Tilapia genetic improvement:

achievements and future directions

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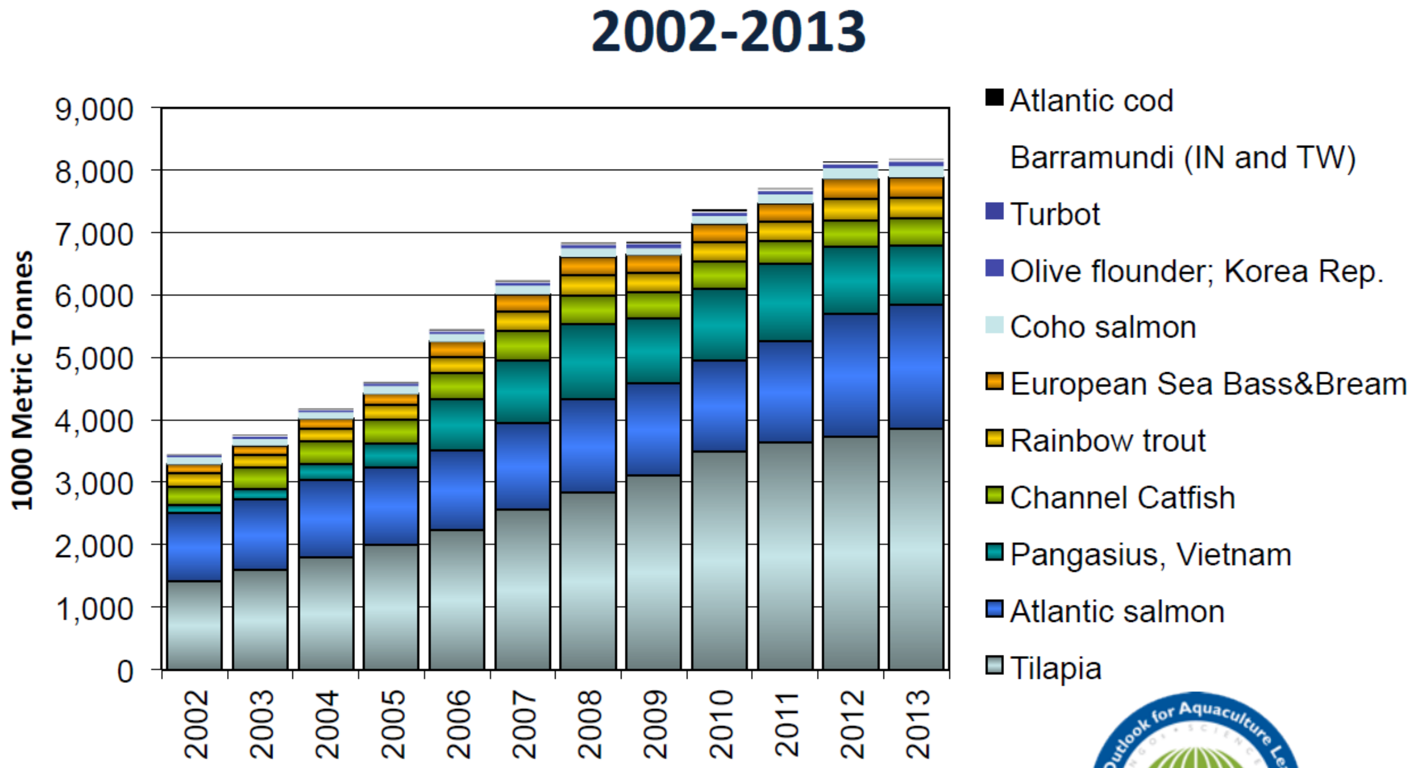
Nile tilapia: a fast growing herbivore

In 2012 the FAO listed world Nile Tilapia production at 3,5 million mt, valued at $5 billion USD.

