HARD CLAM STOCK IMPROVEMENT THROUGH HYBRIDIZATION AND BACKCROSSING

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Clam Species

- The northern hard clam supports commercial fisheries and aquaculture industries along Atlantic coast from MA to FL
- The southern quahog found from NC to Caribbean, recreationally fished in FL
  - May have production traits for resisting environmental stressors
  - Not cultured because of their tendency to gape in refrigerated storage
- *Mercenaria* species are normally separated by environmental tolerances, but readily hybridize where they do co-occur or under hatchery conditions

Northern hard clam
Mercenaria mercenaria notata

Southern quahog
Mercenaria campechiensis

BACKGROUND

- Hybridization is a breeding technique used in commercial agriculture and finfish aquaculture
- Hybrids may yield superior traits to either parental species: e.g., improved growth or environmental resistance
- The use of clam hybridization for “mariculture” potential was examined by Winston Menzel at Florida State University in the 1960-70s
  - Showed hybrids had superior commercial traits to either parent species; i.e., growth, shelf life
  - Little data reported on merit of hybrids for improved survival

HYBRIDIZATION

= crossing genetically dissimilar parents

- intra-specific: *M. mercenaria* farm strains
- inter-specific: *M. mercenaria, M. campechiensis*
- inter-generic: *Spisula* x *Mulinia*

Hatchery Production

- Northern hard clams obtained from a Florida hatchery
- Southern quahogs obtained from the wild (Sarasota Bay), where highly pure populations are known to exist – conditioned in hatchery
- Clams spawned by thermal stimulation
- Single parent crosses utilized

Hatchery Production

- Difficult to have spawns occur at same time
- Five spawns accomplished with different sets of parents, October-December, 2007

Hatchery Production

Larval culture, setting, and post-set rearing performed using standard hard clam culture protocols

Hatchery Production

Parental shells (left) and resulting post-set juveniles from 10.24.07 spawn (right). Crosses are listed female by male.

Starch gel of PGI exhibiting allozyme differences between Northern and Southern hard clams

Genetic Analysis

(Parental Allozyme Analysis)

Bill Arnold and Steve Geiger

Date	M♀	M♂	C ♀	C♂	Good	Bad
10/24	M	M	C	C	G	
10/31	M	M	C	C	G	
11/02	Hy	M	Hy	C		B
11/15	M	M	C	C	G	
11/27	Hy	Hy	C	C		B

Nursing Hybrid Seed

- Standard hard clam protocols used
- Land-based nursing
  - Downwellers
  - March-June 2008
  - Cedar Key
  - 73-82%
- Field nursing
  - Bottom bags, 4mm
  - June–September 2008
  - Cedar Key
  - 73-86%
- Negligible differences


M x M (♀ x ♂)
M x C
C x M
C x C

Growout Trials

- Stock Comparison
- Replicated plants - Parental stocks and reciprocal crosses from 3 families
  - Cedar Key
  - Sept 2008-Sept 2009
- Standard planting procedures
  - Bottom bags, 9 mm
  - Net coated and covered with wire
  - Stocked at 1150/bag (72/ft^2)

Harvest Results (12 months)–All Families

Average

Stock	Shell Width (mm)	Total Weight (g)	Dry Meat Wt. (g)	Survival (%)	Production (lbs/bag)
M x M	23.1^{b}	26.8^{a}	0.59^{bc}	93.3^{a}	62.8^{a}
M x C	24.3^{a}	30.2^{a}	0.73^{a}	99.5^{a}	76.1^{a}
C x M	23.3^{ab}	27.5^{a}	0.68^{ab}	90.9^{ab}	67.2^{a}
C x C	20.4^{c}	17.3^{b}	0.52^{c}	72.3^{b}	32.5^{b}

Note: ANOVA were performed using the PROC GLM procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$. Tukey's test groupings are displayed

Harvest Results (12 months) – Family A
Average

Stock	Shell Width (mm)	Total Weight (g)	Dry Meat Wt. (g)	Survival (%)	Production (lbs/bag)
M x M	22.6 b	25.8 b	0.58 b	81.8 ab	53.0 b
M x C	24.5 a	31.0 a	0.76 a	96.8 a	75.8 a
C x M	20.7 bc	19.4 c	0.56 ab	68.4 b	34.4 c
C x C	20.1 c	16.5 c	0.50 b	72.5 ab	32.1 c

Note: ANOVA were performed using the PROC GLM procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$. Tukey's test groupings are displayed.

