

The ontogeny of salinity tolerance in the tilapias *Oreochromis aureus*, *O. niloticus*, and an *O. mossambicus* \times *O. niloticus* hybrid, spawned and reared in freshwater

Wade O. Watanabe^a, Ching-Ming Kuo^{*} and Mei-Chan Huang^{**}

^a 1439 B Alewa Drive, Honolulu, HI 96817, U.S.A.

^{*} International Center for Living Aquatic Resources Management, MCC P.O. Box 1501, Makati, Metro Manila The, Philippines

^{**} Institute of Marine Biology, National Sun Yat-Sen University, Kaohsiung 800, Taiwan

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Abstract

The ontogeny of salinity tolerance was studied in the tilapias *Oreochromis aureus*, *O. niloticus*, and an *O. mossambicus* (\square) \times *O. niloticus* (\square) ($M \times N$) hybrid, spawned and reared in freshwater. Several indices were used as practical measures of salinity tolerance: (1) Median Lethal Salinity — 96 h (MLS-96), defined as the salinity at which survival falls to 50%, 96 h following direct transfer from freshwater to various salinities; (2) Mean Survival Time (MST), defined as the mean survival time over a 96 h period, following direct transfer from freshwater to full seawater (32‰); and (3) Median Survival Time (ST50), defined as the time at which survival falls to 50% following direct transfer from freshwater to full seawater.

No significant age-specific differences in salinity tolerance were observed in either *O. aureus* or *O. niloticus* on the basis of the MLS-96 index. Mean MLS-96 values over all ages from 7 to 120 days post-hatching were 18.9‰ for *O. niloticus*, and 19.2‰ for *O. aureus*. In contrast, the $M \times N$ hybrid exhibited relatively greater changes in salinity tolerance with age, MLS-96 ranging from 17.2‰ at 30 days post-hatching to 26.7‰ at 60 days post-hatching. Distinct age-specific differences in salinity tolerance were observed in all three on the basis of the MTS and ST50 indices.

These ontogenetic changes in salinity tolerance were determined to be more closely related to body size than to chronological age. No consistent relationship was observed between salinity tolerance and condition factor. The practical implications of these findings for the saltwater culture of tilapias are discussed.

Influence of egg size on the growth, onset of feeding, point-of-no-return, and survival of unfed *Oreochromis mossambicus* fry

K. J. Rana

Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Great Britain

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Abstract

The variation in egg size within and between egg clutches of *O. mossambicus*, and the subsequent influence of mean egg size on growth, feeding incidence and survival of unfed fry were investigated.

The individual egg sizes within 90% of the egg clutches examined were normally distributed and the coefficient of variation of egg size within clutches ranged from 7.4% to 15.4%. Fry emerging from the small, medium and large egg size groups reached their maximum length and weight at 9, 9 and 12 days after hatching, respectively. Maximum attainable fry length and weight were significantly correlated with egg size ($r = 0.885$ and 0.947 , respectively, with $P < 0.01$).

Egg size had little influence on the onset of feeding. Fry were capable of exogenous feeding within 6 to 7 days of hatching. Fry originating from small and medium egg size classes reached the point-of-no-return at 15–16 days after hatching compared to 21 days for fry from the large egg size class. The mean survival time (ST₅₀) of fry on their yolk reserves was significantly correlated ($r = 0.923$; $P < 0.01$) with their original mean egg weight and ranged from 9.5 days for fry hatching from 0.91-mg eggs to 21 days for fry from 1.93-mg eggs.

The influence of stocking density and food ration on fry survival and growth in *Oreochromis mossambicus* and *O. niloticus* female × *O. aureus* male hybrids reared in a closed circulated system

D. J. Macintosh and S. S. De Silva¹

Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Great Britain

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Abstract

First-feeding stage tilapia fry were reared for 40 or 50 days in 20-l capacity aquaria at six stocking densities (2, 4, 6, 8, 10, 12 l⁻¹) and three feeding levels (6, 12, 24% of body weight daily). Fry survival and growth were improved at the higher feeding levels, but the percentage of fry surviving showed no consistent relationship to stocking density. Cannibalism accounted for a mortality rate of 10–35% in each experimental group and was inversely related to the level of feeding. Under equivalent conditions, *O. niloticus* female × *O. aureus* male fry had a higher rate of survival, better food conversion and were more uniform in size than *O. mossambicus* fry.

¹ Present address: Department of Zoology, Ruhuna University College, Matara (Sri Lanka)

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Short communication

The use of lidocaine-sodium bicarbonate as anaesthetic in fish

S. Carrasco^a, H. Sumano^a and R. Navarro-Fierro^b

^a Department of Physiology, Faculty of Veterinary Medicine, University of Mexico, 20 D.F. C.P. 04340, Mexico

^b Department of Genetics, Faculty of Veterinary Medicine, University of Mexico, 20 D.F. C.P. 04340, Mexico


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Abstract

Lidocaine and lidocaine-sodium bicarbonate mixture were evaluated as anaesthetics for carp (*Cyprinus carpio*), catfish (*Ictalurus punctatus*) and tilapia (*Tilapia MOSSAMBICA* = *Oreochromis mossambicus*¹). Although both induced anaesthesia, the mixture was more effective for induction and recovery, and was able to achieve the required time for the fish to be out of water. The responses varied for the three test species.

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Biochemical investigations into the influence of environmental salinity on starvation of the tilapia, *Oreochromis mossambicus*

K. Jürss, Th. Bittorf, Th. Vökler and R. Wacke

Department of Biology: Subdepartment of Animal Physiology, Wilhelm Pieck University Rostock, 25, Rostock, German Democratic Republic

Accepted 8 February 1984.; Available online 6 October 2003.

Abstract

Tilapias held in fresh water, diluted sea water (10‰) and sea water (33‰) were starved or fed on trout pellets. In terms of live weight losses, the effects of starvation were the same for the fish under all three salinity conditions, but the growth rate of the fed fish in fresh water was lower than in 10‰ or 33‰. Glutamate dehydrogenase activity (units/g) increased in the liver of starving tilapias, whereas the alanine and aspartate aminotransferase activities (units/g) remained unchanged. Na—K-ATPase activity was significantly higher in the gills of the fishes held at 33‰ than in those kept in fresh water or at 10‰. Starvation reduced the Na/K-ATPase activity in the gills of tilapias held in fresh water and diluted sea water by over 50%. It is striking that no increase was observed in the activity of this enzyme in the gills of starved fishes kept in sea water, although it increased significantly in the fed fish held at the same salinity. In other words, food deprivation makes it more difficult for tilapias to adapt to a saline environment and will increase the negative effects of handling when the fishes are farmed in sea water.

Growth rates of Mozambique tilapia (*Oreochromis mossambicus*) and silver carp (*Hypophthalmichthys molitrix*) without artificial feeding in floating cages in plankton-rich waste water

I. G. Gaigher^a and J. B. Krause^b

^a Institute for Environmental Sciences, University of the Orange Free State, P.O. Box 339, Bloemfontein 9300, Republic of South Africa

^b P.O. Box 17140, Bainsvlei 9338, Republic of South Africa

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Abstract

Hypophthalmichthys molitrix and *Oreochromis mossambicus* were reared without artificial feeding in 0.57 m³ wire cages suspended in human sewage and pig feedlot waste treatment systems. At a cage density of 17 m⁻³ *H. molitrix* grew from 15 to 260 g in 190 days but then growth ceased due to unknown factors. *O. mossambicus* grew rapidly at various densities; the maximum being from 10 to 130 g in 98 days. In both species the maximum individual daily mass increase of 2.5 (*H. molitrix*) and 1.4 g (*O. mossambicus*) occurred during December to January. Mortalities were probably mainly due to handling. Tilapia grown in the human sewage treatment system were in a better condition than those from the pig feedlot waste treatment system.

Evaluation of nitrofurazone baths in the treatment of bacterial infections of *Sparus aurata* and *Oreochromis mossambicus*

A. Colorni^a and I. Paperna^b

^a Israel Oceanographic and Limnological Research, Mariculture Laboratory, Elat, Israel

^b Heinz Steinitz Marine Biology Laboratory of the Hebrew University of Jerusalem, Elat, Israel

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Abstract

Nitrofurazone, an antibacterial agent routinely used in our laboratory for prophylactic treatment to prevent vibriosis in *Sparus aurata*, was chosen for a series of immersion experiments aimed at determining whether a therapeutic tissue concentration was, in fact, reached. Two different species of fish, *Oreochromis mossambicus* and *Sparus aurata*, and two different techniques for detecting the agent were utilized but no trace of nitrofurazone could be detected in the blood or muscle of any fish at any time during the experiments. Nitrofurazone, however, prevented bacterial colonization in skin lesions and small injuries that would otherwise often develop into systemic infections.