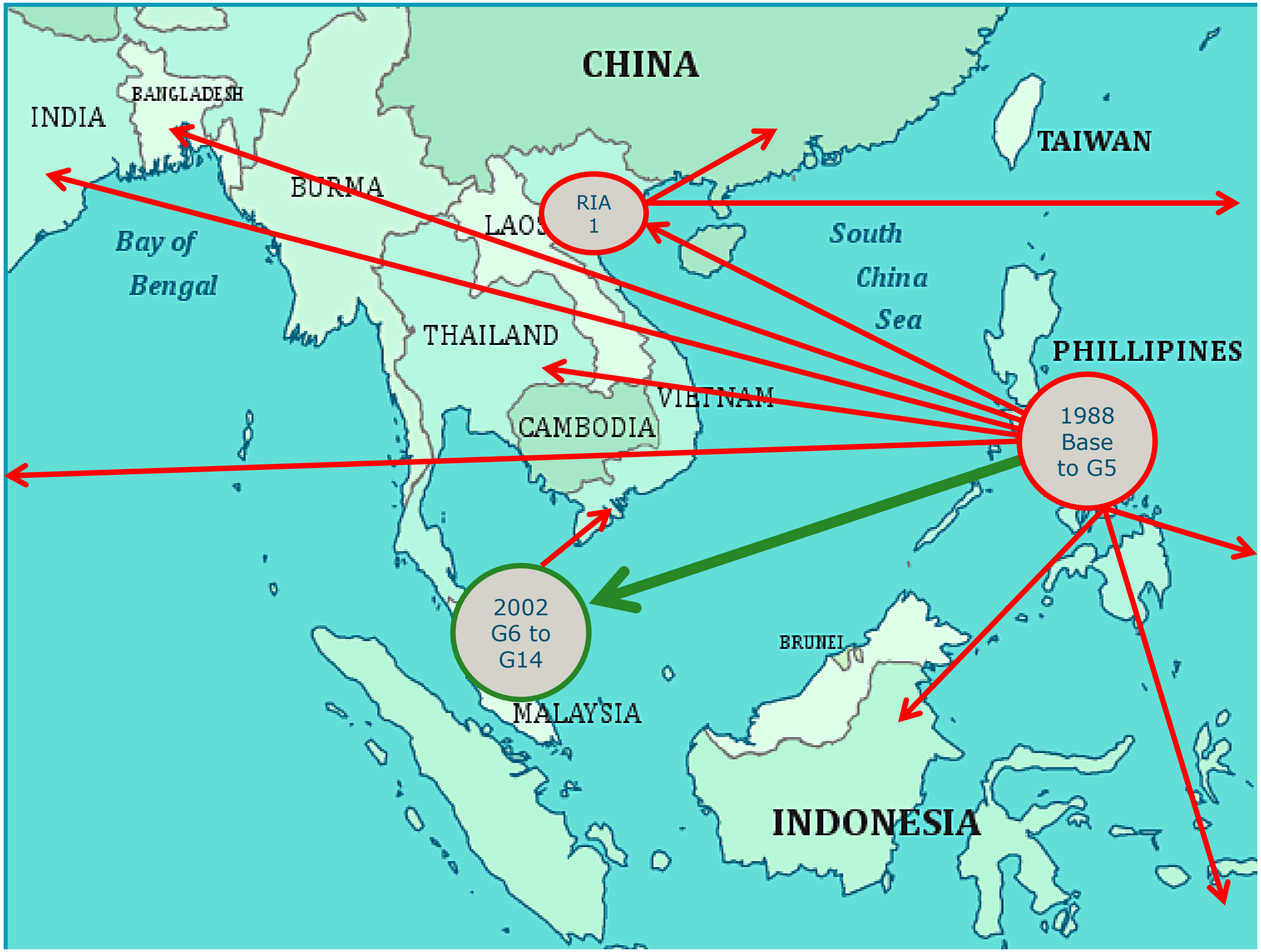


Breeding programs for Tilapia (all species)

	All programs	Family selection	
		Private	Public
China	16	5	2
Thailand	10	2 (3)	
Egypt	1		1
Mexico	9	3	
Brazil	6	5	1
Peru	2	2	
Colombia	6	1	
Ecuador	2	1	
Total	**52**	**19**	**4**

Source: www.inocap.no / year 2014

GIFT – a brief history



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Examples of commercial strains with ancient GIFT ‘heritage’

- Genomar supreme tilapia
- Spring genetics
- ProGift Hainan

Realized genetic gains in harvest weight

Strain	Avg Gain %/gen	reference
GIFT Base to G9[1)]	7-9	Khaw, 2008
GIFT G6 to G14 [2)]	12.5 ->5*	Khaw, 2010
ProGift Hainan G2 to G6 [2)]	13.2 ->5.3*	Thodesen, 2011
Nicanor G0-G3 [2)]	3.5	Gjerde, 2012
FaST G0 to G12 [2)]	12.9	Bolivar and Newkirk, 2002

1) Relative to unselected base (cryopreserved sperm)
2) Regression on EBV
*) reduction due to decreased selection intensity in later generations

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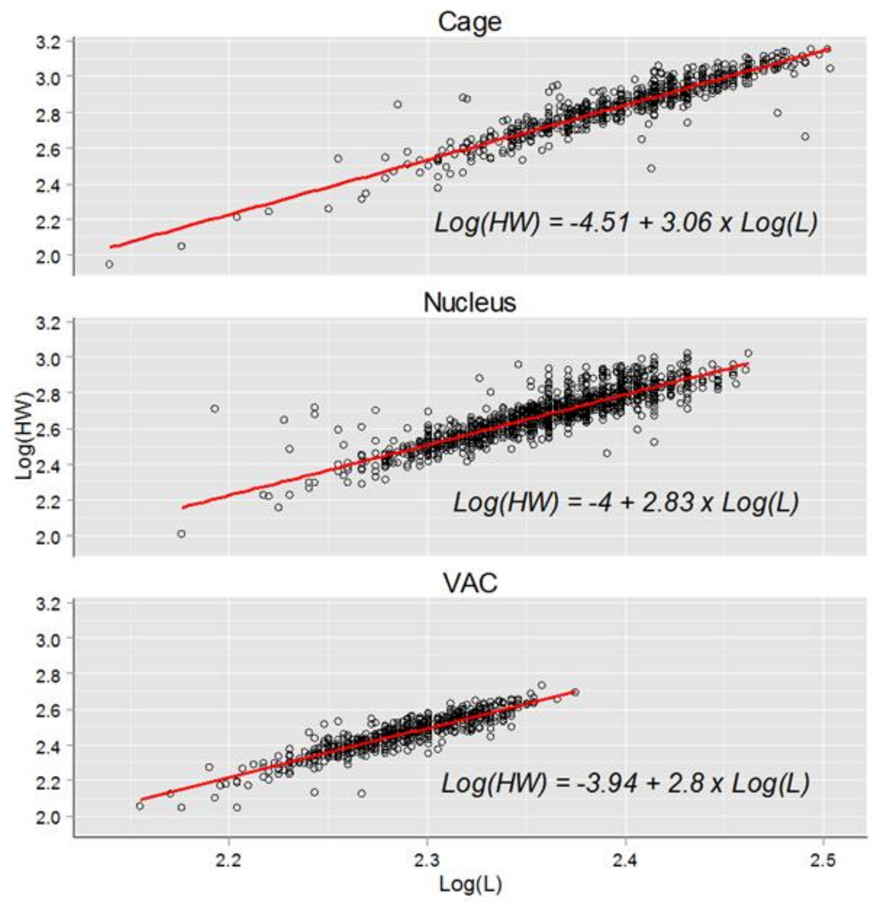
Benchmarking: growth rate