Harvest Results (12 months) – Family C
Average

Stock	Shell Width (mm)	Total Weight (g)	Dry Meat Wt. (g)	Survival (%)	Production (lbs/bag)
M x M	24.1 bc	29.8 b	0.67 b	92.9 a	70.1 b
M x C	24.3 ab	30.5 ab	0.77 ab	104.1 a	80.4 b
C x M	25.6 a	34.4 a	0.89 a	110.2 a	95.3 a
C x C	21.0 c	18.4 c	0.60 b	59.0 b	28.1 c

Note: ANOVA were performed using the PROC GLM procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$. Tukey's test groupings are displayed.

Harvest Results(12 months) – Grower A

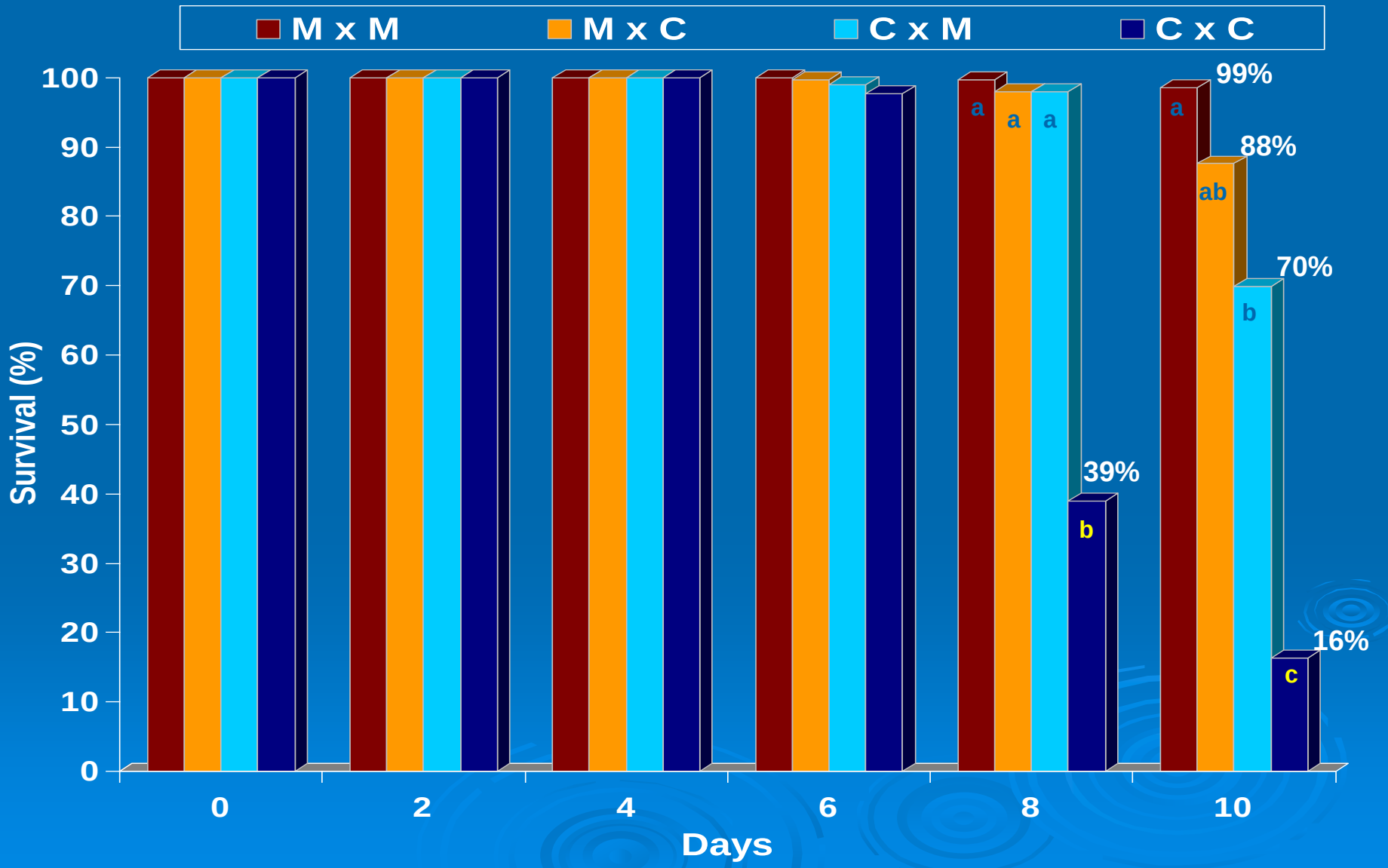
Average

Stock	Shell Width (mm)	Shell Length (mm)	Total Weight (g)	Survival (%)	Production (lbs/bag)
M x M (Family A)	21.9 [b]	41.9 [b]	22.7 [b]	52.2 [b]	31.3 [b]
