INTEGRATED APPROACHES TO REDUCING INDIVIDUAL VARIABILITY AND PROVIDING YEAR ROUND HARVEST OF CHANNEL-BLUE HYBRID CATFISH

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Participants	Auburn University	Rex A. Dunham and Terry Hanson
	USDA-ARS Warmwater Aquaculture Research Unit	Nagaraj Chatakondi

PROJECT OBJECTIVES

1) Evaluate production methods that will provide year-round availability of hybrid catfish food fish, and determine the resulting cost of production.

   a) Effect of stocking different sizes of fingerlings at different times of year on time and size of harvest in ponds, split ponds and in-pond raceways. (Auburn University and USDA)
   b) Case study of the feasibility of multi-batching for hybrid catfish (Auburn University and USDA)
   c) Economic analysis of objectives 1a and 1b (Auburn University)

2) Evaluate management techniques that will reduce the size variation of hybrid catfish food fish, and determine impacts of these techniques on net production and production costs.

   a) Effect of fingerling variability on variability at harvest (Auburn University and USDA)
   b) Effect of grading going into a pond or raceway on harvest variability (Auburn University and USDA)
   c) Effect of stocking density on hybrid catfish variability (Auburn University and USDA)
   d) Effect of genetics on variability and sexual dimorphism (Auburn University and USDA)
   e) Effect of feeding rate on hybrid catfish variability (Auburn University and USDA)
   f) Economic analyses of objective 2a – 2e (Auburn University)

ANTICIPATED BENEFITS

The adoption rate of hybrid catfish farming in the US farm-raised catfish industry has been increasing in commercial settings over the last decade. Though the use of the hybrid has been profitable, it does have some oversized and undersized fish issues due its rapidly growing nature. Since the fish processor demands a premium sized fish and not very small or very large fish, the current evaluation was conducted to find out the causative factors of hybrid catfish growth variation and their economic impact on US catfish producers. This outcome will help farmers in selecting the best management practices for a more economical and profitable operation.

METHODS (OBJECTIVES 1 AND 2)

A comprehensive industry-wide fish sampling effort and owner/manager survey were conducted in Mississippi, Arkansas, and Alabama from 2015 to 2017. In total, 164 culture units, most commonly used for hybrid catfish production, were sampled which included single batch (N=25), multiple batch (N=16), split pond (N= 98) and in-pond raceway system (IPRS, N=25 for harvest information and N=4 for economic analysis).

Ponds were harvested when there were at least 15,000-20,000 kg of on-flavor market-sized fish (> 0.45 kg). The harvested fish were typically held overnight in a "sock" (a type of net pen used to hold fish) to allow sub-marketable-sized fish (100-300 gm in weight/head) to grade out of the sock and go back into the pond. Fish were then loaded onto hauling trucks early next morning for delivery to the processing plant. Prior to loading, fish sampling was conducted by transferring approximately 300 (minimum) to 500 (maximum) live hybrid catfish from the sock to a portable plastic container (placing it on the pond bank). Before transferring the fish, the plastic container was filled with approximately 250 to 300 gallons of water from the sampling pond. Dissolved oxygen was provided through a portable aerator by connecting it with a portable generator. Dissolved oxygen was maintained at the rate of >5 ppm during the whole sampling period to ensure fish welfare. Individual fish were weighed on a digital weight scale and returned to the loading truck or pond after finishing the sampling.

A face to face interview was conducted with the pond owner/farm manager to obtain details of the production cycle. This survey questionnaire included 44 questions. Fish processors were also contacted by phone and email to collect growth variation data from the same cycle, dockage price ($/kg) and quantities of premium size (0.45 -1.81 kg or 1 to 4 lb.), undersized (<0.45kg or <1 lb) and oversized (>1.81 kg or >4 lb) fish. This procedure helped to crosscheck the percentage of undersized and oversized fish that were obtained from the fish sampling survey. In total, more than 5 million fish were weighed.

Collected production data (independent variables) included pond area, aeration, stocking density, feeding rate, culture period, feed fed during winter (Y/N), graded fingerlings used (Y/N), feeding cap (Y/N), and fingerling sources while the other data (dependent variables) included undersized, oversized and premium sized fish (%). Principal component analysis, linear regression, residual test and variance inflation factor were used for causative factor analysis while enterprise budget, partial budget and sensitivity analysis methods were used in the economic analyses resulting from the growth variability research project.

Economic analyses were performed by developing standardized enterprise budgets (Kay et al. 2016; Engle 2012) to estimate the cost and return of surveyed hybrid catfish production in 4 systems. These budgets were developed based on the production data collected (Table 1). A uniform set of prices were used to ensure consistency in comparisons among culture systems (Table 2) and were derived from secondary (producer) sources and expert opinion. The average price for different sizes of hybrid catfish, feed and fingerlings were calculated from average annual price data (Table 2). Labor cost (full time/seasonal) was calculated from the employees' annual salary that was provided by catfish farm owners in Arkansas, Mississippi and Alabama (Table 2). In general, the average farm size used for catfish production was 32 ha in the surveyed areas (Ganesh Kumar, personal communication). An additional labor cost was added for the split pond system because extra labor is required for feeding (Table 2). The unit prices of plankton control, gas and diesel, electricity, repairs and maintenance, bird depredation supplies, telephone, office supplies, interest on operating capital and investment cost varied among the production systems (Table 2). These assumed prices were the empirical average price ($/ha) taken from secondary enterprise budget sources. In the case of IPRS, production data from research settings were considered for the economic analysis due to the unavailability of similar data from commercial operations. An interest rate of 10% per annum was used for calculating interest on operating and investment capital in the current analysis. The annual depreciation cost for equipment was calculated based on the straight line method with a salvage value of zero for traditional (single and multiple batch) (Hanson (2015); Hanson et al. 2005; Hanson 2005) and split pond systems (Kumar et al. 2016), but for IPRS, a salvage value of 13% was considered (Kubitza et al. 2017). The calculation was on an annual basis.

Table 1. Mean ($\bar{X}$) and standard deviation (SD) of production variables that were obtained in different hybrid catfish (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) farming systems in MS, AL and AR.

Variables	Unit	Single batch (N=25)		Multiple batch (N=16)		Split pond (N=98)		IPRS (research) (N=4)	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Stocking density	head/ha	24,433*	12,441	24,302*	11,949	32,433*	7,901	23,487*	3,845
Weight/ fingerling	kg	0.04*	0.01	0.04*	0.01	0.06*	0.04	0.04*	0.00
Initial biomass	kg/ha	1,093*	678	897*	446	2,104*	2,044	977*	265
Total feed used	kg/ha	31,573*	11,419	39,324*	18,486	42,298*	13,766	21,905*	2,318
FCR	ratio	2.47*	0.50	2.75*	0.66	2.48*	0.55	1.58*	0.03
Gross yield	kg/ha	13,821*	4,149	15,766*	5,025	19,122*	5,237	14,789*	1,256
Net yield	kg/ha	12,728*	3,865	14,869*	4,781	17,017*	5,314	13,812*	4,246
Harvest weight	kg	0.85*	0.31	0.90*	0.45	0.74*	0.32	0.73*	0.27
Undersized fish	%	5*	6	4*	4	13*	5	10*	5
Oversized fish	%	4*	5	12*	8	4*	2	1*	2
Premium size fish	%	91*	8	84*	8	83*	4	89*	5
Survival rate	%	84*	15	87*	10	80*	11	86*	7
Culture period	days	372*	90	383*	86	221*	47	268*	0

Values are given as mean ($\bar{X}$) and standard deviation (SD) to show the variability in the data among the four production systems

* Production variables are significantly different from each other (among the 4 systems), $P < 0.05$, ANOVA test

Table 2 Empirical unit prices used in enterprise budgets development for different hybrid catfish (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) farming systems

