

NATURAL HISTORY AND BEHAVIOUR OF ZEBRAFISH

5th Annual International Zebrafish
Husbandry Meeting

Talk Outline

- ▣ Taxonomy
- ▣ Ecology
 - Distribution
 - Habitat type
- ▣ Life History traits
 - Growth rates
 - Age to sexual maturity
 - Reproduction
 - Spawning/social Behaviour

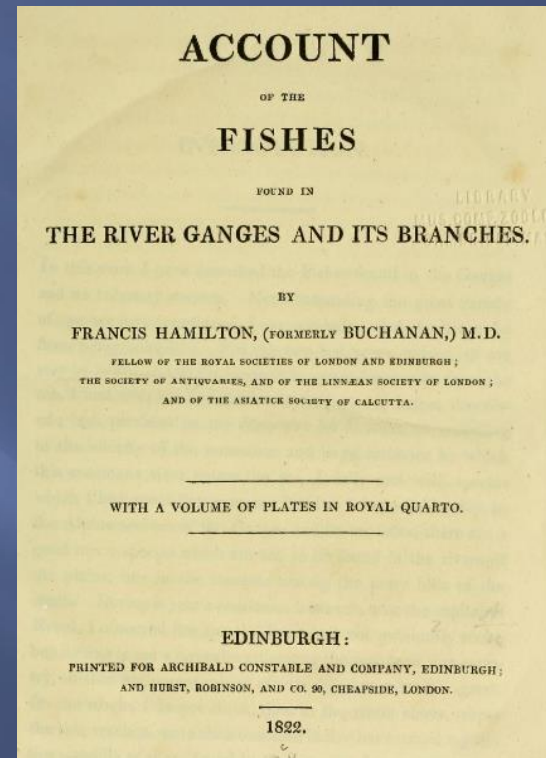


ZEBRAFISH TAXONOMY

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Zebrafish Taxonomy

- ▣ *Danio rerio* first described in 1822
 - Francis Hamilton, surgeon
British East India company
 - 1916 - assigned subgenus *Brachydanio*
 - 1991 - *Danio* & *Brachydanio* synonymised
 - 2003 - Separated into *Danio* & *Devario*
based on 38 morphological characters
 - ▣ Giant Danio
 - actually a *Devario* (*D. Aequipinnatus*)
 - >30 described species



Zebrafish Taxonomy

- ▣ 9 described danio species
- ▣ All relatively small
 - ▣ typically 30mm - 50mm
- ▣ Common body shape, fusiform & laterally compressed, terminal oblique mouth pointing upwards
- ▣ Members of the family Cyprinidae
 - ▣ carps & minnows
 - ▣ Very specious (>2000sp) family of fishes Europe, Asia, Africa & North America

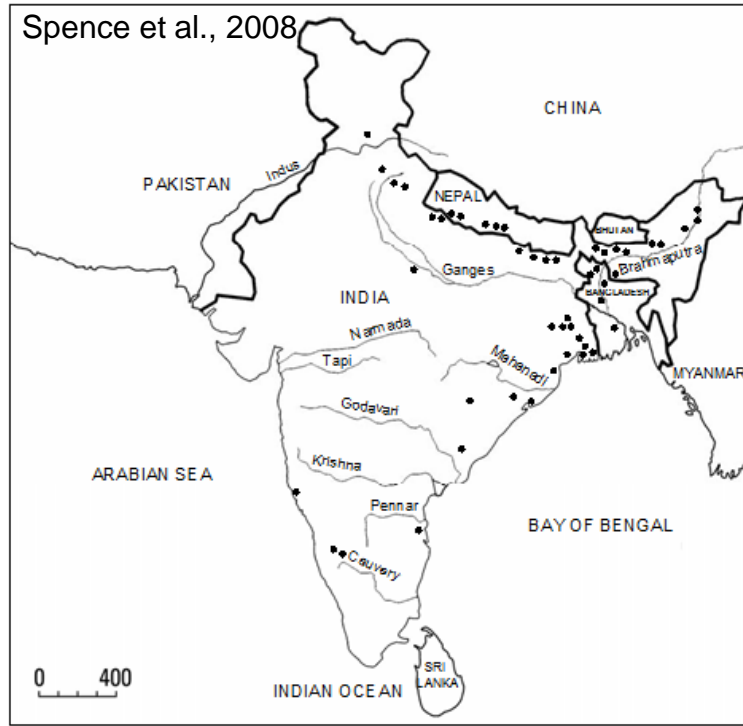


ZEBRAFISH ECOLOGY – distribution & habitat type

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Zebrafish Ecology - Distribution