$$TGC = [(HW)^{0.33} - (SW)^{0.33}]/ T*days *100$$

i.e. $W \approx L^3$

TGC can be used to predict weight at given age and temperature

TGC can be used to compare performance across strains and environments



A comparison across strains

environment	TGC	Strain
Pond	1.56	Sagana, Base Pop+1, Kenya;
Cage	5.05	ProGIFT, G12, China
Pond	4.67	
Pond	3.11	GIFT G13, Vietnam
River cage	3.85	
RAS	4.46	G6 (Base AIT x GIFT)

30-35% protein diets

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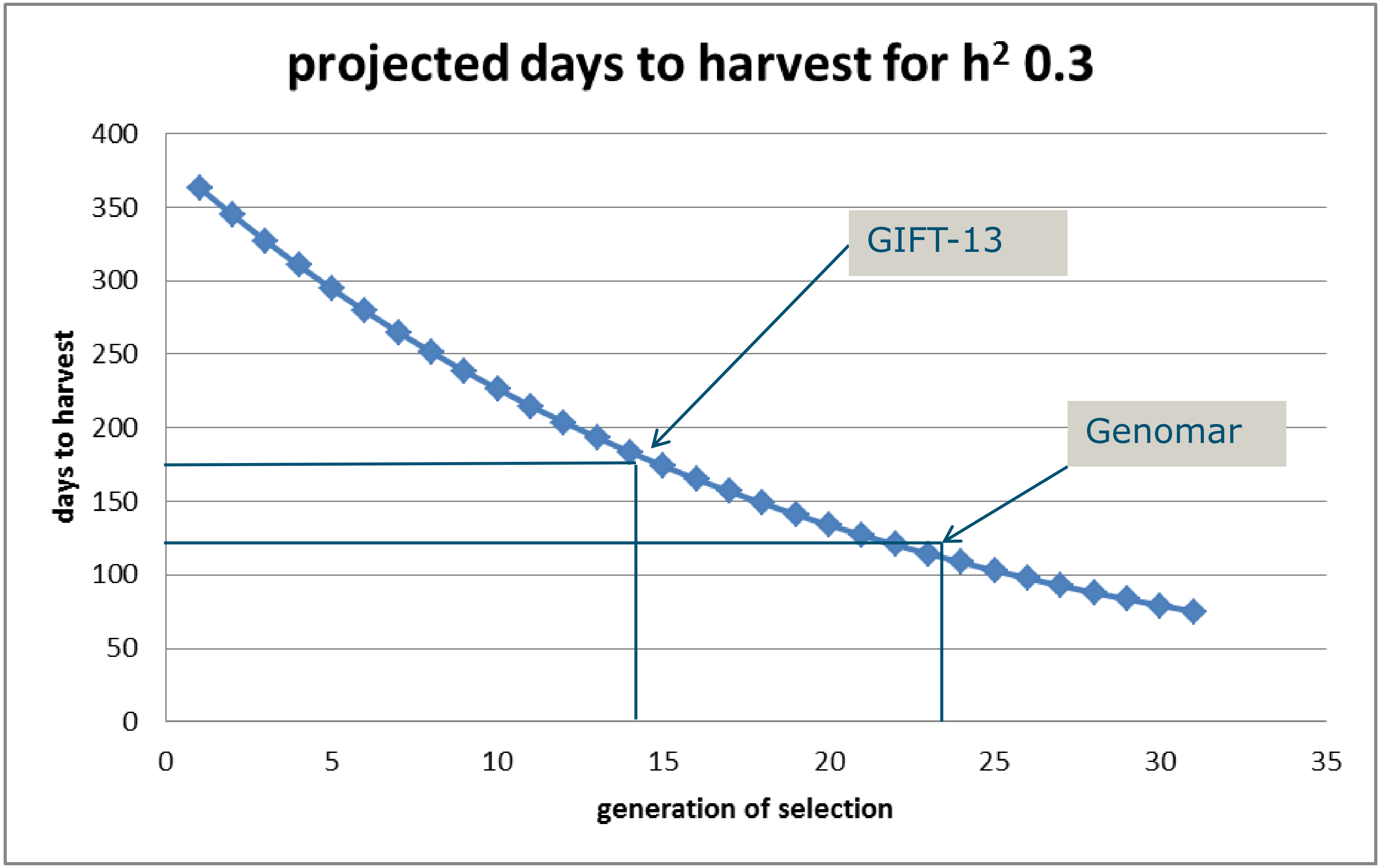
Reduction in grow-out time due to selection (days to 1 kg)