Item	Description	Price/Cost			
		Unit	Single/multiple batch	Split pond [q]	IPRS (research)[r]
Gross receipts					
Premium size	0.45-1.81 kg	$/kg	2.24 [a]	2.24 [a]	2.24 [a]
Undersized fish	<0.45 kg	$/kg	2.14 [a]	2.14 [a]	2.14 [a]
Oversized fish	> 1.81 kg	$/kg	1.92 [a]	1.92 [a]	1.92 [a]
Operating costs					
Feed	28% protein	$/MT	442 [b]	442 [b]	
	32% protein	$/MT			473 [b]
Hybrid fingerling size	18 cm (7 inch)	$/cm	0.0101 [c]		0.0101 [c]
	20 cm (8 inch)	$/cm		0.0112 [c]	
Labor	Hourly rate	$/hr	12 [d]	12 [d]	12 [d]
	Salary/year	$/year	25,000 [e]	25,000 [e]	6,818 [m]
	Seasonal/6 month	$/6 month	12,500 [f]	12,500 [f]	
	Extra feeding	hr./ha		83 [g]	
Plankton control	Empirical average	$/ha	322[h]	38 [l]	665 [m]
Gas and diesel	Empirical average	$/ha	365[h]	228 [l]	333 [n]
Electricity	Empirical average	$/ha	486[h]	1,445 [l]	1,524 [m]
Repairs and maintenance	Empirical average	$/ha	308 [i]	268 [l]	1,498 [n]
Bird depredation supplies	Empirical average	$/ha	15[j]	15 [l]	16 [n]
Seining and hauling	Food fish	kg	0.13[k]	0.11 [l]	0.11 [o]
Telephone	Empirical average	$/ha	42 [j]	26 [l]	26 [n]
Office supplies	Empirical average	$/ha	27 [j]	28 [l]	28 [n]
Interest on operating capital	Opportunity cost	%	10 [j]	10 [l]	10 [n]
Fixed costs					
Pond insurance	Empirical average	$/ha	108 [j]	63 [l]	63 [n]
Legal/accounting	Empirical average	$/ha	46 [j]	15 [l]	15 [n]
Interest on Investment					
Land	Empirical average	$/ha	2,030 [j]	2,055 [l]	2,900 [n]
Wells	Empirical average	$/ha	2,015 [j]	1,880 [l]	2,015 [j]
Pond construction	Empirical average	$/ha	2,141[i]	3,495 [l]	920 [p]
Equipment	Empirical average	$/ha	8,923 [i]	12,125 [l]	15,583 [m]
Annual depreciation					
Equipment	Empirical average	$/ha	665 [i]	1255 [l]	1,572 [m]

[a] Gross receipts= Seven-year average annual price (2011-2017) for catfish (premium size, undersized and oversized) (Terry Hanson, Personal communication);

[b] Feed = Seven-year average annual price (2011-2017) (28% and 32% protein) were used (Terry Hanson, Personal communication);

[c] Hybrid fingerling=Two-year average (2010 and 2017) price for fingerling (18 and 20 cm) were used (Kumar and Engle (2010) and Nagaraj Chatakondi, Personal communication);
[d]Terry Hanson, Personal communication;
[e,f,g] Ganesh Kumar, Personal communication;
[h]Courtwright (2013); Hanson et al. 2005); Hanson (2005);
[i]Hanson (2015); Hanson et al. 2005); Hanson (2005);
[j]Engle (2012a);
[k]Hanson (2015); Bott (2015);
[l]Kumar et al. (2016);
[m]Kubitza et al. (2017);
[n]Kumar et al. (2017);
[o]Fullerton (2016);
[p]Hanson (2005)
[q]IPRS (in-pond raceway system). IPRS is comprised of two units; a) fish culture unit b) oxygen production/waste treatment unit. Economic analysis for IPRS was based on research data only
[r] A split pond includes two basins; a) fish culture basin b) oxygen production/waste treatment lagoon;
MT=metric ton; Avg.= Average

Partial budget analysis

A partial budget analysis was conducted to compare the net benefit of increasing hybrid catfish production after changing the fingerling size from medium (≤ 18 cm) to large (20 cm) for all four production systems. Partial budgeting is a useful tool to compare the benefits and costs that would result from a relatively small change on a farm (Kay et al. 2016). As part of this, individual enterprise budgets were developed, which were based on the baseline assumptions. Original production data were used for enterprise budget development and was collected from the producer harvest surveys. Collected data were split into two units. One unit included the farmers that used ≤ 18 cm fingerlings, while the rest were included in second unit that used 20 cm size fingerling in growing hybrid catfish. In terms of IPRS (research) system, an added assumption was made since the sample size was quite low (N=4). The assumption was that the production parameters did not significantly vary in the IPRS (research) system after changing the fingerling size from ≤18 to 20 cm. After finishing the enterprise budget analysis, the partial budget was formatted by quantifying the benefits that could be obtained either from additional revenue or reduced cost after making the proposed changes from using ≤ 18 cm fingerlings to using 20 cm fingerlings. Costs were quantified in an opposite manner by adding the additional costs or reduced revenue in the analysis. The bottom line of partial budget analysis is to calculate the net benefit, which can be obtained by subtracting the total additional cost from the total additional benefit. If the value of the net benefit is positive, then the change is profitable; if negative, the change is not recommended for the farm (Engle 2010).

In similar manner, the partial budgets of altering the usage of hybrid catfish fingerling from graded to ungraded manner was developed. Eight enterprise budgets were developed for two groups of farmers who were using either graded or ungraded fingerlings (four production systems* two group of users). In terms of IPRS (research) system, an added assumption was made since the sample size was quite low (N=4). The assumption was that the production parameters as well as the price did not significantly vary in the IPRS (research) after using either graded or ungraded fingerlings.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

Objective 1) *Evaluate production methods that will provide year-round availability of hybrid catfish food fish, and determine the resulting cost of production.*

Subobjective 1a) *Effect of stocking different sizes of fingerlings at different times of year on time and size of harvest in ponds, split ponds and in-pond raceways.*
Auburn University and USDA

The effect of using different sizes of hybrid catfish fingerling (≤ 18 vs 20 cm) had a significant impact on the production variables and sizes at harvest in all four-production systems (Table 3). Results showed that the split pond system would provide the highest percentage of undersized fish if a farmer stocked the pond with ≤ 18 cm size fingering. In contrast, multiple batch users would receive the highest percentage of oversized fish if they used ≤ 18 cm size fingering. Overall, single batch producers would receive the highest percentage of premium size fish due to the lesser growth variation resulted from stocking either the ≤ 18 or 20 cm size fingerlings.

Subobjective 1c) Economic analysis of Subobjective 1a (Auburn University)

Partial budgets were developed based on enterprise budget analyses after capturing the data variation (production) mentioned in Table 3. Current results showed that the single batch production system had potential additional benefits from selling additional premium and undersized fish with saving money from feed input if a farmer would stock 20 cm size instead of ≤ 18 cm size fingerlings (Table 4). Overall, this additional benefit was slightly higher than the total additional costs, which included the additional fingerling cost and other input usage costs and reduced revenue resulted from oversized fish categories. A positive net benefit was evident for the practice of stocking 20 cm size in comparison to ≤ 18 cm size fingerlings in single batch production system (Table 4).

In multiple batch production system, the total additional costs were higher after stocking 20 cm size fingerlings (Table 4). Additional costs along with a reduced revenue led to a higher total additional cost. Additional benefits were obtained from the feed and fingerling costs with savings in the other variable/fixed costs. This additional benefit was small; thus, a negative net benefit was found for using 20 cm size rather than ≤ 18 cm size fingerlings in hybrid catfish production.

