Comparisons of Reproductive Parameters Among Improved Strains of Nile Tilapia *Oreochromis niloticus* L.

Graham C. Mair
Sukonta Lakapunrat
Wilson L. Jere
Amrit Bart

Aquaculture & Aquatic Resources Mngt.
The Asian Institute of Technology,
Bangkok, Thailand

Context

- *A number of improved lines of tilapia have been developed through selective breeding*
- *Mainly focusing on growth in extensive and semi-intensive systems*
- *Correlated response to selection in reproductive traits might be expected in selection for growth*
  - *Time of maturation*
  - *Fecundity*
  - *Spawning frequency*
- *No studies on comparative reproductive traits of improved tilapia stocks*
- *No long term studies on breeding patterns in tilapia*

Overall Objective

To compare the initial growth, maturation and reproductive performance of three selectively improved Nile tilapia strains (GIFT, Fishgen-selected & Philippine - Selected) and one locally adapted strain (Chitralada) in low input pond systems

Specific objectives

1. To compare the growth rates of strains during grow out in fertilized pond systems (separate and communal stocking)
2. To evaluate traits of sexual maturation during initial grow-out
3. To evaluate initial reproductive parameters of broodstock following maturation
4. To carry out long term evaluation of comparative reproductive performance of the four strains

The Strains

- ***Chitralada***
  - *Introduced to Thailand from Japan in 1965*
  - *Until recently was almost ubiquitous in Thai aquaculture. Considered good performer*
  - *AIT maintained strain in isolation for 18 years (~10 generations). Good N_e but no selection*
- ***GIFT (Genetically Improved Farmed Tilapia)***
  - *G7 from combined selection programme for growth (12-15% genetic gain per generation, cumulative gains of 85%) on a genetically variable base population derived from 8 accessions*
  - *Partially replaced Chitralada in Thai Aquaculture*
  - *Obtained from Philippines and distributed by Thai NAGRI*
  - *Anecdotal evidence for late maturation*

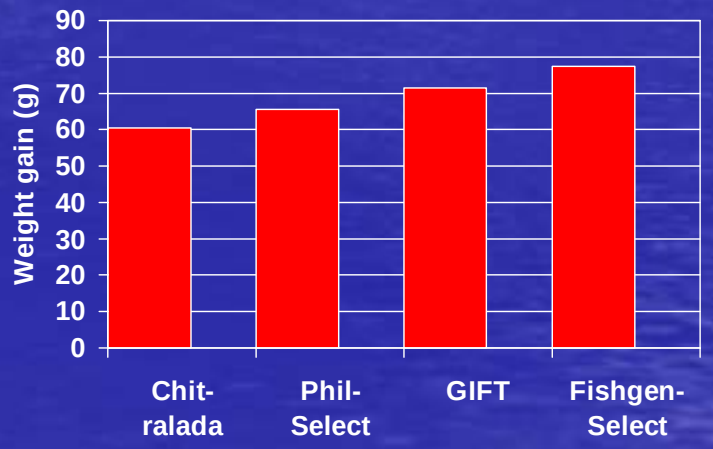
The Strains

- ***Fishgen-selected***
  - *Developed by Fishgen Ltd. (Philippines) as female line for crossing with YY males to produce GMT®*
  - *Three generations of within family selection for growth with genetic gains estimated at 18 – 50%*
  - *Not used in commercial production as stand alone strain*
  - *Broodstock obtained from Philippines via AIT*
- ***Philippine - selected***
  - *Developed by FAC (Philippines) known as IDRC or FAST*
  - *Basic within family selection for growth (rotational mating)*
  - *12^{th} generation broodstock obtained from the Philippines*
  - *Genetic gains of 3.6% per generation (cumulative gain ≈ 45%)*
  - *Some commercial production in the Philippines*

Summary of growth rate evaluations

- *Under replicated stocking (strains separate) in half ponds, no significant differences in sex ratio, survival or growth were observed*
- *The empirical ranking of weight gain among the strains was:*

  F-S > P-S > GIFT = Chit
- *Under communal stocking of marked fish there were no differences in survival or sex ratio but growth was ranked as follows:*
- *$F\text{-}S^{a} > GIFT^{a,b} > P\text{-}S^{b,c} > Chit^{c}$*
- *No significant differences in GSI between strains*

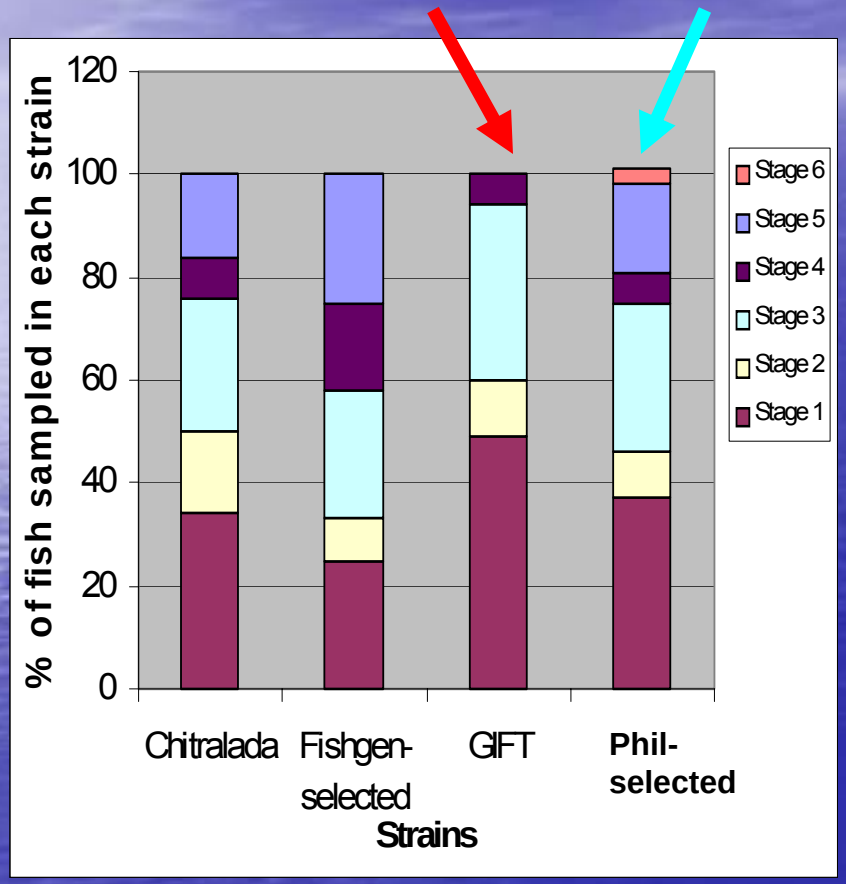


Staging of sexual maturation at harvest in males

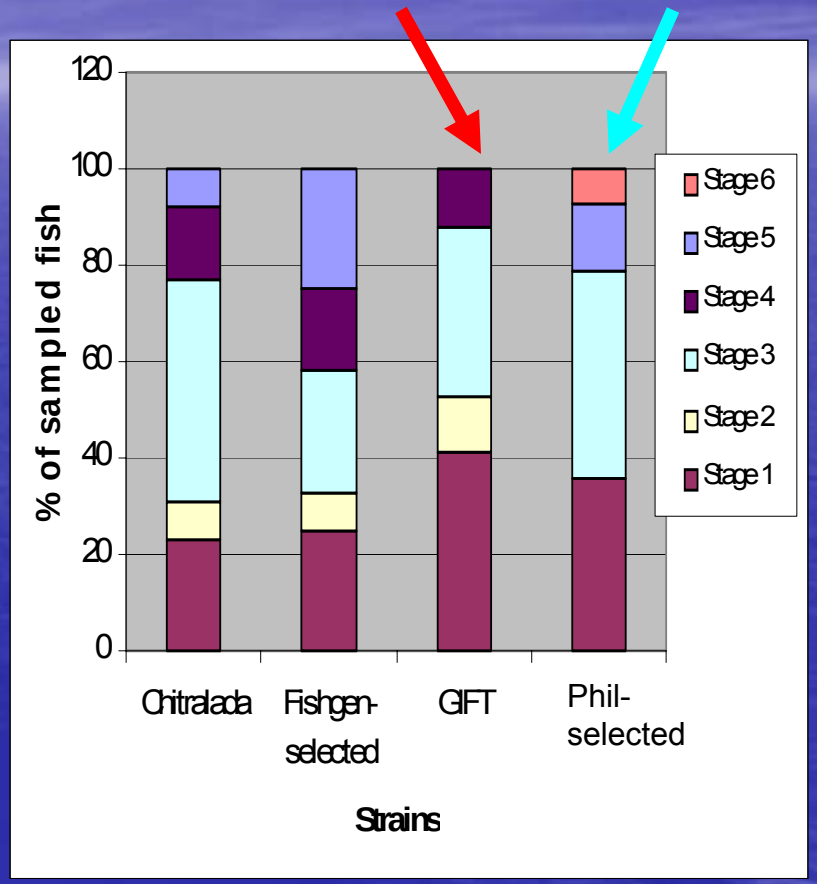
Maturity Stage (score)	Appearance of testis
1. Immature	Thread-like, colorless
2. Inactive	Translucent, wider than above
3. Inactive	Flesh color, still thin
4. Inactive - active	White/yellowish, thickened, no milt apparent when cut
5. Active - ripe	Cream colored, thick and enlarged
6. Ripe	Distended fully over length of visceral cavity, milt evident if testis cut
7. Ripe - running	White/silvery, milt runs freely under pressure

From Hörstgen-Schwark and Langhölz (1998)

Sexual maturation staging - males



Separate (119 days)



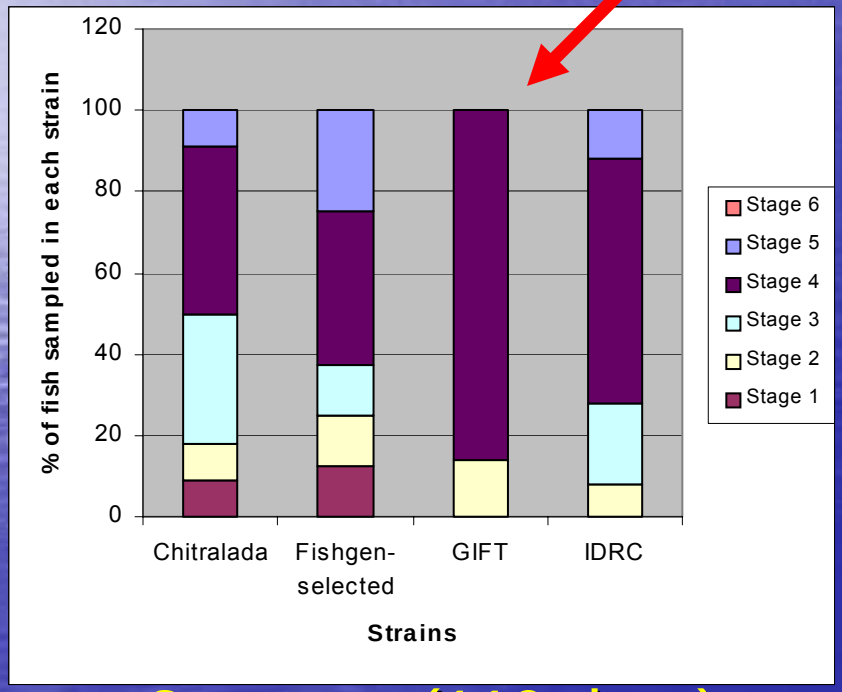
Communal (127 days)

Staging of sexual maturation at harvest in females

Maturity Stage (score)	Appearance of ovaries
1. Immature/inactive	No egg visible
2. Inactive-active	< 20 eggs visible, size < 0.2 mm
3. Active	> 20 eggs visible, size < 0.2 mm
4. Active - ripe	Eggs yellow, size 0.2 – 1.1 mm
5. Ripe-ripe running	Eggs yellow, size > 1.1 mm
6. Spent	Absorption of yolk material, egg white

Sexual maturation staging - females

GIFT later maturing?