M x C (Family A)	25.7 [a]	46.9 [a]	34.5 [a]	90.2 [a]	82.0 [a]
M x M (Family C)	23.3 [b]	42.1 [b]	25.0 [b]	49.9 [b]	33.2 [b]
C x M (Family C)	24.6 [a]	43.5 [a]	28.8 [a]	86.2 [a]	65.1 [a]

Note: T tests were performed using the PROC TTEST procedure of SAS. Treatment means were considered significantly different when $p \leq 0.05$.

Shelf Life: Survival in 45°F Storage

Average of Families A,B,C – Harvested at 84.6°F



Note: A repeated measures analysis (PROC GLIMMIX) was performed ($p \leq 0.0001$).

Shelf Life: Gapping in 45ºF Storage

Average of Families A, B, C

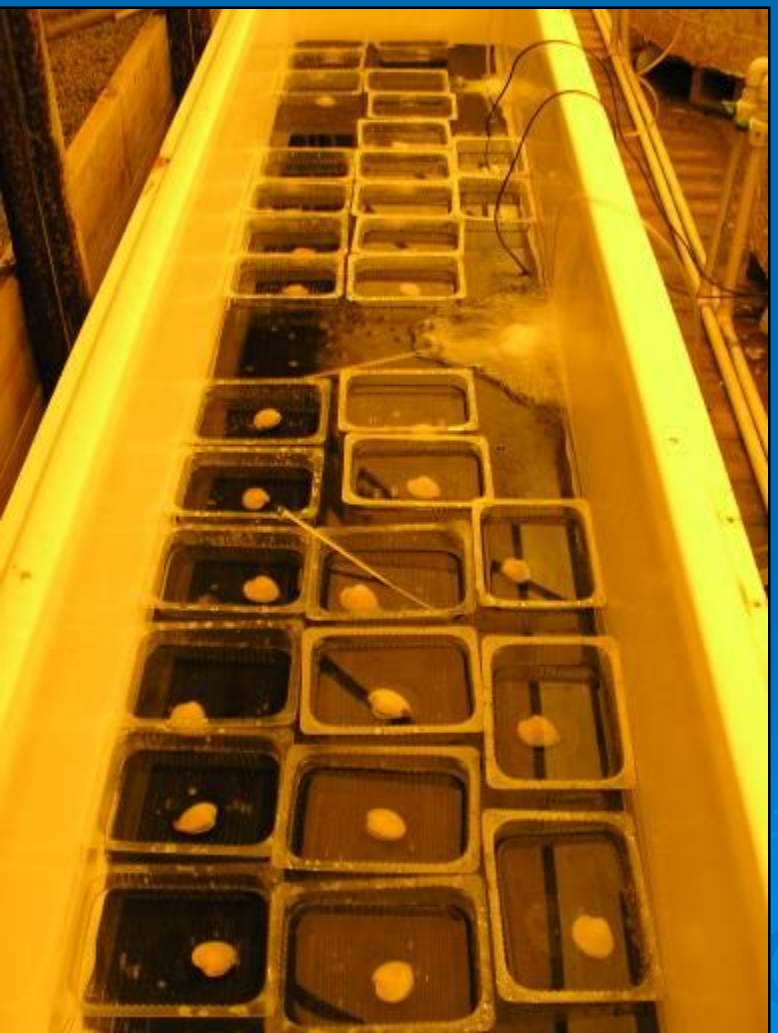
Note: A repeated measures analysis (PROC GLIMMIX) was performed (p=0.0237).