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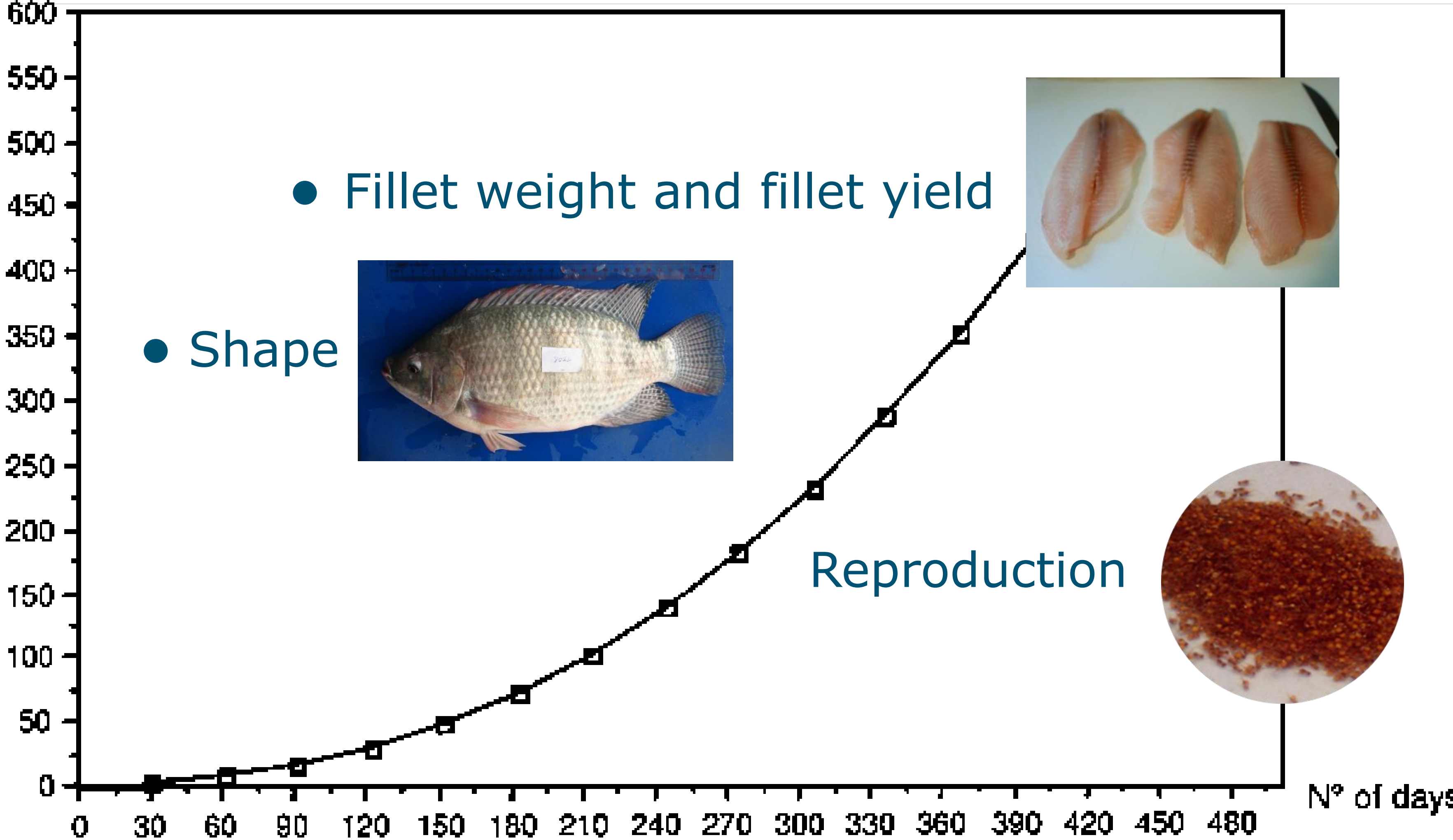
Correlated responses to selection

