Sea Bream *Sparus aurata* fed pelleted or extruded diets. Aquaculture Nutrition 15:390–401.

Zar, J. H. 1984. Biostastistical analysis, 2nd edition. Prentice-Hall, Englewood Cliffs, New Jersey.