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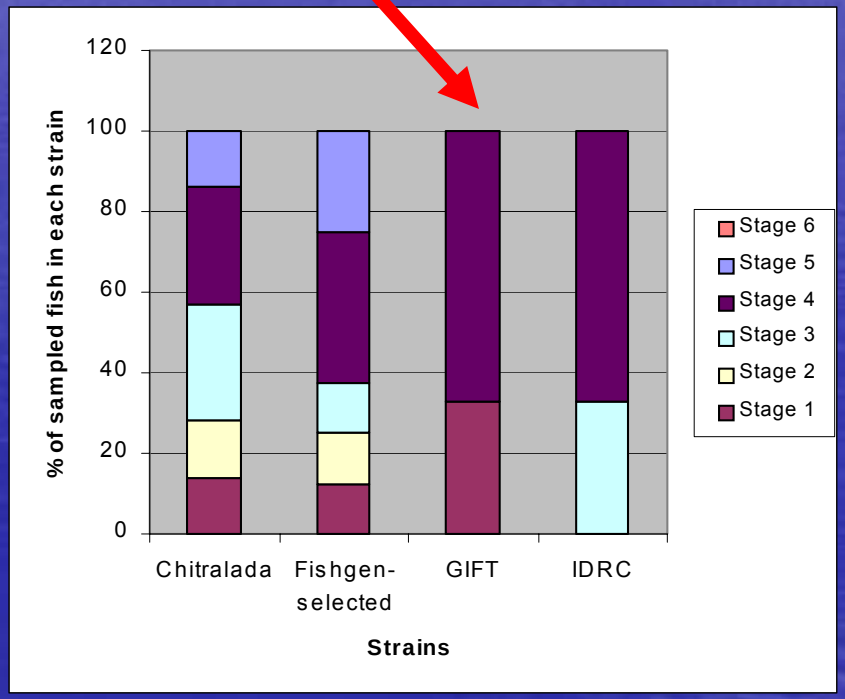


Communal (127 days)

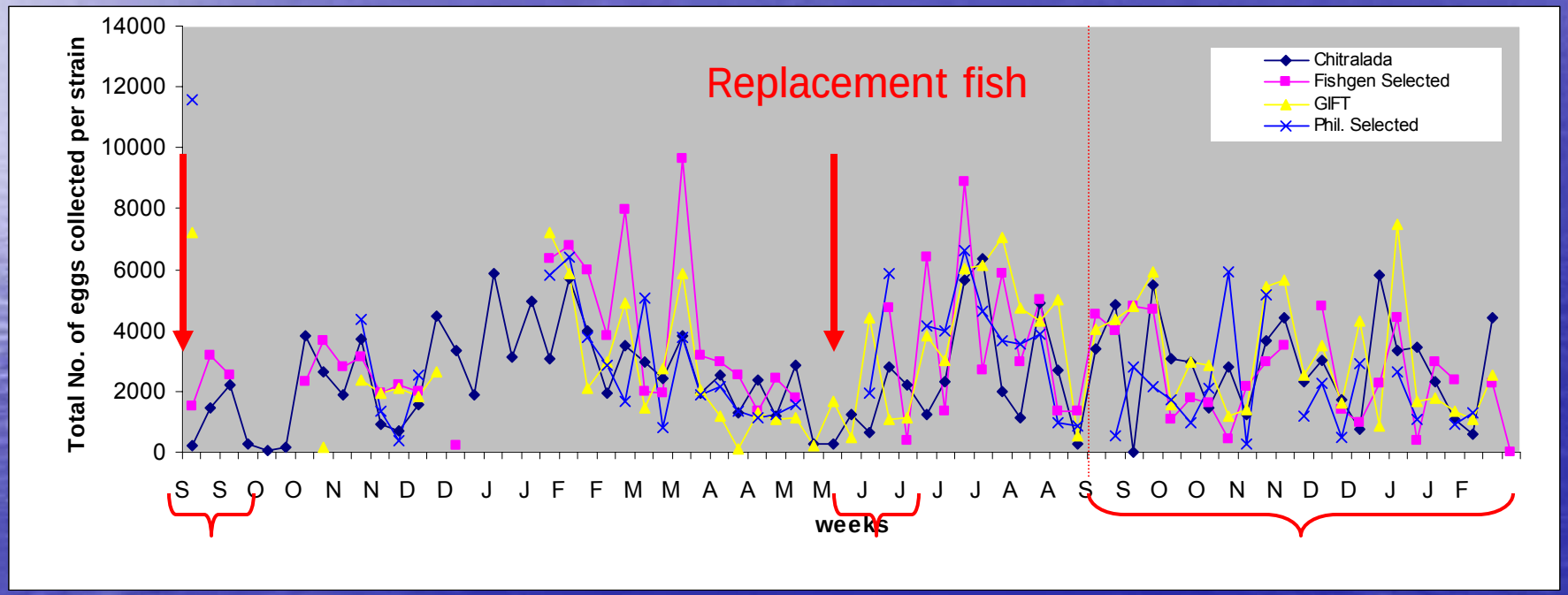
Comparative assessment of reproductive capacity

- *Fish from grow out phase were stocked in hapas for breeding @ 180 days old*
- *Four 5 m² hapas per strain*
- *15 females and 5 males per hapa*
- *Eggs/ collected every 7 days*

- *Spawned females weighed, PIT tagged and returned*
- *Eggs weighed, counted and staged*
- *Data collection continued long term (70 weeks)*

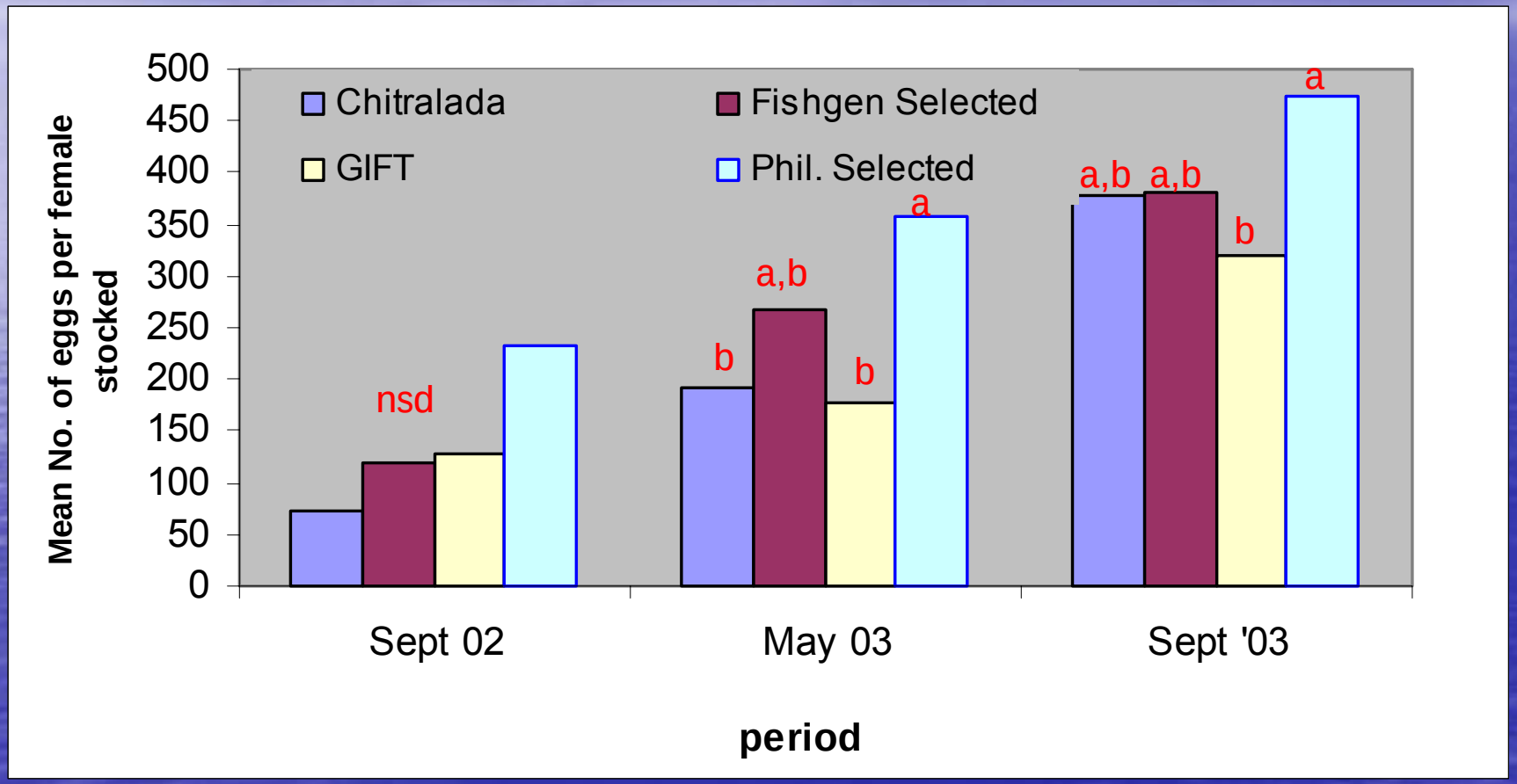
Summary egg/fry production – 13 months

Some problems with counting fish!