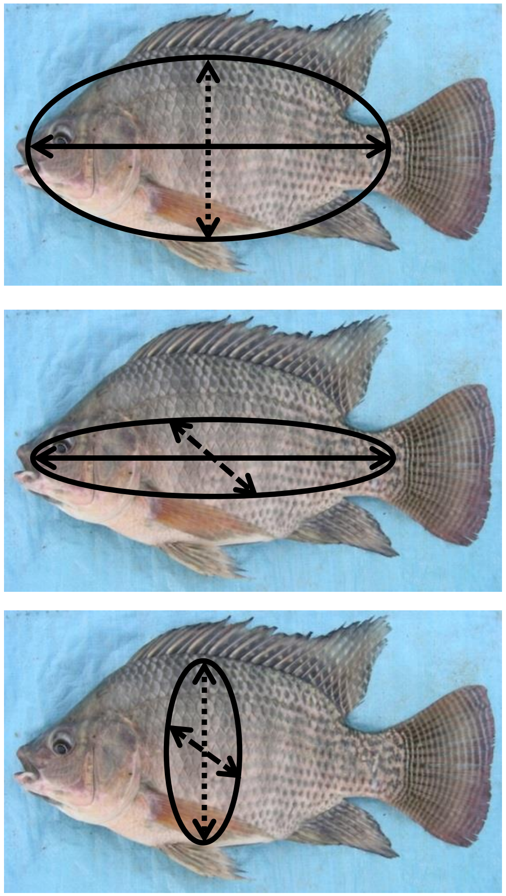
- Fillet weight and fillet yield
- Shape

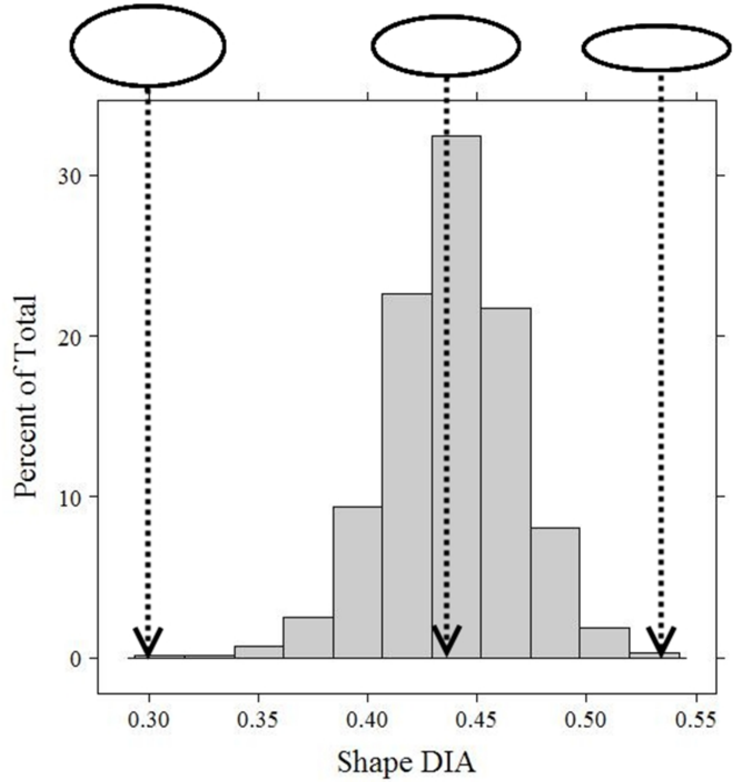
Reproduction



Shape and ellipticity

$$E_{L-H} = \frac{(L-H)}{(L+H)}$$





Blonk, Aquaculture 307, 6-10

Shape is a low-heritable trait with genetic correlation to growth

Trait	TGC	E_{L-H}	E_{L-T}	E_{H-T}
HW	0.94	0.47	–0.15	–0.42
TGC		0.15	–0.42	–0.52
E_{L-H}		**0.08**		
E_{L-T}			**0.14**	
E_{H-T}				**0.08**

Trong, Aquaculture 384-387, 119

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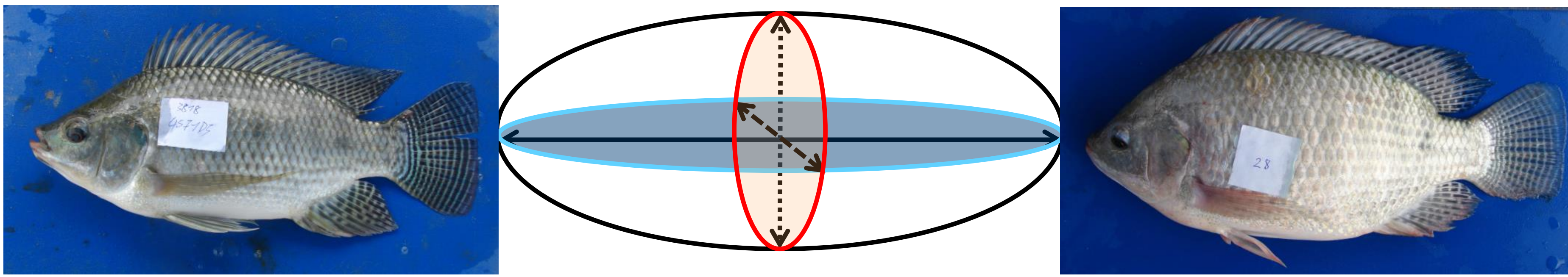
Fish selected for high growth rate become more round & thicker