Spence et al., 2008



- ▣ Focused in the Ganges & Brahmaputra river basins in north-eastern India, Bangladesh & Nepal
 - Confirmed sightings more widely over the Indian subcontinent

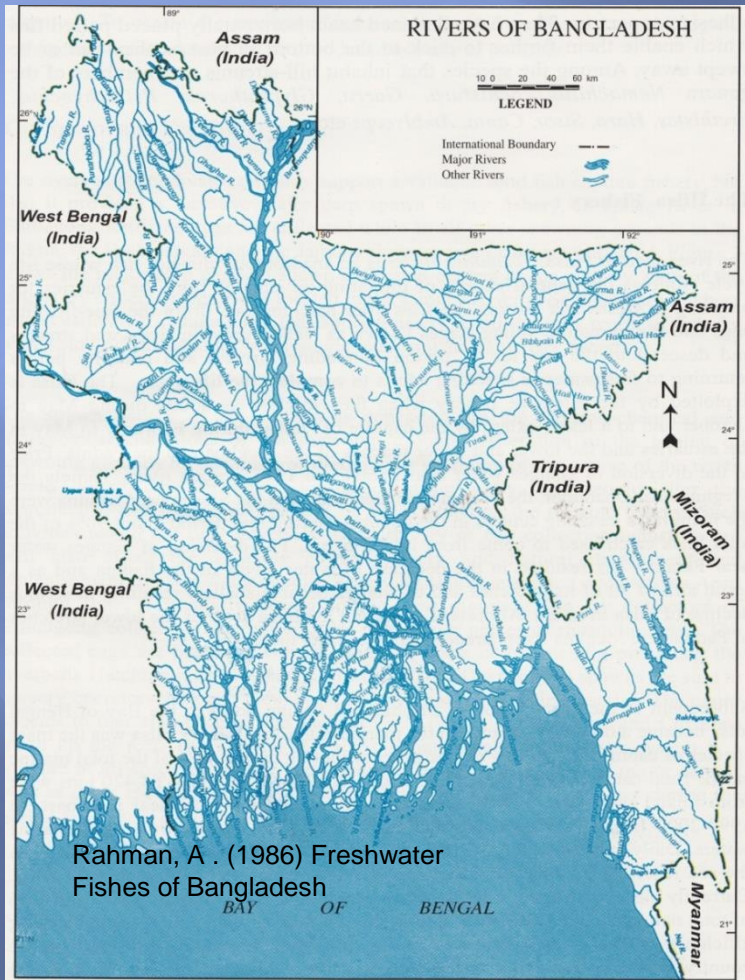
Zebrafish Ecology – Distribution

3 major rivers -
Brahmaputra, Jamuna,
Meghna

Rivers & streams cover
some 5.8% total area of
the country

Monsoon Climate –
Annual flooding June to
October inundates about
70% of the total land
surface

Up to 4 metres of rain
annually – 80 % during
monsoon



Zebrafish Ecology – habitat type

- ▣ Monsoon climate creates diverse wetland habitats
 - Rivers, streams, lakes, ponds, ditches, floodplains, rice paddies, mangrove swamps
 - ▣ 'haors', 'baors', 'beels', 'jheels'
- ▣ Support some 260 freshwater fish species & 63 prawn species & an elaborate food web
 - ▣ Including zebrafish



Ponds & ditches are home to zebrafish



Cover a similar
area to rivers &
streams; 300,000
– 400,000
hectares (3,000 –
4,000 sq. km)



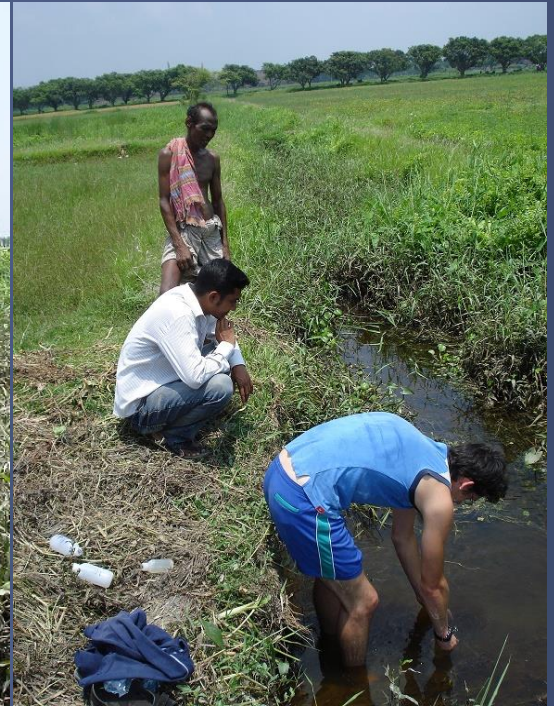
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Rice paddies are home to zebrafish



