2nd Symposium on Welfare in Aquaculture
Operational Welfare Indicators for Fish

Operational Welfare Indicators for Tilapia

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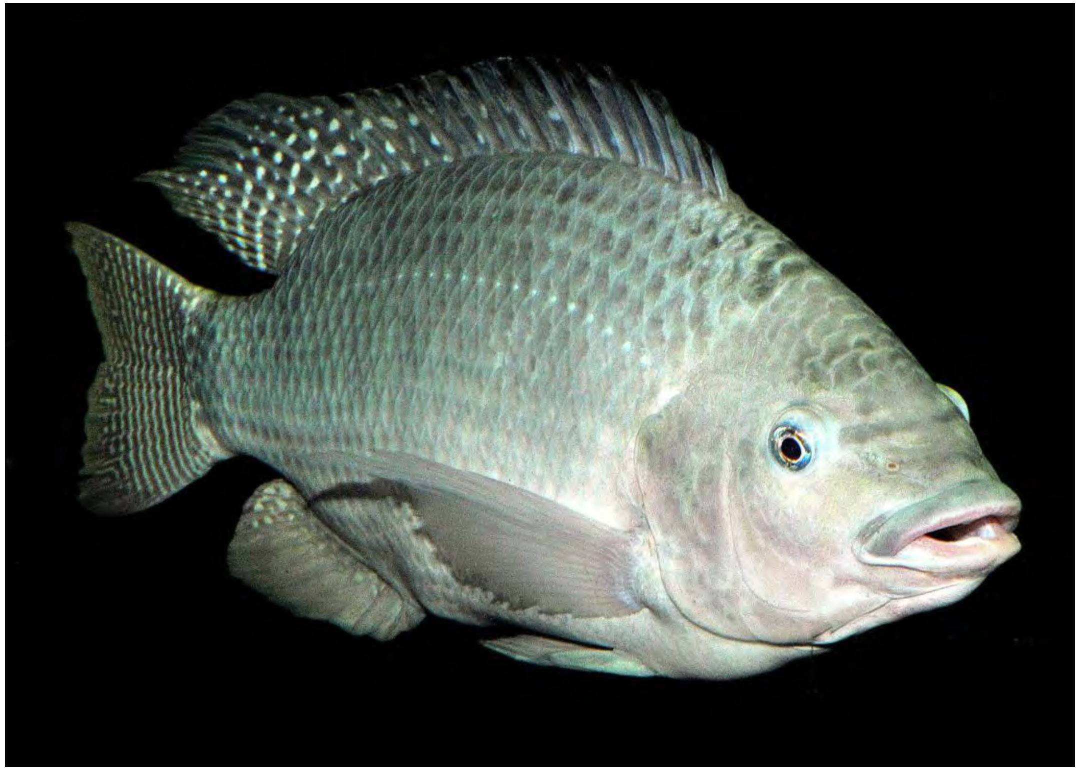

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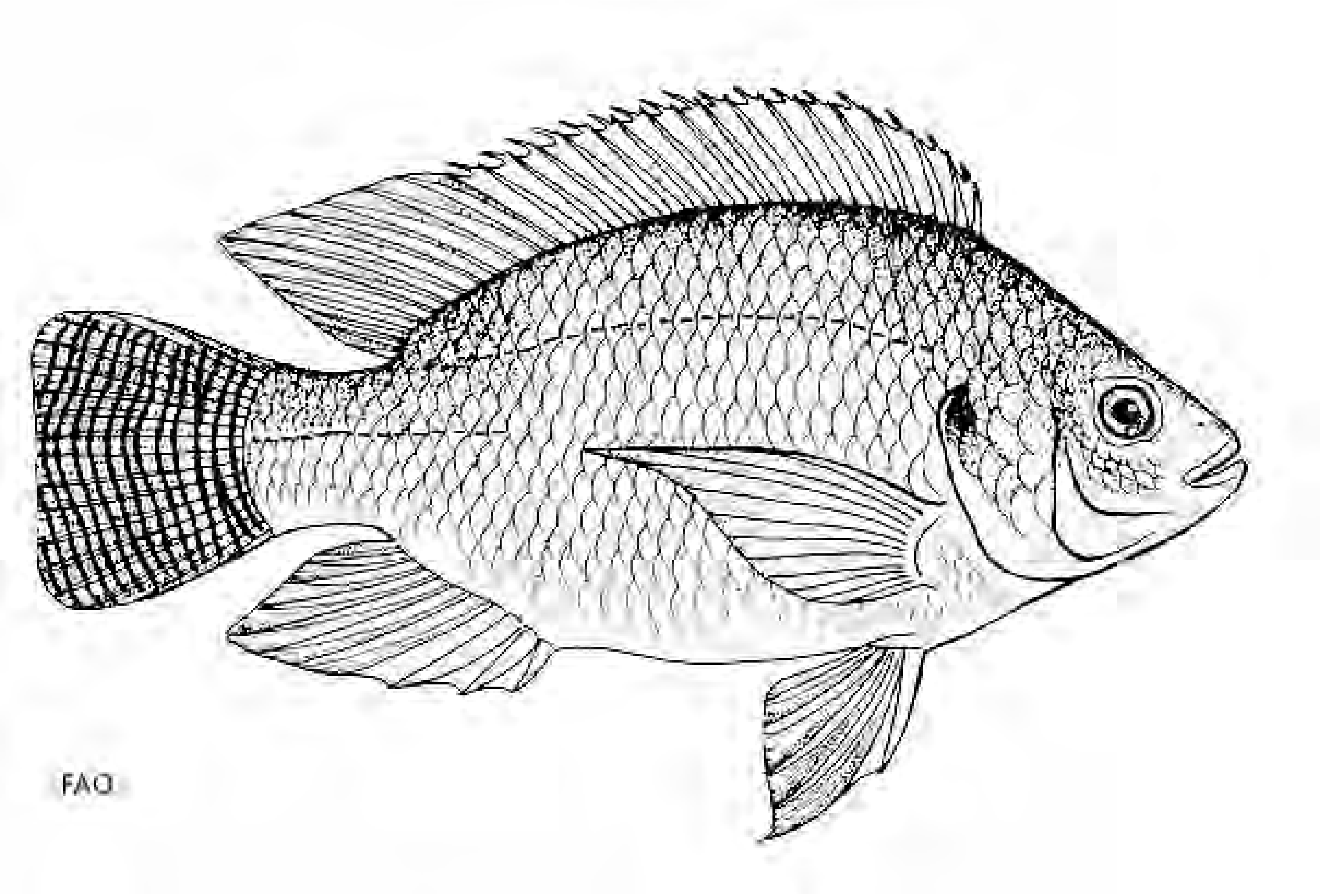
Presentation plan

1. What is a Tilapia? Comparison between wild and farmed.
2. Tilapia farming. Different systems and stages/different Welfare problems.
3. OWI development for Tilapia and Welfare assessment tool for farmed fish (WATFF) under the 5 domains framework.
4. General conclusion:

   +what has been done

   +what needs to be done



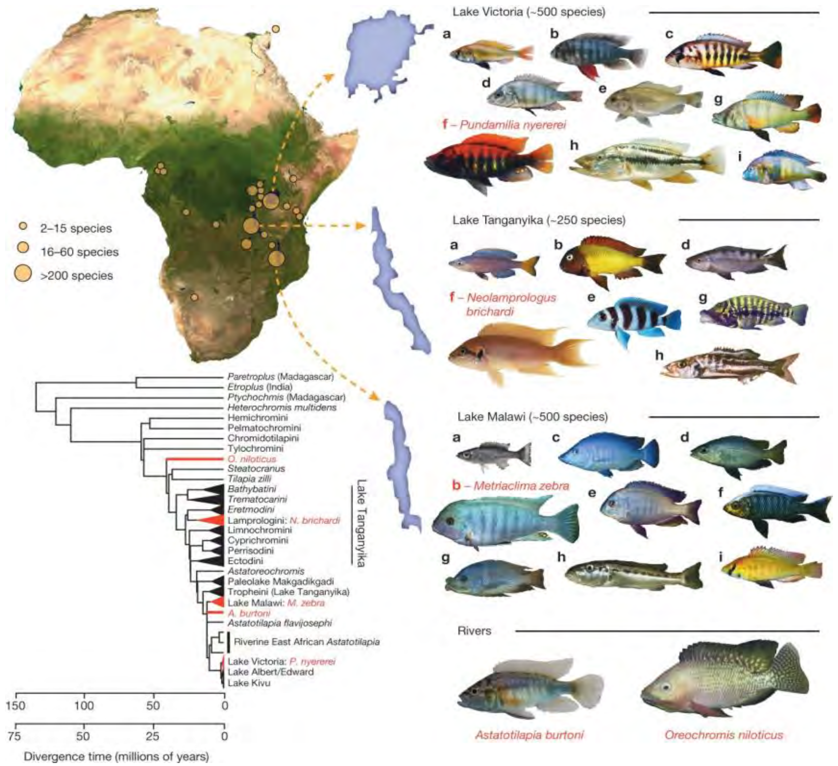
WHAT IS A TILAPIA?