Elimination of orally administered 17α -methyltestosterone by *Oreochromis mossambicus* (tilapia) and *Salmo gairdneri* (rainbow trout) juveniles

R. Johnstone^a, D. J. Macintosh^b and R. S. Wright^a

^a DAFS Marine Laboratory, Aberdeen, Great Britain

^b Institute of Aquaculture, University of Stirling, Stirling, Great Britain


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Abstract

Juvenile tilapia and rainbow trout receiving dietary levels of 17α -methyl-4-androstene- 17β - 3α -ol-3-one (17α -methyltestosterone, 17 MT) to effect masculinization and sterility respectively were fed tritium labelled steroid and the rates of depletion of radioactivity from body tissues were measured. Radioactivity remained high for the first 8 to 12 h following withdrawal of hormone and was largely confined (>95%) to the visceral tissues. Thereafter there was a rapid depletion of radioactivity from both viscera and carcass, with less than 1% of the initial whole-body levels remaining after 100 h.

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Brief technical note

Genetic groupings of Tilapiini used in aquaculture

E. Trewavas

British Museum (Natural History), Cromwell Road, London SW7 5BD, Great Britain

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Abstract

The tilapias were formerly included in the genus *Tilapia*. Now only the substrate-brooders retain the generic name *Tilapia*, e.g. *Tilapia sarrmanii*, *T. guineensis*. There are two main kinds of mouth-brooders, *Sarotherodon* (e.g. *S. galilaeus*) and *Oreochromis* (e.g. *O. mossambicus*, *O. niloticus*, *O. macrochir*). In *Sarotherodon* brooding is paternal or biparental (where known), in *Oreochromis* maternal. All are included, with a few other genera, in the Tribe Tilapiini and may be referred to colloquially as tilapias, with a small 't' and no italics.

Partial and complete replacement of fish meal with gambusia meal in diets for red tilapia '*Oreochromis niloticus* × *O. mossambicus*'

A.E. Abdelghany

Abstract

A 12-week experiment was conducted to evaluate the suitability of gambusia (*Gambusia affinis*) fish meal (GFM) as a partial and complete substitute for the protein supplied by herring fish meal (HFM) in diets for red tilapia fingerlings (mean weight 0.42 g). Seven isonitrogenous (35% crude protein), isolipidic (9% fat) and isoenergetic (15.9 kJ DE-g⁻¹) diets were formulated in which GFM replaced 0.0, 10, 25, 50, 75, 90 and 100% of the protein supplied by HFM. In general, GFM exhibited good potential as a substitute for HFM in red tilapia diets with no adverse effects on growth, feed efficiency, body composition, blood parameters or apparent digestibility of dry matter, protein and gross energy compared with the HFM-based control diet. Growth performance (in terms of final weight, weight gain, per cent increase in weight and growth rate) of fish fed diets containing GFM at 25 or 50% level of replacement for HFM-protein (diets 3 and 4) was statistically higher than for fish fed diets containing GFM at replacement levels >50%. Diet 4 had the best economic efficiency of fish weight gain. Partial or complete substitution of GFM for HFM did not affect feed utilization efficiency (in terms of FCR, FER, PER and APU) or digestibility coefficients of dry matter, protein and gross energy compared with those of the HFM-based diet. Apparent protein digestibility varied little between diets, ranging from 84.2 to 87.3% with no significant differences. Survival of fish fed all the experimental diets (except for fish fed GFM at 90 or 100% level of replacement for HFM-protein) was comparable with that of fish fed the control diet and ranged from 91.7 to 98.3%.

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Affiliations

Central Laboratory of
Aquaculture Research, Abbassa,
Abohamad, Sharkia, Egypt

Correspondence

Correspondence: A.E.

Abdelghany, 12 Sakr-Korish,

Apt.#23, Maadi El-Gadeda,

Cairo, Egypt. E-mail:

abdelgh@thewayout.net

Utilization of torula yeast (*Candida utilis*) as a protein source in diets for tilapia (*Oreochromis mossambicus* Peters) fry

M.A. OLVERA-NOVOA¹, C.A. MARTÍNEZ-PALACIOS² & L. OLIVERA-CASTILLO¹

A 63 day⁻¹ feeding trial was conducted under laboratory conditions to evaluate the effects of substituting animal protein with a mixture of plant feedstuffs including 25, 30, 35, 40 and 45% of the protein with torula yeast (*Candida utilis*), 20% with soybean meal and 15% with Alfalfa Leaf Protein Concentrate (ALC), in diets for tilapia (*Oreochromis mossambicus* Peters) fry. Feeding efficiency was compared against a diet with fish meal as the sole protein source. Diet nutritional quality was very similar independent of composition, with no differences in growth parameters, but fish fed with 30% yeast diet showed the best growth performance. Diet composition did not affect feed or protein utilization, with the best feed conversion ratio, protein efficiency ratio and apparent nitrogen utilization in the 25% yeast diet. Protein digestibility was above 80% for all diets, and no differences in carcass composition were observed. The best incidence cost was obtained with 25% yeast and the highest profit index with 30% yeast, but no statistical differences were observed with the other treatments. The results suggest that it is possible to replace up to 65% of animal protein with a mixture of plant proteins, including 30% from torula yeast, in tilapia fry diets without adverse effects on fish performance and culture profit.

Affiliations

¹Centro de Investigación y de Estudios Avanzados del IPN, Unidad Mérida (CINVESTAV), Mérida, Yucatán, México,

²Universidad Michoacana de San Nicolás de Hidalgo, Instituto de Investigaciones sobre los Recursos Naturales, Morelia, Michoacan, México

Growth, feed utilization and body composition of tilapia (*Oreochromis* sp.) fed with cottonseed meal-based diets in a recirculating system

Mbahinzireki, Dabrowski, Lee, El-Saldy & Wisner

The suitability of cottonseed meal (CSM) as a major source of plant protein in feeds for tilapia (*Oreochromis* sp.) was tested by examining growth and feed intake, feed digestibility, liver gossypol concentrations, feed utilization, and body mineral composition. Juvenile tilapia at an initial average size of 11.8 ± 1.6 g were divided into triplicate groups per dietary treatment and offered five different formulated diets. In these feeds fish meal (FM) protein was gradually replaced by protein from CSM (0, 25, 50, 75, and 100%; diets 1, 2, 3, 4 and 5, respectively). The experiments were conducted in a recirculation system at a water temperature of $27 \pm 1^\circ\text{C}$ in glass aquaria for 16 weeks. Tilapia growth did not differ significantly ($P > 0.05$) with up to 50% substitution of FM with CSM. Fish meal replacement above 50% resulted in significant growth decline with time. Fish fed with 100% FM and diets including 50% CSM had significantly better daily weight gain, daily feed intake and feed efficiency ratio than those fed with 100% CSM. Fish fed with 75% CSM and above had lower concentrations of body iron, calcium and phosphorus than controls (100% FM). Concentrations of total gossypol in diets (ranging from 0.11 to 0.44% in diets 2–5) resulted in proportional increase of total gossypol in fish liver (32.3, 72.3, 99.4 and $132.1 \mu\text{g g}^{-1}$ wet weight) in groups fed with diet 2, 3, 4, and 5, respectively. We concluded that CSM can partially replace FM as a main source of protein in feed for tilapia at not more than 50%. The presence of gossypol in CSM was identified as the major limiting factor for acceptance and utilization of CSM-based diets in tilapia farming.