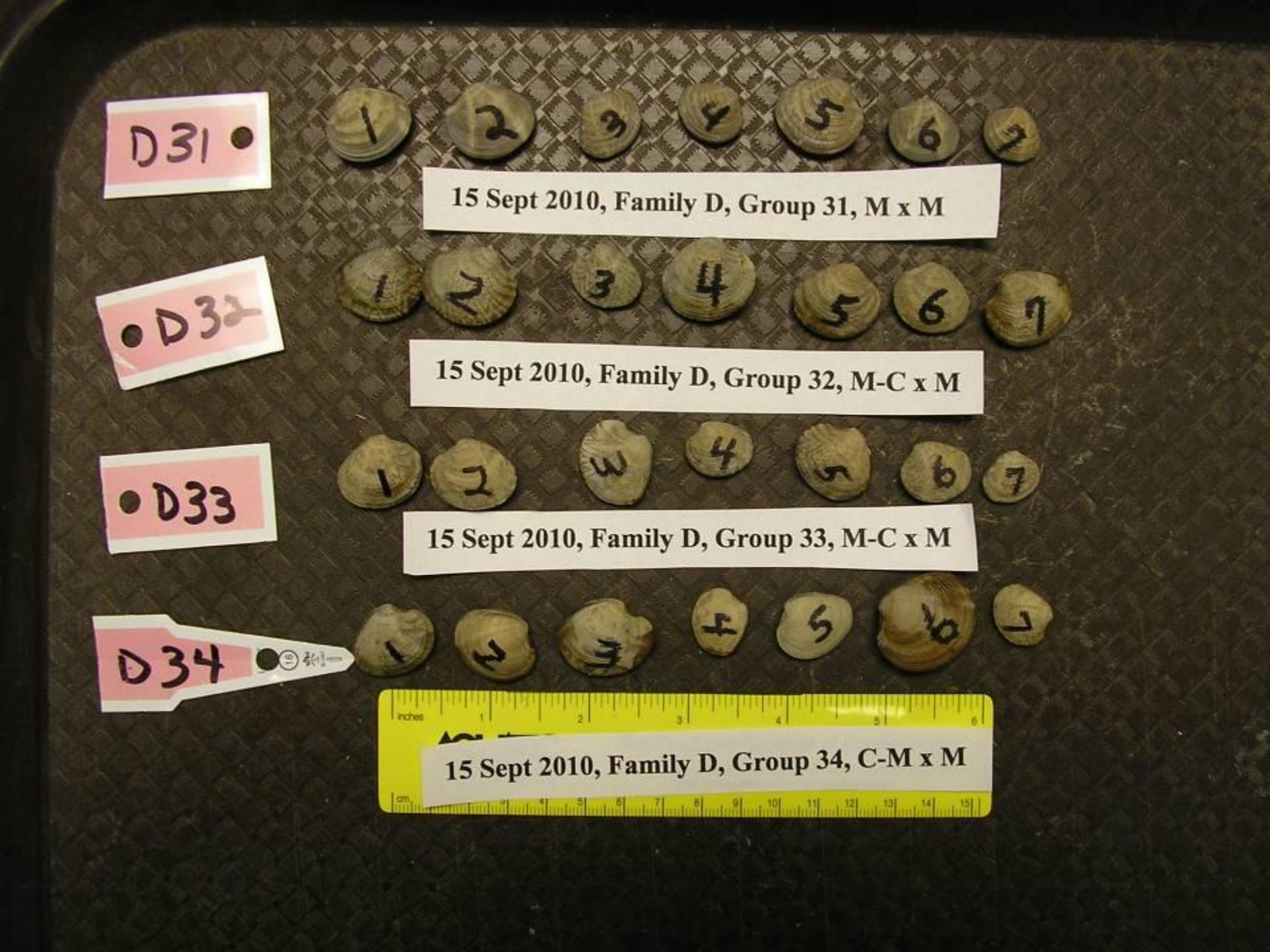
BACKCROSS

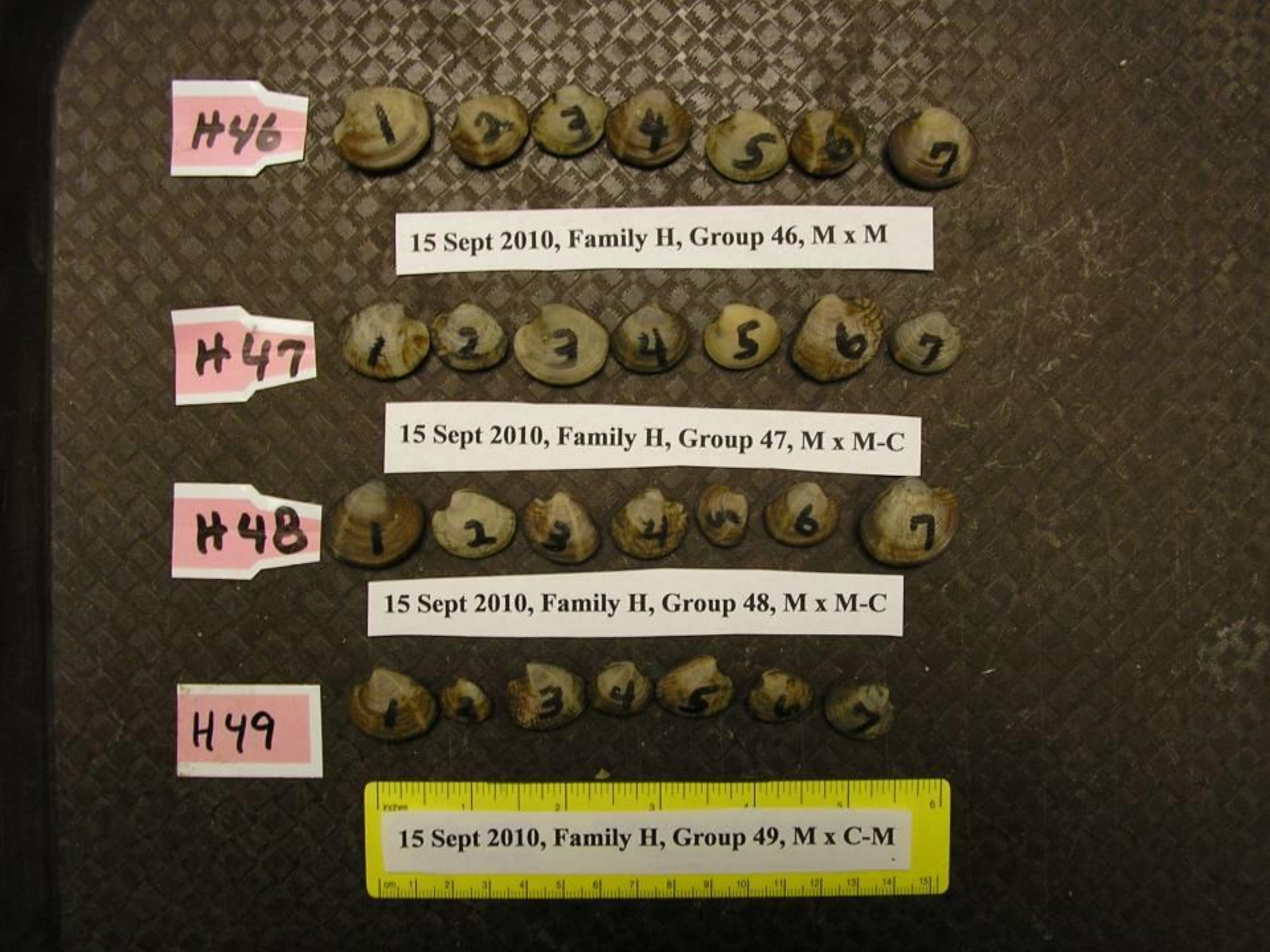
- Mating of a hybrid with one of its parents (or parental species).
- Hybrid (MxC or CxM) backcrossed to MxM (as female or male).
- Objective: Reduce gapping, but maintain improved growth and survival.