However, partial budget analysis for the split pond system also showed a positive net benefit if a farmer adopted the practice of stocking large sized fingerlings (20 cm) instead of medium size fingerlings (≤ 18 cm) (Table 4). Total additional benefits for stocking large sized fingerlings (20 cm) increased by saving significant amount of money from feed inputs. Hence, a positive net benefit was found in this partial budget analysis of changing from the current ≤ 18 cm fingerling to stock 20 cm fingerling at the end of the production (Table 4).

Similarly, IPRS (research) also had a negative net benefit due to the increasing additional fingering cost and interest on operating capital after adopting the larger size fingerling (20 cm) (Table 4). Individual enterprise budget analysis for traditional and IPRS (research) production systems yielded similar results with the net return to operator's labor and management being higher for medium sized fingerlings (≤ 18 cm) compared to the 20 cm sized fingerlings in split pond system.

Table 3. Effect of fingerling size (cm) on the production variables, outputs and net returns to operator's labor, and management of growing hybrid catfish (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) in different production systems

System	N	Fingerling size	Stocking density (X̄)	Feed (X̄)	Undersized fish		Premium size fish		Oversized fish		Total		Net returns
Unit		cm	#/ha	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	$/ha
Single	16	≤ 18	21,530	30,878	4	592	91	12,001	5	663	100	13,256	7,064
batch	8	20	28,689	29,907	5	726	92	13,204	3	374	100	14,304	7,325
Multiple	14	≤ 18	25,049	40,320	4	696	83	13,517	12	2,022	100	16,236	6,932
batch	2	20	19,073	32,350	5	587	89	11,120	6	774	100	12,480	3,343
Split	38	≤ 18	33,552	45,259	14	2,642	82	15,615	4	824	100	19,081	8,498
pond	42	20	30,893	41,590	13	2,398	83	15,729	4	840	100	18,968	9,093
IPRS	4	≤ 18	23,487	21,905	10	1,410	89	13,238	1	141	100	14,789	491
(research)	4	20	23,487	21,905	10	1,410	89	13,238	1	141	100	14,789	-708

- [a] Split pond includes two basins; a) fish culture basin b) oxygen production/waste treatment lagoon. Pond size of 3.60 ha is the summation of two basins (a + b), but production data are obtained from the a) basin only
- [b] Raceway also includes two units; a) fish culture unit b) oxygen production/waste treatment unit. Pond size of 0.4 ha is the summation of two units (a+ b), but production data are obtained from a) unit only;
- X̄=mean

Table 4. A partial budget analysis of growing hybrid catfish (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) in four different production systems changing the fingerling size from ≤ 18 cm to 20 cm

Category	Items	Description	Unit	Single batch	Multiple batch	Split pond	IPRS (research)
Benefits							
	Additional revenue						
		Premium size fish	$/ha	2,960		280	
		Undersized fish	$/ha	313			
		Oversized fish	$/ha			33	
		Inventory of sub-marketable fish	$/ha		742		
	Reduced cost						
		Feed cost	$/ha	429	3,525	1,623	
		Fingerlings	$/ha		154		
		Interest on operating capital	$/ha			65	
		Other fixed costs	$/ha	12	10	293	
		Other variable costs	$/ha		1,162	8	
			$/ha	3,714	5,593	2,021	
Total additional benefits							
Cost	Additional cost						
		Fingerlings	$/ha	-2,529		-857	-1,107
		Interest on operating capital	$/ha	-186	-347		-92
		Other variable costs	$/ha	-136			
	Reduced revenue						
		Premium size fish	$/ha		-6,440		
		Undersized fish	$/ha		-293	-569	
		Oversized fish	$/ha	-601	-2,102		
Total additional costs			$/ha	-3,453	-9,183	-1,427	-1,199
Net benefit			$/ha	261	-3,589	595	-1,199

Subobjective 1b) *Case study of the feasibility of multi-batching for hybrid catfish*
Auburn University and USDA

The multiple- or multi-batch production system is a feasible enterprise for hybrid catfish production. As with other systems, multi-batch users also have experienced growth variation problems during its production. Results showed that most of the variables under feeding and stocking management influenced the growth variability of hybrid catfish in multiple batch systems (Table 5). The undersized fish (%) was most heavily influenced by stocking density, FCR and pond area (Table 5; Figs. 1-2). Oversized fish (%) were caused by pond depth, weight/fingerling, FCR and stocking density. Using deeper ponds (2.1-3.0 m) reduced the proportion of oversized fish compared to pond depths of 0.1-2 m (Fig. 3). Using larger size fingerlings (0.03- 0.06) (kg) reduced the growth variation and production of oversized fish (%) (Fig. 4). Using higher stocking density reduced the percent of undersized and oversized fish (Fig. 1). Increasing the number of harvested fish (20,001-30,000) reduced the proportion of oversized fish (Fig. 5). FCR, however, had the inverse relationship with oversized fish production because increasing the FCR reduced the oversized fish (%) in this system (Fig. 2). Opposite result existed for premium size fish where increasing FCR increased the percentage of premium size fish (Table 5).

Subobjective 1c) Economic analysis of Subobjective 1b (Auburn University)

Economic analyses showed that multiple batch farming is an economically feasible enterprise as it can yield a net return of $6,495/ha at the end of the production cycle (Table 6). Receipts ($/ha) from the premium size fish followed by sub-marketable fish, oversized and undersized fish were the prime contributors to gross revenue. In contrast, feed and fingerlings costs were the highest individual input costs among all input item expenditures. Overall, multiple batch users would receive an additional contribution from the valuation of sub-marketable fish inventory resulting from the repeated stocking and harvesting procedures characteristic of this production strategy (Table 6).

Table 5 Potential causative factors for growth variation in hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) of multiple batch production systems

System	Y[a]	Causative factors	Unit	Coefficients[b]	Std. error[c]	t value	Pr (>t) [d]	M. R^{2f}	Adj. R^{2g}	P[h]
Multiple batch	CV	Fingerling graded	Y/N	1.790e-01	8.064e-02	2.220	0.0572	0.7741	0.5764	0.03727
		Weight/ fingerling	kg	-7.731e+00	3.486e+00	-2.218	0.0573			
	Undersized Fish	Area	ha	-2.800e+00	1.288e+00	-2.173	0.0615	0.7161	0.4677	0.08057
		Stocking density	#/ha	-2.621e-04	9.966e-05	-2.630	0.0302			
	Oversized Fish	FCR	ratio	-1.339e+01	5.361e+00	-2.498	0.0371	0.6302	0.3067	0.185
	Premium size fish	FCR	ratio	1.158e+01	5.751e+00	2.014	0.0788	0.5442	0.1453	0.3344

Y[a]= dependent variable; Coefficients[b]= regression coefficients; Std. error[c]= standard error; Pr (>t) [d]= probability value> t value; M. R^{2g}= multiple r square; Adj. R^{2h}= adjusted r square; P[i]=probability value