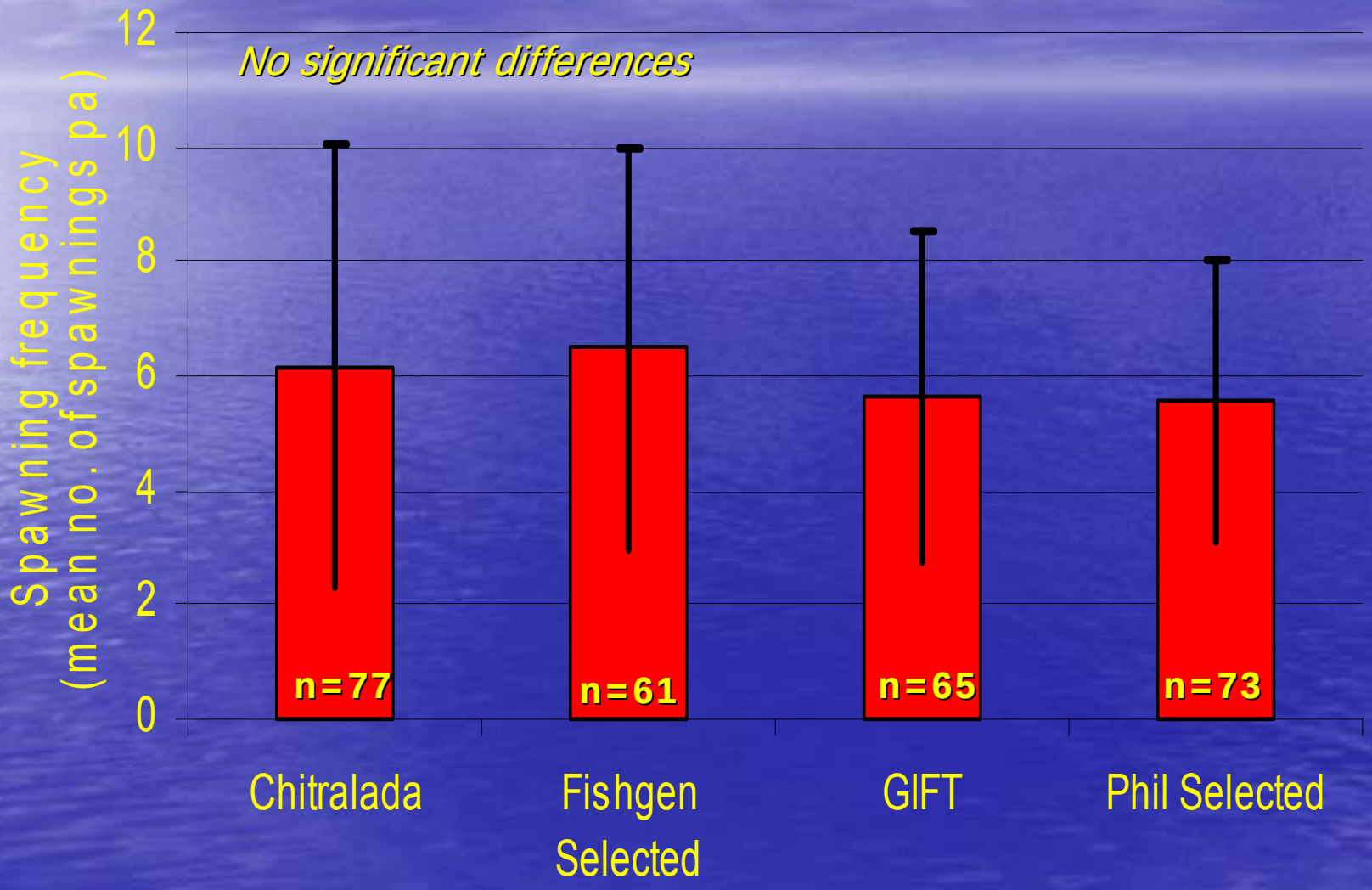


Spawning cycles of individual fish varied widely

Comparisons of overall egg/fry production *(when no. of females stocked known)*

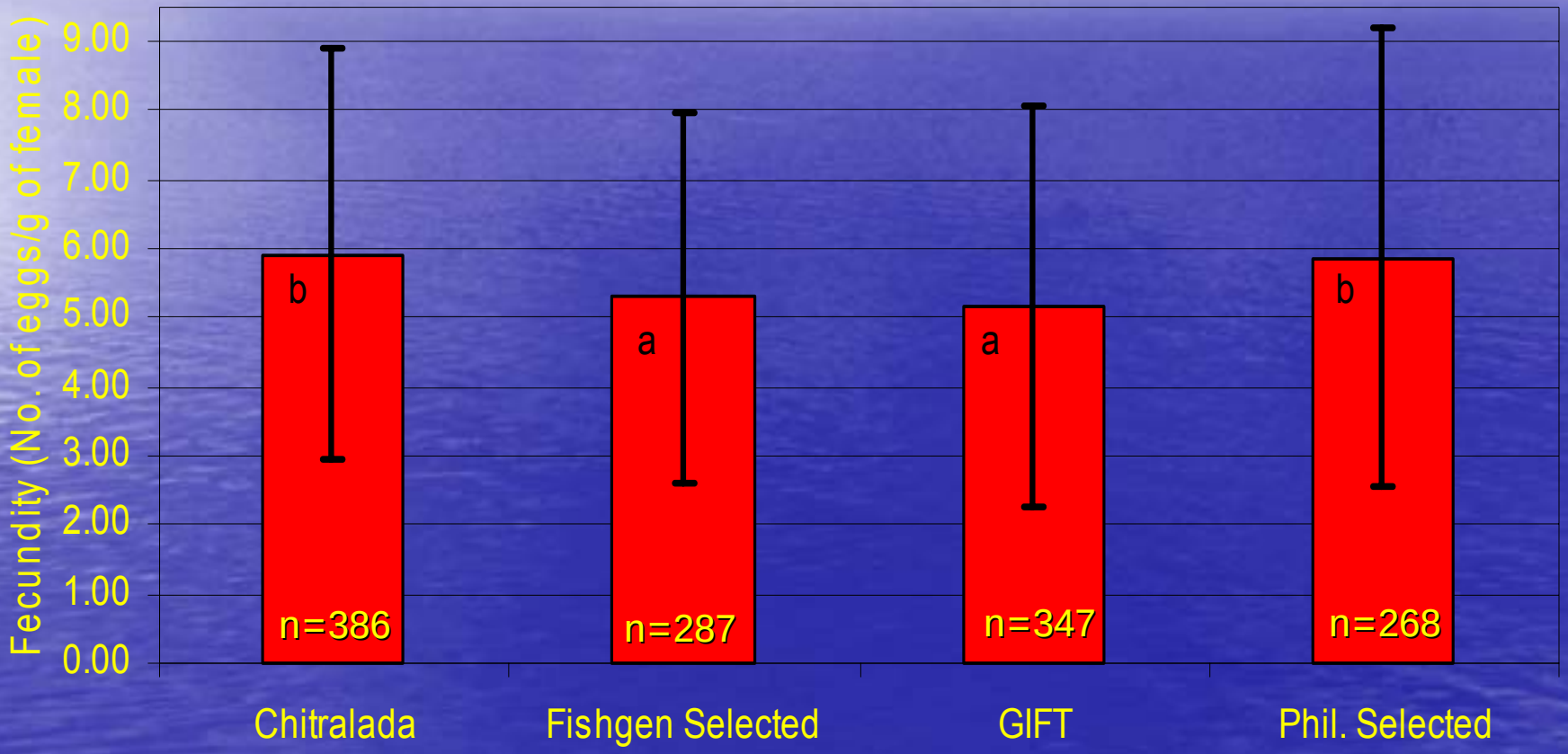


Spawning frequency for strains

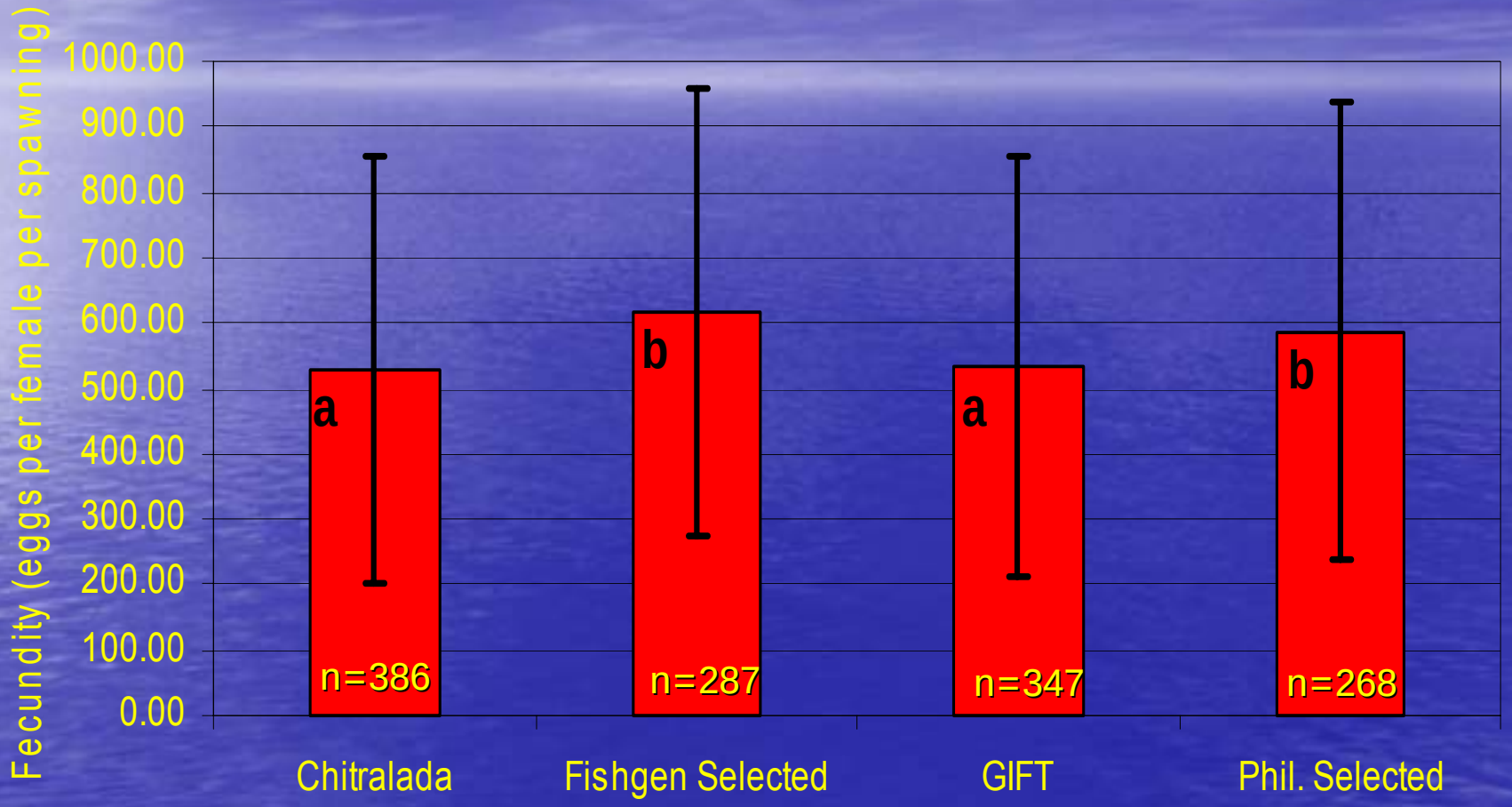


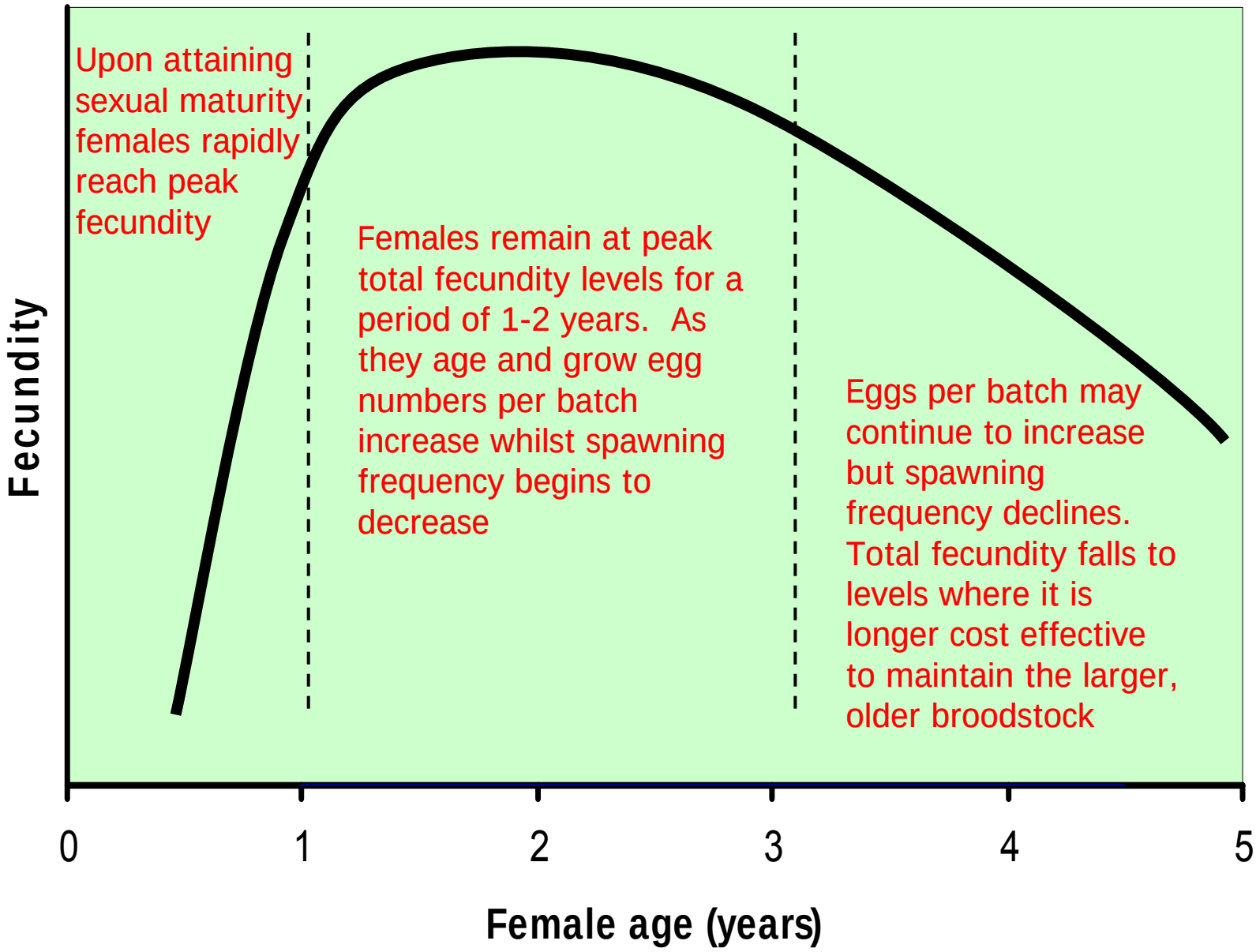
Comparative fecundity

(eggs per unit weight female per spawning)

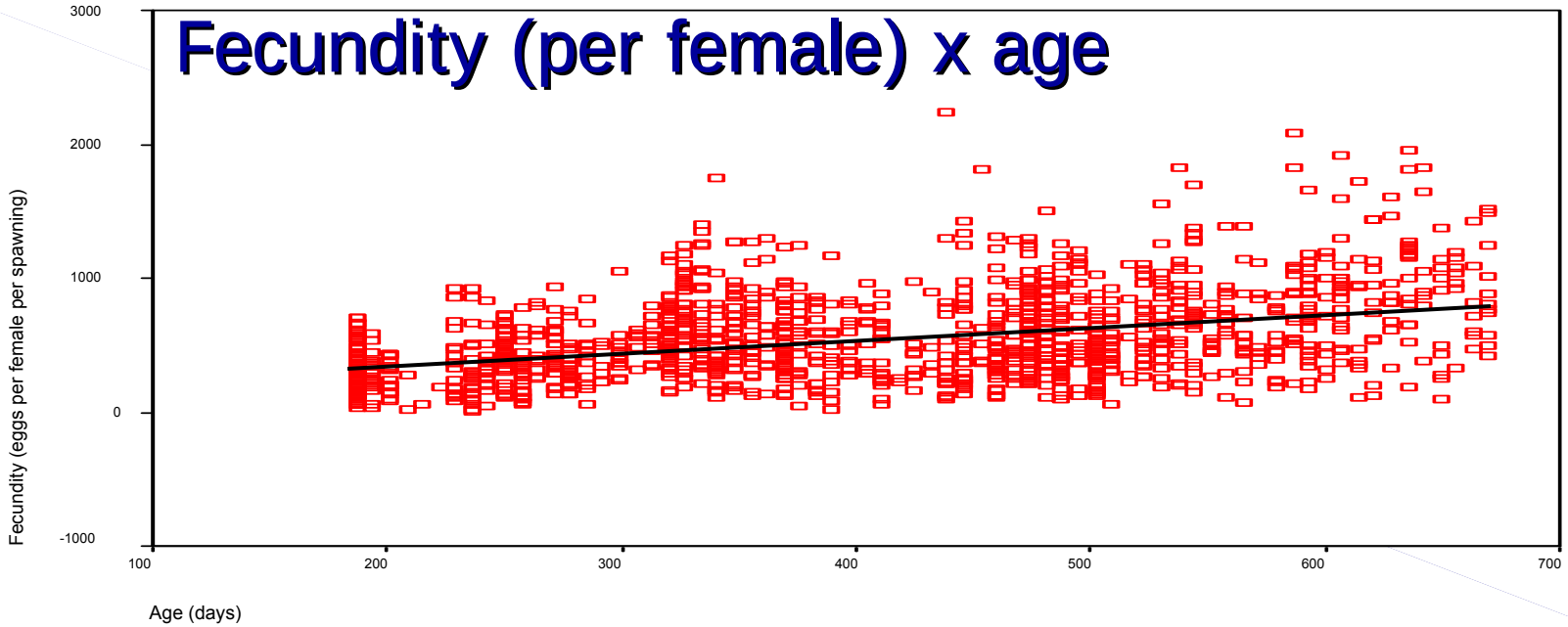


Comparative fecundity
(eggs per female per spawning)