BACKCROSS

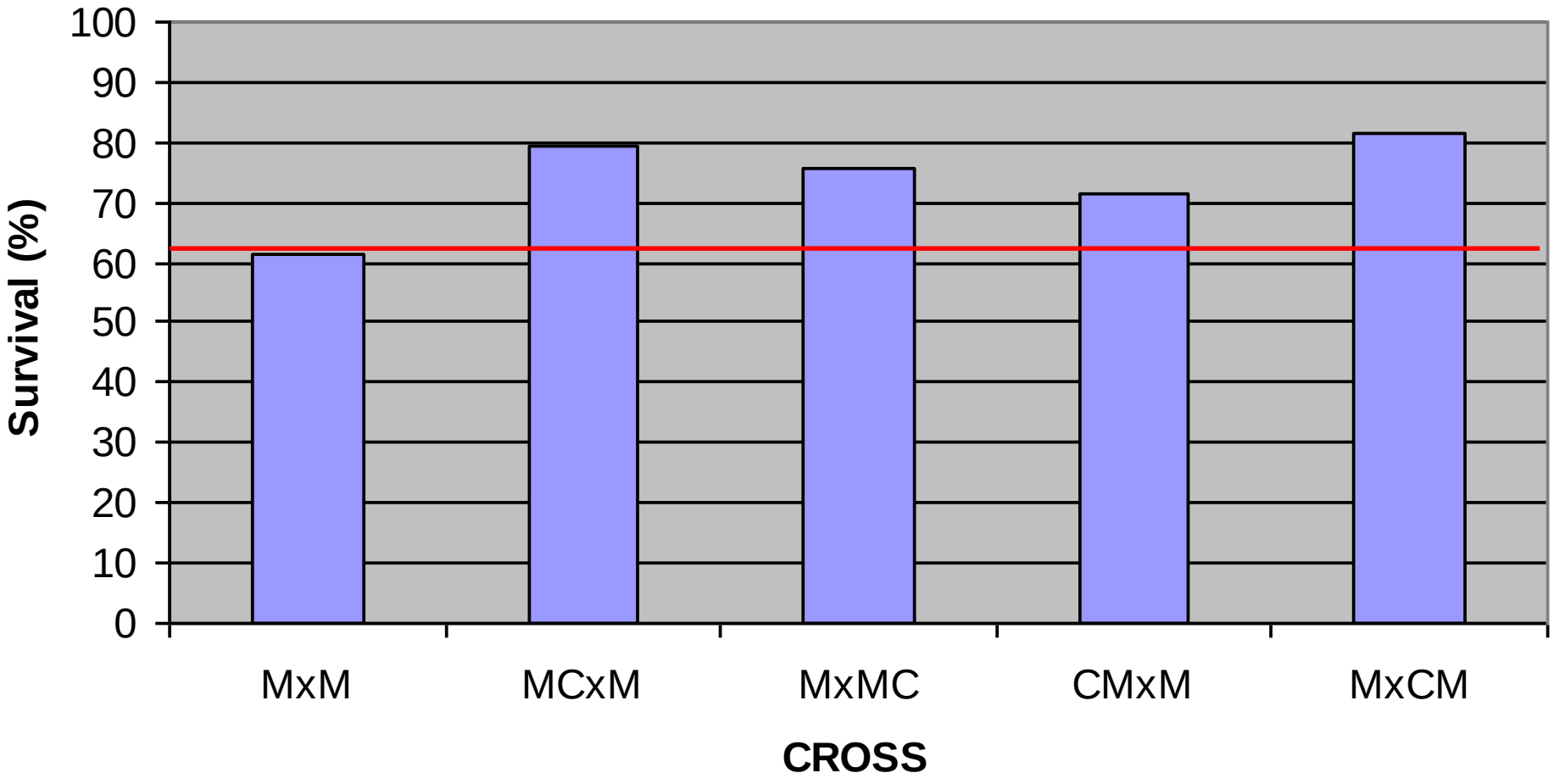
- Pure M.m. crossed with Hybrids (MxC or CxM).