Affiliations

¹School of Natural Resources,
The Ohio State University,
Columbus, OH, USA;
Mbahinzireki's present address,
FIRI, Jinja, Uganda²Department
of Poultry Production, Menofiya
University, Shebin El-Kom,
Egypt³Department of Veterinary

Comparative study of biochemical parameters in response to stress in *Oreochromis aureus*, *O. mossambicus* and two strains of *O. niloticus*

Avner Cnaan¹, Simon Tinman², Yaacov Avidar³, Micha Ron¹ & Gideon Hulata¹

Abstract

This study was aimed at detecting differences among tilapia species in immunological and biochemical parameters that are indicators for fish health. In addition, six blood parameters that are indicators of stress were measured, glucose concentration, ceruloplasmin activity, lysozyme activity, respiratory burst activity, haematocrit and leucocrit, and their levels were compared among groups. A calibration experiment was conducted with commercial stock of tilapia to optimize a protocol for measuring stress response in tilapia. An air exposure stress was induced to six groups of fish and blood samples were taken at six different times: 15 min, 1, 2.5, 4.5, 6 and 24 h, after inducing stress. The highest responses to stress were observed after 2.5–4.5 h. A second experiment was conducted with four tilapia species: *Oreochromis aureus* (Steindachner), *O. mossambicus* (Peters), a red strain and the wild type of *O. niloticus* L. Levels of serum biochemical components and parameters of the innate immunity response to stress were compared in ten fish from each species. Significant differences were observed. *Oreochromis aureus* differed from the other three species (notably from *O. mossambicus*) in most of the measured immune response traits (glucose concentration, lysozyme activity, haematocrit and levels of total protein and IgM after stress) and serum biochemical components (protein, albumin, triglyceride, cholesterol, calcium, magnesium, phosphorus, bilirubin and β -hydroxybotric acid). The identified differences suggest that hybrid families from *O. aureus* and *O. mossambicus* may be used to construct a segregating population for genetic analysis of the innate immune response to stress. Thus, these two species were bred for segregating F₂ population, suitable for quantitative trait loci studies for the innate immune response to stress.

[References](#)

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Affiliations

¹Institute of Animal Science, Agricultural Research Organization, Bet-Dagan, Israel

²The Central Fish Health Laboratory, Nir David, Israel

³Biochemistry Department, Kimron Veterinary Institute, Bet-Dagan, Israel

Correspondence

Experimental evaluation of mass selection to improve red body colour in Fijian hybrid tilapia (*Oreochromis niloticus* × *Oreochromis mossambicus*)

P B Mather¹, S N Lal² & J Wilson¹

Abstract

Mass selection was trialed on Fijian hybrid tilapia (*Oreochromis niloticus* × *Oreochromis mossambicus*) to reduce the amount of black spots on otherwise red phenotypes. The responses of two selection intensities (low-selection line, top 50% - L) and (high-selection line, top 30% - H) were compared with that of a control line (no selection - C) across three generations. The relative growth performance of treatments (C, L and H) was examined in parallel in each generation to assess whether mass selection had a correlated negative effect on growth performance. The results show clearly that red phenotype can be improved significantly by applying mass selection, without affecting growth performance. We propose that black spots on an otherwise red phenotype could represent the allelic products of a second genetic locus influencing skin colour, which can be expressed in red individuals (genotype Rr) but which may be masked in black individuals (genotype rr).

[References](#)

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Affiliations

¹School of Natural Resource Sciences, Queensland University of Technology, 2 George St Brisbane 4001,

Australia²Naduruloulou Aquaculture Research Station, Ministry of Agriculture, Fisheries and Forests, Nausori, Fiji

Correspondence

Correspondence: Dr P B Mather, School of Natural Resource Sciences, Queensland University of Technology, 2 George St Brisbane 4001, Australia

Contamination of palm kernel meal with *Aspergillus flavus* affects its nutritive value in pelleted feed for tilapia, *Oreochromis mossambicus*

H-A Lim, W-K Ng, S-L Lim & C O Ibrahim

Abstract

An assessment of the nutritive value of palm kernel meal (PKM) and aflatoxin-contaminated PKM (obtained by fermenting PKM with *Aspergillus flavus*) as a dietary ingredient in pelleted feed for tilapia, *Oreochromis mossambicus* Peters, was carried out in a 12-week feeding trial. Seven isonitrogenous (40% crude protein) and isoenergetic (15.1 kJ g^{-1}) practical diets were formulated and fed close to apparent satiation to triplicate groups of 12 fish (mean initial weight $8.4 \pm 0.1 \text{ g}$). The control diet contained 30% fish meal and 10% soybean meal (SBM) proteins. Four other experimental diets containing 20% and 50% of the SBM protein replaced by either PKM or fermented PKM, respectively, were formulated. Two additional diets containing either PKM or fermented PKM supplemented with a commercial aflatoxin adsorber (0.5% SorbatoxTM) were also formulated. Measured aflatoxin B₁ levels in the fermented PKM-based diets ranged from 75 to $100 \mu\text{g kg}^{-1}$ diet. The growth performance and feed utilization efficiency of tilapia fed fermented PKM-based diets were significantly lower than in fish fed the control diet at all inclusion levels ($P < 0.05$). Despite a small reduction, weight gains of tilapia fed PKM-based diets were not significantly different compared with fish fed the control diet. The addition of 0.5% Sorbatox did not produce any beneficial or negative effects to the growth of tilapia. Under the dietary conditions of the present experiment, it was concluded that PKM can substitute up to 50% SBM in practical diets for *O. mossambicus* without much adverse effect to fish growth. However, when PKM was contaminated with *A. flavus*, its incorporation into tilapia diets resulted in growth depression as a result of decreased diet digestibility and also possibly because of the presence of anti-nutrients found in the contaminated PKM.

Affiliations

School of Biological Sciences,
Universiti Sains Malaysia,
Penang 11800, Malaysia

Correspondence

Correspondence: W-K Ng, Fish
Nutrition Laboratory, School of
Biological Sciences, Universiti
Sains Malaysia, Penang 11800,
Malaysia. E-mail: wkng@usm.my

Investigation into the mode of inheritance of allozyme and random amplified polymorphic DNA markers in tilapia *Oreochromis mossambicus* (Peters)

S. A. Appleyard¹ & P. B. Mather²

Abstract

Feral Australian *Oreochromis mossambicus* (Peters) (Pisces: Cichlidae) and an interspecific hybrid population (most probably originally derived from crosses of *O. mossambicus* and *O. niloticus* stocks) were used as model organisms to study the inheritance patterns of 24 allozyme loci and 31 random amplified polymorphic DNA (RAPD) loci in tilapia. Single-paired matings of parents of known genotype were used to generate families, and 10–15 full-sib offspring from each mating were used to test for mode of inheritance. The majority of allozyme and RAPD loci tested segregated in a Mendelian fashion. Allozyme markers in general showed co-dominant inheritance patterns, while RAPD markers conformed to expectations for band presence/absence under a dominant allele model. Although only a small number of families and offspring were used, the results highlight the suitability of allozymes and RAPDs as genetic markers for population analysis in tilapia.

Affiliations

¹Centre for Molecular Biotechnology, School of Life Science, and ²School of Natural Resource Sciences, Queensland University of Technology, GPO Box 2434, Brisbane, QLD, 4001, Australia

Correspondence

Correspondence: S. A. Appleyard, CSIRO Marine Research, GPO Box 1538, Hobart, Tasmania 7000, Australia

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Investigation into the mode of inheritance of allozyme and random amplified polymorphic DNA markers in tilapia *Oreochromis mossambicus* (Peters).

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Effect of the use of the microalga *Spirulina maxima* as fish meal replacement in diets for tilapia, *Oreochromis mossambicus* (Peters), fry

M A Olivera-Novoa¹, L J Domínguez-Cen¹ & L Olivera-Castillo¹ Carlos A Martínez-Palacios²

Abstract

The present study addresses the use of the microalga *Spirulina maxima* as a protein source in diets for tilapia, *Oreochromis mossambicus* (Peters), fry. Animal protein was replaced with algae protein at ratios of 20%, 40%, 60%, 80% and 100%, and the substitution effect was compared with a control diet in which fish meal was the sole protein. An additional 100% spirulina protein diet was supplemented with phosphorous to test for possible mineral deficiency in the plant-protein-based diet. The six treatments were tested in triplicate in a closed-recirculating system where the fish were fed by hand at 6% of their body weight. After a 9-week feeding period, the growth rate and protein utilization of fish fed the diet with 20% and 40% *Spirulina* were elevated and not significantly different ($P > 0.05$) from those fed the control diet. Further increases in the alga protein content significantly decreased the growth and feeding performance. The addition of P to the 100% *Spirulina* diet slightly improved performance in comparison to the same diet without P. None of the treatments produced any clear adverse effects on carcass composition. It is observed that *Spirulina* can replace up to 40% of the fish meal protein in tilapia diets.

Influence of salinity and dietary composition on blood parameter values of hybrid red tilapia, *Oreochromis niloticus* (Linnaeus) × *O. mossambicus* (Peters)

M C J Verdegem, A D Hilbrands & J H Boon

The influence of salinity and dietary composition on blood parameter values (haematocrit, leucocrit, immature lymphocytes, mature lymphocytes, granulocytes, plasma osmolarity and total plasma protein) of red hybrid tilapia, *Oreochromis niloticus* (Linnaeus) × *O. mossambicus* (Peters), was studied. Two groups of tilapia were fed a high-protein diet while kept in fresh or brackish water, respectively, and compared with two groups fed a low-protein diet under similar environmental conditions. Treatments were executed *in duplo*. Results show that salinity influenced all cellular blood parameters except the haematocrit. Dietary composition influenced the total plasma protein and haematocrit, while all parameters changed as time progressed during the experiment. It was concluded that the environmental parameters investigated in the present study should be considered when estimating fish health based on blood parameter values.