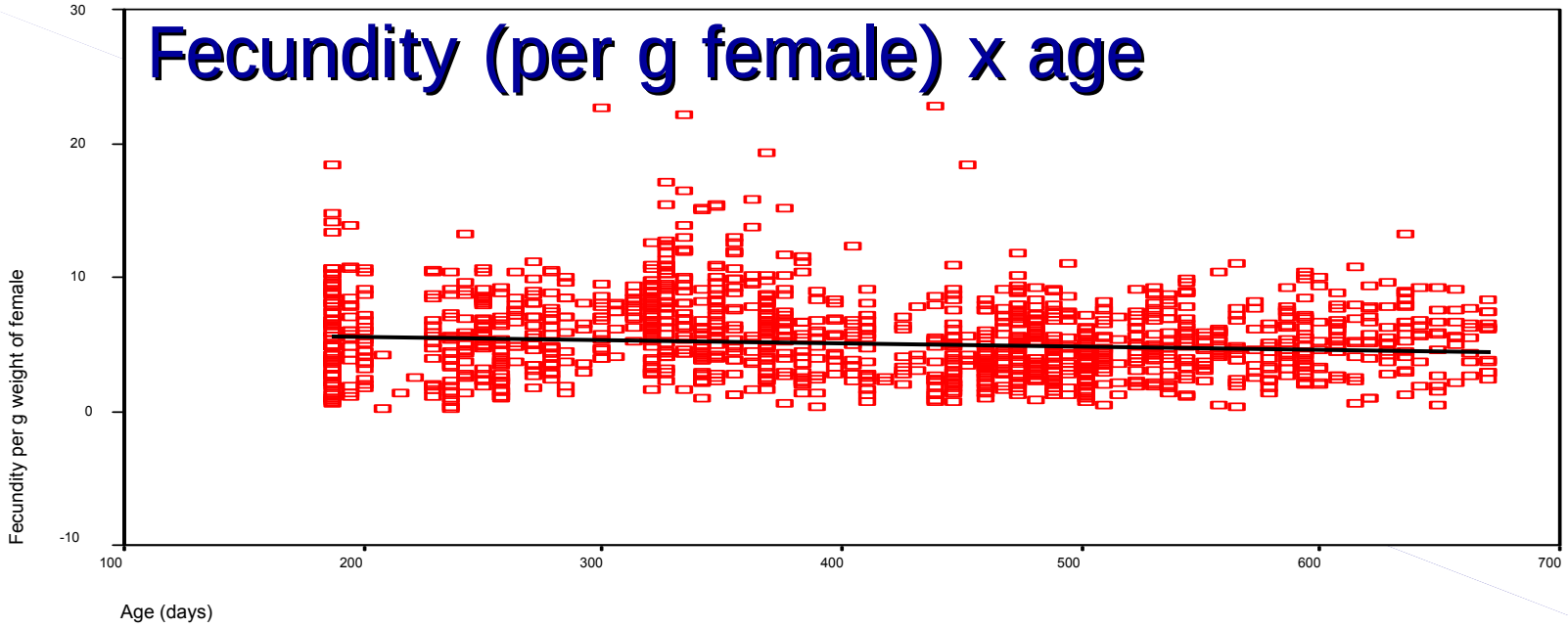



Upon attaining sexual maturity females rapidly reach peak fecundity
Females remain at peak total fecundity levels for a period of 1-2 years. As they age and grow egg numbers per batch increase whilst spawning frequency begins to decrease
Eggs per batch may continue to increase but spawning frequency declines. Total fecundity falls to levels where it is longer cost effective to maintain the larger, older broodstock
Fecundity
0
1
2
3
4
5
Female age (years)