Name Danio derives from the Bengali name 'dhani' meaning 'of the rice field'

Streams are home to zebrafish



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Subsistence fish farms are home to zebrafish



Catla (*Catla catla*)
Rohu (*Labeo rohita*)



Butter fish (*Ompok* sp.)



Some of the
largest zebrafish
captured at
these sites

No zebrafish in the main rivers



Botia dario



Pseudambassis sp.



Tetraodon cutcutia



Mystus sp.



Puntius sp.



Macrogathus sp.

No zebrafish on commercial farms



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Living alongside Zebrafish – Identified over 30 fish species



Esomus danricus
(flying barb)



Puntius ticto



Aplocheilichthys panchax

Colisa lalia
(dwarf
gourami)



Trichogaster chuna
(honey gourami)



Pseudambassis
sp. (Indian glassfish)



Channa punctatus
(Snake-head)



Macrognathus aculeatus
(Spiny eel)



Monopterus albus
(mud eel)



....plus many invertebrates

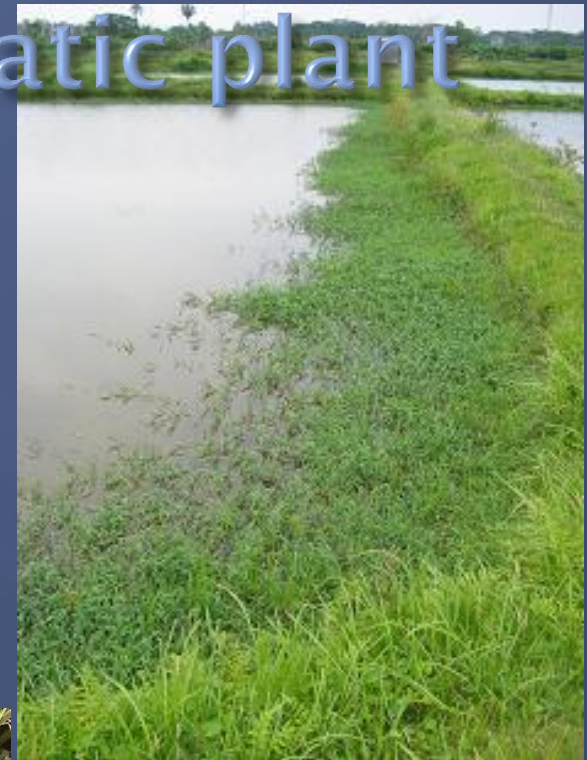


Macrobrachium sp.



Identified over 20 aquatic plant species

- *Eichhornia crassipes*,
Pistia stratiotes,
Lemna sp., *Salvinia*
natans
- Terrestrial & semi
aquatic vegetation



Water Transparency



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Site	Habitat Description	Area (Square meters)	Water Depth (cm)	Secchi Depth (cm)	Vegetative surface cover (%)	Temp (°C)	pH	Conductivity (µS)	Zebrafish Abundance	Zebrafish fork length (mm) range & (mean)
1	Disused pond (still)	140	66	52	90	28	7.65	371	37 (93 <i>C. lalia</i>)	22-38 (31)
2	Drainage ditch (still)	1000	50	48	40	28.5	7.73	534	20 (47 <i>Esomus</i>)	28-35.5 (32.1)
3	Edge of paddy field (slow moving)	>1000	16	16	90	29	6.99	242	25 (22 panchax)	20.5-27 (23.3)
4	Stream between paddy fields (slow moving)	1 – 2 meters wide – 100's meters long	22	22	75	28	7.06	490	29 (12 panchax)	15-27 (20.9)
5	Large pond – rice and fish production (still)	>3000	35	24	<1	30.5	6.85	317	30 (279 <i>Oryzias</i>)	16-29.5 (21.1)
6	Large pond – rice and fish production (still)	>2000	50	8	<1	27	7.46	298	104 (41 <i>Esomus</i>)	20.5-30.5 (27.4)
7	Paddy field (still)	~4000	30	30	90	30.5	6.94	152	49 (>500 <i>Esomus</i>)	17-32 (24.4)
8	Small pond – subsistence aquaculture (still)	625	107	7	<1	30.5	7.53	221	38 (-)	29-40 (33.3)