Fillet weight and Fillet %

Fillet Weight		Fillet-%		ΔG F-%	reference
h^2	r_g HW	h^2	r_g HW		
0.24	0.99	0.12	0.74	-	Rutten, 2005
0.33	0.96	0.25	0.44	No reps.	Nguyen, 2010
0.16	0.99	0.06	0.21	0.28%	Gjerde, 2012
0.30	-	0.17-0.23	0.09	0.3%	Thodesen, 2012

selection for harvest weight will increase fillet yield by correlated response

Maturity: correlations with HW

- Kronert, 1989: zero genetic correlation
- Longalong, 1999 (visual inspection)

Body weight records	Progeny group		Significance level (P)[a]
	LFM	HFM	
Stocking	4.06 ± 0.20	4.23 ± 0.15	ns
Intermediate recording			
Females	113.68 ± 4.81	125.82 ± 3.51	(0.0523)
Males	149.94 ± 6.47	151.62 ± 4.16	ns
Harvest			
Females	133.62 ± 4.61	139.41 ± 3.41	ns
Males	181.86 ± 7.75	204.94 ± 5.95	0.0269

- Charo-Karisa, 2007 (dissected gonads): 0.18 ± 0.24

Genetic correlations with HW: egg size and number

	NEGG 0.08	RFEC 0.05	EGGW 0.05	EGGD 0.05
HW	0.51 ± 0.29	–0.72 ± 0.14	–0.48 ± 0.41	–0.50 ± 0.64
NEGG		0.99 ± 0.01	–0.74 ± 0.50	–0.40 ± 0.52
RFEC			0.25 ± 0.51	–0.07 ± 0.81
EGGW				0.79 ± 0.60

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Summary-I

Phenotypic trends suggest considerable improvement in growth rate

- Correlated response in
  - fillet yield small but positive
  - “age at maturity” probably zero
  - relative fecundity and egg size negative?

Future directions: the yield gap

Production efficiency

$$PE = \frac{\text{Total net weight gain at Harvest}}{\text{Total feed used or procured}}$$

loss from mortality due to

+ disease

+ handling/grading

+ escapes

+ predation

over entire production cycle.

Estimated mortalities (%) during grow-out from case studies

Egypt	**25-60**
Vietnam	**25-50**
Thailand	**35-50**
Bangladesh	**30**
Philippines	**40**

Courtesy: Krishen Rana

Overall Performance of Diets - FCR

	China	Thailand	Philippines	Egypt		Ghana	
System	Pond	Pond	Cages/pond	Cage	Pond	Cage	Pond
Comm. Feed	1.69	1.4-1.6	1.5 -1.7	1.3-1.7	1.4-1.9	1.2-1.4	1.8-2.3

- Irrespective of country or system PE in similar range
- Significant effort still devoted to nutritional quality/ formulations/substitutions
- What about genetics?

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Genotype by Environment interaction: Diet might be important