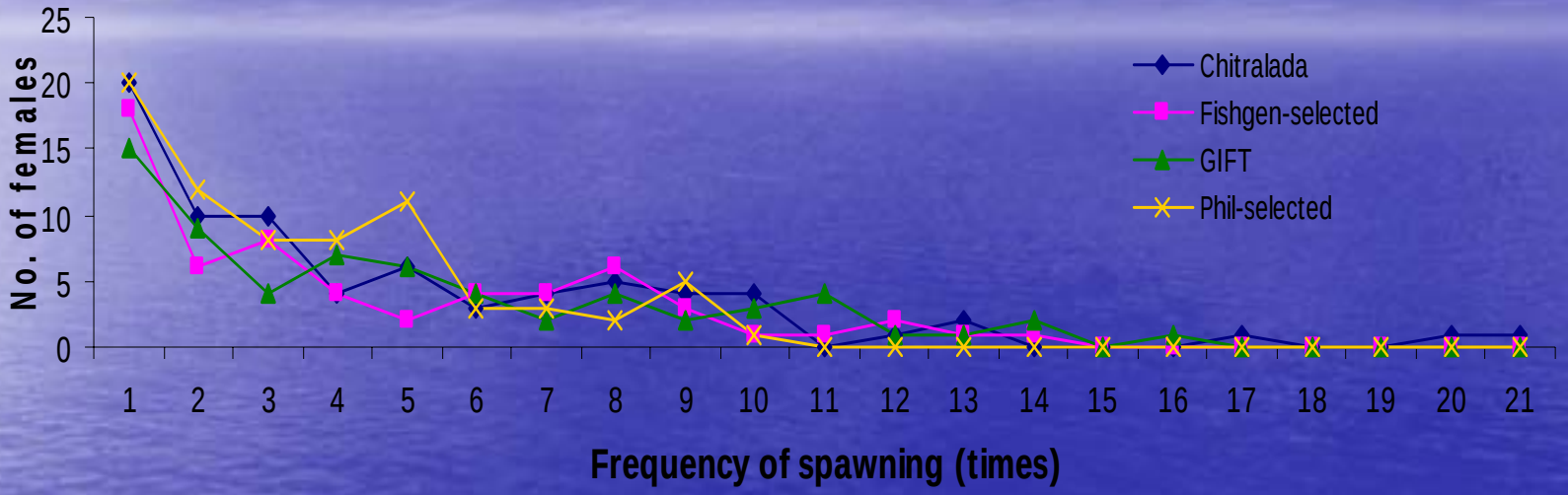
Fecundity (per female) x age



Fecundity (per g female) x age

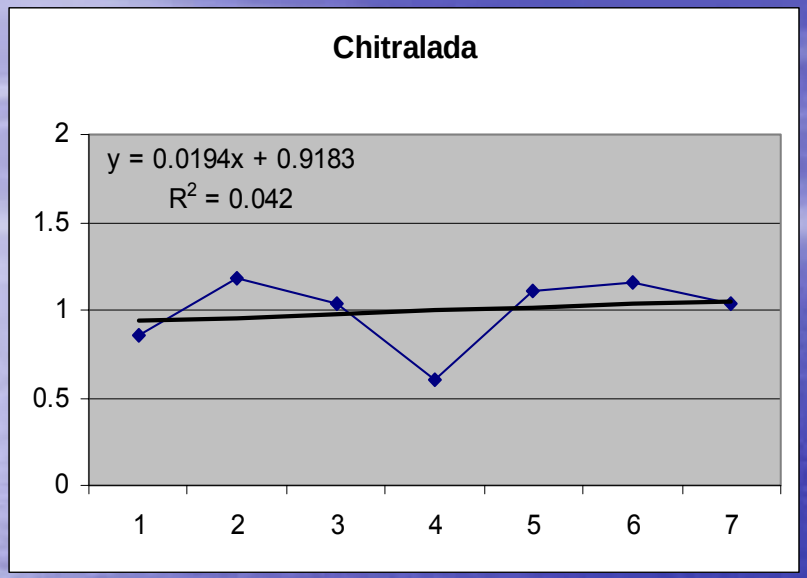


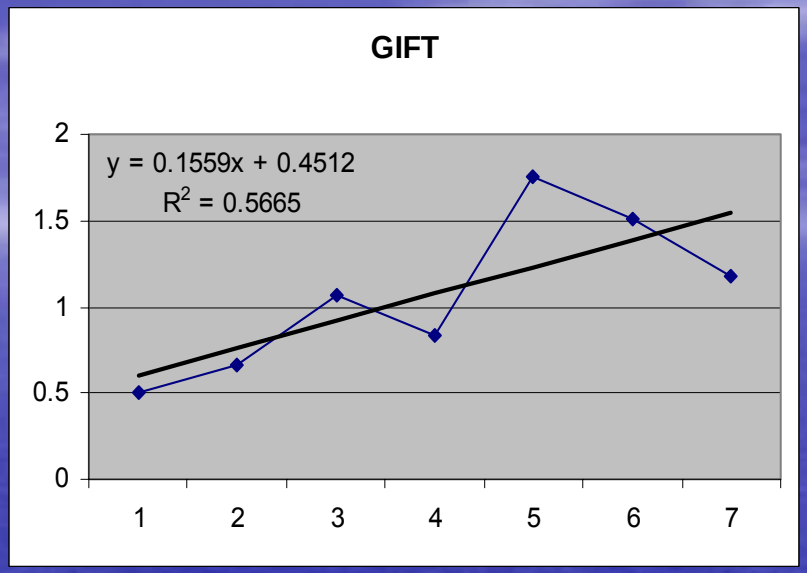
Spawning frequency of individuals

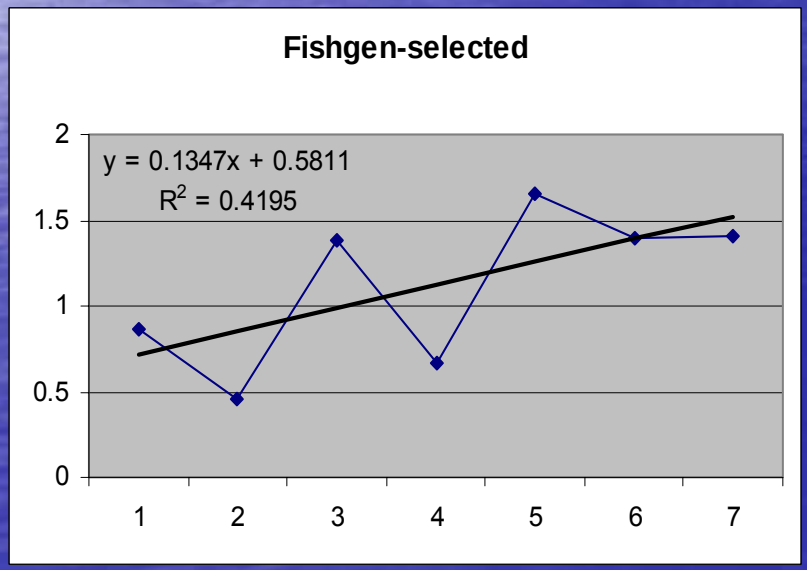


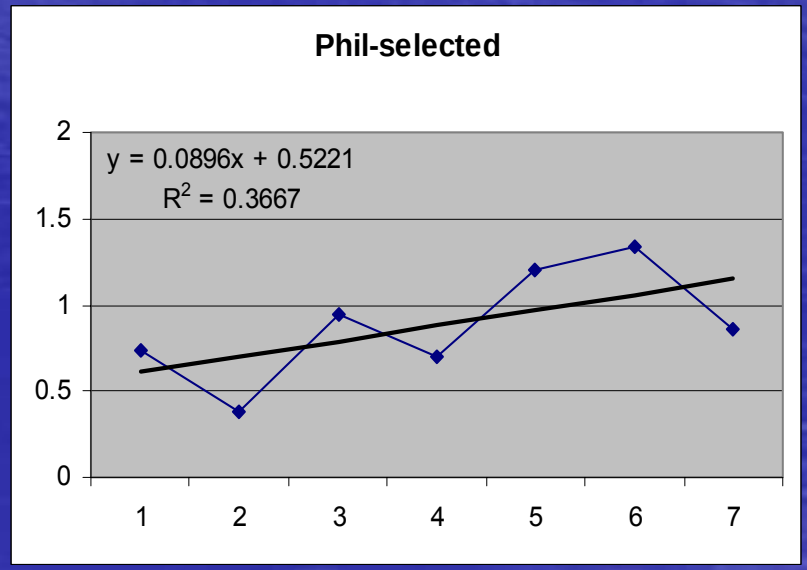
- *High variability between individuals*
- *Many different spawning patterns*
- *No indication that spawning frequency correlated with relative fecundity*