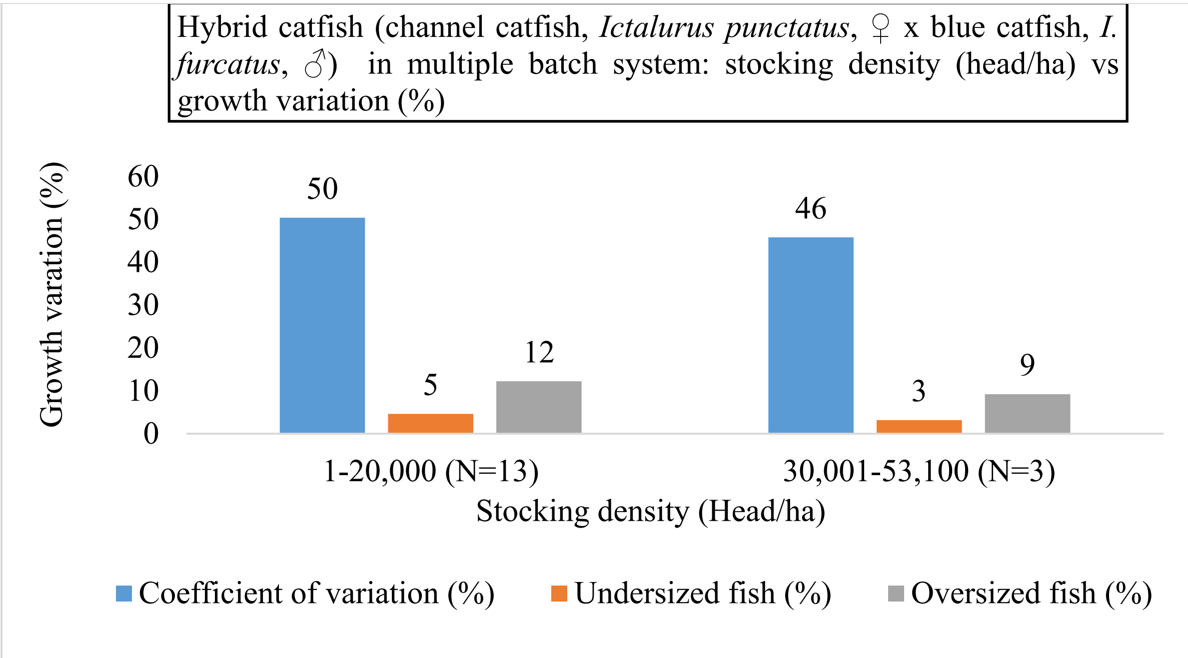

Figure 1. Effect of stocking density on the growth variation of hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) in multiple batch system

Significant differences at P< '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1, t-test.

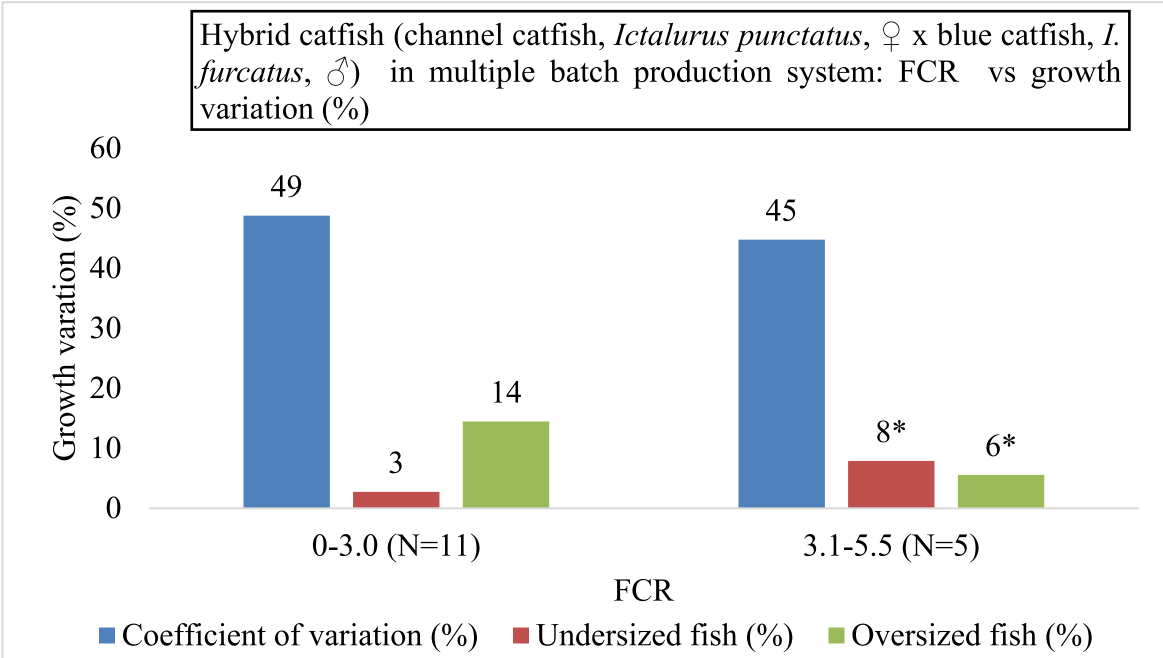

Figure 2. Effect of FCR on the growth variation of hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) in multiple batch system

Significant differences at P< '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1, t-test.

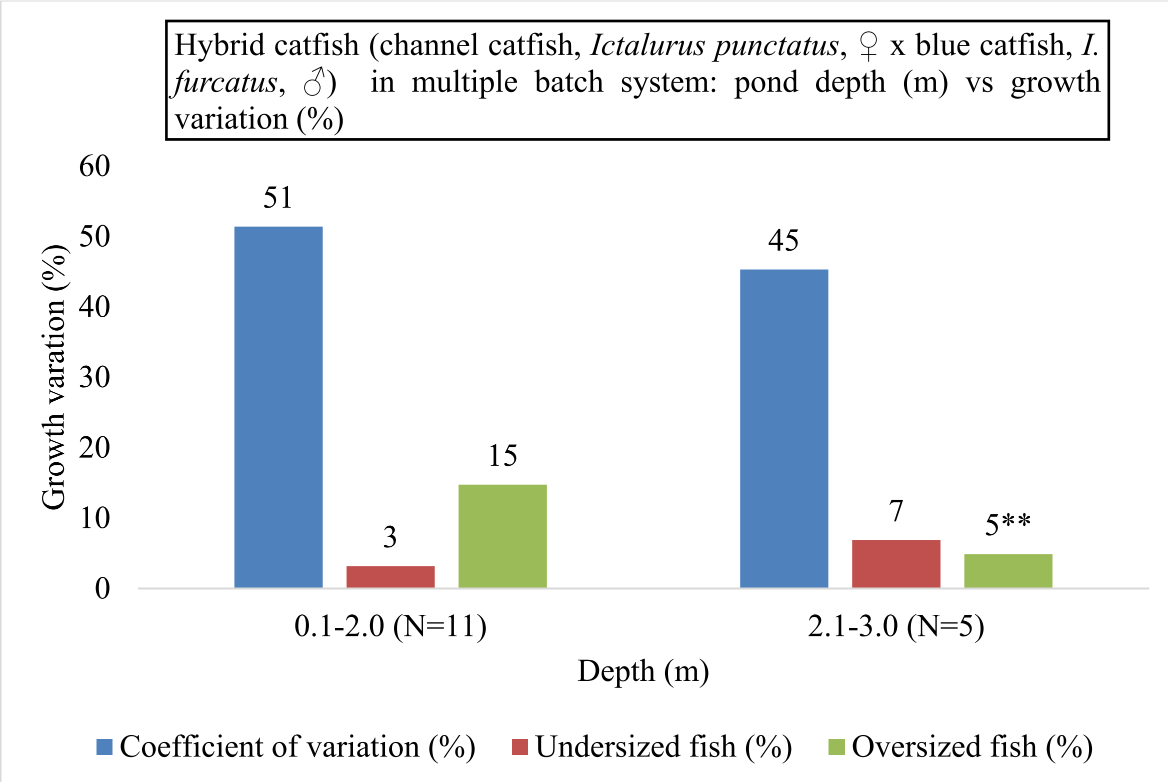

Figure 3. Effect of pond depth on the growth variation of hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) in multiple batch system

Significant differences at P< '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1, t-test.