Pink body colour in Tilapia shows single gene inheritance

K.C. Majumdar, K. Nasaruddin & K. Ravinder

Segregation of a wide range of body colour in the progenies was observed in breeding experiments with the Taiwanese red tilapias. Homozygous stocks of pink, red and golden colour morph were selected from such a stock by brother-sister crossing for six generations. DNA fingerprinting analysis using multilocus M13 and Bkm 2(8) probe and *Hinf*I enzyme combinations of pink individuals, showed homozygosity in their genome. Pink individuals when crossed to black *Oreochromis mossambicus* (Peters) resulted in all pink F1 progenies. F1 × F1 crosses resulted in segregation of pink and black in the F2 progenies in a 3 : 1 ratio. F1 pink individuals when backcrossed to *O. mossambicus* gave progeny in the ratio of 1 : 1 of pink and black. Black individuals from the F2 generation, when crossed to *O. mossambicus* and pink separately, resulted in all black and all pink progenies, respectively. These results show that the pink colour is dominant over the black phenotype and is inherited as an autosomal locus with complete penetrance.

Forward Links to Citing Articles

- Mario Garduño-Lugo, Ivonne Granados-Alvarez, Miguel A Olvera-Novoa & Germán Muñoz-Córdova. (2003) Comparison of growth, fillet yield and proximate composition between Stirling Nile tilapia (wild type) (*Oreochromis niloticus*, Linnaeus) and red hybrid tilapia (Florida red tilapia Stirling red *O. niloticus*) males. *Aquaculture Research* 34:12, 1023-1028
Online publication date: 1-Oct-2003.

The diet of hybrid red tilapia *Oreochromis niloticus* (L.) × *Oreochromis mossambicus* (Peters) reared in the freshwater ponds of north-eastern Brazil

S. Chellappa, N.T. Chellappa, E.A. Silva, F.A. Huntingford & M.C.M. Beveridge

To assess potential competition for food with indigenous species prior to their release into reservoirs in north-eastern Brazil, the diet of hybrid red tilapia, *Oreochromis niloticus* × *O. mossambicus*, maintained without supplementary feed in monocultures in freshwater ponds, was studied. The stomach contents of 160 fish (140–220 mm total length), collected monthly from February to September 1993, were analysed. Fish of all size categories were found to be phytoplanktivores. A total of 40 microalgal species were observed in the stomach contents (17 species of Chlorophyceae, 11 species of Bacillariophyceae, eight species of Cyanophyceae, three species of Chrysophyceae and one of Euglenophyceae), together with a few rotifers and some organic material. In terms of cell numbers, the overall composition of the diet was 70% Chlorophyceae, 21% Bacillariophyceae, 3% Chrysophyceae, 2% Cyanophyceae, 1% Euglenophyceae and 3% organic matter. Neither diet composition nor stomach fullness varied with fish size. However, fish had relatively fuller stomachs, with higher proportions of Chlorophyceae, Bacillariophyceae and Cyanophyceae, during the rainy season. Hybrid red tilapia appear unlikely to compete for food with a native species and so may have a role in aquaculture or for deliberate release into reservoirs in north-eastern Brazil.

Recycling of poultry droppings through tilapia fish culture. Effect of monosex and mixed-sex culture on production

M. Natarajan

Recycling Project, Division of L.P.T., Indian Veterinary Research Institute, Izatnagar (UP) 243 122, India

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Abstract

Tilapia fish production in tanks manured with poultry droppings and stocked either with tilapia males and females separately or together is compared and discussed.

The mixed-sex group gave the highest production rate of $34.2 \text{ kg ha}^{-1} \text{ day}^{-1}$ with a manure coefficient of 2.2. The 'all female' group ranked last with a production rate of $22.9 \text{ kg ha}^{-1} \text{ day}^{-1}$ and a manure coefficient of 3.3. Sixty per cent of the tilapia biomass produced in the 'mixed-sex' tanks was contributed by reproduction. While monosex culture is better for the production of large fish for human consumption, where small fish do not matter, as in the case of the preparation of fishmeal for animal feeding, mixed-sex culture may be adopted without curtailing production.

Preliminary studies on the treatment of sorghum beer brewery effluent in an integrated bacterial/algal/fish/macrophyte culture system

I. G. Gaigher, D. F. Toerien and J. U. Grobbelaar

Institute for Environmental Sciences, University of the Orange Free State, Bloemfontein 9300, Republic of South Africa

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Abstract

A pilot integrated aquaculture system for the treatment of effluent ($COD = 3000-4000 \text{ mg litre}^{-1}$) from a sorghum beer brewery was monitored for water quality and fish production over a period of 10 months. The system consisted of cultures of photosynthetic bacteria, algae (*Closterium*), fish (*Oreochromis mossambicus*) and macrophytes (*Aponogeton distachyos*) operated in series. The cultures remained operative for the whole period but retention times had to be increased to impractical levels from time to time due to variations in temperature and effluent composition. Nitrogen deficiency limited nutrient removal but water quality generally improved rapidly throughout the system and during efficient operation the final outflow complied with present standards for industrial effluent. Fish growth rate and production varied but were generally unsatisfactory.

EST-based identification of genes expressed in the hypothalamus of adult tilapia, *Oreochromis mossambicus*

Yow-Ling Shiue ^a, Li-Hsueh Wang ^b, Ting-Ying Chao ^c, Chorng-Horng Lin ^b and Ching-Lin Tsai ^{b, c}

^a Institute of Biomedical Science, National Sun Yat-sen University, Kaohsiung 80424, Taiwan, ROC

^b National Museum of Marine Biology and Aquarium, 2 Houwan Road, Checheng, Pingtung 944, Taiwan, ROC

^c Department of Marine Resources, National Sun Yat-sen University, Kaohsiung 804, Taiwan, ROC

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Abstract

The hypothalamus is involved in many physiological functions in teleosts. To accelerate the molecular analysis of hypothalamic functions, a list of transcripts expressed in the hypothalamus of adult tilapia, *Oreochromis mossambicus*, was compiled using the expressed sequence tag (EST) strategy. Of 161 clones, 130 clones were unique genes and 31 clones were found to be redundant. Of 130 unique genes, 32.3% (42/130 ESTs) were identified as known genes and 67.7% (88/130 ESTs) as unknown genes. The functional categorization of the known genes was analyzed. Bioinformatic analysis revealed that 62 of 88 unknown genes (62/130 ESTs, 47.7%) showed a significant homology to neither nucleotide nor translated peptide sequences in the public database. These genes might be particularly expressed in the tilapia hypothalamus.

Author Keywords: Author Keywords: Expressed sequence tags; Hypothalamus; Tilapia; *Oreochromis mossambicus*

Regular Article

Hepatocyte Nuclear Factors-1 α , -1 β , and -3 β Expressed in the Gonad of Tilapia (*Oreochromis mossambicus*)

Wei-Tung Huang^a, Hong-Yi Gong^{b, a}, Cliff Ji-Fan Lin^{b, a}, Ching-Feng Weng^{c, a}, Mark Hung-Chih Chen^{b, a} and Jen-Leih Wu^{a, 1}

^a Institute of Zoology, Academia Sinica, Nankang, 11529, Taipei, Taiwan, Republic of China

^b Graduate Institute of Life Science, National Defense Medical Center, Taipei, Taiwan, Republic of China

^c Institute of Biotechnology, National Dong Hwa University, 97401, Hualien, Taiwan, Republic of China

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Abstract

Hepatocyte nuclear factors (HNFs) are upstream regulators of many liver-specific genes and are involved in many cellular functions in the body, but their existence, expression, and function in gonads are still poorly understood. Here we report on the first cloning of partial cDNAs of HNF-1 α and -1 β and full HNF-3 β cDNA from a tilapia (*Oreochromis mossambicus*) liver cDNA library. The deduced amino acid sequence of tilapia HNF-3 β has a 90 to 96% identity with those of other fishes (dwarf gourami, medaka, and zebrafish), 74% with mammals (human, rat, and mouse), and 82% with *Xenopus*. RT-PCR detected IGF-I and -II and HNF-1 α , -1 β , and -3 β in both liver and gonads and the identity of the PCR fragments was confirmed by PCR hybridization. Immunoprecipitation and Western blotting also detected all three HNF proteins in both liver and gonads. Expression of HNFs in the gonads of the tilapia suggests that multi-HNFs may form a cascade to regulate gonadal physiology in the bony fish.