Open Access | Published: 03 September 2014

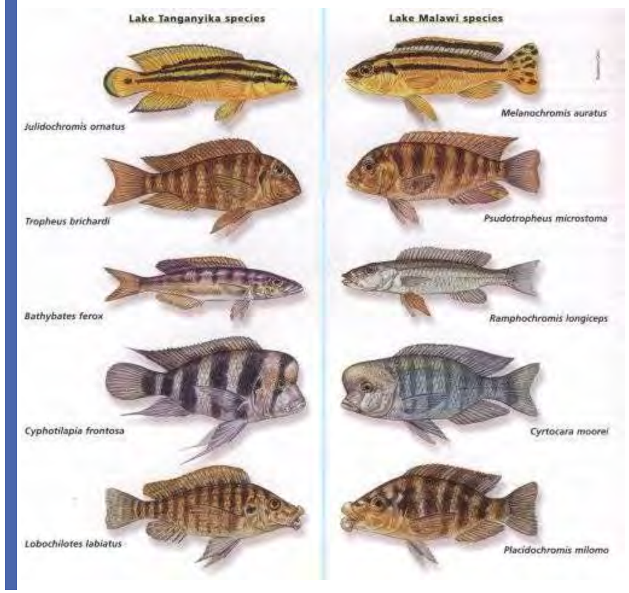
The genomic substrate for adaptive radiation in African cichlid fish

David Brawand, Catherine E. Wagner, […] Federica Di Palma

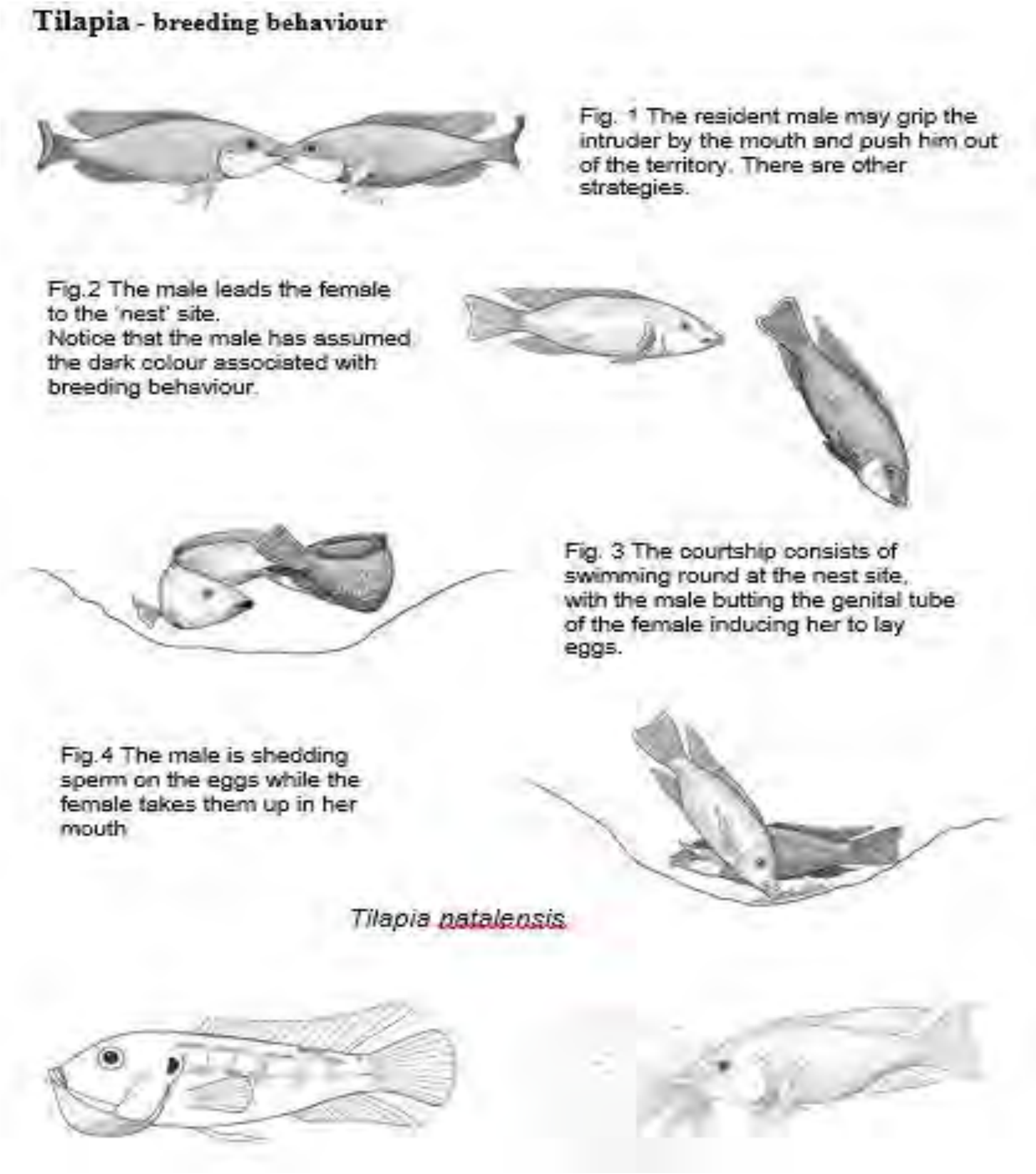
Nature **513**, 375–381(2014) | Cite this article



Convergent evolution



CICHLIDS: highly diverse in native environments (1350 sps aprox)due to adaptive radiation
>100 tilapias in the wild and only 3 main species are used for aquaculture (nile, mossambic and blue)