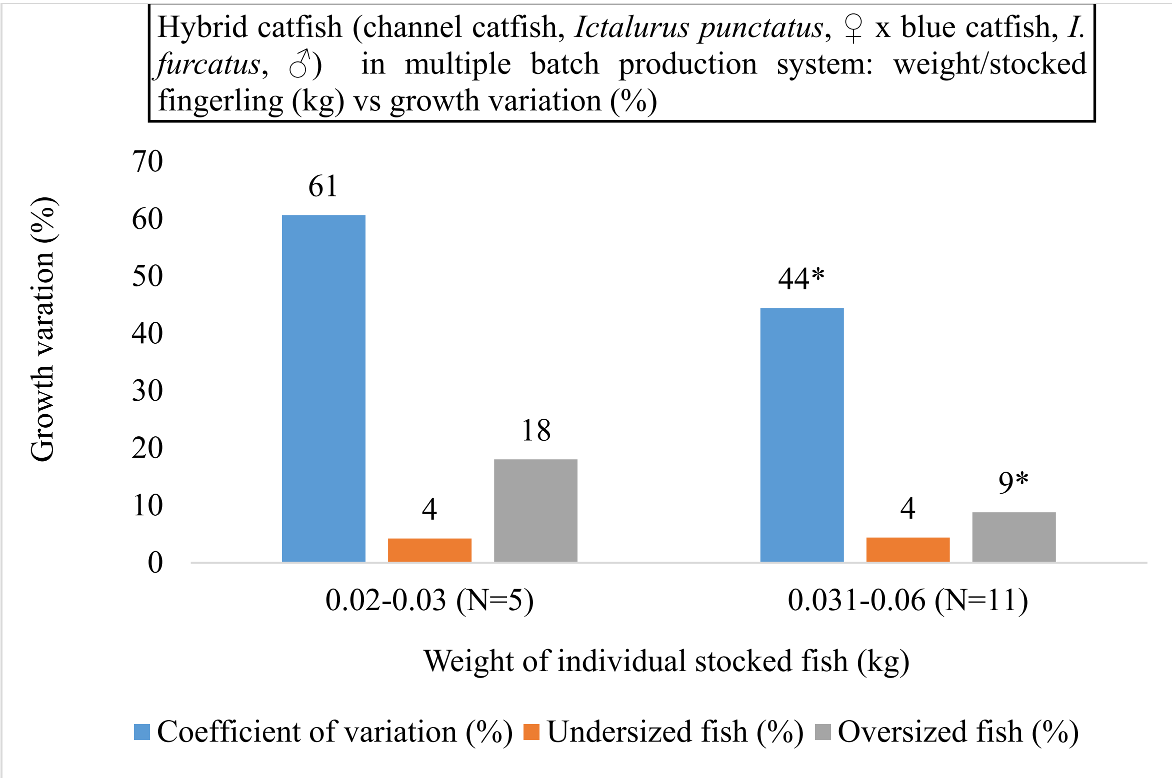

Figure 4. Effect of weight/fingerling (kg) on the growth variation of hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) in multiple batch system

Significant differences at P< '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1, t-test.

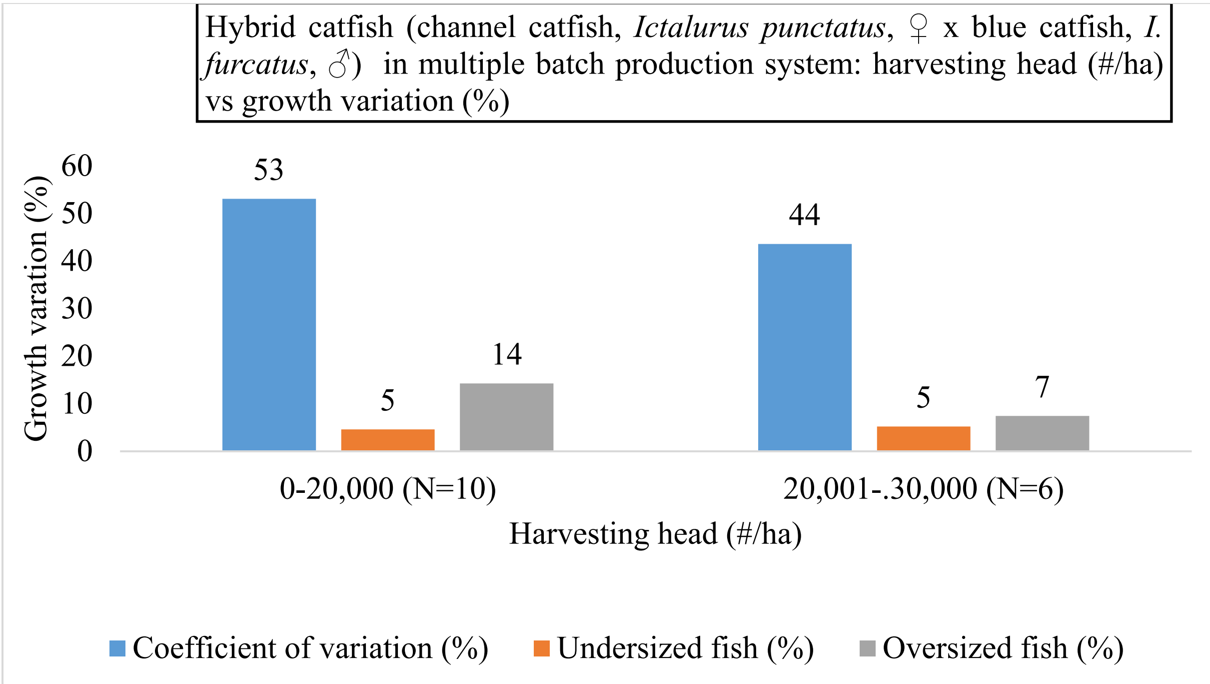

Figure 5. Effect of number of fish harvest (#/ha) on the growth variation of hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) in multiple batch system Significant differences at P< '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1, t-test.

Table 6 Enterprise budget for the hybrid catfish (channel catfish, *Ictalurus punctatus*, ♀ x blue catfish, *I. furcatus*, ♂) production in MULTIPLE BATCH systems (area 3.42 ha; stocking density 24,302 /ha; fingerling size 18 cm, feed 39 [a]MT/ha, yield 15,766 kg/ha, inventory of sub-marketable fish 3,795 kg/ha, culture period 383 days)

Item	Description	Unit	Quantity	Price/ Cost	Total ($)	Total ($/ha)	Annualized total ($/yr)	Annualized ($/ha/yr)
1. Gross receipts	Premium size	kg	34,407	2.46	84,604	24,722	80,523	23,530
	Undersized fish	kg	1,778	2.34	4,162	1,216	3,961	1,158
	Oversized fish	kg	4,782	2.08	9,940	2,905	9,461	2,765
	Inventory of Sub-marketable fish	kg	12,987	1.87	24,245	7,085	23,076	6,743
Total Gross receipts		kg	53,954	2.28	122,951	35,928	117,021	34,195
2. Operating costs								
Feed	28% protein floating	MT	135	442	59,516	17,391	56,645	16,552
Fingerlings	Size: 18 cm	Each	83,164	0	14,828	4,333	14,113	4,124
Labor	Owner supplied	$/ha	3.42	772	2,643	772	2,515	735
	Seasonal labor	$/ha	3.42	386	1,321	386	1,258	367
Chemicals	Empirical average	ha	3.42	322	1,102	322	1,049	307
Gas and diesel	Empirical average	ha	3.42	365	1,251	365	1,190	348
Electricity	Empirical average	ha	3.42	486	1,664	486	1,584	463
Repairs and maintenance	Empirical average	ha	3.42	308	1,055	308	1,004	293
Bird depredation supplies	Empirical average	ha	3.42	15	53	15	50	15
Seining and hauling	Empirical average	kg	40,967	0	5,326	1,556	5,069	1,481
Telephone	Empirical average	ha	3.42	42	144	42	137	40
Office supplies	Empirical average	ha	3.42	27	93	27	89	26
Interest on operating capital		$	74,162	0.10	7,416	2,167	7,059	2,063
Total variable costs	Per pond				96,411	28,173	91,761	26,814
3. Income above variable costs	Per pond				26,540	7,755	25,260	7,381
4. Fixed costs								
Farm insurance	Empirical average	ha	3.42	108	369	108	351	103
Legal/accounting	Empirical average	ha	3.42	46	159	46	151	44
Interest on Investment								
Land	Empirical average	$	2,030	0.10	203	59	193	56
Wells	Empirical average	$	2,015	0.10	202	59	192	56
Pond construction	Empirical average	$	2,141	0.10	214	63	204	60
Equipment	Empirical average	$	8,923	0.10	892	261	849	248
Annual depreciation								
Equipment	Empirical average	Ha	3.42	665	2,275	665	2,165	633
Total Fixed costs	Per pond				4,313	1,260	4,105	1,200