Author Keywords: hepatocyte nuclear factor (HNF); HNF-1 α ; HNF-1 β ; HNF-3 β ; gonads; tilapia (*Oreochromis mossambicus*)

¹ To whom correspondence and reprint requests should be addressed. Fax: 886-2-2785-8059.
E-mail: zojlwu@ccvax.sinica.edu.tw.

Regular Article

Molecular Cloning of CLC Chloride Channels in *Oreochromis Mossambicus* and Their Functional Complementation of Yeast CLC Gene Mutant

Hiroaki Miyazaki^{b, a, 1}, Shinichi Uchida^a, Yoshio Takei^b, Tetsuya Hirano^b, Fumiaki Marumo^a and Sei Sasaki^a

^a Second Department of Internal Medicine, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo, Tokyo, 113-8519, Japan

^b Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo, 164-8639, Japan

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Abstract

We have cloned two members of the CLC chloride channel family (OmCLC-3 and OmCLC-5) from gill cDNA libraries of the euryhaline tilapia (*Oreochromis mossambicus*). At the amino acid level, OmCLC-3 is 90.5% identical to rat CLC-3 and OmCLC-5 is 79.2% identical to rat CLC-5. Ribonuclease protection assay revealed that OmCLC-5 was mainly expressed in the gill, kidney, and intestine in both freshwater- (FW) and seawater- (SW) adapted tilapia. Although the mRNA of OmCLC-3 was broadly expressed in tissues of FW- and SW-adapted tilapia, the most intense signals were observed in the gill, kidney, intestine, and brain. Injection of OmCLC-3 and OmCLC-5 cRNAs into *Xenopus* oocytes did not elicit chloride currents, but these clones did functionally complement the *gef1* phenotype of YPH250(*gef*), a yeast strain in which a single CLC channel (GEF1) has been disrupted by homologous recombination. These results clearly indicated that CLC channels closely related to the mammalian CLC-3, -4, and -5 subfamily exist also in tilapia and that OmCLC-3 and OmCLC-5 function as intracellular chloride channels.

¹ To whom correspondence should be addressed at Second Department of Internal Medicine, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo, Tokyo 113-8519, Japan. Fax: 81-3-5803-0172. E-mail: hmiyazak@ori.u-tokyo.ac.jp.

Biogas plant-effluent as an organic fertilizer in monosex, monoculture of fish (*Oreochromis mossambicus*)

P. R. Balasubramanian[✉] and R. Kasturi Bai

School of Energy, Environment and Natural Resources, Madurai Kamaraj University, Madurai 625 021, India

Received 2 January 1995; revised 5 November 1995; accepted 13 November 1995.; Available online 17 February 1999.

Abstract


Effluent collected from a KVIC model biogas plant fed on cattle dung was utilised in monosex (all male), monoculture of the fish *Oreochromis mossambicus*, at field level in 0.002 ha ponds. Biogas-plant effluent was supplied at 0.15% (W/V) concentration level at 3 day intervals. No supplementary feed was given for the fishes grown in biogas plant effluent. *Oreochromis mossambicus* attained a maximum weight gain of 0.67 g fish⁻¹ day⁻¹. Growth rate was independent of stocking density upto 60 000 fish ha⁻¹. Total maximum fish production was 4826 kg ha⁻¹ in 125 days.

Author Keywords: Biogas-plant effluent; *Oreochromis mossambicus*; monosex; monoculture; population density

[✉]Corresponding author. Author to whom correspondence should be addressed.

Short communication

Effect of a biogas-plant effluent-based pelleted diet on the growth of *Oreochromis mossambicus* fingerlings

V. Gopal, S. Prabakaran and P. R. Balasubramanian 


Department of Environmental Sciences, Bharathiar University, Coimbatore-641 046, Tamil Nadu, India.

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Abstract




Cattle-dung-based biogas-plant effluent was evaluated as a dietary ingredient in pelleted feed in place of rice bran for tilapia culture over a period of 42 days. The mean growth rate of fish ($0.032 \text{ g individual}^{-1} \text{ day}^{-1}$) and muscle protein ($39.28 \text{ mg } 100 \text{ mg}^{-1}$) showed no change when the biogas-plant effluent was used. It is recommended that dried biogas-plant effluent could take the place of rice bran in pelleted fish feed.

Author Keywords: Pelleted fish feed; biogas-plant effluent; rice bran; *Oreochromis mossambicus*; feed utilization

 Corresponding author. Author to whom correspondence should be addressed.

Short communication

Effects of photoperiod on the development of the central glutamate system in tilapia, *Oreochromis mossambicus*

Li-Hsueh Wang^a and Ching-Lin Tsai^{, , }

^a National Museum of Marine Biology and Aquarium, 2 Houwan Road, Checheng, Pingtung 944, Taiwan

^b Department of Marine Resources, National Sun Yat-sen University, Kaohsiung 804, Taiwan


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Abstract



The effect of photoperiod (light/dark cycle) on the development of the central glutamate system was investigated in tilapia, *Oreochromis mossambicus*. Tilapia, at 0, 5, and 10 days posthatching were respectively divided into three equal groups to be kept in different photoperiods: 12/12 h, 24/0 h (full day), and 0/24 h (full night). Neither the full-day nor the full-night photoperiod showed any influence on the development of the central glutamate system, including glutamate content and mRNA expression of glutamate receptor 3 α , in the developing tilapia brain. These results suggest that neither constant light nor dark photoperiods affected the influence of the central glutamate system on brain sex differentiation in tilapia during the early developing period.

Author Keywords: Developing brain; Glutamate; Glutamate receptor; Photoperiod; Tilapia

Neurotransmitters, modulators, transporters and receptors, Excitatory amino acid receptors: structure, function, and expression

 Corresponding author. National Museum of Marine Biology and Aquarium, 2 Houwan Road, Checheng, Pingtung 944, Taiwan. Tel.: +886-8-882-5390; fax: +886-8-882-5392.

Dietary supplementation with arachidonic acid in tilapia (*Oreochromis mossambicus*) reveals physiological effects not mediated by prostaglandins

R.D. Van Anholt^{a,  }, F.A.T. Spanings^a, W.M. Koven^b and S.E. Wendelaar Bonga^a

^aDepartment of Animal Ecology and Ecophysiology, Faculty of Science, University of Nijmegen, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands


^bDepartment of Larval Rearing, The National Center for Mariculture, P.O. Box 1212, Eilat 88112, Israel

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Abstract

This study aims to clarify the role of the polyunsaturated fatty acid arachidonic acid (ArA, 20:4n-6) in the stress response of Mozambique tilapia (*Oreochromis mossambicus*). ArA is converted into eicosanoids, including prostaglandins, which can influence the response to stressors. Tilapia, a species able to form ArA from its precursor, was supplemented with ArA for 18 days, after which they were confined for 5 min. Acetylsalicylic acid (ASA, COX-inhibitor) was subsequently administered to distinguish ArA-mediated effects from enhanced prostaglandin E₂ (PGE₂) synthesis. ArA supplemented fish had higher ArA levels in gills and kidneys, and these levels were further enhanced after ASA treatment. Levels of total monounsaturated and polyunsaturated fatty acids as well as docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and ArA, were altered 24 h after confinement, particularly in the kidneys. ArA supplementation had no effect on basal cortisol levels, while ArA + ASA reduced basal cortisol levels. ArA + ASA augmented the cortisol response to confinement. The combination of ArA + ASA also elevated plasma basal prolactin (tPRL)₁₇₇ and 3,5,3'-triiodothyronine (T₃) levels. Neither ArA nor ASA affected the stress-associated increases in plasma glucose and lactate. Na⁺, K⁺-ATPase activity in the gills was reduced after ArA supplementation and was even further suppressed by subsequent ASA treatment. In an additional feeding trial, ArA supplementation enhanced the renal Na⁺, K⁺-ATPase activity. In vitro, ArA was a potent inhibitor of the Na⁺, K⁺-ATPase activity of gill and kidney homogenates. In contrast, PGE₂ had no effect on branchial ATPase, whereas the effect on renal ATPase activity was concentration dependent. Modifying the dietary intake of ArA alters the response of tilapia to an acute stressor and influences osmoregulatory processes and it is unlikely that these effects are due to an enhanced production of prostaglandins.

