Genotype-Environment Interactions of Channel Catfish, *Ictalurus punctatus*, ♀ X Blue Catfish, *I. furctatus*, ♂ Hybrids - Changing Culture Environments -Changing Climate

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The catfish industry is still the largest aquaculture industry in the US. The industry was valued at $423 million in 2012 without economic multipliers

The catfish industry has been in distress.

Catfish production peaked at 300 million kg in 2003 then contracted to 226, 127, 138 and 150 million kg in 2007, 2008, 2011 and 2013, respectively (NASS 2012, Hanson and Sites 2014.) due to increased feed and fuel prices, the recession and increased imports.

POTENTIAL GE INTERACTIONS- ONE GENETIC TYPE BEST FOR ALL SYSTEMS?

The wide spread implementation of the hybrid between channel catfish, *Ictalurus punctatus*, females and blue catfish, *I. furcatus*, males (hybrid) which exhibits heterosis for several traits (Dunham et al. 2008) and now about 50% of the US catfish production is from the culture of the channel catfish (*Ictalurus puntatus*) (female) x blue catfish, *I. furcatus* (male) hybrids (Brune et al, 2003; Dunham et al. 2014). It is key for successful implementation of high density systems.

Performance of hybrid catfish can be further improved through strain selection and likely through reciprocal recurrent selection.

Will a single genetic improvement program serve to improve hybrid catfish for these different environments or are multiple breeding programs needed to address the needs of all farms?

With the advent of new culture systems for hybrid catfish, assessment of GE interactions is critical for design of effective breeding programs to improve hybrid catfish.

Global climate change could result in water temperature extremes and alterations in salinity in aquaculture environments. Will the best genotypes under current conditions still be the best when climate changes water conditions?

OBJECTIVES

1. **To measure genotype-environment interactions for growth and survival for different genotypes of hybrid catfish grown in low density ponds, high density ponds, split ponds and in-pond raceways.**
2. **Initiate studies to compare channel catfish, blue catfish and hybrid catfish for survival and growth at temperature and salinity extremes.**

MATERIALS AND METHODS

Experimental Fish

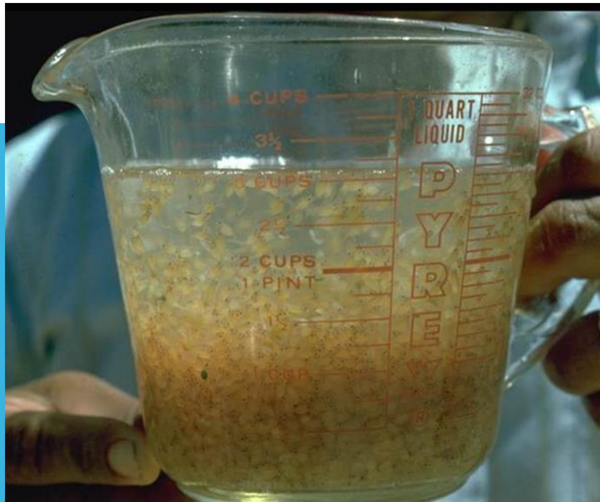
Five lines of channel catfish females were hybridized with 2 lines D&B (DB) and Rio Grande (RG)) of blue catfish males in various combinations in June of 2012.

Channel catfish lines were Kansas random (KR), Marion random (MR), Marion select (MS, selected for 8 generations for increased body weight), Kansas select (KS, selected for 8 generations for increased body weight) and 103KS (an F2 generation cross between NWAC-103 and KS).

Fry were stocked in ponds

They were then stocked back to their respective ponds, for multiple rearing (Moav and Wohlfarth 1973, Dunham et al. 1982b, Dunham 2011) to equalize body weights to begin the stocker phase of this experiment.

In July 2013, the fingerlings were seined from the ponds, weighed, heat branded and stocked communally so that each genetic group was equally represented in each experimental unit to minimize the environmental factor.



Experimental units

The fingerlings/stockers were raised in 3-4 different environments; split pond, in - pond raceway, a high density pond and a low density pond.

One experimental unit- communal stocking-individuals are the replicates for the genetic types.