CICHLIDS: also have highly developed social behaviours

Life cycle of a wild Tilapia

Tilapias are highly social and hierarchical species

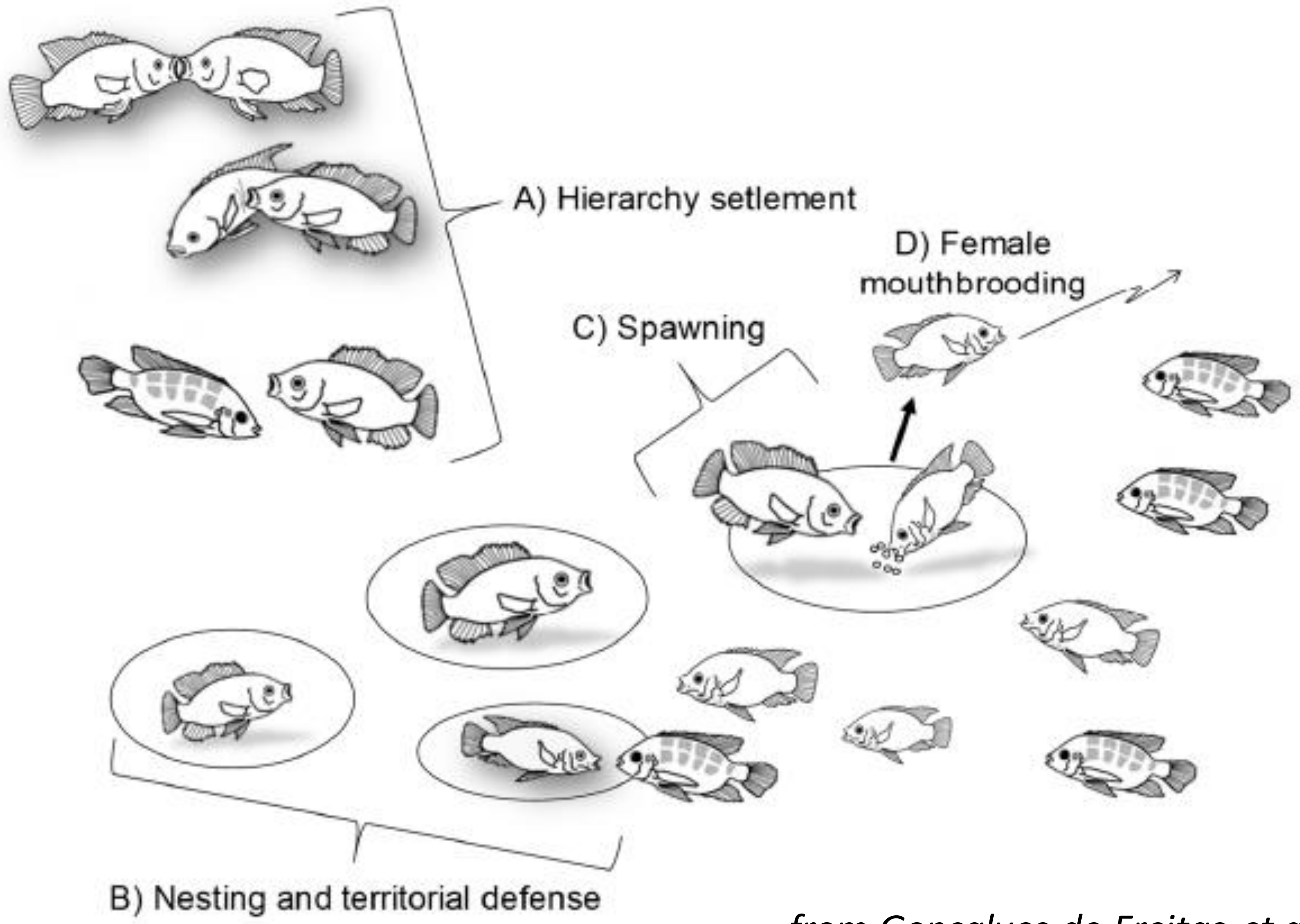
Complex life cycle

Reproduction with a courtship behaviour, nesting males and mouth breeder females

That makes them very territorial and sometimes aggressive even in early life stages

Very visual animals, highly cognitive capacities and they learn very fast

Omnivorous and very tolerant to Oxygen, temperature and changes on the environmental conditions: Highly flexible fish (evolutionary radiation)



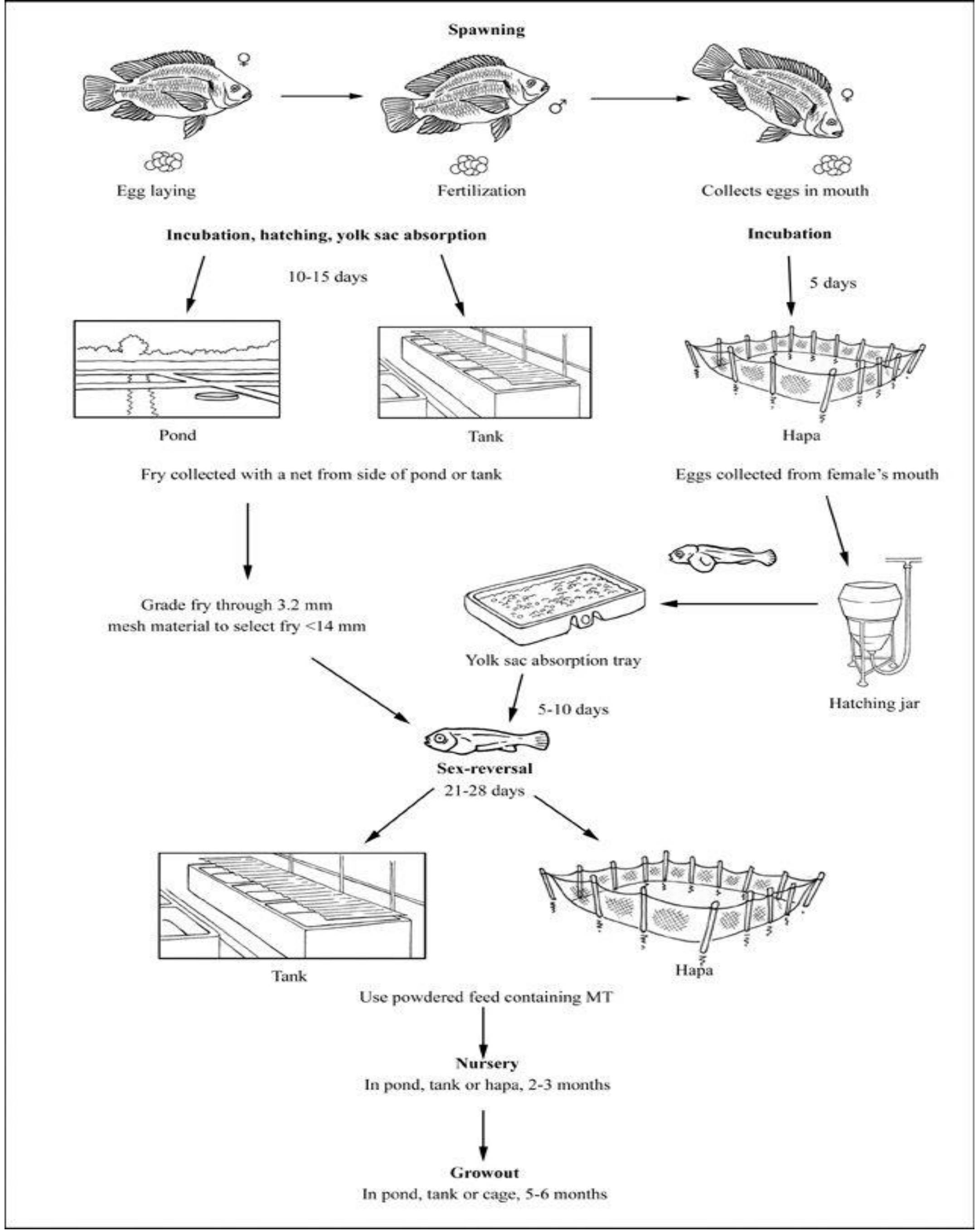
from Goncalves-de-Freitas et al 2019 in Social Behaviour and Welfare in Nile Tilapia

Life cycle of a farmed Tilapia

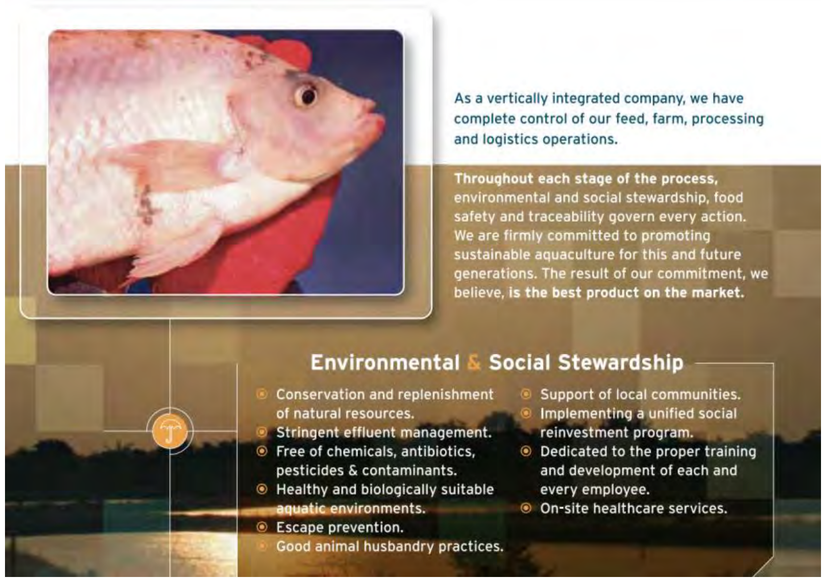
Nile Tilapia is the most cultured sps *(Oreochromis niloticus)*

Others are: O. mossambicus and O. aureus (Blue Tilapia)