Keywords: Acetylsalicylic acid; Arachidonic acid; Cortisol; Fatty acids; Prostaglandins

 Corresponding author. Fax: +31 24 365 2714

Ontogeny of corticotropin-releasing factor and of hypothalamic–pituitary–interrenal axis responsiveness to stress in tilapia (*Oreochromis mossambicus*; Teleostei)

Peter P.L.M. Pepels[✉] and Paul H.M. Balm

Department of Animal Physiology, Faculty of Sciences, Radboud University Nijmegen, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands

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Abstract

The ontogeny of the corticotropin-releasing factor (CRF) system and of the ability of the hypothalamic–pituitary–interrenal (HPI) axis to respond to stressors (capture or confinement), or to cortisol treatment was investigated in tilapia (*Oreochromis mossambicus*). In 2 days post hatching (dph) larvae, the first developmental stage used for immunohistochemistry, CRF-immunoreactivity (ir) was observed in the nucleus preopticus (npo), and in two hypothalamic nuclei (nlt and nrl). In this stage, CRF- and AVT-ir was found in the neural part of the pituitary, and endocrine cells in the pars distalis and pars intermedia contained POMC-derived peptides. In the ventral telencephalon, CRF-ir cells were first observed 5 dph, whereas projections from these cells into the anterior part of the latero-dorsal telencephalon (Dla) from 7 dph onwards. CRF, ACTH, β -MSH, and cortisol were quantified by radioimmunoassays in homogenates of the anterior-cranial region of the larvae containing brain, pituitary, and headkidneys. CRF contents increased from 43 ± 3 to 1070 ± 70 pg/larvae between 5 and 110 dph. Larvae of age 5, 12, 24, and 42 dph were captured sequentially from a group. All life stages were able to rapidly increase their cortisol content in response to this stressor (ANOVA: $P < 0.001$). Overall, the developmental stage affected cortisol content (ANOVA: $P < 0.001$), but developmental stage did not influence the cortisol reaction to stress (ANOVA: $P > 0.162$). Whole brain CRF content did not change during the 20 min stress period and the relationship between CRF-producing neurons and the initial HPI stress response in early life stages remains to be established. Cortisol feeding of 18 and 29 dph larvae for periods ranging from 2 to 24 days resulted in elevations of the CRF content ($P < 0.003$) in comparison to controls. In 18 dph larvae cortisol feeding abolished the cortisol response to capture stress as observed in control fed larvae ($P < 0.008$). We propose that cortisol induced upregulation of CRF takes place in the telencephalon and is restricted to a time period during larval development, characterised by the absence of glucocorticoid receptor (GR) expression in the telencephalic Dm region in these larvae. Finally, the stress response to 24 h confinement was compared between saltwater adapted and freshwater adapted juveniles (age 77 dph). Confinement stress (24 h) affected cortisol and CRF content (ANOVA: $P < 0.001$, $P < 0.008$, respectively), but not ACTH content. Interactions were observed between salinity and confinement regarding cortisol and β -MSH contents (ANOVA: $P < 0.02$), but not regarding CRF and ACTH contents. The increase in cortisol levels induced by confinement was remarkably high in freshwater adapted larvae (five times higher than in saltwater adapted larvae). Regarding the cortisol response it is concluded that during and after the period of mouth breeding tilapia larvae respond to capture stress in a similar fashion (onset and height) as adults. Previously, we reported that the initial plasma cortisol response to capture stress in adult tilapia occurred independently from changes in plasma ACTH levels. The current finding that also brain CRF contents do not alter during the initial cortisol response in larvae further indicates that the initial cortisol response in this species may be regulated independently from CRF and ACTH.

Keywords: Ontogeny; Early development; Embryology; Corticotropin-releasing hormone; CRH; Headkidney; HPI axis; Glucocorticoid receptor; GR; β -MSH; ACTH; Cortisol; Pituitary; Stress; Teleost

Hormone release is tied to changes in cell size in the osmoreceptive prolactin cell of a euryhaline teleost fish, the tilapia, *Oreochromis mossambicus*

Gregory M. Weber^{a, 1}, Andre P. Seale^a, N. Harold Richman III^a, M. H. Stetson², Tetsuya Hirano^a and E. Gordon Grau^{✉, ✉, a}

^a Hawaii Institute of Marine Biology, University of Hawaii, PO Box 1346, Coconut Island, Kaneohe, HI 96744, USA

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Abstract

Prolactin (PRL) cells from a teleost fish, the tilapia, *Oreochromis mossambicus*, facilitate the direct study of osmoreception. The release of two prolactins, PRL₁₈₈ and PRL₁₇₇, which act in freshwater osmoregulation in teleost fish, rises in vitro within 5 min after extracellular osmolality falls. An increase in cell size accompanied this rise. Cell size and PRL release also increased, albeit more slowly, following the partial replacement of medium NaCl (55 mOsmolal) with an equivalent concentration of urea, a membrane-permeant molecule. Similar replacement using mannitol, which is membrane-impermeant, elicits no response. These findings suggest that osmoreception is linked to changes in cell volume rather than to extracellular osmolality per se.

Author Keywords: Prolactin; Osmoregulation; Osmoreception; Tilapia; *Oreochromis mossambicus*

[✉] Corresponding author. Fax: 1-808-956-3014

¹ Present address: USDA/ARS National Center for Cool and Cold Water Aquaculture, Kearneysville, WV 25 & 30, USA.

² Department of Biological Sciences, University of Delaware, Newark, DE 19716, USA.

Development and validation of a radioimmunoassay for fish insulin-like growth factor I (IGF-I) and the effect of aquaculture related stressors on circulating IGF-I levels

Anthony R. Dyer^{a,b}, Zee Upton^b, David Stone^c, Philip M. Thomas^d, Kathleen L. Soole^d, Naomi Higgs^e, Kirsty Quinn^e and John F. Carragher^d

^a TGR Biosciences, P.O. Box 185, Hindmarsh, SA 5001, Australia

^b School of Life Sciences, Queensland University of Technology, Brisbane, Qld, Australia

^c NSW Fisheries, Port Stephens Research Centre, Taylors Beach, NSW 2316, Australia

^d School of Biological Sciences, Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia

^e GroPep, 28 Dalgleish Street, Thebarton, SA 5031, Australia

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Abstract

This paper describes the development and validation of a commercially available radioimmunoassay (RIA) for the detection of fish insulin-like growth factor-I (IGF-I). The assay was developed using recombinant barramundi IGF-I as antigen and recombinant tuna IGF-I as radiolabelled tracer and standard. Assay sensitivity was 0.15 ng/ml, inter-assay variation was 16% (n=9) and intra-assay variation was 3% (n=10). Cross reactivity of less than 0.01% was found with salmon insulin, salmon IGF-II and barramundi IGF-II, less than 0.5% with human IGF-I and less than 1% with human IGF-II. Parallel dose-response inhibition curves were shown for barramundi (*Lates calcarifer*), coho salmon (*Oncorhynchus kisutch*), Southern Bluefin tuna (*Thunnus maccoyii*), tilapia (*Oreochromis mossambicus*), and seabream (*Pagrus auratus*) IGF-I. The assay was then used to measure stress related changes in different aquacultured fish species. Salt water acclimated Atlantic salmon smolts (*Salmo salar*) bathed for 2 h in fresh water showed significantly lower IGF-I concentrations than control smolts two days after the bath (53.1 compared to 32.1 ng/ml), with levels of IGF-I also lower in smolts exhibiting stunted growth (stunts). Capture and confinement of wild tuna in sea-cages resulted in a significant decrease in IGF-I levels (28 ng/ml) when compared to tuna captured and sampled immediately (48 ng/ml), but had recovered to starting levels after 3 weeks (43 ng/ml). Handling and isolation in silver perch (*Bidyanus bidyanus*) led to a gradual decline in IGF-I over a 12 h period (36–19 ng/ml) but showed signs of recovery by 24 h (24 ng/ml) and had recovered fully 72 h after treatment (40 ng/ml). A similar trial in black bream (*Acanthopagrus butcherii*) showed comparable results with IGF-I levels gradually decreasing (40–26 ng/ml) over 24 h, results that were mirrored by cortisol concentrations which increased during this time (1–26 ng/ml). In the studies presented here changes in IGF-I levels were not observed for at least 3 h after exposure to the stressor. We suggest this is due to the endocrine nature of IGF-I regulation and the clearance rate of IGF-I in vivo.

Author Keywords: Insulin-like growth factor-I; IGF-I; Radioimmunoassay; Fish; Stress; Stunting

[✉] Corresponding author. Fax: +61-8-8354-6188

Changes in plasma concentrations of immunoreactive ouabain in the tilapia in response to changing salinity: is ouabain a hormone in fish?