5. Total costs	Per pond		100,725	29,433	95,866	28,014
6. Net returns to operator's labor, and management	Per pond		22,227	6,495	21,155	6,182
	Per ha		6,495		6,182	
Breakeven Price	Above variable costs	$/kg	1.79		1.79	
	Above total costs	$/kg	1.87		1.87	
Breakeven Yield	Above variable costs	kg	42,308	12,363	40,267	11,767
	Above total costs	kg	44,201	12,916	42,069	12,293

[a]MT= metric ton

Objective 2) *Evaluate management techniques that will reduce the size variation of hybrid catfish food fish, and determine impacts of these techniques on net production and production costs.*

Subobjective 2a) *Effect of fingerling variability on variability at harvest*

Auburn University and USDA

Subobjective 2f) Economic analyses of Subobjective 2a (Auburn University)

The effect of using two different fingerling sizes of hybrid catfish (≤ 18 vs 20 cm) had significant impact on the variability at harvest (Table 3) and net returns (Table 4) in all four-production systems. The details of these two sub-objectives were mentioned in sub-objectives 1a and 1c above.

Subobjective 2b) *Effect of grading going into a pond or raceway on harvest variability*

Auburn University and USDA

The use of graded and ungraded fingerlings had a considerable effect on the growth variation in hybrid catfish production in all four systems (Table 7). Results showed that split pond system users would receive the highest percentage of both undersized and oversized fish after using ungraded and graded fingerlings, respectively. The IPRS (research) users would also face this same outcome for oversized fish if they stocked graded fingerlings. However, the replication for graded fingerling users for split pond system (N=1) or IPRS (research) (N=2) were quite low, and thus, a firm recommendation cannot be made based on these results (Table 7).

Subobjective 2f) Economic analyses of Subobjective 2b (Auburn University)

Using graded and ungraded hybrid catfish fingerlings had an impact on the production variables and economics in all four-production systems (Table 7). Partial budgets were developed based on full enterprise budgets from the graded/ungraded production data variation mentioned in Table 7. Results showed that farmers would receive higher net returns to operators labor and management from the traditional (single and multiple batch) and IPRS (research) systems if they used ungraded compared to graded hybrid catfish fingerlings (Table 7). Single batch producers using ungraded fingerlings would receive additional revenue from the greater quantity of premium and oversized fish sold while having reduced costs from less feed fed and lower total fingerling costs due to using ungraded hybrid catfish fingerlings (Table 8). In a similar manner, multi-batch users saved money from less feed and lower fingerling costs; but no change from the sale of premium, undersized and oversized fish categories (Table 8). In IPRS (research), farmers could only receive additional revenue from the premium and undersized fish categories (Table 8). Since the total additional benefits were higher than the total additional costs, the two traditional and IPRS (research) system users would receive a higher net benefit at the end (Table 8). Opposite results were found for the split pond system user, where farmers would receive a higher net benefit for using the graded compared to ungraded hybrid catfish fingerlings (Table 8). This was mostly due to the additional costs stemmed from feed and fingerling items and the reduced revenue derived from the oversized fish categories (Table 8).

Table 7. Effect of graded vs ungraded hybrid catfish fingerlings (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) on the production variables, outputs and net returns to operator's labor, and management in different production systems

System	N	Fingerling size	Stocking density (X̄)	Feed (X̄)	Undersized fish		Premium sized fish		Oversized fish		Total		Net returns
Unit		cm	#/ha	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	$/ha
Single	16	Graded	33,917	31,674	8	1,030	91	11,994	1	183	100	13,207	4,146
batch	9	Ungraded	19,099	31,516	3	396	92	12,987	6	784	100	14,166	9,293
Multiple	3	Graded	40,521	63,802	7	1,004	82	12,480	12	1,761	100	15,245	798
batch	13	Ungraded	20,559	33,675	4	429	84	9,475	12	1,313	100	11,216	7,690
Split	1	Graded	34,535	29,296	2	618	80	20,290	17	4,365	100	25,272	26,624
pond	6	Ungraded	40,073	49,363	13	3,366	83	20,805	4	900	100	25,071	17,102
IPRS	4	Graded	23,487	21,905	2	362	80	11,873	17	2,554	100	14,789	-303
(research)	4	Ungraded	23,487	21,905	10	1,410	89	13,238	1	141	100	14,789	491

- [a] Split pond includes two basins; a) fish culture basin b) oxygen production/waste treatment lagoon. Pond size of 3.60 ha is the summation of two basins (a + b), but production data are obtained from the a) basin only
- [b] Raceway also includes two units; a) fish culture unit b) oxygen production/waste treatment unit. Pond size of 0.4 ha is the summation of two units (a+ b), but production data are obtained from a) unit only
- X̄=mean

Table 8. A partial budget analysis after altering the hybrid catfish (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) fingerling from graded to ungraded manner

Category	Item	Description	Unit	Single batch	Multiple batch	Split pond	IPRS (research)
Benefits							
	Additional revenue						
		Premium size fish	$/ha	2,441		1,266	3,356
		Undersized fish	$/ha			6,433	2,453
		Oversized fish	$/ha	1,249			
	Reduced cost						
		Feed cost	$/ha	70	13,324		
		Fingerlings	$/ha	2,700	3,559		
		Interest on operating capital	$/ha	220	1,451		
		Other variable costs	$/ha		524	22	
		Other fixed costs	$/ha	76	97		
			$/ha	6,757	18,955	7,721	5,809
Total additional benefits							
Cost	Additional cost						
		Feed				-7,989	
		Fingerlings	$/ha			-1,261	
		Interest on operating capital	$/ha			-769	
		Other variable costs	$/ha	-125			
		Other fixed costs				-23	
	Reduced revenue						
		Premium size fish	$/ha		-7,390		
		Undersized fish	$/ha	-1,485	-1,347		
		Oversized fish	$/ha		-932	-7,201	-5,015
		Inventory of sub-marketable fish			-2,393		
Total additional costs			$/ha	-1,610	-12,062	-17,243	-5,015
Net benefit			$/ha	5,147	6,893	-9,522	794

Subobjective 2c) *Effect of stocking density on hybrid catfish variability*
Auburn University and USDA

Stocking density had an impact on the growth variability of hybrid catfish production. Results found that the frequency of undersized fish would be highest if farmers stocked fingerlings at a high-density rate in all four systems (Table 9). In contrast, multi-batch users received the highest percentage of oversized fish if they stocked the fingerlings at an average density rate. In general, the effect of stocking density had a mixed consequence in all four systems (Table 9), but the split pond users had the lowest percentage of premium sized fish at harvest for the three stocking density ranges. Therefore, the percent of premium size fish varied across the production system. Hence, the recommended best management practices for stocking density could be solved through running an economic analysis. The details are mentioned below in sub-objectives 2d (Table 9)

Table 9. Effect of stocking densities on the production variables, outputs and net returns to operator's labor, and management of hybrid catfish production (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) in different production systems