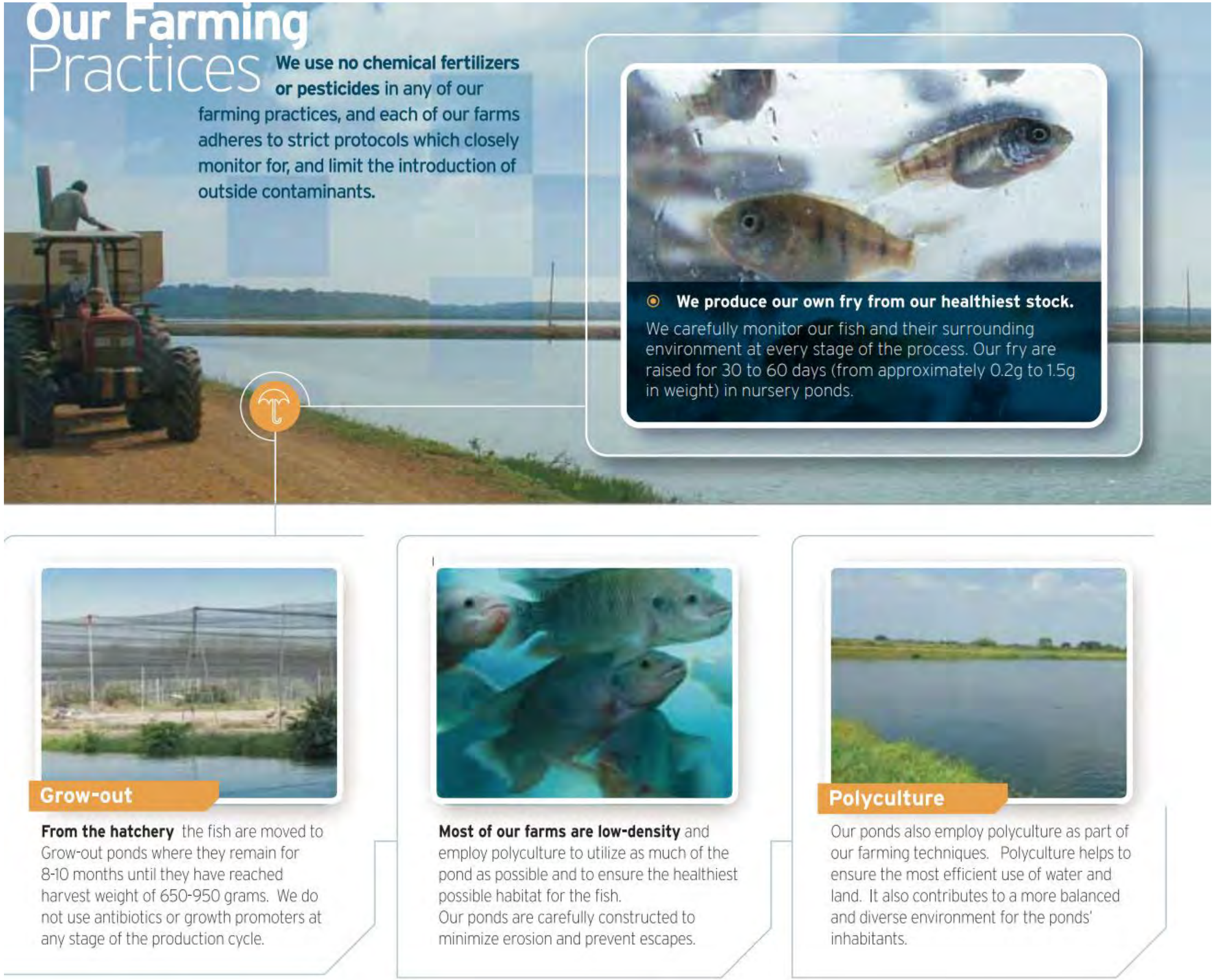
Shortened life cycle (4 months from egg to market)



Videos on Tilapia farming US company (Ecuador, Colombia and Brazil)



Environmentally friendly
Good welfare (by good animal and Husbandry practices)



Our Farming Practices

We use no chemical fertilizers or pesticides in any of our farming practices, and each of our farms adheres to strict protocols which closely monitor for, and limit the introduction of outside contaminants.

We produce our own fry from our healthiest stock.
We carefully monitor our fish and their surrounding environment at every stage of the process. Our fry are raised for 30 to 60 days (from approximately 0.2g to 1.5g in weight) in nursery ponds.

Grow-out

From the hatchery the fish are moved to Grow-out ponds where they remain for 8-10 months until they have reached harvest weight of 650-950 grams. We do not use antibiotics or growth promoters at any stage of the production cycle.

Most of our farms are low-density and employ polyculture to utilize as much of the pond as possible and to ensure the healthiest possible habitat for the fish.
Our ponds are carefully constructed to minimize erosion and prevent escapes.

Polyculture

Our ponds also employ polyculture as part of our farming techniques. Polyculture helps to ensure the most efficient use of water and land. It also contributes to a more balanced and diverse environment for the ponds' inhabitants.

Healthy stock
No chemicals
Low densities
Polyculture
No antibiotics
Sustainable food