S. Kajimura^{a, b}, T. Hirano^a, S. Moriyama^c, O. Vakkuri^d, J. Leppäluoto^d and E. G. Grau^{EE, EN, a}

^a Hawaii Institute of Marine Biology, University of Hawaii, P.O. Box 1346, Kaneohe, HI 96744, USA

^b Department of Aquatic Science, Graduate School of Agricultural and Life Science, University of Tokyo, Tokyo 113-8657, Japan

^c School of Fisheries Science, Kitasato University, Sanriku, Iwate 022-0101, Japan

^d Department of Physiology, University of Oulu, 90401, Oulu, Finland

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Abstract

Ouabain, a cardiac glycoside and inhibitor of Na⁺, K⁺-ATPase, is now believed to be a steroid hormone in mammals, involved in blood pressure and volume regulation and possibly acting as a natriuretic hormone. We have identified ouabain-like immunoreactivity in the plasma and tissues of a euryhaline teleost, the tilapia (*Oreochromis mossambicus*), by means of solid-phase extraction followed by a specific radioimmunoassay. Plasma concentrations of immunoreactive ouabain were 5–20 pg/ml. Ouabain immunoreactivity was detected in all the tissues examined, with highest concentrations in the head kidney followed by intestine and body kidney. When the fish in fresh water were transferred to seawater, plasma osmolality increased significantly after 2, 4, 8, and 24 h. Significant increases were observed in plasma ouabain immunoreactivity after 4 and 24 h, and a significant correlation was seen between ouabain immunoreactivity and plasma osmolality. There was also a significant correlation between the plasma osmolality and cortisol concentrations. Upon transfer from seawater to fresh water, significant increases were seen in plasma cortisol after 4 and 8 h and in immunoreactive ouabain after 4 h. When the correlation was analyzed using all the data obtained during the two transfer experiments, plasma ouabain immunoreactivity and cortisol were significantly correlated with plasma osmolality, whereas there was a significant negative correlation between plasma prolactin and osmolality. A significant positive correlation was also seen between plasma cortisol and ouabain immunoreactivity. These results suggest that immunoreactive ouabain may be involved, together with cortisol, in the maintenance of hydromineral balance in the tilapia.

Author Keywords: Tilapia; *Oreochromis mossambicus*; Ouabain; Cortisol; Prolactin; Osmoregulation

^{EE} Corresponding author. Fax: 1-808 956-3014

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In vitro effects of cortisol on the release and gene expression of prolactin and growth hormone in the tilapia, *Oreochromis mossambicus*

Katsuhisa Uchida^{a, b}, Joanne S. M. Yoshikawa-Ebesu^a, Shingo Kajimura^{a, c}, Takashi Yada^{a, d}, Tetsuya Hirano^a and E. Gordon Grau^{b, ✉, a}

^a Hawaii Institute of Marine Biology, University of Hawaii, P.O. Box 1346, Kaneohe, HI 96744, USA

^b Center for Developmental Biology, RIKEN, Kobe 650-0047, Japan

^c Department of Aquatic Science, Graduate School of Agricultural and Life Science, University of Tokyo, Tokyo 113-8657, Japan

^d Nikko Branch, National Research Institute of Aquaculture, Nikko, Tochigi 321-1661, Japan

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Abstract

Exposure to cortisol inhibits prolactin (PRL) release from the tilapia pituitary within 10–20 min through a plasma membrane-associated, non-genomic pathway. In the present study, in vitro effects of cortisol on the release and mRNA levels of two PRLs (PRL₁₈₈ and PRL₁₇₇) and growth hormone (GH) were examined in the organ-cultured pituitary of the Mozambique tilapia, *Oreochromis mossambicus*. The PRL release was significantly greater in hyposmotic (300 mOsmolal) than in hyperosmotic (350 mOsmolal) medium during the 2–8 h of incubation. The mRNA levels of two PRLs, as estimated by RNase protection assay, were increased after 8 h in hyposmotic medium. Cortisol (200 nM) inhibited the release of two PRLs under hyposmotic conditions within 1 h, and the inhibitory effects lasted for 24 h. Cortisol also reduced the gene transcription of both PRLs during 2–8 h of incubation but not after 24 h. No effect of cortisol was observed on PRL release or on its mRNA levels under hyperosmotic condition. There was no significant effect of medium osmolality on the release or mRNA levels of GH during 8 h of incubation. However, GH release was significantly stimulated by cortisol after 4 h, and the effect lasted for 24 h under both hyposmotic and hyperosmotic conditions. Cortisol also caused a significant increase in GH mRNA levels at 8 and 24 h. These results suggest that cortisol inhibits PRL release from the tilapia pituitary through non-genomic and also through transcriptional pathways, while stimulating GH release through classical genomically mediated glucocorticoid actions.

Author Keywords: Prolactin; Growth hormone; Cortisol; Osmoregulation; Tilapia

[✉] Corresponding author. Fax: +808-956-3014

Glucocorticoid receptor upregulation during seawater adaptation in a euryhaline teleost, the tilapia (*Oreochromis mossambicus*)

D. Brian Dean, Zackary W. Whitlow and Russell J. Borski , 


Department of Zoology, North Carolina State University, Box 7617, Raleigh, NC 27695-7617, USA

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Abstract

Cortisol is an important seawater (SW) osmoregulatory hormone in the Mozambique tilapia (*Oreochromis mossambicus*), a highly euryhaline cichlid able to live in environments ranging from fresh water (FW) to salinities well in excess of full-strength seawater. Previous studies indicate that cortisol may promote SW adaptation by increasing gill chloride cell differentiation, Na^+/K^+ -ATPase activity and subsequent excretion of excess salt following seawater acclimation. Despite cortisol's widely accepted role as a SW-adapting hormone, cortisol receptor regulation during SW acclimation is not well understood. The purpose of these studies was to determine whether the intracellular glucocorticoid receptor (GR) might be regulated in a manner consistent with cortisol's actions in SW adaptation. Saturation radioligand binding assays were conducted on gill cytoplasm preparations from fish sampled 4 and 24 h and 4 and 14 days after transfer from FW to 2/3 SW or FW (control). Affinity (K_d) of the gill GR remained constant over the timecourse, while numbers of receptors (B_{max}) in SW fish were significantly elevated compared with controls at 24 h and 4 days after transfer. Plasma osmolality was higher in fish transferred to SW for 24 h, 4 days, and 14 days compared with those animals moved to FW. Plasma cortisol levels and hepatic cortisol binding remained constant between SW and FW fish throughout the timecourse of the salinity challenge. These studies indicate that seawater acclimation is accompanied by a specific upregulation of intracellular GR numbers in gill tissue. The lack of increase in circulating cortisol following SW adaptation may reflect enhancement of clearance of the steroid. It appears that an increase in cortisol receptors, which is closely associated with the rise in blood osmotic pressure that accompanies SW exposure, is an important component of cortisol's ability to promote SW adaptation in the tilapia.

Author Keywords: Cortisol; Osmoregulation; Seawater adaptation; Receptor affinity; Receptor capacity; Gill

 Corresponding author. Fax: 1-919-515-2698

Vitellogenin synthesis via androgens in primary cultures of tilapia hepatocytes

Byung-Ho Kim^a, Akihiro Takemura^{  ^a}, Se Jae Kim^b and Young-Don Lee^c

^a Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, 3422 Sesoko, Motobu, Okinawa 905-0227, Japan

^b Department of Biological Sciences, Cheju National University, Jeju 690-756, South Korea


^c Marine Research Institute, Cheju National University, Hamdeok, Jocheon, Jeju 695-810, South Korea

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
Abstract

Involvement of androgens in vitellogenin (VTG) synthesis was investigated using the primary hepatocyte cultures of tilapia, *Oreochromis mossambicus*. Concentration of VTG in the medium was assessed by enzyme-linked immunosorbent assay. When the hepatocytes of females were treated with testosterone (T), 17 α -methyltestosterone (MT) and 5 α -dihydrotestosterone (DHT), VTG concentration in the medium slightly increased or maintained. DHT, but not T and MT, increased VTG in the medium of male hepatocyte cultures. However, VTG production in the male hepatocytes, which were previously treated with estradiol-17 β (E₂), maintained high level by treatment of T. Similarly, co-treatment of E₂ and the androgens to the male hepatocytes enhanced VTG concentration in the medium. These results suggest that the androgens have some roles in VTG synthesis in the hepatocytes. Tamoxifen, a nonsteroidal antiestrogen, reduced VTG synthesis by the androgens. On the other hand, co-treatment of T and fadrozole, an aromatase inhibitor, failed to inhibit the effect of VTG synthesis by T alone. Analysis with RT-PCR did not demonstrate expression of the brain and the ovarian types of aromatase mRNA in the liver. These results suggest that the possibility of local aromatization of the androgens in the tilapia liver is low and that androgens bind estrogen receptor and, consequently, exert estrogenic action. Treatment of cyproterone acetate, an antiandrogen reagent, increased production of VTG with DHT. Involvement of androgens might not be ignored in regulation of VTG synthesis in the liver.