System	N	Stocking density range	Status	Stocking density ($\bar{X}$)	Feed ($\bar{X}$)	Undersized fish		Premium sized fish		Oversized fish		Total		Net returns
Unit		#/ha		#/ha	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	$/ha
Single batch	3	10,000-15,000	Low	14,883	29,348	4	447	90	10,542	6	728	100	11,717	5,451
	11	15,001-20,000	Average	17,189	29,601	2	280	92	12,077	6	777	100	13,134	8,194
	11	20,001-65,000	High	34,283	34,151	7	1,097	91	13,749	2	236	100	15,082	7,266
Multiple batch	2	10,000-15,000	Low	12,599	21,123	5	399	94	7,953	1	109	100	8,461	1,801
	6	15,001-20,000	Average	17,475	31,803	4	576	82	13,073	15	2,369	100	16,017	10,561
	8	20,001-65,000	High	32,347	49,514	5	836	83	14,491	12	2,077	100	17,404	4,561
Split pond	16	7,000-25,000	Low	21,946	28,938	12	1,650	84	11,708	4	530	100	13,888	4,738
	74	25,001-40,000	Average	33,089	45,338	13	2,616	82	16,365	4	867	100	19,849	8,627
	8	40,001-80,000	High	47,334	40,892	19	4,252	78	17,779	4	831	100	22,862	11,192
Raceway (research)	2	15,000-25,000	Average	19,649	19,623	7	1,087	93	14,943	0	0	100	16,031	5,389
	2	25,001-30,000	High	27,324	24,187	12	1,663	86	11,625	2	259	100	13,547	(4,390)

$\bar{X}$= mean

Sub-objective 2f) Economic analyses of Subobjective 2c (Auburn University)

Comparative enterprise budget analysis for traditional systems (single batch and multiple batch) showed that average stocking density (15,001-20,000/ha) would provide the highest net returns to operator's labor, and management compared to the pond stocked with hybrids at low (10,000-15,000/ha) and high density rate (20,001-65,000/ha) (Table 9). Fluctuation in gross revenue resulted from growth variation, feed and fingerling costs and played a major role in net return variation among the analyzed stocking density scenarios. In low stocking density scenarios, gross revenue, feed and fingerling costs were usually lower than the pond stocking with average and high density scenarios. However, in high stocking density scenarios, gross revenue was higher compared to the other two scenarios, but in the end, net returns were lower due to greater costs required for feed and fingerling items (Table 9). Therefore, a lower net return resulted for low and high stocking density scenarios compared to ponds stocked at the average density rate. In addition, the presence of sub-marketable fish, valued on a per weight basis, also contributed significantly to the gross revenue in all potential scenarios for the multiple batch users. This contribution was higher for the high stocking density scenario compared to the other two cases.

In the split pond system, net returns increased proportionately with changing the stocking density of hybrids from low (7,000-25,000/ha) to high (40,000-80,000/ha) rate (Table 9). Even though the percent of undersized fish was higher in the high stocking density scenario compared to the low and average (25,001-40,000/ha) scenarios, it did not affect the net returns due to the higher revenue contribution from the premium size fish.

In the IPRS (research), net returns were higher and positive if the farmer stocked the pond at an average stocking rate of 15,000-25,000/ha (Table 9). However, this outcome could change and did turn into a negative net return when the unit was stocked at a high stocking rate (25,001-30,000/ha). Increasing the frequency of undersized and oversized harvested fish could be the reason for this outcome (Table 9).

Subobjective 2d) *Effect of genetics on variability and sexual dimorphism*

Auburn University and USDA

Subobjective 2f) Economic analyses of Subobjective 2d (Auburn University)

Results showed that the genetic strain of the parent species affects variability in the hybrid. Both sire and dam effects were significant. Genotype-environment interactions affect the body weight variability. Nonetheless, environment was more important than genetics in causing variability. However, the survey data from the commercial setting (N=164) showed that almost all farmers were **not** aware of the hybrid catfish strain or line that they used in the reported sampled ponds during their stocking periods. Hence, statistical and economic analyses could not be performed due the unavailability of any strain data.

Subobjective 2e) *Effect of feeding rate on hybrid catfish variability*

Auburn University and USDA

Feeding rate had an effect on the growth variability in hybrid catfish production. Results showed that the frequency of undersized fish would be highest if farmers fed at a low rate in the single and split-pond systems and at a high feeding rate in the multi-batch and IPRS (research) systems (Table 10). In contrast, multi-batch users received the highest percentage of oversized fish if they fed the fish at low to average rate. In general, the effect of feeding rate had a mixed impact and varied across the four production systems.

Subobjective 2f) Economic analyses of Subobjective 2e (Auburn University)

Results showed that increasing the feeding rate increased net returns in the two traditional and split pond systems but not in the IPRS (research) (Table 10). In the IPRS (research), increasing the feeding rate yielded negative net returns, which was likely due to the increasing frequency of undersized and oversized fish combined with the additional cost required for additional feed purchases. Results also found that the highest percentage of undersized fish was evident in the split pond production system if the fish were fed at low feeding rate (15,000-30,000 kg/ha). In contrast, the highest percentage of oversized fish was found for multiple batch users, if the feeding rate was either the low or average rate applied (3,000-25,000 or 25,001-50,000 kg/ha). Repeated stocking and harvesting procedures could be the reason for such an outcome. Above all, the multiple-batch users were receiving the highest net returns if they applied high feeding rate scenarios (50,001-77,000) after stocking hybrid fingerings at the rate of > 36,000/ha in the commercial pond settings.

Table 10. Effect of feeding rate on the production variables, outputs and net returns to operator's labor, and management of hybrid catfish production (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) in different production systems

System	N	Feeding rate range	Status	Stocking density ($\bar{X}$)	Feed Mean ($\bar{X}$)	Undersized fish		Premium size fish		Oversized fish		Total		Net returns
Unit		kg/ha		#/ha	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	$/ha
Single	3	3,000-20,000	Low	20,175	12,227	7	418	93	5,553	0	0	100	5,971	235
batch	17	20,001-40,000	Average	25,518	30,482	5	741	91	12,594	4	577	100	13,911	7,958
	5	40,001-57,000	High	23,301	46,889	1	122	93	16,991	6	1,112	100	18,225	10,367
Multiple	3	3,000-25,000	Low	16,338	22,752	3	339	84	10,284	13	1,554	100	12,176	8,136
batch	8	25,001-50,000	Average	19,674	34,446	4	658	82	12,808	13	2,100	100	15,566	11,674
	5	50,001-77,000	High	36,453	67,617	5	1,314	86	20,801	8	1,953	100	24,069	17,336
Split	19	15,000-30,000	Low	28,121	24,016	16	2,089	79	10,526	5	664	100	13,280	4,155
pond	51	30,001-50,000	Average	31,943	40,489	13	2,467	83	15,275	4	772	100	18,514	7,773
	27	50,001-80,000	High	36,552	59,257	12	2,916	84	20,764	4	917	100	24,597	11,711
Raceway	2	18,000-22,000	Average	19,649	19,623	7	1,968	93	13,756	0	306	100	16,031	5,389
(research)	2	22,001-25,000	High	27,324	24,187	12	1,663	86	11,625	2	259	100	13,547	- 4,390

- $\bar{X}$= mean

IMPACTS

The comprehensive analysis that is emerging from this project is a valuable guide for hybrid catfish farmers to reduce the growth variation and find out the best management practices that are economically profitable. The output of this project has documented hybrid catfish growth variability across four production systems implemented on US farms and has allowed for estimates of comparative economic net returns. The developed dataset provides a more complete picture of the comparative production and economic benefits of these production systems and enables extension personnel to better assist farmers to make informed decisions related to adoption of these traditional and new technologies.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Publications

Gosh, K., T.R. Hanson, R.A. Dunham, N. Chatakondi. In Preparation. "Economic effect of hybrid catfish (channel catfish, Ictalurus punctatus, ♀ x blue catfish, I. furcatus, ♂) growth variability on four production systems."