Videos on Tilapia farming in Thailand

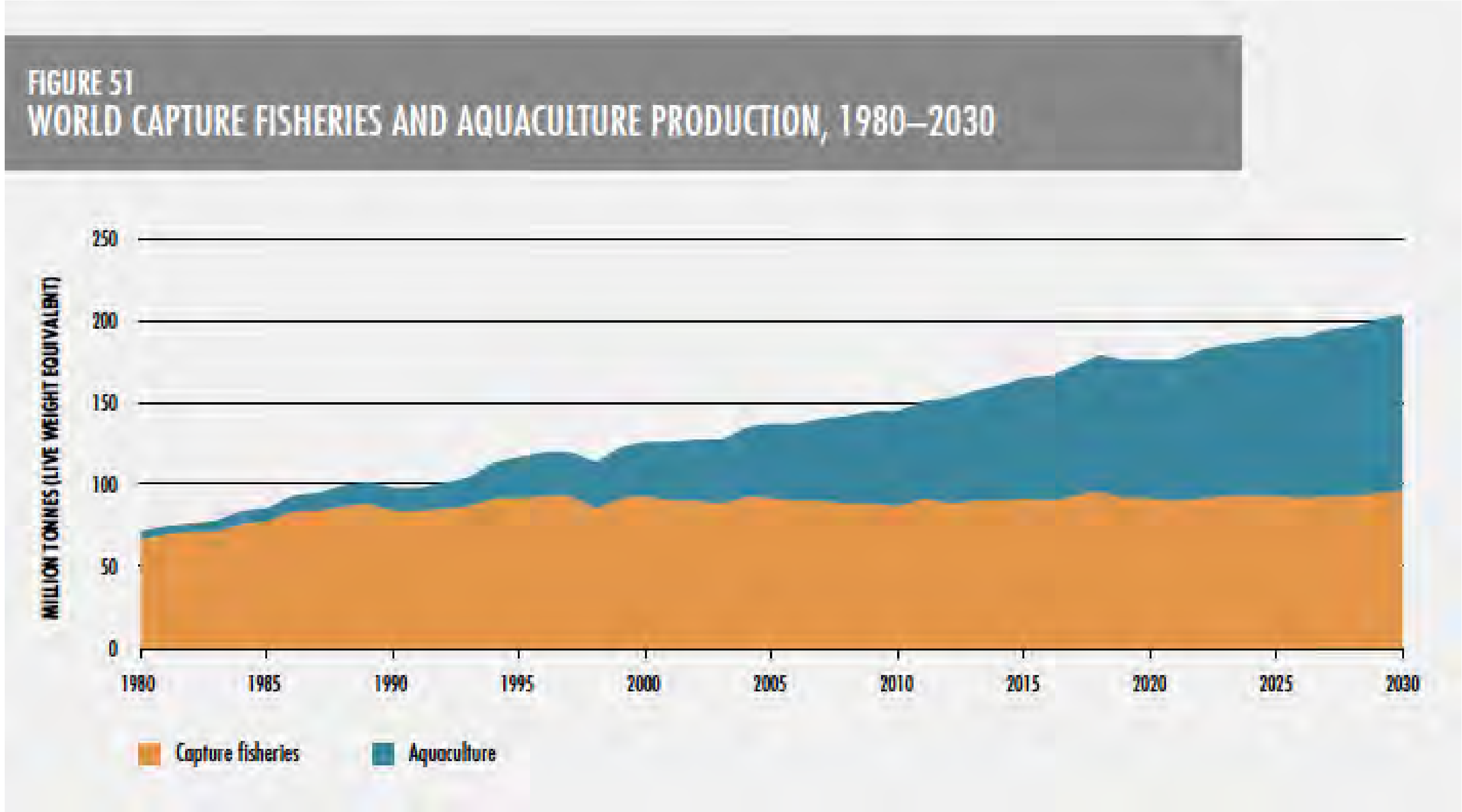
Egg collection

Egg incubation

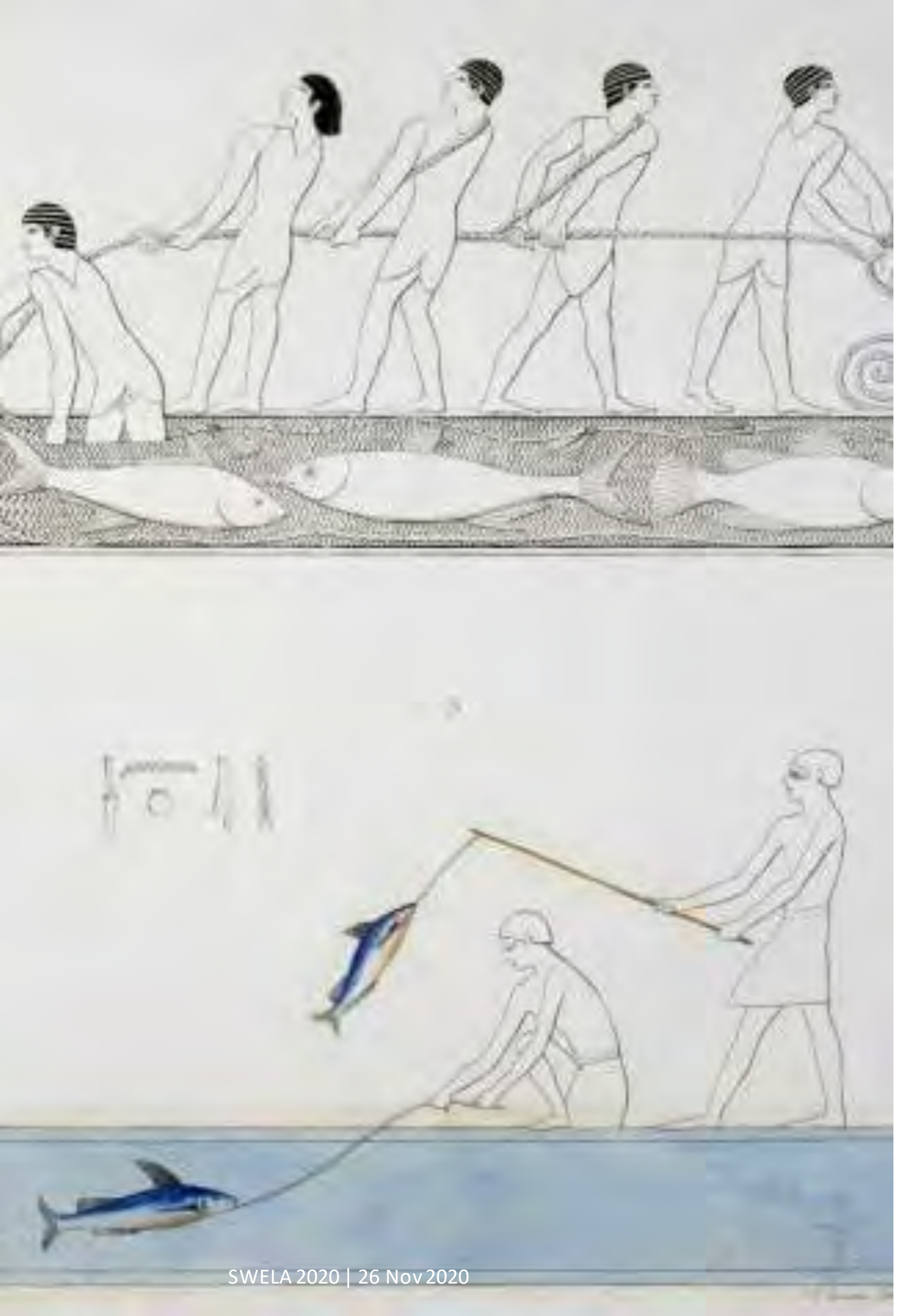
Videos on Tilapia farming

Sex reversal

Worldwide, the most important fish species produced in fish farming are carp, **tilapia**, salmon, and catfish.



'if the aquaculture industry is going to reduce the pressure on wild fish stocks and provide food for the world's growing population, substantial changes must be made by governments, the private sector and international funding agencies. They must protect coastal ecosystems; promote research and development of native species; and ***encourage farming of low-trophic-level fish — those low on the food chain****'* Perez et al 2000; Nature correspondence



How adequate is Tilapia as a farming species

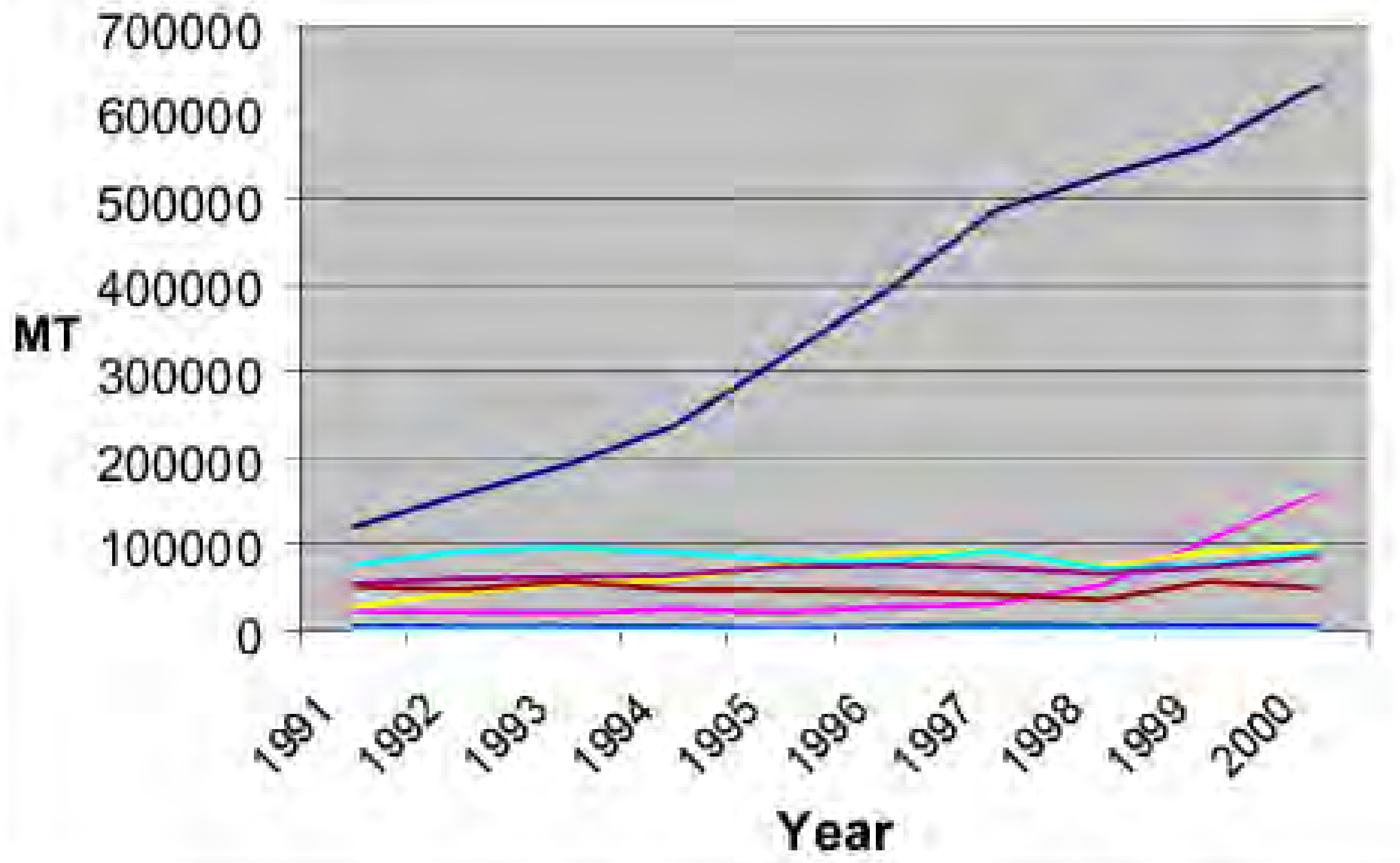
Farmed from old times by Egyptians: **Scientists said that evidence of fish farming in Ancient Egypt dating back 3,500 years ago is the first documented evidence of the practice on earth.**

The earliest fish domesticated species

It's been introduced all over the world with good and bad consequences (invasive species in most countries depleting the native fish populations when escapes from ponds)

Pros: low trophic level fish, very tolerant to changes in the environment and flexible