Spawning frequency over time



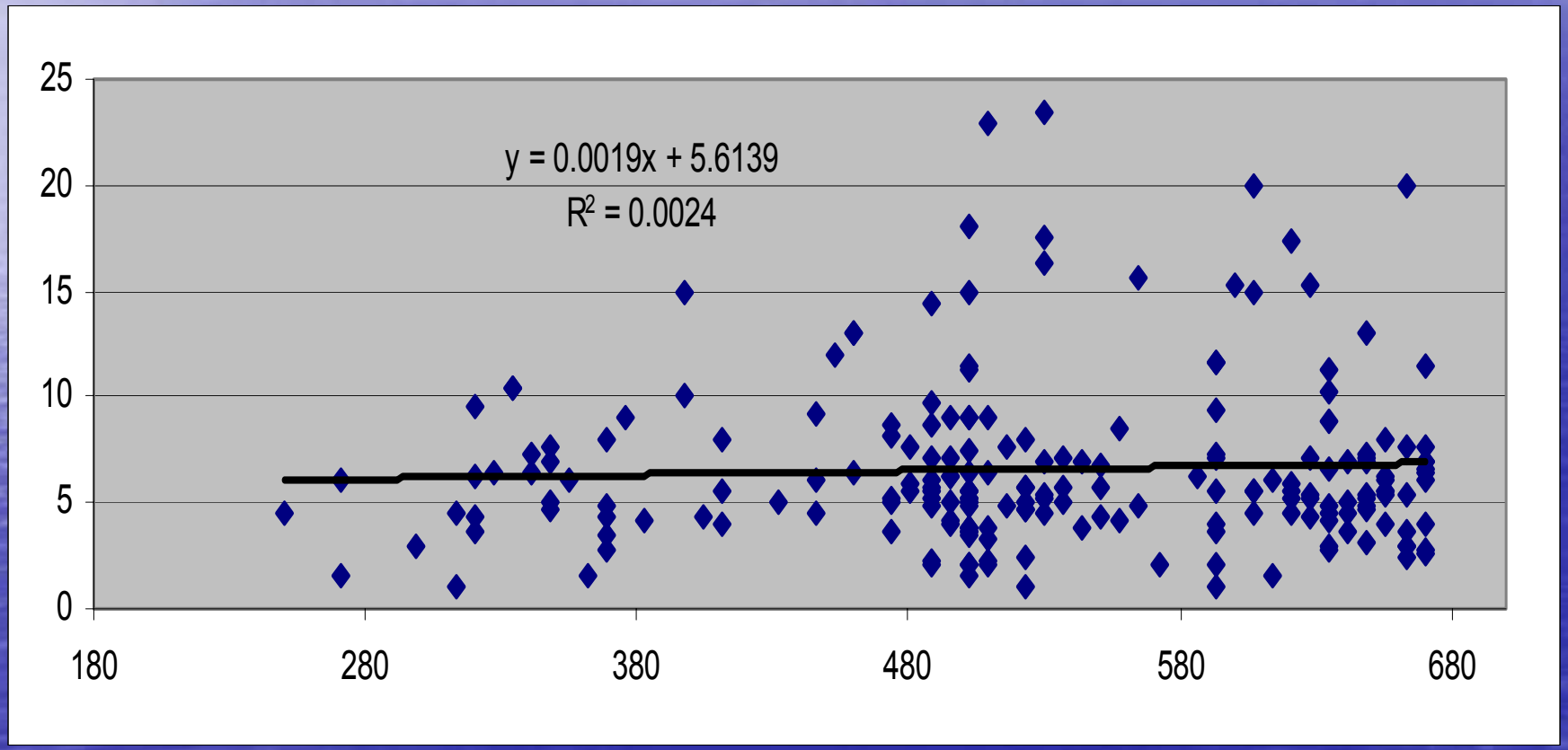




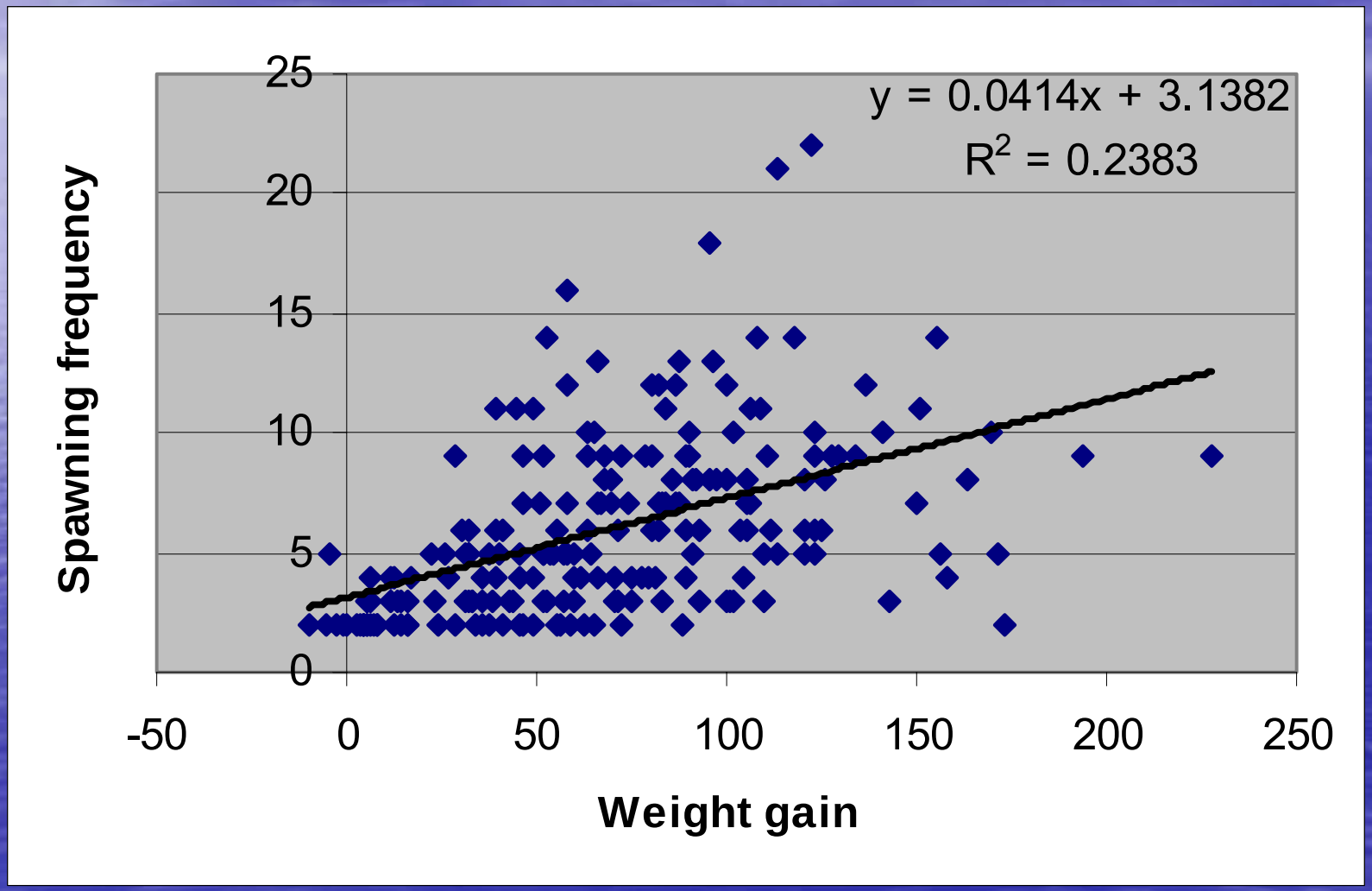


No. of spawnings per 10 weeks period

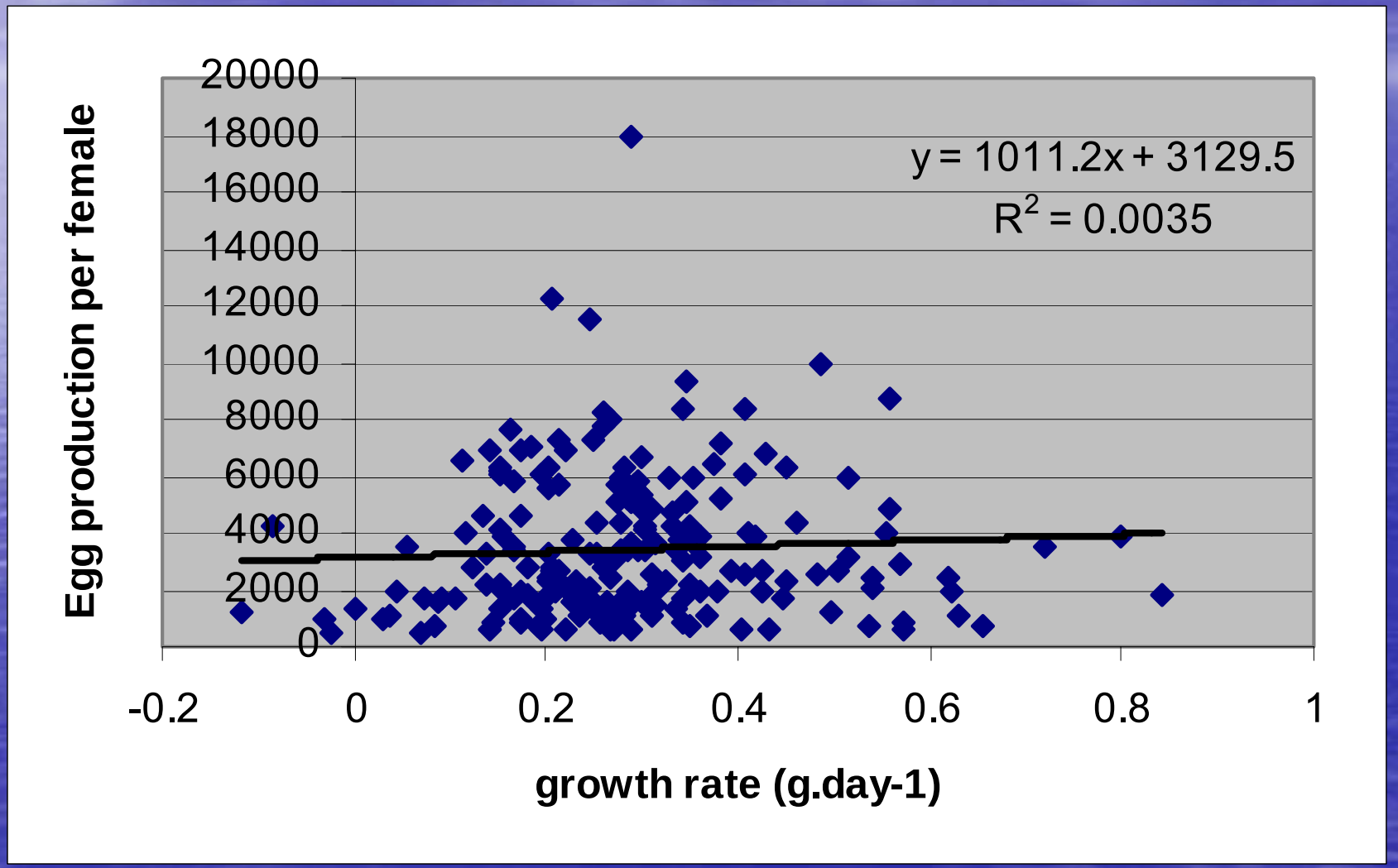
Inter-spawn interval vs. age

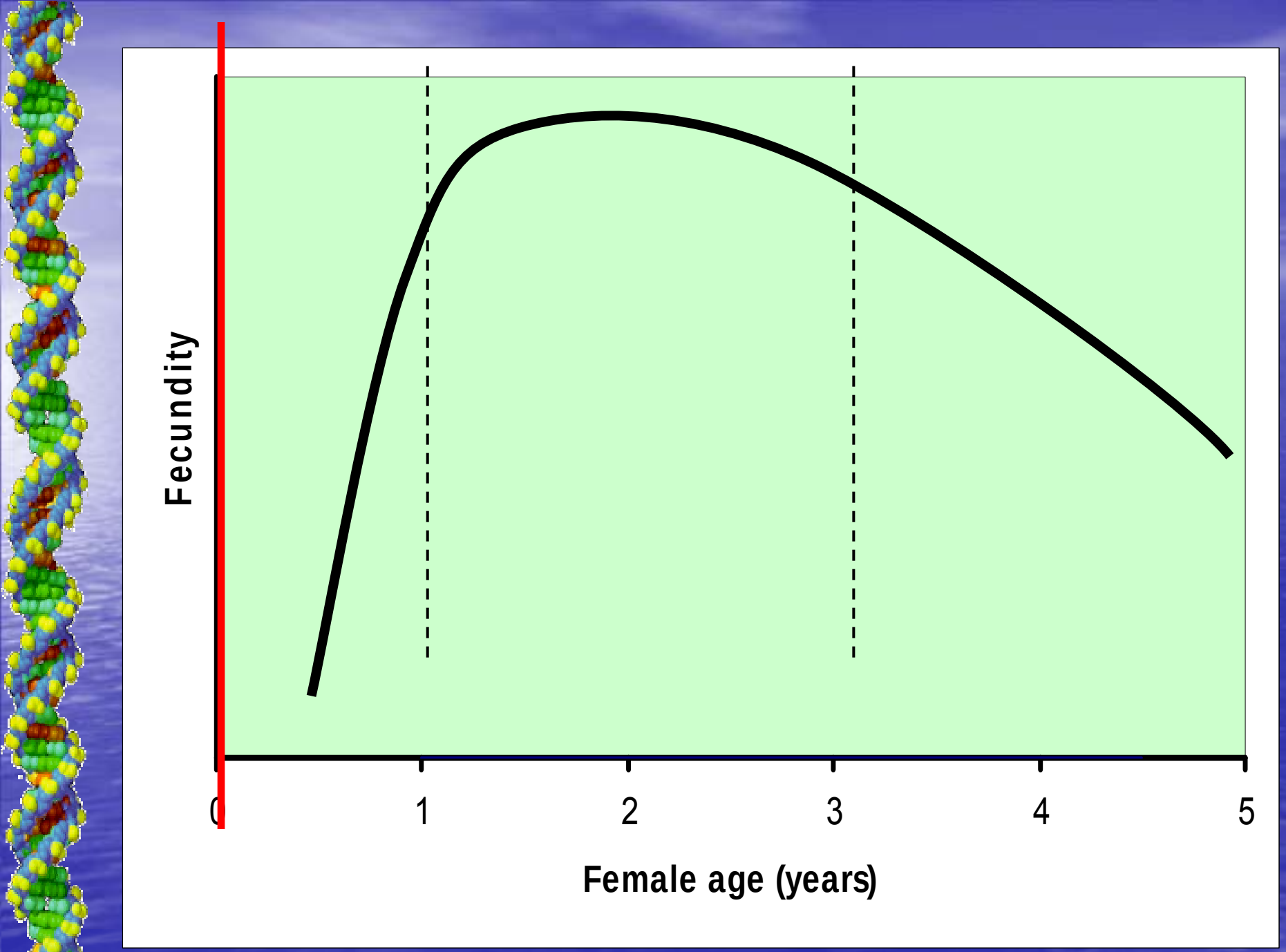


Relationship between growth of females and spawning frequency



Relationship between egg production and growth of females




Fecundity
0
1
2
3
4
5
Female age (years)