The distribution and habitat preferences of the zebrafish in Bangladesh: Journal of Fish Biology (2006) 69, 1435-1448

TABLE II. Environmental variables for each sampling site: Khulna District: 1, ditch; 2, large artificial lake; 3, seasonally isolated arm of a canal; 4, pond treated with lime and rotenone; 5, semi-natural pond; 6, natural ponds; 7, village pond; 8, Bhatiaghata River; 9, isolated river channel; 10, artificial pond; 11, isolated river channel; 12, irrigation channel; 13, isolated river channel. Mymensingh District: 14, cultivated pond; 15, cultivated pond; 16, isolated pond; 17, isolated pond; 18, isolated pond; 19, Brahmaputra River; 20, Dhuno River; 21, old fish farm; 22, semi-natural pond; 23, ditch; 24, small semi-natural pond; 25, channel; 26, creek

Site	<i>Danio rerio</i> log ₁₀ abundance	Locality	Flow	Depth (cm)	Secchi depth (cm)	Substratum	Vegetation	Temperature (° C)	pH	Ammonia or ammonium (mg l ⁻¹)	Salinity	Connection with paddy	Predators
1	1	Khulna	Still	80	51	Mud		20	8	0.01	0		Yes
2	0	Khulna	Still	100	92	Mud	Yes	22	8	0.01	0		Yes
3	0	Khulna	Still	80	16	Mud		18.5	8	0.1	0.4		
4	0	Khulna	Still	73	37	Mud		20	7.4	0.1	0.2		Yes
5	0	Khulna	Still	50	50	Mud	Yes	17.5	7.6	0.1	0.2		
6	0	Khulna	Still	35	35	Mud	Yes	20	8	0.1	0	Yes	Yes
7	0	Khulna	Still	85	37	Mud		18	7.4	0.1	0.8		
8	0	Khulna	Running	125	75	Mud		21.5	8	0.1	0.6		Yes
9	1	Khulna	Still	50	19	Mud	Yes	20	8	0.1	0		
10	0	Khulna	Still	71	64	Mud	Yes	20.5	8	0.1	0		
11	0	Khulna	Still	73	52	Mud	Yes	20.3	8	1	0.4		
12	0	Khulna	Still	50	44	Mud		19	8	0.1	0.4		
13	0	Khulna	Still	76	23	Mud		22	8	0.1	0.2		
14	0	Mymensingh	Still	30	16	Mud	Yes	20	7.6	0.01	0.6		
15	3	Mymensingh	Still	15	15	Mud	Yes	20.5	8	0.01	0.6	Yes	
16	2	Mymensingh	Still	40	15	Mud		19.5	8	0.01	0.6		
17	2	Mymensingh	Still	103	30	Mud		16.5	8	0.01	0.6		
18	0	Mymensingh	Still	25	32	Mud		19	8	0.01	0.6		
19	0	Mymensingh	Running	200	197	Sandy Mud	Yes	21	8	0.01	0.4		Yes
20	0	Mymensingh	Running	130	46	Sandy Mud	Yes	21	7.6	0.01	0.4		Yes
21	0	Mymensingh	Still	80	12	Mud		22	8	0.01	0.4		
22	1	Mymensingh	Still	96	31	Mud	Yes	21	8	0.01	0.4		
23	2	Mymensingh	Still	50	50	Mud	Yes	23	8	0.01	0.4	Yes	
24	2	Mymensingh	Still	65	15	Mud	Yes	33	8	0.01	0		
25	2	Mymensingh	Still	75	15	Mud	Yes	33	8	0.01	0	Yes	
26	0	Mymensingh	Running	120	15	Mud	Yes	30	8	0.01	0	Yes	Yes

Summary of zebrafish habitat

- ▣ Shallow, slow-moving or standing water bodies which may have seasonal connections to the main rivers as well as man-made lakes, ponds, & irrigation channels, constructed for fish and rice cultivation
- ▣ Zebrafish habitat highly transitory & intrinsically linked to patterns of rainfall