Cons: It is a highly social and aggressive fish with high cognitive capacities



Production of Tilapia worldwide in Million Tones per year

TABLE 8

MAJOR SPECIES PRODUCED IN WORLD AQUACULTURE

	2010	2012	2014	2016	2018	2018 share
	(thousand tonnes)					(percentage)
Finfish						
Grass carp, *Ctenopharyngodon idellus*	4 213.1	4 590.9	5 039.8	5 444.5	5 704.0	10.5
Silver carp, *Hypophthalmichthys molitrix*	3 972.0	3 863.8	4 575.4	4 717.0	4 788.5	8.8
Nile tilapia, *Oreochromis niloticus*	2 657.7	3 342.2	3 758.4	4 165.0	4 525.4	8.3
Common carp, *Cyprinus carpio*	3 331.0	3 493.9	3 866.3	4 054.7	4 189.5	7.7
Bighead carp, *Hypophthalmichthys nobilis*	2 496.9	2 646.4	2 957.6	3 161.5	3 143.7	5.8
Catla, *Catla catla*	2 526.4	2 260.6	2 269.4	2 509.4	3 041.3	5.6
Carassius spp.	2 137.8	2 232.6	2 511.9	2 726.7	2 772.3	5.1
Freshwater fishes nei,[1] Osteichthyes	1 355.9	1 857.4	1 983.5	2 582.0	2 545.1	4.7
Atlantic salmon, *Salmo salar*	1 437.1	2 074.4	2 348.1	2 247.3	2 435.9	4.5
Striped catfish, *Pangasianodon hypophthalmus*	1 749.4	1 985.4	2 036.8	2 191.7	2 359.5	4.3
Roho labeo, *Labeo rohita*	1 133.2	1 566.0	1 670.2	1 842.7	2 016.8	3.7
Milkfish, *Chanos chanos*	808.6	943.3	1 041.4	1 194.8	1 327.2	2.4
Torpedo-shaped catfishes nei, *Clarias* spp.	343.3	540.8	867.0	961.7	1 245.3	2.3
Tilapias nei, *Oreochromis* (=Tilapia) spp.	472.5	693.4	960.8	972.6	1 030.0	1.9
Rainbow trout, *Oncorhynchus mykiss*	752.4	882.1	794.9	832.1	848.1	1.6
Wuchang bream, *Megalobrama amblycephala*	629.2	642.8	710.3	858.4	783.5	1.4
Marine fishes nei, Osteichthyes	467.7	567.2	661.0	688.3	767.5	1.4
Black carp, *Mylopharyngodon piceus*	409.5	450.9	505.7	680.0	691.5	1.3
Cyprinids nei, Cyprinidae	639.8	601.1	628.0	596.1	654.1	1.2
Yellow catfish, *Pelteobagrus fulvidraco*	177.8	233.7	302.7	434.4	509.6	0.9
Other finfishes	6 033.9	6 869.3	7 730.0	8 217.1	8 900.2	16.4
Finfish total	**37 745.1**	**42 338.2**	**47 219.1**	**51 078.0**	**54 279.0**	**100**