Mean Initial Body Weights

Genetic type[1]	Brand	Low density Pond No.	Low density Pond Wt (g)	High density Pond No.	High density Pond Wt (g)	In-pond Raceway No.	In-pond Raceway Wt (g)
103KS X DB	0L	75	41.1	1146	32.4	500	42.1
MR X DB	1L	75	46.4	377	42.5	443	41.3
KS X DB	1R	75	42.4	983	40.3	400	40.8
KR X DB	2L	75	43.6	500	43.7	318	41.5
103KS X RG	6L	75	34.1	366	32.9	**500**	**51.0**
MS X RG	**6R**	**75**	**61.9**	**362**	**56.9**	**406**	**58.2**
KR X RG	7L	75	40.0	399	40.9	370	39.0
KS X RG	7R	75	39.9	**387**	**47.0**	**400**	**48.6**

RESULTS

Body weight

Sex (S), genetic type (G), environment (E) and their interactions; sex x environment (S X E), sex x genetic type (S X G) and genetic type x environment (G X E) were all significant ($P < 0.05$) for final body weight.

The interaction effect (S X E, S X G and G X E) demonstrated that genetic types and gender responded differently to the variation in environmental conditions.

Magnitude

Stocker final body weights (kg) ± standard deviation

Genetic type	Low density	High density	Raceway
1) 103KS x DB	0.110^{h} ± 0.054	**0.101^{e} ± 0.045**	0.131^{e} ± 0.066
2) MR X DB	0.184^{cde} ±0.083	0.145^{bc} ±0.071	0.209^{ab} ± 0.112
3) KS X DB	0.186^{cde}± 0.097	0.139^{cd} ± 0.056	0.179^{c} ± 0.070
4) KR X DB	0.177^{cde} ±0.091	0.103^{e} ± 0.050	0.145^{de}± 0.090
5) 103KS X RG	**0.136^{fg} ± 0.055**	**0.109^{e} ± 0.040**	*0.146^{de} ± 0.019*
6) MS X RG	*0.253^{a} ± 0.122*	*0.176^{a} ± 0.080*	*0.217^{a} ± 0.111*
7) KR X RG	0.202^{bcd}± 0.097	0.104^{e} ± 0.045	0.130^{ef} ± 0.069
8) KS X RG	0.235^{ab}± 0.119	*0.155^{b} ± 0.070*	*0.224^{a} ± 0.097*

Genetic type[1]		**FOOD FISH BW ± SD**			
		Low density	High density	Split pond	Raceway
103KS X DB		0.686^{a} ± 0.376	**0.217^{d} ± 0.094**	**0.368^{e} ± 0.163**	0.745^{c} ± 0.293
MR X DB		0.684^{a} ±0.260	0.276^{bc} ± 0.131	0.491^{bc} ±0.200	0.909^{b} ± 0.376
KS X DB		0.760^{a}± 0.354	0.260^{c} ± 0.113	0.433^{cd} ± 0.183	0.862^{b} ± 0.316
KR X DB		0.621^{a} ±0.294	0.204^{d} ± 0.091	0.370^{e} ± 0.162	0.829^{bc}± 0.342
103KS X RG		**0.790^{a} ± 0.560**	**0.241^{cd} ± 0.103**	**0.415^{de} ± 0.173**	*0.812^{bc} ± 0.373*
MS X RG		*1.046^{a} ± 0.29*	*0.369^{a} ± 0.214*	*0.580^{a} ± 0.287*	*1.121^{a} ± 0.484*
KR X RG		0.656^{a} ± 0.131	0.216^{d} ± 0.098	0.387^{e} ± 0.179	0.737^{c} ± 0.323
KS X RG		0.780^{a} ± 0.329	*0.312^{b} ± 0.155*	*0.521^{ab} ± 0.227*	*1.029^{a} ± 0.411*