35% protein -> 3.8

Natural feed -> 2.2

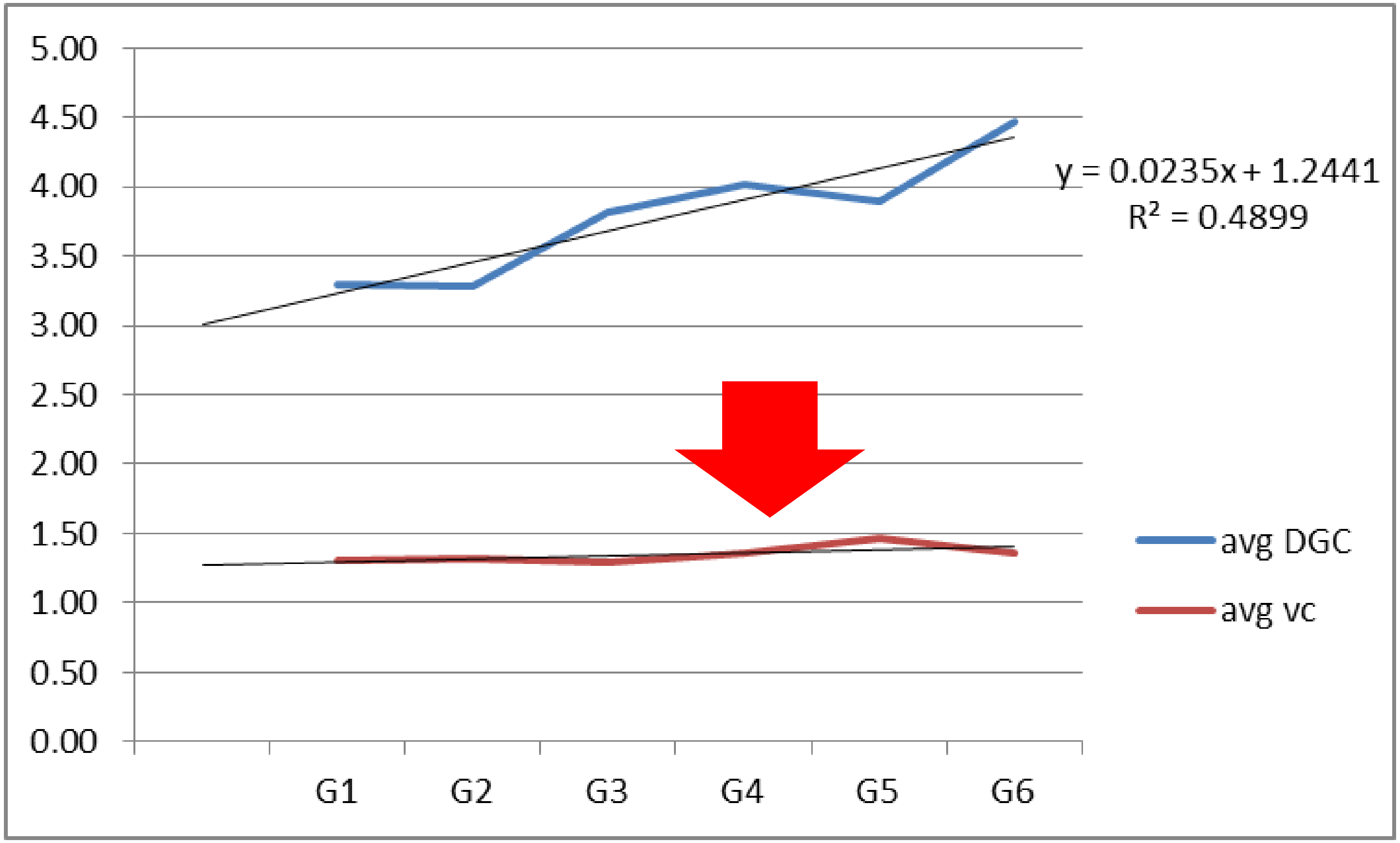
r_g HW: 0.7-0.9

heterogeneity of variance

GxE: mixed sex vs all-male (Kenya)

Parameter	Traits			
	HW	DGC	L	H
h^2	0.24 ± 0.07	0.32 ± 0.07	0.16 ± 0.04	0.12 ± 0.02
r_A	0.74 ± 0.14	0.59 ± 0.10	0.77 ± 0.09	0.46 ± 0.09

Selection and feed efficiency....



Selection for growth (increased harvest weight) should be accompanied by evaluations on realized FCR