Hatching and fry survival

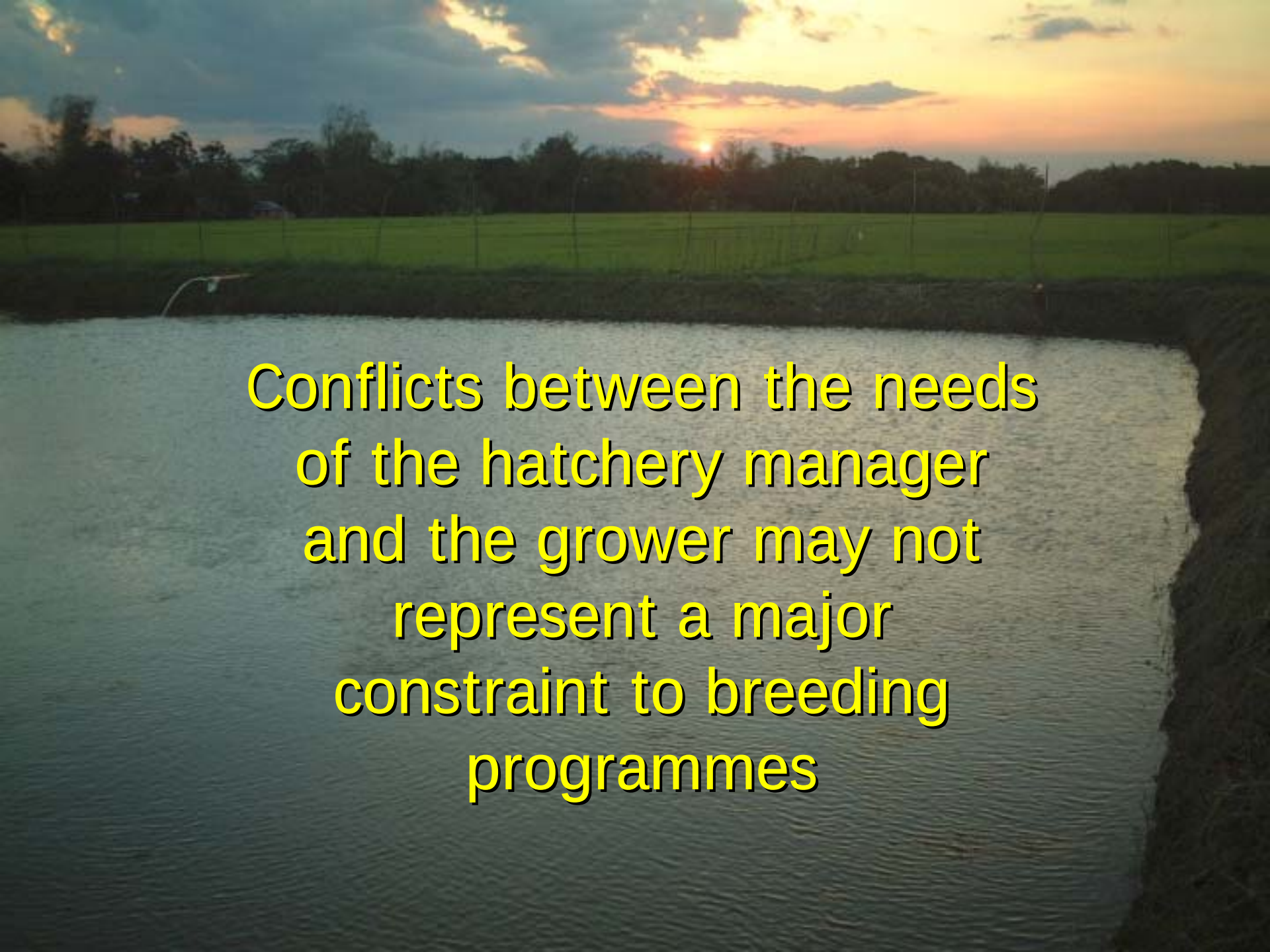
- *Compared for different stages of eggs*
  - *Downwelling incubators for eggs*
  - *Hatching trays for hatchlings*
- *Huge variability between replicates*
- *No significant difference detecting between strains over 2 month period*

Summary

- *Indications that both males and females are late maturing in GIFT based on gonad development*
- *GIFT has lower relative fecundity than other strains*
- *Fecundity (per female) increases with age but relative fecundity remains constant*
- *No clear trend of changing spawning frequency or ISI over time*
- *Huge variability in fecundity and ISI within and between females*
- *No evidence for negative correlation of reproductive capacity and growth*
- *Production has not peaked by 680 days*

Conclusions

- *Environment plays a major role in determining seed production*
- *Anecdotal evidence of late maturation and lower fecundity of GIFT in commercial hatcheries partly supported*
- *Two years would appear to be a minimum useful lifespan for broodstock in this type of system*
- *Expected inverse relationship between growth and fecundity not seen indicating that correlated response may not be major factor*
- *Means of selecting regularly spawning individuals could dramatically improved efficiency of seed production*


Conflicts between the needs
of the hatchery manager
and the grower may not
represent a major
constraint to breeding
programmes

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Thank you

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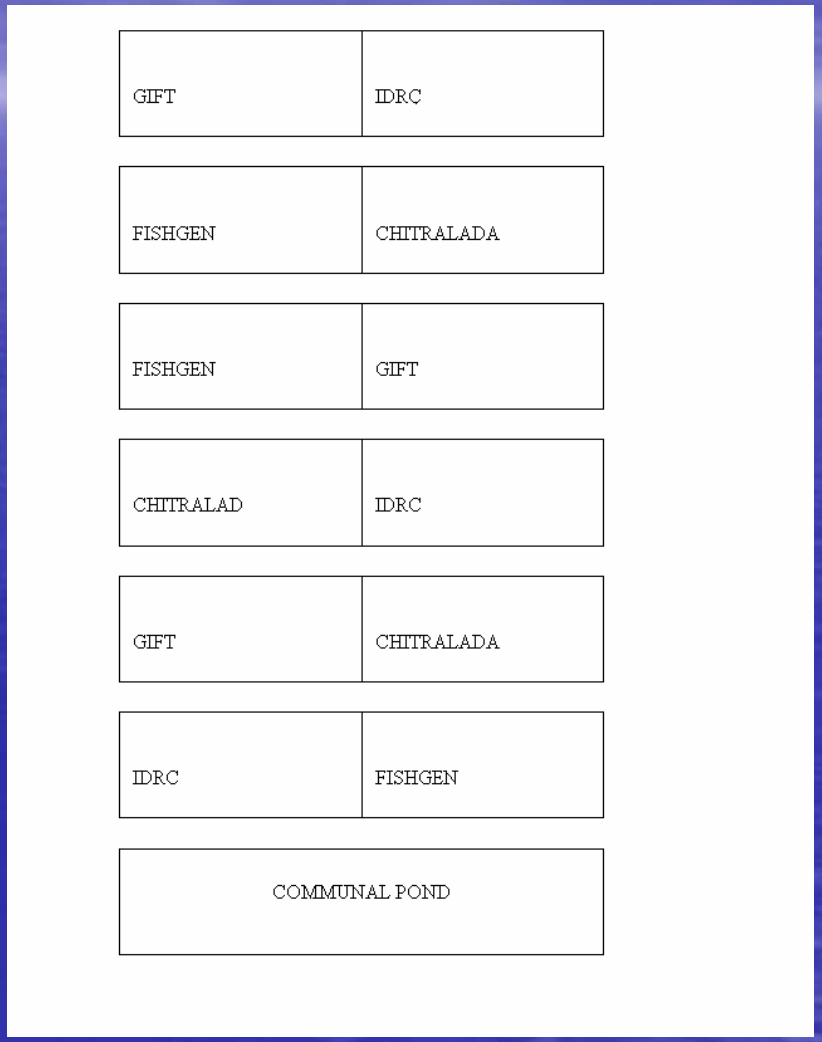
Growth rate evaluations

- *Fry with max age difference of 14 days*
- *Nursed in hapas then tanks at standard densities*
- *Stocked at 5-6g at 3 per m²*
- *Separate stocking*
  - *3 replicate half ponds (100m²) per strain (6 ponds)*
  - *Grown for 91 days with sampling (wt, SL & sex) every 21 days*
  - *30 fish (10%) sampled; 20 fish removed for determination of SM*
- *Communal stocking*
  - *Fish marked with combination of fin clip and CWT*
  - *Stocked communally in a single 200 m² pond (with excess)*
  - *Grown for 85 days with sampling at 21 days*
  - *25 fish per strain sampled, 20 fish removed for determination of SM*

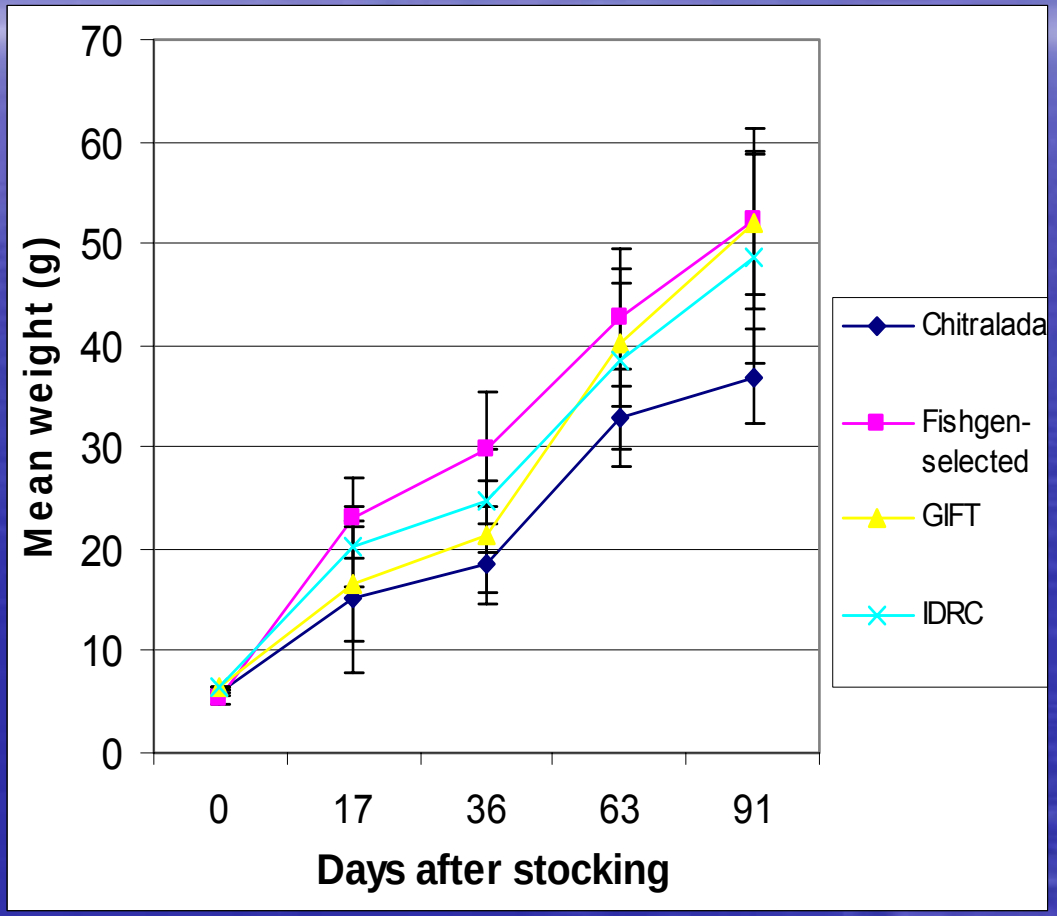
Experimental layout & data

- *Individual wt & SL of 30 fish per strain plus bulk wt of sample*
- *20 fish sacrificed*
  - *Stage of maturation*
  - *Hepatosomatic index (HSI)*
  - *Gonadosomatic index (GSI)*
- *Data management (growth)*
  - *Corrections for sample bias*
  - *Corrections for pond effects*
  - *Transformed if necessary*