Oral Presentations (2015-2019)

Gosh, K. T. Hanson, R. Dunham, N. Chatakondi. 2019. Identifying the economically feasible best management practices to reduce growth variability in channel-blue hybrid catfish production. Aquaculture 2019, Aquaculture – The Big Easy Choice! New Orleans, LA March 7-11.

Gosh, K., T. Hanson, R. Dunham, and N. Chatakondi. 2018. Studying the economic impact of channel-blue hybrid catfish growth variability on production. Abstract: School of Fisheries, Aquaculture & Aquatic Science, Auburn Univ. Research Symposium, Auburn. AL

Gosh, K., T. Hanson, R. Dunham, N. Chatakondi, and G. Kumar. 2018. Analyzing the economic impact of channel-blue hybrid catfish growth variability on production. 2018. Auburn Univ. Grad. Student 'This is Research Symposium 2018'.

Gosh, K., T. Hanson, R. A. Dunham, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. C. Jeffers, J. A. Chappell, F. Kubitza and G. Kumar. 2018. Economic impact of channel-blue hybrid catfish growth variability on production. Meeting abstracts. Aquaculture America 2018. Las Vegas, NV.

Gosh, K., R. A. Dunham, T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. C. Jeffers, J. A. Chappell, F. Kubitza, and C. Y. Chen. 2018. Analyzing the effect of production variables on the growth variability of channel-blue hybrid catfish. Meeting abstracts. Aquaculture America 2018. Las Vegas, NV.

Dunham, R.A., K. Gosh., T. R. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, N. Backenstose. 2018. Factors affecting the frequency of oversized and undersized hybrid catfish. Alabama Fisheries Association Symposium, 01 Feb. 2018. Auburn University, Auburn. AL

Dunham, R., Gosh, K., T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, N. Backenstose and C. Jeffers. 2017. Causative factors of the oversized and undersized hybrid catfish. Annual Catfish Update Meeting, Demopolis Convention Center, Alabama, Auburn University – School of Fisheries, Aquaculture and Aquatic Sciences & Aquaculture and Fisheries Business Institute (AFBI). December 6, 2017.

Gosh, K., R. A. Dunham, T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. 2017. Biology and economics of oversized and undersized hybrid catfish. School

Seminar, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University. Nov. 17, 2017.

Gosh, K., R. A. Dunham, T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. 2017. Analyzing the economic impact of growth variability on the channel-blue hybrid catfish production. Auburn University Graduate Student 'This is Research Symposium 2017'.

Robinson, D., R. Dunham, N. Chatakondi, T. Hanson, W. Bugg, K. Gosh, D. Drescher and N. Backenstose, 2017. Effect of genetics on body weight variability in channel catfish Ictalurus punctatus Female × blue catfish I. furcatus hybrids. 2017 Meeting abstracts. Aquaculture America 2017. San Antonio, TX.

Dunham, R. A., N. Chatakondi, T. Hanson, W. Bugg, K. Gosh, D. Drescher and D. Robinson. 2016. Integrated approaches to reducing individual variability and providing year round harvest of channel-blue hybrid catfish. 2016 Meeting abstracts. Aquaculture America 2016. Las Vegas, NV.

Gosh, K., R. A. Dunham, N. Chatakondi, T. Hanson, D. Drescher, D. Robinson, W. Bugg and C. Chen. 2016. Studying the growth variability of channel-blue hybrid catfish: an integrated base approach. Auburn Univ. Grad. Student 'This is Research Symposium 2016'.

Dunham, R., K. Gosh, D. Drescher, D. Robinson, T. Hanson and N. Chatakondi. 2016. SRAC hybrid catfish genetics project. 2016 Annual Catfish Update Meeting, Demopolis Convention Center, Alabama, Auburn University – School of Fisheries, Aquaculture and Aquatic Sciences & Aquaculture and Fisheries Business Institute (AFBI). December 13, 2016.

Gosh, K., R. A. Dunham, T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. 2016. Integrated Approaches to Reduce Growth Variability & Provide Year-round Availability of Channel-Blue Hybrid Catfish. School Seminar, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University. Nov. 16, 2016.

Gosh, K., D. Drescher, D. Robinson, R. Dunham, T. Hanson and N. Chatakondi. 2015. Integrated approaches to reducing individual variability and providing year round harvest of channel-blue hybrid catfish. School Seminar, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University. Nov. 6, 2015.

Dunham, R., K. Gosh, D. Drescher, D. Robinson, T. Hanson and N. Chatakondi. 2015. SRAC hybrid catfish genetics project. 2015 Annual Catfish Update Meeting, Demopolis Convention Center, Alabama, Auburn University – School of Fisheries, Aquaculture and Aquatic Sciences & Aquaculture and Fisheries Business Institute (AFBI). December 15, 2015.

Poster presentations (2018)

Gosh K., R. A. Dunham, T. R. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg and N. Backenstose. 2018. Evaluating the impact of management factors that cause growth variation in channel-blue hybrid catfish production. Auburn Univ. Graduate Student 'This is Research Symposium 2018'.

Theses and Dissertations (2015-2018)

Gosh Kamal. 2018. "Factors affecting the frequency of oversized and undersized channel catfish, Ictalurus punctatus, (male) x Blue Catfish, I. furcatus, (female) hybrid catfish at food fish harvest and their economic impact." Ph.D., School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University, Auburn, AL. December 2018. https://etd.auburn.edu/handle/10415/6305

Drescher, David. 2017. "Combining Ability of Channel Catfish (Ictalurus punctatus) Females and Blue Catfish (Ictalurus furcatus) Males for Tolerance of Low Oxygen." M.S. School

of Fisheries, Aquaculture and Aquatic Sciences, Auburn University, Auburn AL. May. https://etd.auburn.edu/bitstream/handle/10415/5669/Drescher_thesis.pdf?sequence=2&isAllowed=y

Robinson, Dalton. 2017. "Effect of Genetics on body weight variability in channel catfish (*Ictalurus punctatus*) female x blue catfish (**I. furcatus**) hybrids." M.S. School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University, Auburn, AL. December. https://etd.auburn.edu/bitstream/handle/10415/5978/Dalton_Robinson_Thesis.pdf?sequence=2&isAllowed=y

RESULTS AT A GLANCE

The growth variability problem in hybrid catfish farming could be reduced by using the best management practices, particularly giving attention to the stocking and feeding management.

The best management practices may vary from one production system to another, and the results for the in-pond raceway system were the most unique compared to the pond systems. For example, deep ponds reduced oversized fish percentage, but deep raceways increased the oversized fish frequency.

Grading aggravated the wrong size fish problem when average sized fingerlings were used, but using large fingerlings alleviated the wrong sized fish problem.

Multiple batch systems had the largest frequency of oversized fish and intensive systems such as split-ponds and in-pond raceways had the most undersized fish.

Strain and family of male blue catfish and female channel catfish affects growth variability of hybrids.

A combination of the individual processors pricing structure and cut-offs for undersized and oversized hybrids coupled with the percentage of undersized and oversized hybrids can cause the breakeven price to range from $0.81-$1.09 to the farmer.

Multiple farms were identified that successfully raised multi-batch hybrids.

Although, the factors affecting size distribution were not always exactly the same or of the same magnitude among the different production systems, some generalizations can be made regarding which variables, high stocking rates, stocking of large fingerlings, everyday feeding, relatively high feeding rates, adequate length of culture, use of small ponds, utilization of more than 4 hp/ha (aeration rate) and harvest of large numbers of fish (presumed efficient harvest and grading), had the most impact for reducing the oversized hybrid catfish problem.