Summary of zebrafish habitat

- ▣ Most fish associated with vegetation
- ▣ Catch success
 - daytime – zebrafish amongst vegetation
 - at dawn & dusk 'skirted' between vegetation & open water



Summary of zebrafish abundance

- ▣ All sites contained fish of mixed sex & size
- ▣ Shoal in groups of 10-20 individuals (Spence et al, 2006)
- ▣ Potential for larger shoals where;
 - fish become confined to small water bodies (dry season)
 - presence of perennial ponds
 - where artificially rich sources of food occur
- ▣ 'with the rains come new fishes' – belief of local people

ZEBRAFISH LIFE-HISTORY

- growth & maturation, reproduction & behaviour

Zebrafish Life-history - growth

- ▣ Wild fish collected from a single site over a 12 month period reached 25mm & sexual maturity
 - ▣ Max size recorded - 35mm
- ▣ F1 wild fish in captivity mature at 23mm (Spence et al, 2006)
- ▣ Comparable to domesticated strains ([23.1mm (males), 24.9mm (females)] (Eaton and Farley, 1974b))

Zebrafish Life-history - growth

- Gut contents revealed adult zebrafish to be omnivorous:
 - adults primarily feed on zooplankton, insects, some plant and algal materials – (Spence et al, 2008)
- Dietary composition varied between months
 - selectivity or seasonal availability?
- High proportion of planktonic & terrestrial items indicates zebrafish feed chiefly in the water column & at the surface
 - NB - terminal oblique mouth pointing upwards

Zebrafish Life-history – growth

- Interestingly we collected fish up to 40mm in length
 - Possibly larger than might be expected from an annual fish
- Fish containing mature ova collected in January
 - outside the typical spawning period
- Individuals survive to a 2nd season, different cohorts?
 - generally regarded as an annual species
- Otolith study required to establish age class structure of different populations

Zebrafish Life-history - reproduction

- ▣ Paucity of information on reproductive strategies of wild zebrafish
 - ▣ fish observed with mature gametes at differing times of the year suggests spawning may not be cued by season alone, but may also be dependent on food availability, which is likely to co-vary with season
 - ▣ daily, semi lunar or lunar cycles are then often expressed once spawning has been initiated
 - ▣ observed in the lab & in the wild
 - ▣ Spawning easily entrained to a short period at dawn



Zebrafish Life-history – reproduction and behaviour

- ▣ Spawning behaviour in wild fish appears similar to that observed in domesticated strains
 - ▣ group spawning
 - ▣ males actively pursuing females up & down the water column before diving to the substratum to spawn
- ▣ Understanding subtleties of behaviour in group spawning species is notoriously difficult
 - ▣ Not always random

Zebrafish Life-history – reproduction and behaviour

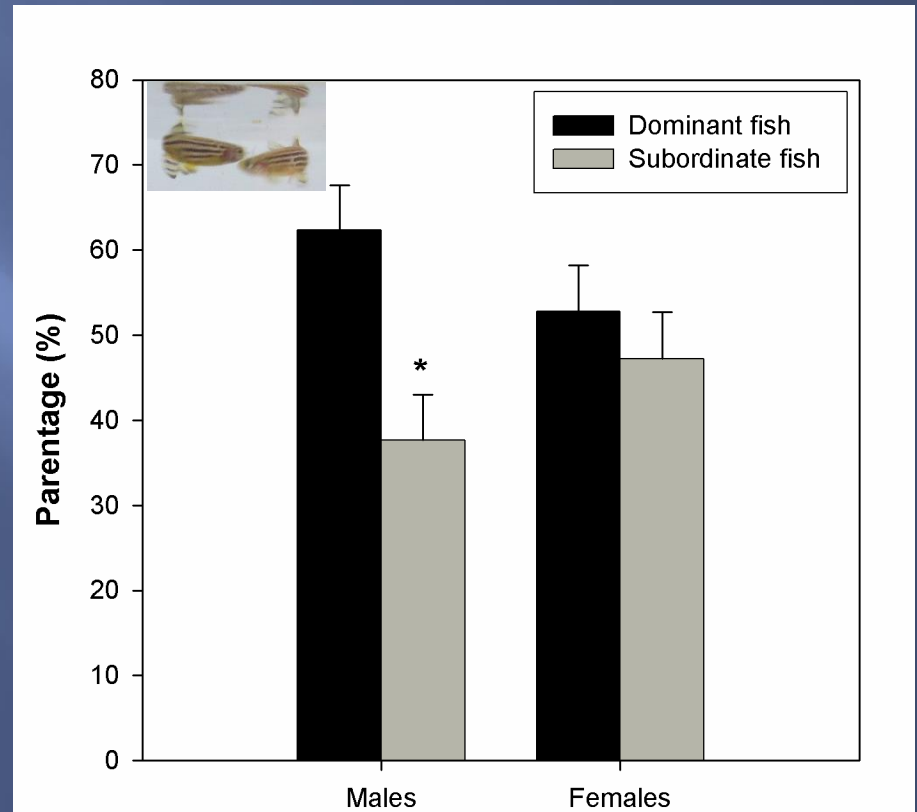
- ▣ Controlled lab experiments reveal a lek-like mating system
 - males defend small territories but non-territorial males may sneak in contributing to fertilisation events
 - females shown to be choosy over oviposition sites
 - maximising offspring survival
 - aggression used to establish & maintain dominance
 - physical and threat displays
 - size dependent
 - not sex specific