Nile tilapia

O niloticus + others

8.3+1.9=10.2%

2018

4525.4 +1030.0=

5,555.4 Thousand tonnes

Atlantic salmon: 4.5%

Marine fishes: 1.4%

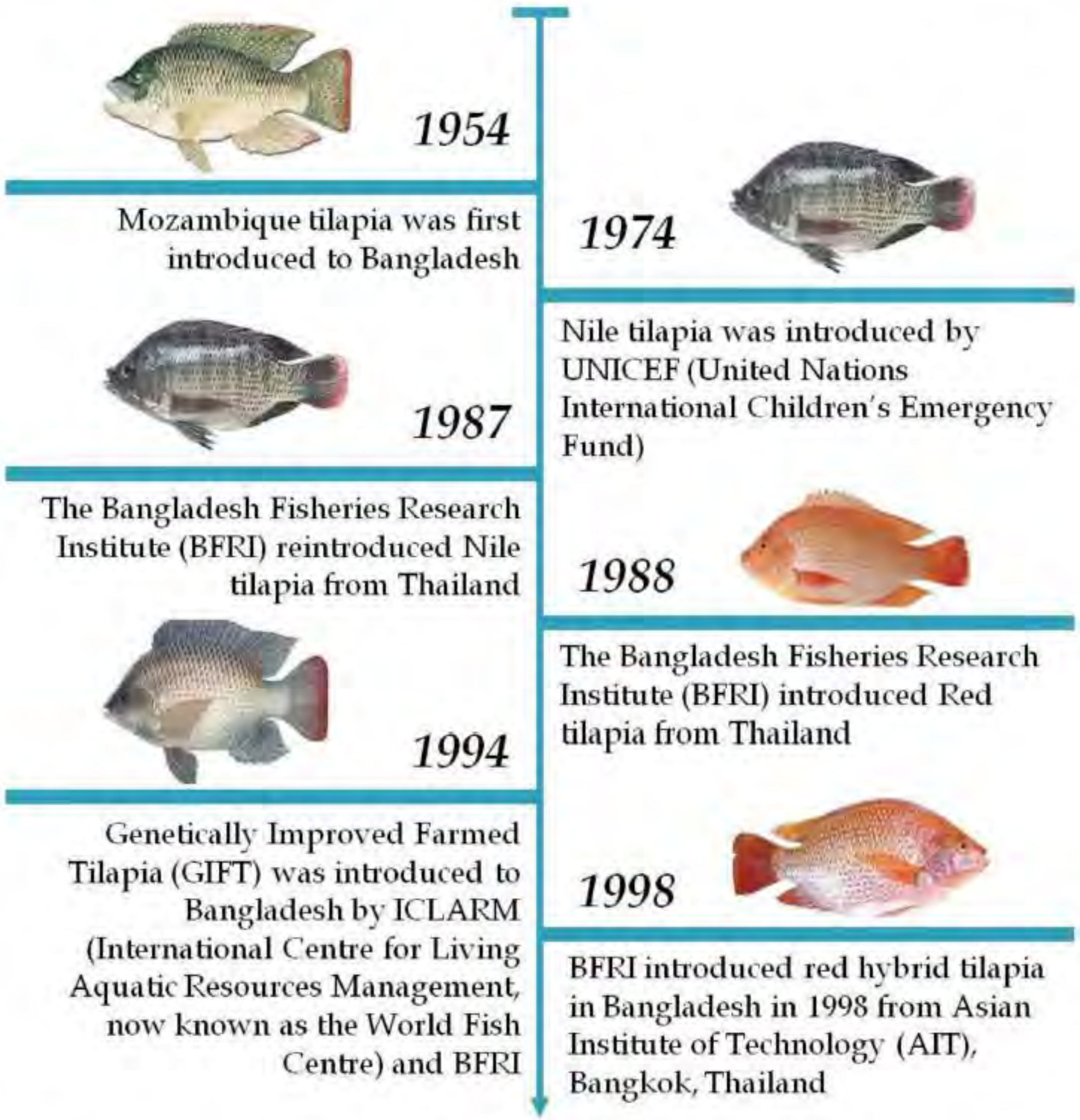


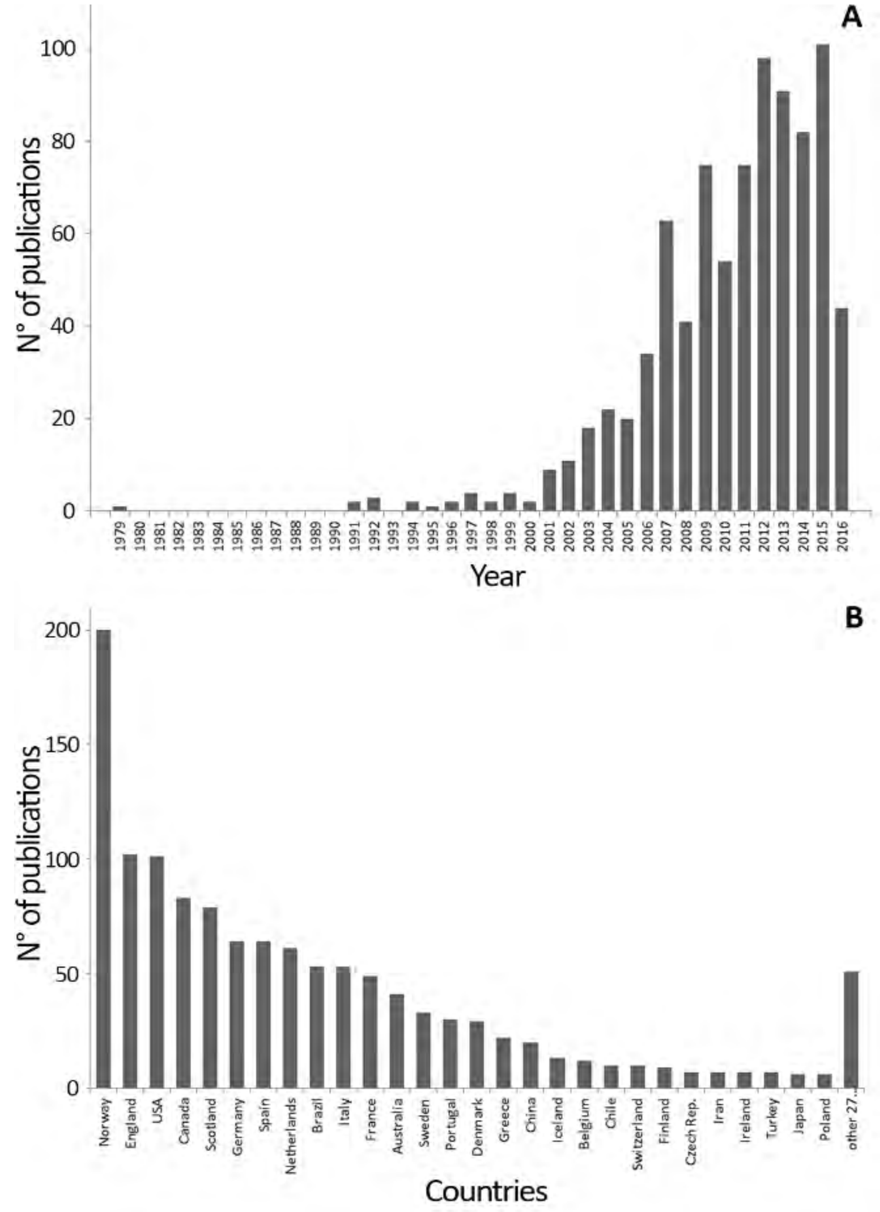
Fig. 1. Timeline showing a brief history of tilapia in Bangladesh (Source: Authors' own construction based on reviewed literature).

Welfare in metrics

Fish species cited in each welfare publication until 2016

Fish under study	Nº of publications	%
Salmo salar	139	19.50
Oncorhynchus mykiss	72	10.10
Dicentrarchus labrax	46	6.45
Sparus aurata	32	4.49
Danio rerio	30	4.21
Gadus morhua	29	4.07
Oreochromis niloticus	**23**	**3.23**
Cyprinus carpio	20	2.81
Clarias gariepinus	13	1.82
Solea senegalensis	13	1.82
Anguilla anguilla	9	1.26
Oreochromis mossambicus	**9**	**1.26**

Adapted fromFish welfare: the state of science by scientometrical analysis Ghisi and Oliveira, 2016



This graph shows publications on fish and welfare

OPERATIONAL WELFARE INDICATORS

Animal-based measures (outcome measures)

- Behaviours
- Physiological measures
- Disease incidence levels/mortality

Resource-based measures (input measures)

- Space in tanks or ponds (Density)
- Husbandry procedures
- Type of food provided

Based on the 5 freedoms or **The Five Domains Model (Mellor and Reid, 1994)**

Operational welfare indicators

Fry

Indirect: water Q and temp, feeding

Direct: morts and behaviour

On growing

Indirect: feed and water parameters

Direct:

- Husbandry
- Fin damage
- Skin damage
- Eyes
- Colour
- Behaviour

Breeders

Indirect: feeding, water parameters

Direct:

methods of handling breeders
Damage
Ratios
Behaviour

Animal based main OWI in Tilapia (output/direct)

GENERAL

- Mortality (daily, weekly or monthly rates)
- Condition index (relates weight and length)
- Standard growth rates (relates to the growth over time)
- Fin damage (dorsal/caudal)-Scoring
- Skin damage-Scoring
- Opercular damage- Scoring
- Emaciation-Scoring
- Exophthalmia-Yes/no
- Disease-Yes/no and iD if possible

Animal based main OWI in Tilapia (output/direct)

SPECIFIC

- Emanciation-Scoring
- Eye/skin darkening-Scoring (sign of stress) *Volpato et al 2003*
- Abnormal behaviour- loss of appetite, mouthing, balling and approaching the edges of the ponds-scoring
- Number of nests per area (density of nests)

OWI in Tilapia

Fig. 5 showing fish with damaged lips and mouth ulcer.

Fig. 6 showing fish with a broken dorsal spine.

Fig. 7 showing fish with opercular damage.

Fig. 8 showing fish with skin lesions.

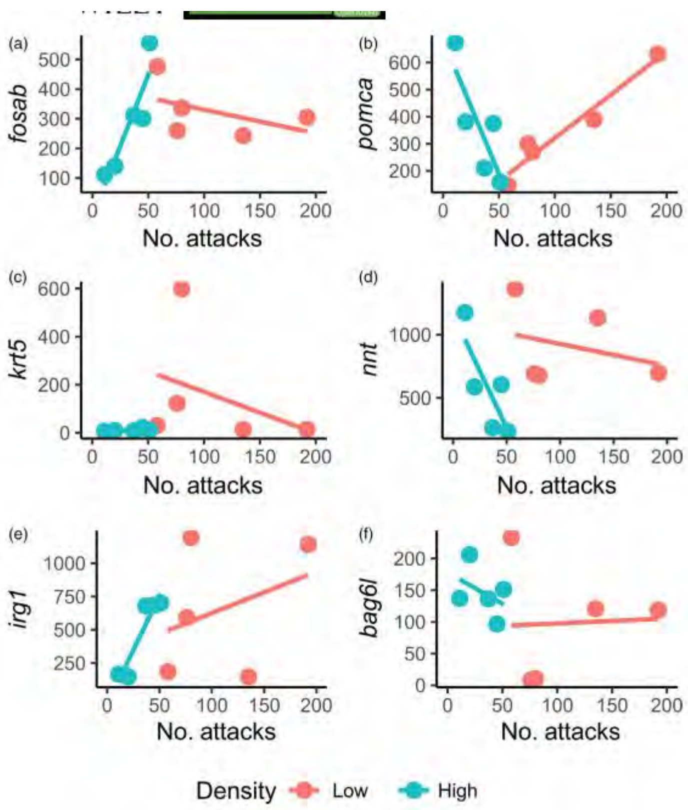
J John 2020, MSc dissertation
IoA, University of Stirling

ORIGINAL ARTICLE

Evolutionary Applications | WILEY

Transcriptomic response to aquaculture intensification in Nile tilapia

Deiene Rodriguez-Barreto[1] | Olivier Rey[1,2] | Tamsyn M. Uren-Webster[1] | Giovanni Castaldo[1,3] | Sonia Consuegra[1] | Carlos Garcia de Leaniz[1]



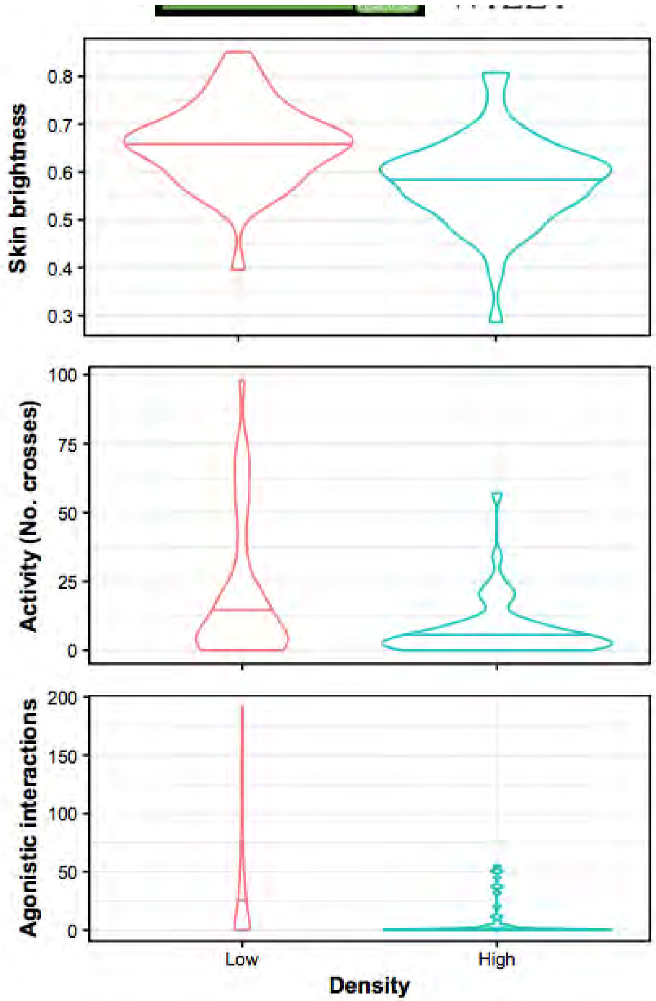


FIGURE 3 Effect of rearing density on variation of (a) skin brightness (0 = black, 1 = white), (b) activity (no. of zone crosses in the test arena) and (c) aggression (no. of agonistic interactions against a mirror image)