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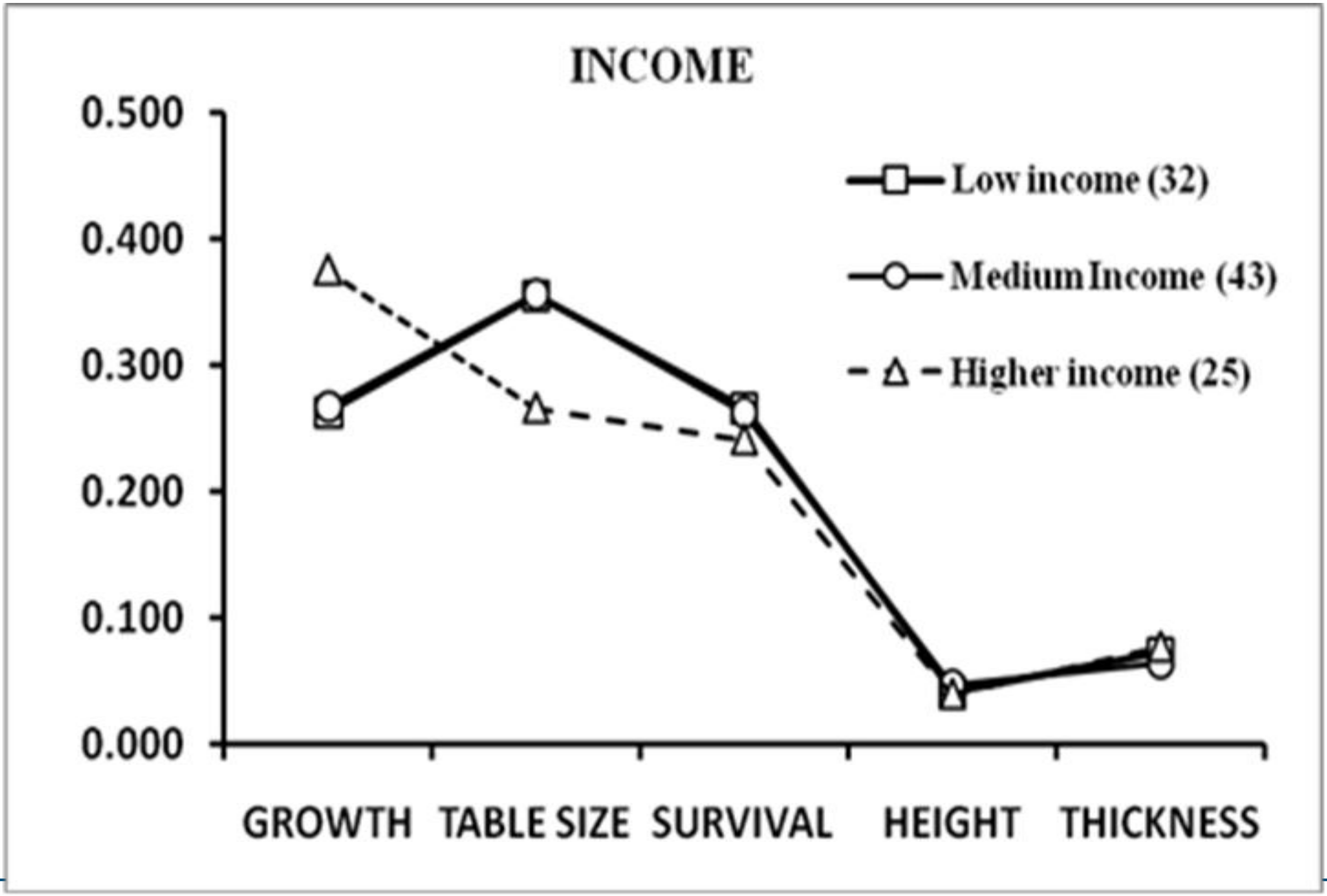
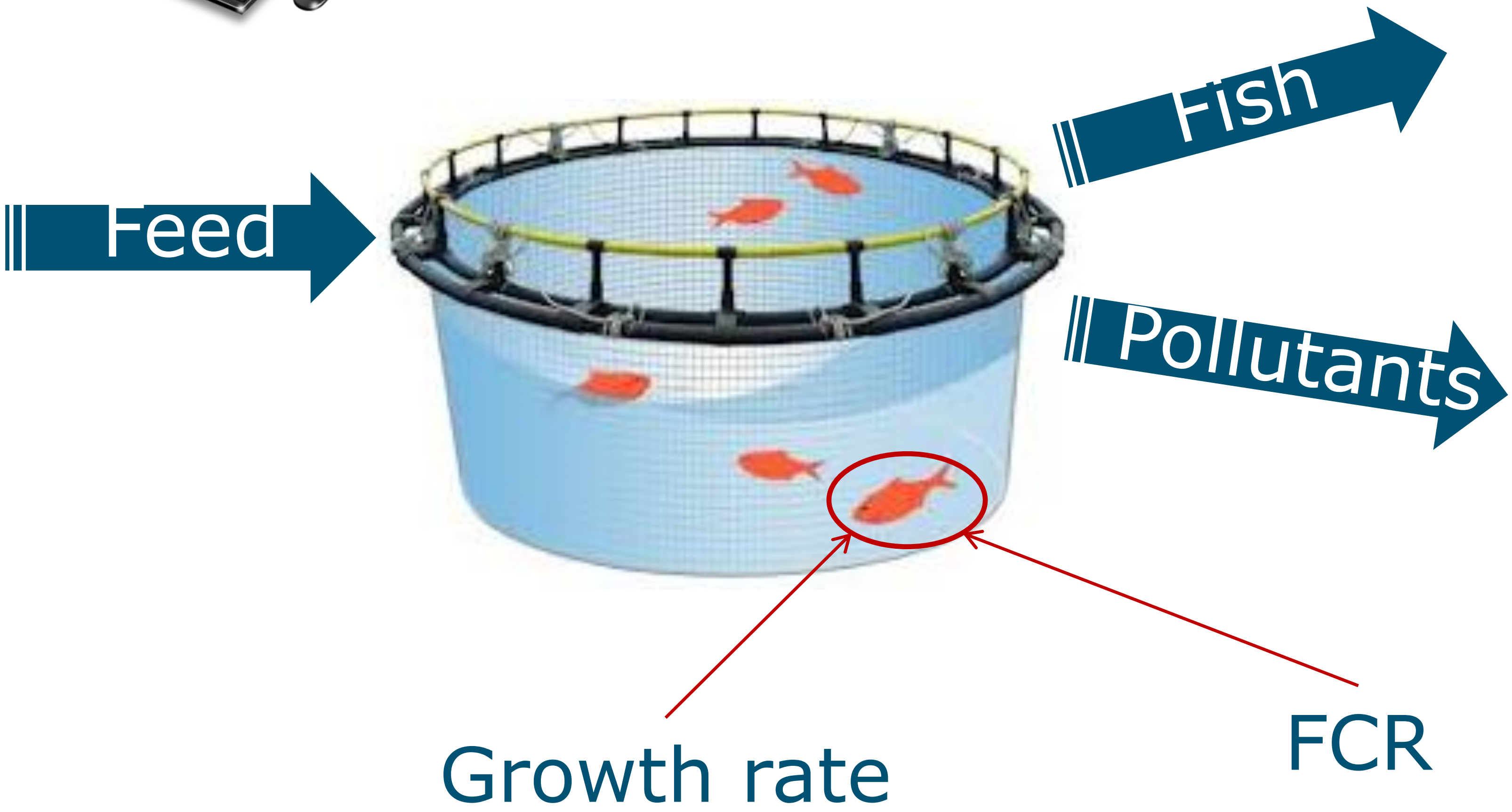
Harvest weight or Growth rate:

depends who you ask...



Bioeconomic model



Predicted economic values for growth rate

Limitation	RAS	Cage	Pond
Density	+	+	+
Farm quota		0	0
Nitrogen	0		0
O_2		0/+	0

Summary-II

- Impact in the field is lacking due to sub-optimal farming systems (high mortality) and low economic value for harvest weight

- Bio-economic analysis can help to understand the yield gap

- Selective breeding programs for tilapia need to focus on production efficiency

Thank you for your attention

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