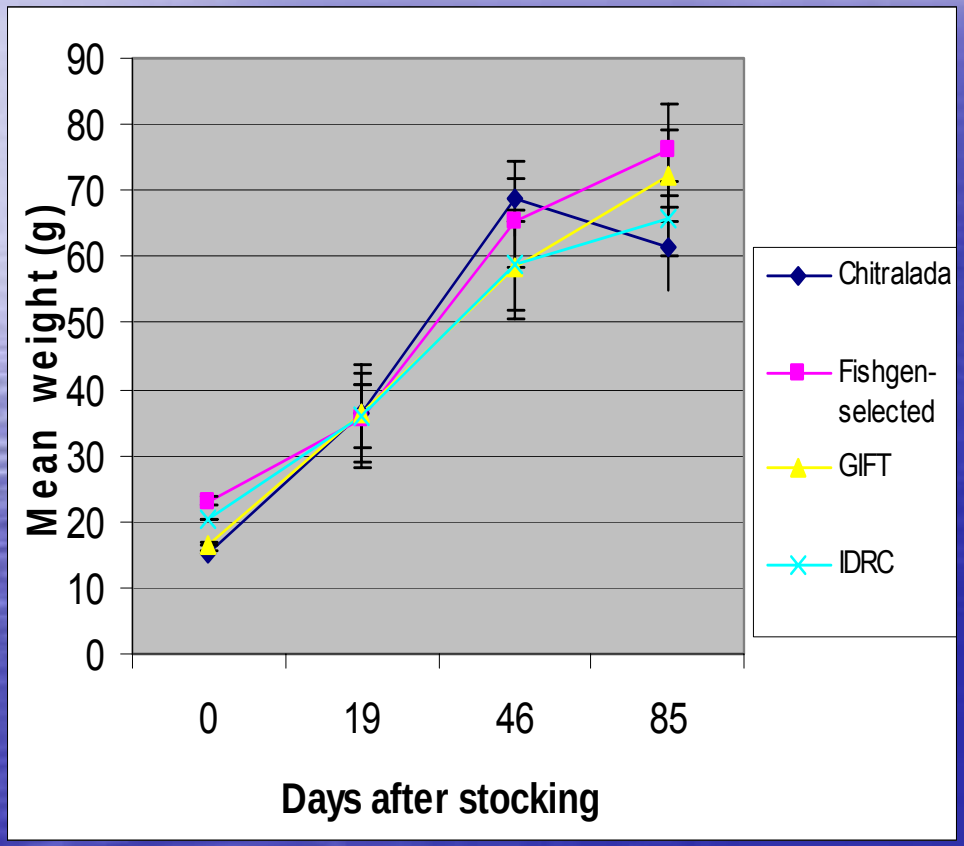


Results – Growth in separate stocking

- *Differences in growth parameters not significant among 4 genotypes*
- *Before correction: FS=GIFT>FAST>>Chit*
- *After correction FS>FAST>GIFT=Chit*
- *No significant differences in sex ratio or survival*

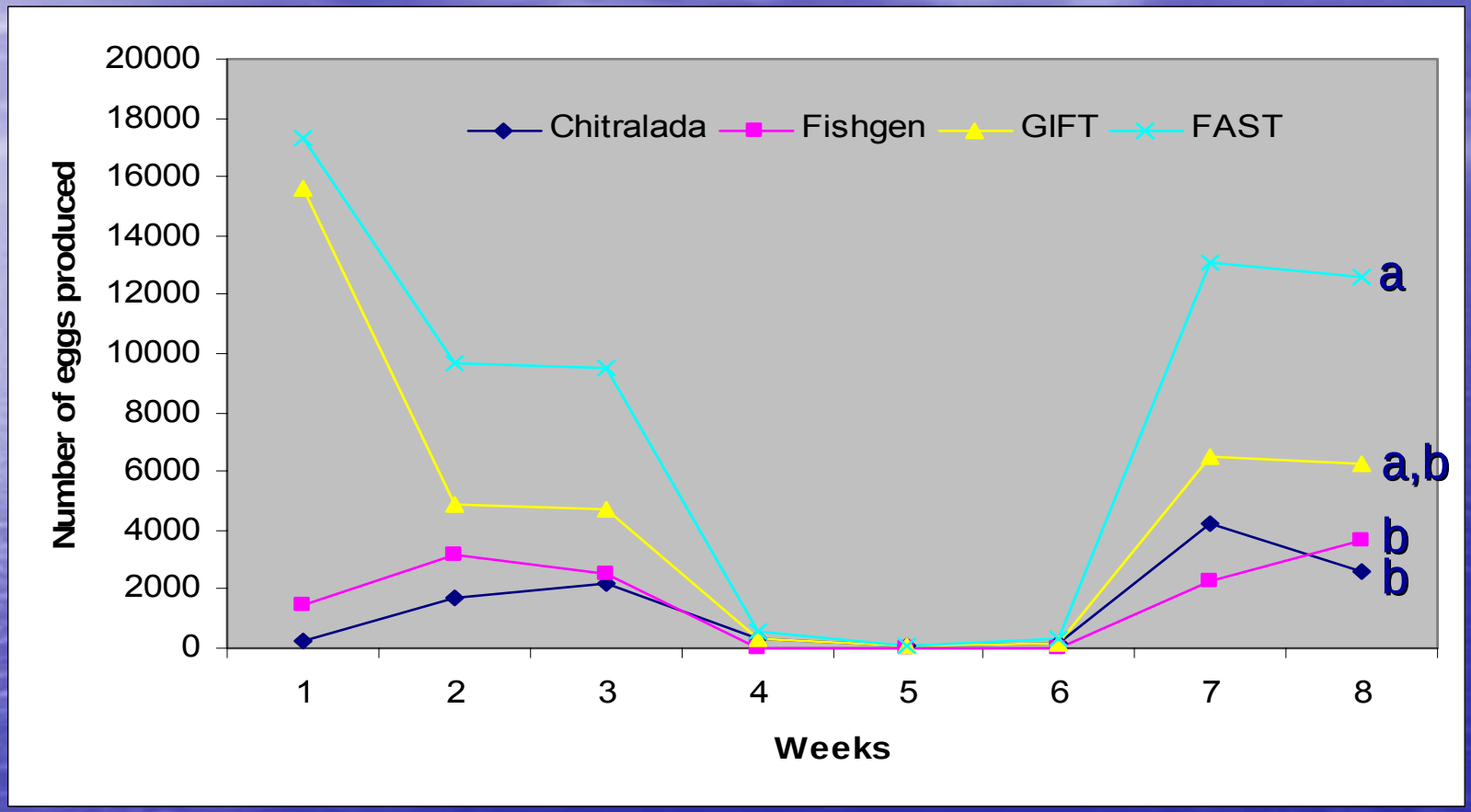


Results – Growth in communal stocking



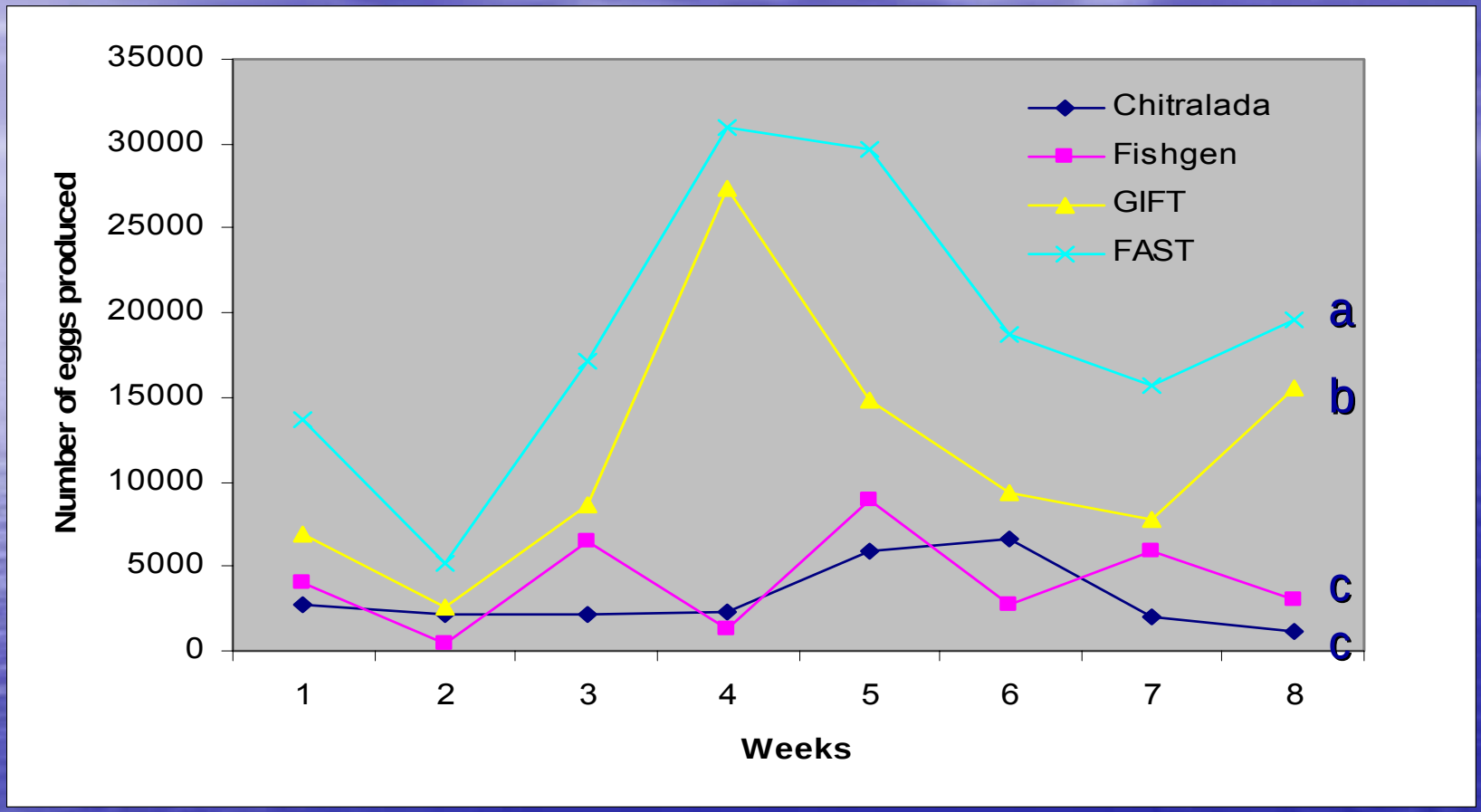
- *Significant differences in growth parameters in both raw and corrected weight data*
- *FS > GIFT > FAST > Chit*
- *FS > FAST & Chit (P>0.05)*
- *GIFT > Chit (P>0.05)*
- *No significant differences in sex ratio*

Initial spawning activity (from 180 days old)



Egg production: FAST=GIFT≥Fishgen=Chitralada ($P<0.05$)

Initial spawning activity (from 450 days old)



Egg production: FAST>GIFT>Fishgen=Chitralada ($P<0.05$)

Summary of monthly means

Affected by survival of females

	No of spawnings per month	*Mean egg/fry no per month*	*Relative fecundity (eggs/fry per female)*	*Relative fecundity (eggs/fry per g female)*
Chitralada	*22.80*	*12135*	*552^{a}*	*5.726^{a,b}*
Fishgen-selected	*17.18*	*10557*	*629^{a}*	*5.385^{b,c}*
GIFT	*20.29*	*10845*	*505^{b}*	*5.099^{c}*
FAST	*17.00*	*9987*	*644^{a}*	*6.950^{a,b}*

Relative fecundity (eggs/g female) over time