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Resource based main OWI in Tilapia (input measures)

- Space in tanks or ponds (Density, usually high)
- Husbandry procedures (sharp and sounders 2011 model of assessment)
- Type of food provided(nutritional domain covered in here, Tilapia feed needs low protein so quite cheap):
  - Live, commercial floating or sinking pellets, local feed, insect-based feed, etc.
- Water quality measures (wide range of tolerance):
  - Oxygen (DO %)
  - Temperature (thermal choice)
  - Turbidity
  - Nitrogen, ammonia and nitrate

Behavioural prophylaxis project in Egypt
Modifications in the tilapia ponds to increase the Temperature gradients within the ponds

PROCEEDINGS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Behavioural fever is a synergic signal amplifying the innate immune response

Sebastian Boltaña, Sonia Rey, Nerea Roher, Reynaldo Vargas, Mario Huerta, Felicity Anne Huntingford, Frederick William Goetz, Janice Moore, Pablo Garcia-Valtanen, Amparo Estepa and S. MacKenzie

Proc. R. Soc. B 2013 **280**, 20131381, published 10 July 2013

PROCEEDINGS B

rspb.royalsocietypublishing.org

Fish can show emotional fever: stress-induced hyperthermia in zebrafish

Sonia Rey[1,2], Felicity A. Huntingford[1], Sebastian Boltaña[1,2], Reynaldo Vargas[2], Toby G. Knowles[3] and Simon Mackenzie[1,2]

Monitoring of the Environmental parameters

Dead bank

Raised platform

Green house

Assessment of overall welfare impact of a husbandry protocol including harvesting and slaughter (Sharp and sounders model)

5 DOMAINS

Nutrition

Environment

Health

Behaviour

Emotional

	No impact	Mild impact	Moderate impact	Severe impact	Extreme impact
Domain 1 (Food deprivation, malnutrition)					
Domain 2 (Environmental challenge)					
Domain 3 (Injury, disease, functional impairment)					
Domain 4 (Behavioural, interactive restriction)					
Domain 5 (Anxiety, fear, pain etc.)					

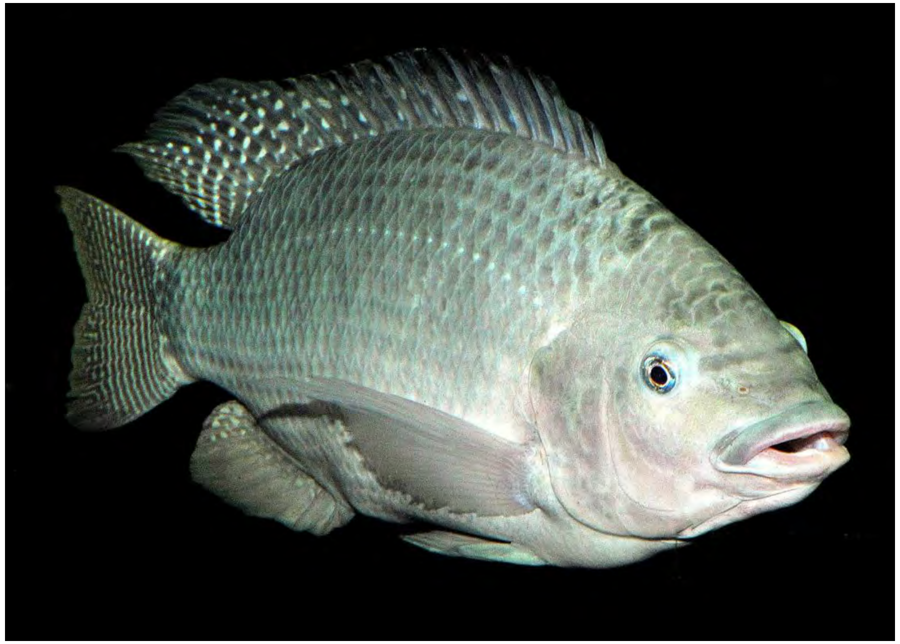
Sharp, T. and Saunders, G. (2011) A model for assessing the relative humaneness of pest animal control methods. Second edition. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, ACT. Printed by: New Millennium Print. Available at: https://www.agriculture.gov.au/sites/default/files/style%20library/images/daff/__data/assets/pdffile/0008/929888/humaneness-pest-animals.pdf

Assessment of overall welfare impact of a husbandry protocol including harvesting and slaughter (Sharp and sounders model)

Overall impact on welfare	Duration of impact				
	Immediate to Seconds	Minutes	Hours	Days	Weeks
EXTREME	5	6	7	8	8
SEVERE	4	5	6	7	8
MODERATE	3	4	5	6	7
MILD	2	3	4	5	6
NO IMPACT	1	1	1	1	1

Level of suffering (after application of the method that causes death but before insensibility)	Time to insensibility (minus any lag time)				
	Immediate to Seconds	Minutes	Hours	Days	Weeks
EXTREME	E	F	G	H	H
SEVERE	D	E	F	G	H
MODERATE	C	D	E	F	G
MILD	B	C	D	E	F
NO IMPACT	A	A	A	A	A

Done and needs to be done



Done:

✓Commercial feed developed

✓Husbandry protocols

✓Reproduction methods

✓Genetic selection program: Partly done (different characteristics: growth, resistance, appearance)

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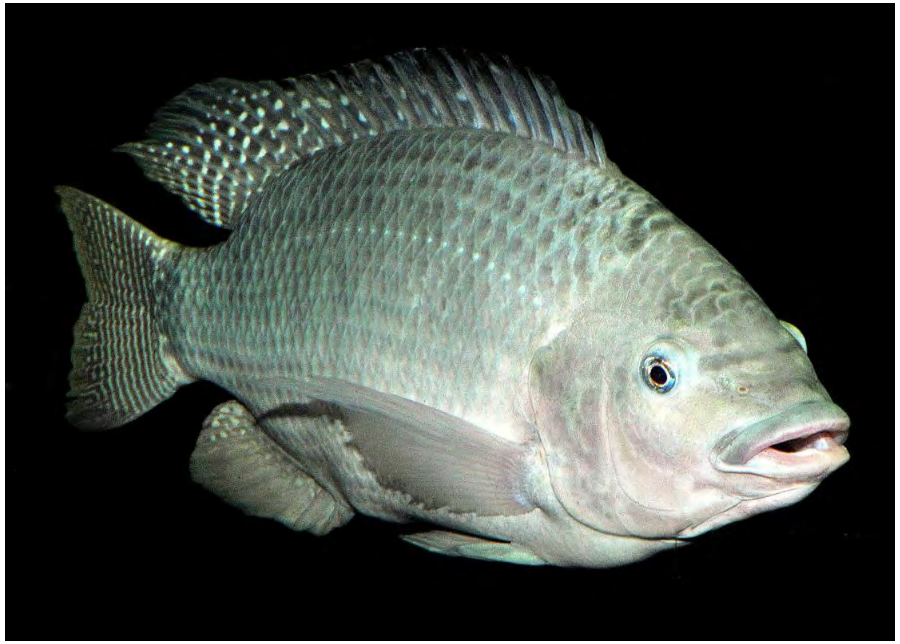
Done and needs to be done



Needs to be done:

- **Refine husbandry protocols** under higher welfare standards
- **Development and validation of OWI** used for fry, juveniles, adults and breeders and at different production systems
- **Welfare assessment tool for farmed** (fish) **tilapia** (WATFF) (scoring and overall welfare impact)
- Use **innovative methods** for welfare assessment: recordings, environmental sensors, biosensors, etc
- Evaluate **potential damaging effects** of several methods like the sex reversal procedure (few work done)
- Promoting **positive welfare and behaviours**: enrichment, better food quality, water aeration, male: female ratios?, natural breeding, behavioural prophylaxis.
- **Life Cycle Assessment (LCA)** for different Tilapia farming in different countries, production systems and life stages and use it for improving the welfare of Tilapia

Thanks for your attention! Questions?

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