Zebrafish Life-history – reproduction and behaviour

Dominance hierarchies

- ▣ Resource centered
 - not just spawning sites
 - food
 - shelter
- ▣ Rank determines life-time success
- ▣ Higher social rank
 - reproductive success

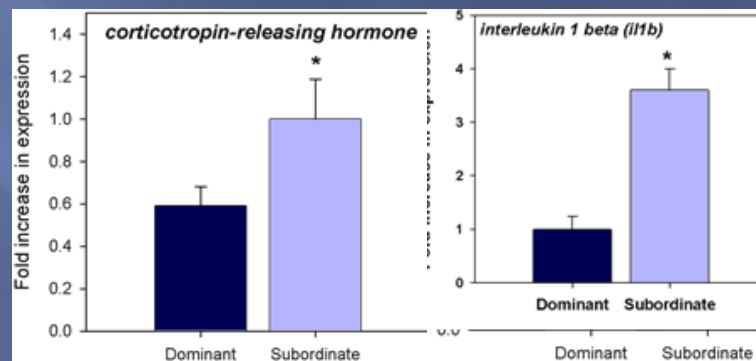
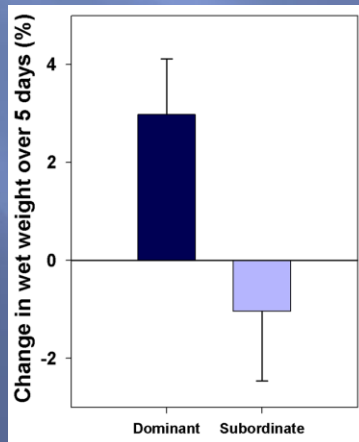
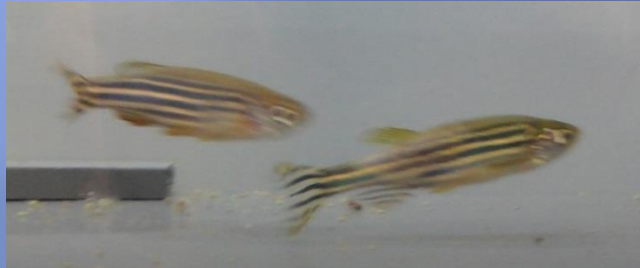


Paull GC, Filby AL, Giddins HG, Coe TS, Hamilton PB, Tyler CR. Dominance hierarchies in zebrafish (*Danio rerio*) and their relationship with reproductive success. *Zebrafish* 2010 Mar;7(1):109-17.



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Dominance hierarchies & behavioural management practices in the lab!



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Contents lists available at ScienceDirect
Physiology & Behavior
 journal homepage: www.elsevier.com/locate/phb

Physiological and health consequences of social status in zebrafish (*Danio rerio*)
 Amy L. Filby^{a,*}, Gregory C. Paull^{a,1}, Emily J. Bartlett^a, Katrien J.W. Van Look^{b,2}, Charles R. Tyler^a

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Therefore, must consider physical & social environment when housing zebrafish

Summary

- ▣ Native habitat of zebrafish is extremely rich – far cry from our laboratory tanks



Environmental requirements	→	Water quality management
Prey selection and diet	→	Feeding practices
Reproductive biology	→	Spawning techniques
Dominance Behaviour	→	Behavioural management