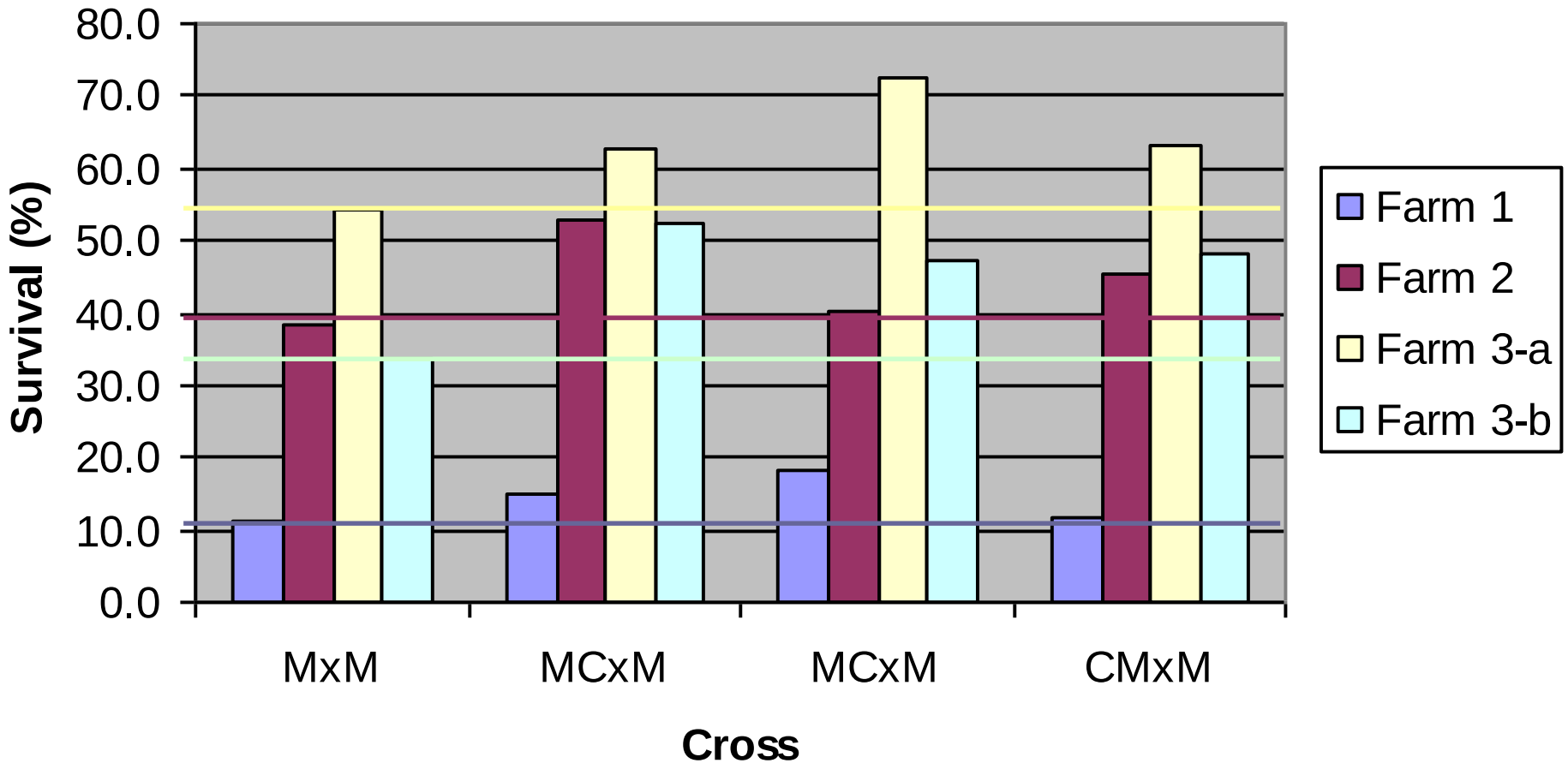

D31
15 Sept 2010, Family D, Group 31, M x M
D32
15 Sept 2010, Family D, Group 32, M-C x M
D33
15 Sept 2010, Family D, Group 33, M-C x M
D34
15 Sept 2010, Family D, Group 34, C-M x M


H46
1
2
3
4
5
6
7
15 Sept 2010, Family H, Group 46, M x M
H47
1
2
3
4
5
6
7
15 Sept 2010, Family H, Group 47, M x M-C
H48
1
2
3
4
5
6
7
15 Sept 2010, Family H, Group 48, M x M-C
H49
1
2
3
4
5
6
7
15 Sept 2010, Family H, Group 49, M x C-M

Backcross Seed Survival (CK)



Backcross Seed Survival (IRL)



SUMMARY

- Genetic testing of parents is paramount for verification of species.
- Hybridization verified.
- Hatchery techniques modified for control of gamete collection.
- Culture techniques are similar.
- Backcross may indicate heterosis.
- Await growout results…

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