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RANK— STOCKER/FOOD FISH

Group	low		high		split		raceway	
MS X RG	1	1	1	1	1	1	2	1
103KS X RG	7	2	5	5	5	5	5	5
KS X RG	2	3	2	2	2	2	1	2
KS X DB	4	4	4	4	4	4	4	4
103KS X DB	8	5	8	6	8	8	7	7
MR X DB	5	6	3	3	3	3	3	3
KR X RG	3	7	6	7	6	6	6	8
KR X DB	6	8	7	8	7	7	8	6

SIRE AND DAM EFFECTS- BW

Genetic type[1]	Low density pond	High density pond	Raceway
C X RG	0.204* + 0.034	0.128* ± 0.003	0.172 ± 0.035
C X DB	0.167 ± 0.033	0.121 ± 0.022	0.175 ± 0.037
103KS X B	0.142* ± 0.033	0.125 ± 0.005	0.133* ± 0.008
M X B	0.189 ± 0.016	0.130 ± 0.008	0.199 ± 0.034
K X B	0.196 ± 0.013	0.121 ± 0.022	0.181 ± 0.027

SURVIVAL (%)

Genetic type	Low density Pond	High density Pond	Raceway
103KSXDB	**82.7[b]**	**43.7[f]**	**70.0[c]**
MRXDB	***53.7[d]***	***28.9[g]***	***35.9[f]***
KSXDB	**72.0b[c]**	**65.5[d]**	**59.3[e]**
KRXDB	**80.0[b]**	**67.4[c]**	**68.0[b]**
103KSXRG	**84.0[a]**	**45.6[e]**	**79.0[a]**
MSXRG	***49.3[e]***	***33.1[g]***	***22.4[g]***
KRXRG	**77.3[bc]**	**88.5[a]**	**64.6[d]**
KSXRG	**80.0[b]**	**71.6[b]**	**55.3[e]**

PRODUCTION (COLUMNARIS)

	Low	High	Raceway
103KS x DB	97.6	52.9	97.3
MR X DB	95.1	39.1	79.0
KS X DB **	137.6	89.1	113.3
KR X DB	144.0	60.0	102.0
103KS X RG	138.6	58.4	100.3
MS X RG	98.6	41.0	39.7
KR X RG **	157.7	111.5	110.5
KS X RG **	163.2	94.5	117.8

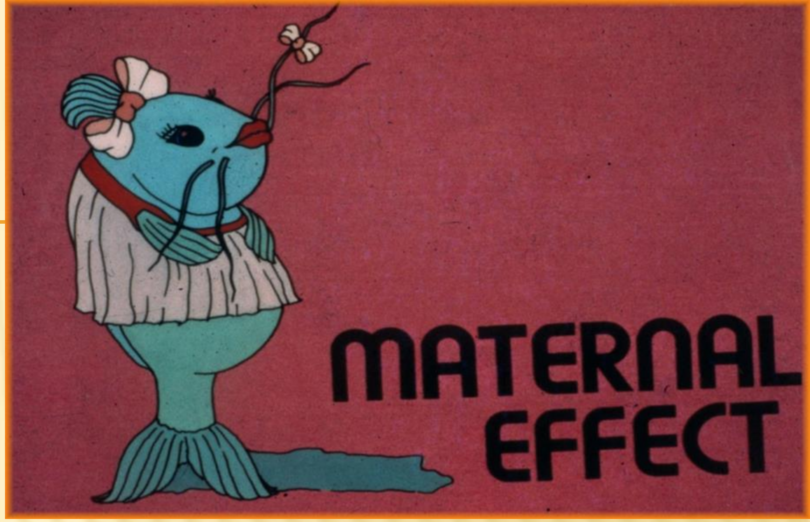
SUMMARY EXPERIMENT 1

- In general, the best performing genetic type of hybrids in one system were the best in all systems, but not always

- There were GE interactions so genetic rank or value did change moderately among environments

- We cannot ignore GE interactions in our breeding programs and on-farm application, although the importance of this is somewhat decreased as the same groups of fish were among the best for growth across environments

Dunham et al. (2014a) found large sire effects for growth rate of hybrids when using different strains. Large sire effects were evident again with RG resulting in the best hybrids. Significant dam effects were observed.



These results from Kansas and Marion females selected for body weight for 8 generations appear to support the results of Bosworth and Waldbieser (2014), though not those of Jeppsen (1995), which used Kansas females selected for 4 generations. The additional 4 generations of selection appeared to impact the general combining ability.

Survival

- Genotype- environment interactions were observed for survival.
- 103 KS X RG had higher survival rates than the other genetic types in the low density environment and in-pond raceway while KR X RG had the highest value for the high density pond with a survival of 88.7%.
- Across environments, hybrids from KR dams had the top two survival rates. Hybrids from M dams had the greatest losses from columnaris
- It appears that intraspecific dam effects impact disease resistance and survival in hybrids, and perhaps general combining ability will be high for this trait.

The genetic type with the best survival, those from KR dams, was not the fastest growing hybrid.

This complicates identification of the best genetic type of hybrid for all culture systems, and may require selective breeding to change combining abilities so that the highest survival and growth are found in the same genetic type.

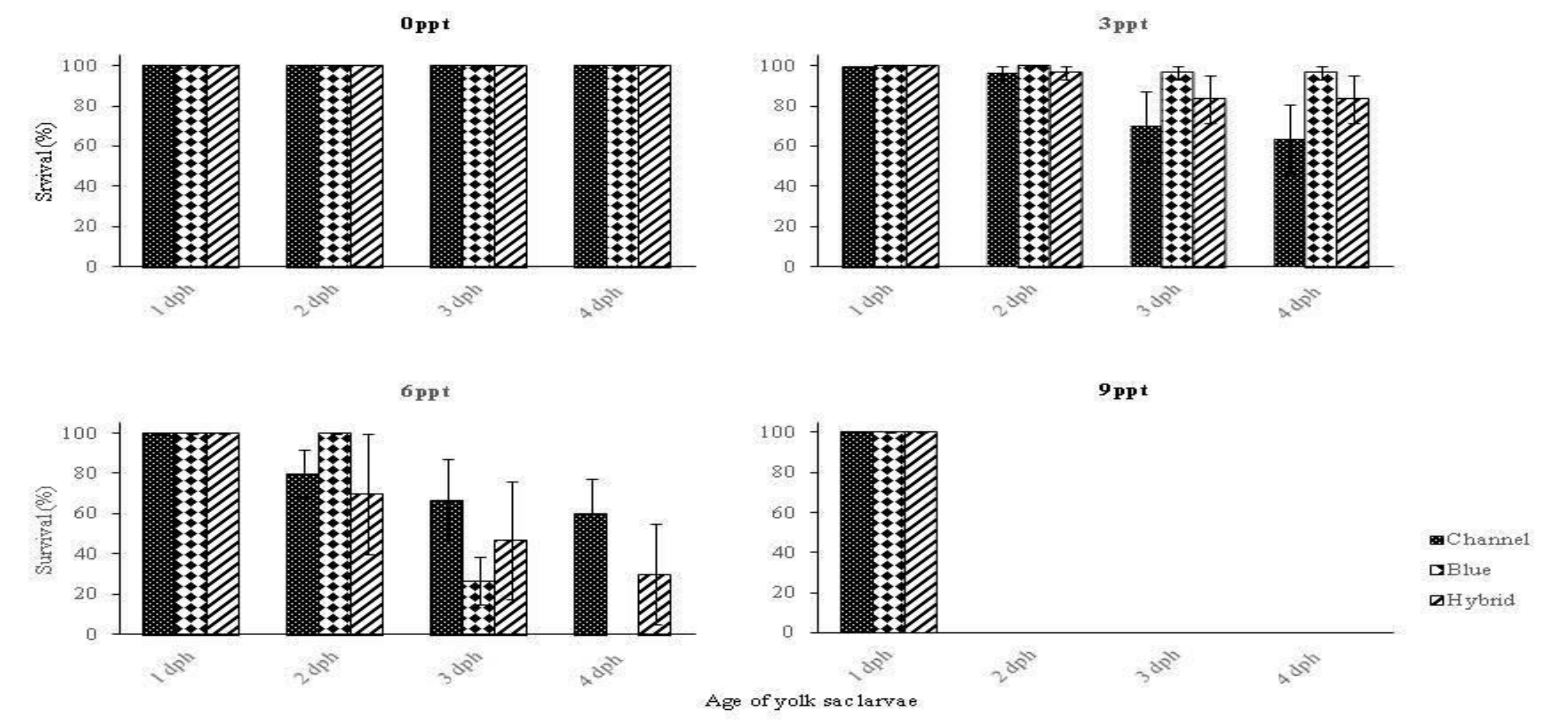
SURVIVAL % AT 40 C

KR Channel	15	E X B	25
K X B	0	*103KS X B*	*55*
J X B	50	Kmix X B	0
MS X B	0	T X B	20
KS X B	*50*	mix X B	0
AR X B	10		
ARMK X B	0		

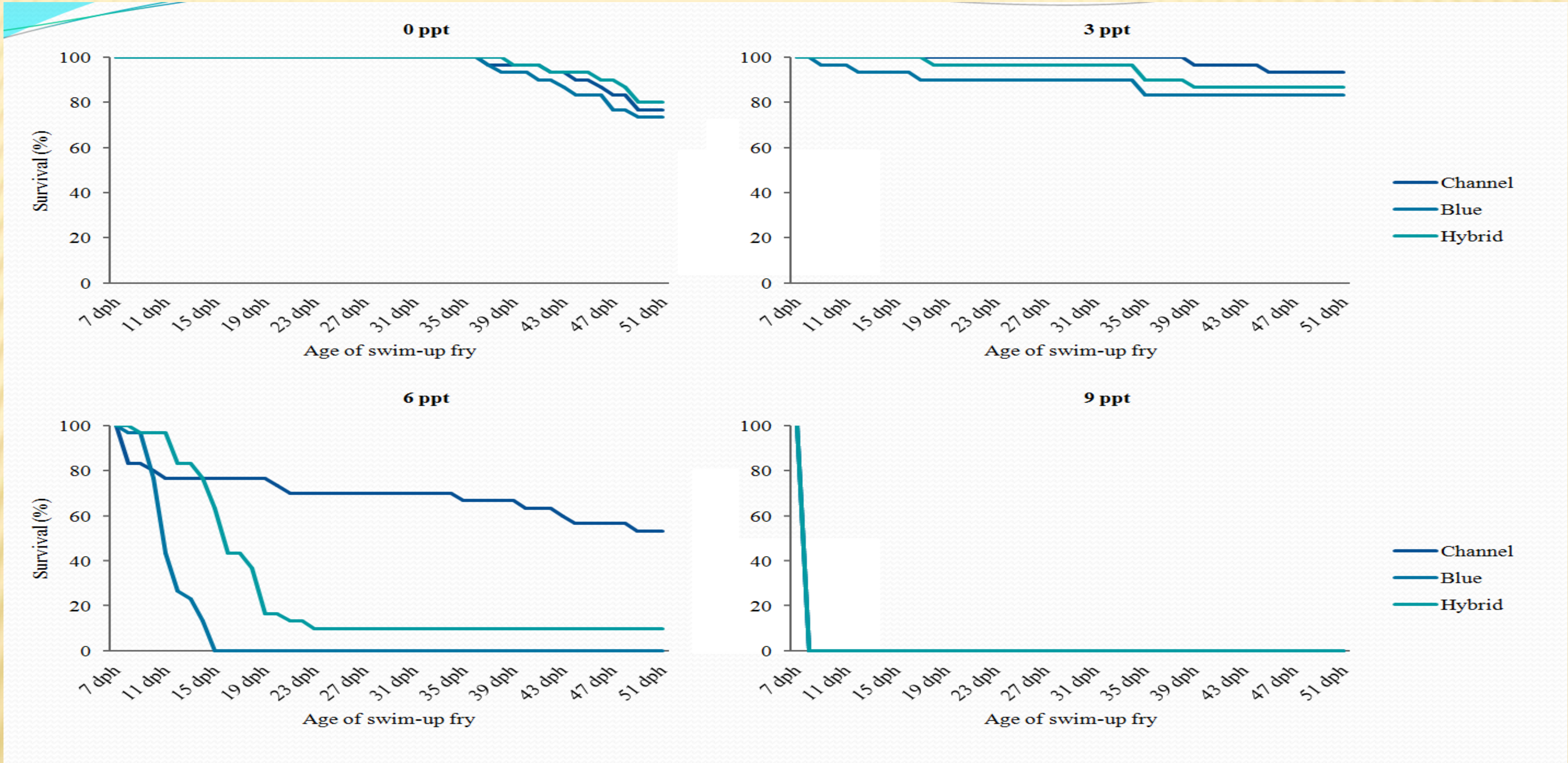
Mean (±SEM) percent survival of different genetic groups recorded in the aquaculture facility throughout study period in different concentrations of NaCl for 14 days

Salinity (ppt)	Genetic groups	Temperature (^oC) - 0.5
0	Channel	2.22±2.22
	Hybrid	0±0
2.5	Channel	97.78±2.22
	Hybrid	17.78±4.44
5	Channel	0±0
	Hybrid	0±0

Genotype-Environment Interactions for Growth and Survival of Channel Catfish (*Ictalurus punctatus*), Blue Catfish (*Ictalurus furcatus*), and Channel Catfish, *I. punctatus*, ♀ × Blue Catfish, *I. furcatus*, ♂ Hybrid Fry at Varying Salinity



Mean (±SEM) percent survival of yolk-sac larvae in different concentrations of NaCl for 4 days (n=3 replicate).



0 ppt
3 ppt
6 ppt
9 ppt
Survival (%)
100
80
60
40
20
0
7 dph
11 dph
15 dph
19 dph
23 dph
27 dph
31 dph
35 dph
39 dph
43 dph
47 dph
51 dph
Age of swim-up fry
Channel
Blue
Hybrid

Salinity (ppt)	Genetic groups	Age of swim-up fry 51 dph
0	Channel	0.195±0.017
	Blue	0.232±0.27
	Hybrid	0.353±0.015
3	Channel	0.336±0.009
	Blue	0.342±0.024
	Hybrid	0.388±0.045
6	Channel	0.211±0.026
	Blue	-
	Hybrid	0.013±0.026

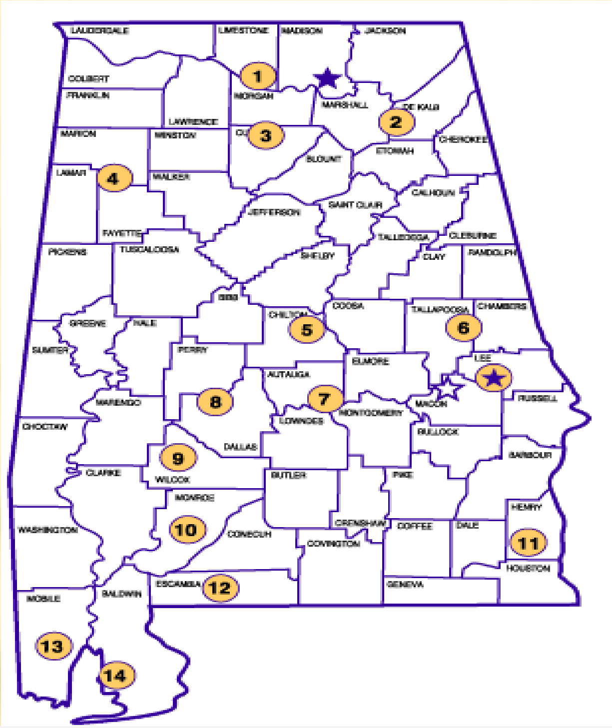
Change in weight (gm) of swim-up fry (Channel, Blue, and Hybrid) from 7 dph to 51 dph in different concentration of salinity. Data are mean ±S.E.M.

Genotype-environment interactions occurred among blue catfish, channel catfish and hybrid catfish for growth and survival at varying salinities and cold temperatures.

Super cold environments and super high saline environments- hybrid heterosis disappears and the channel catfish is superior to the hybrid.

Extreme cold and saline conditions would negate hybrid superiority. Hybrids would have an advantage at high temperature.

Acknowledgement



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THANK YOU