Author Keywords: Androgen; Cyproterone acetate; ELISA; Hepatocytes; *Oreochromis mossambicus*; Primary culture; Tamoxifen; Vitellogenin

 Corresponding author. Fax: +81-980-47-4919

Effects of angiotensin II and natriuretic peptides of the eel on prolactin and growth hormone release in the tilapia, *Oreochromis mossambicus*

Steve M. Eckert^a, Tetsuya Hirano^a, Thomas A. Leedom^a, Yoshio Takei^b and E. Gordon Grau^{, , ^a}

^a Department of Zoology and Hawaii Institute of Marine Biology, University of Hawaii, P.O. Box 1346, Coconut Island, Kaneohe, HI 96744, USA


^b Ocean Research Institute, University of Tokyo, Nakano, Tokyo 164-8639, Japan

Accepted 22 November 2002; Available online 29 January 2003.

Abstract

The effects of angiotensin II (ANG II) and natriuretic peptides (NPs) of the eel (ANP, atrial natriuretic peptide; CNP, C-type natriuretic peptide; and VNP, ventricular natriuretic peptide) on prolactin (PRL₁₈₈ and PRL₁₇₇) and growth hormone (GH) release from the organ-cultured tilapia pituitary were examined. Eel ANG II at concentrations greater than 1 nM stimulated the release of PRL₁₈₈ and PRL₁₇₇ in a dose-related manner during the first hour of incubation. Significant stimulation by 100 nM ANG II on PRL₁₇₇ release was observed until 4 h of incubation, and on PRL₁₈₈ release until 12 h. No effect of ANG II was seen on GH release. None of the NPs altered the release of PRLs at any time point. On the other hand, eel VNP at concentrations greater than 1 nM stimulated GH release in a dose-related manner after 4 h, and significant stimulation was observed until 48 h. Eel CNP was less effective than eel VNP; significant stimulation of GH release was observed at 1 and 10 nM during 24–48 h of incubation. No significant effect of eel ANP on GH release was seen at any concentration. ANG II had no effect on GH release at any time point. There was no change in mRNA levels of PRLs or GH in the pituitaries incubated with ANG II for 8 h or those incubated with the NPs for 48 h. These results indicate rapid and short-lasting stimulation by ANG II on PRL release and slow and long-lasting stimulation by VNP and CNP on GH release from the tilapia pituitary.

Author Keywords: Angiotensin II; Natriuretic peptides; Atrial natriuretic peptide; Ventricular natriuretic peptide; C-type natriuretic peptide; Prolactin; Growth hormone; Tilapia; *Oreochromis mossambicus*; Eel; *Anguilla japonica*

 Corresponding author. Fax: 1-808-956-3014

Regular Article

Effects of Glucocorticoids on Cartilage Growth and Response to IGF-I in the Tilapia (*Oreochromis mossambicus*)

Jason P. Datuin, Kevin P. Ng, Tyrone B. Hayes and Howard A. Bern

Department of Integrative Biology, Group in Endocrinology and Cancer Research Laboratory, University of California, Berkeley, California, 94720-3140

Accepted 27 November 2000.; Available online 4 March 2002.

Abstract

To study the effects of glucocorticoids and IGF-I on the modulation of growth in the tilapia (*Oreochromis mossambicus*), we employed an epiceratobranchial cartilage radioisotope incorporation assay, wherein radiolabeled sulfate and thymidine uptakes are measured *in vitro* to indicate proteoglycan synthesis and cell proliferation, respectively. Cartilage explants were cultured with cortisol or dexamethasone with or without recombinant bovine insulin-like growth factor-I. Cortisol directly inhibited sulfate uptake at 100 and 1000 ng/mL concentrations in a concentration-dependent manner but inhibited thymidine uptake significantly only at the 1000 ng/mL concentration. Dexamethasone inhibited sulfate and thymidine uptake at concentrations similar to the effective concentrations of cortisol. Cortisol did not inhibit IGF-I stimulation of sulfate uptake at any of the concentrations tested. Furthermore, cortisol did not inhibit thymidine uptake when IGF-I was present in the medium. Cortisol appears to act directly on cartilage and not by interacting with the IGF-I system. However, the physiologically significant role of cortisol is mainly an inhibitory one on cartilage metabolism. The data generally indicate an inhibitory role for glucocorticoids on cartilage growth but an inability to counter the stimulation of sulfate uptake by IGF-I.

Regular Article

Effects of Estrogens *in Vitro* and *in Vivo* on Cartilage Growth in the Tilapia (*Oreochromis mossambicus*)

Kevin P. Ng, Jason P. Datuin and Howard A. Bern

Department of Integrative Biology, Group in Endocrinology and Cancer Research Laboratory, University of California, Berkeley, California, 94720-3140

Accepted 29 November 2000. ; Available online 4 March 2002.

Abstract

To study the effects of estrogens on cartilage growth in the tilapia (*Oreochromis mossambicus*), an epiceratobranchial cartilage radioisotope incorporation assay was employed to measure proteoglycan synthesis and prechondrocyte proliferation by incorporation of radiolabeled sulfate and thymidine, respectively. Cartilage explants were cultured with estrogens with or without recombinant bovine insulin-like growth factor-I (IGF-I). *In vitro* experiments using the natural teleost estrogen, 17 β -estradiol (E₂), showed a trend toward inhibition of sulfate incorporation and an inhibition of thymidine incorporation at higher doses (10 μ g/ml), but not at physiological levels. E₂ also showed a trend toward inhibition of sulfate and thymidine incorporation in the presence of IGF-I. Similar results were found with other estrogenic compounds *in vitro*: ethinylestradiol, diethylstilbestrol (DES), genistein, and nonylphenol. Ethinylestradiol inhibited sulfate and thymidine incorporation at 1000 ng/ml in the presence of IGF-I. DES inhibited thymidine incorporation at 1000 ng/ml in untreated or IGF-I-exposed cartilage. Genistein inhibited sulfate incorporation at 100 μ g/ml in IGF-I-exposed cartilage and inhibited thymidine uptake at 1, 10, and 100 μ g/ml in untreated and IGF-I-exposed cartilage. Nonylphenol inhibited sulfate uptake at 100 μ M in untreated and IGF-I-exposed cartilage. Nonylphenol alone at 10 and 100 μ M inhibited thymidine uptake. In IGF-I-exposed cartilage nonylphenol inhibited thymidine uptake at 100 μ M. Fish receiving estrogen injections (E₂ or DES) *in vivo* at a concentration of 2 μ g/g body weight showed increased sulfate incorporation by cartilage *in vitro*. Stimulation *in vivo* by estrogens, in contrast to the inhibition by high doses *in vitro*, may be a result of the influence of estrogen on pituitary growth hormone release.

Regular Article

The Effects of Cortisol on Heat Shock Protein 70 Levels in Two Fish Species

N. Basu^a, T. Nakano^b, E. G. Grau^c and G. K. Iwama^{d, 1}

^a Faculty of Agricultural Sciences and AquaNet, University of British Columbia, Vancouver, Canada

^b Marine Biochemistry Laboratory, Faculty of Agriculture, Tohoku University, Sendai, Japan

^c Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, Hawaii

^d Institute for Marine Biosciences, National Research Council, Halifax, Canada

Accepted 19 June 2001.; Available online 4 March 2002.

Abstract

We studied the relationship between heat stress (2 h, +12°) and increased levels of circulating cortisol (50 µg cortisol/g body weight) on heat shock protein 70 (hsp70) levels in liver and gill tissues of rainbow trout (*Oncorhynchus mykiss*) and tilapia (*Oreochromis mossambicus*). The administration of cortisol by intraperitoneal injection (no heat stress) did not alter tissue hsp70 levels compared to sham implanted (no heat stress) trout and tilapia. We found elevated levels of cortisol significantly suppressed the heat stress-induced levels of hepatic hsp70 by 34.2% and 31.0%, 3 and 24 h post-heat stress, respectively, compared to sham implanted trout. Additionally, elevated levels of cortisol significantly suppressed the heat stress-induced levels of gill hsp70 by 66.2% in trout (3 h post stress) and 26.7% in tilapia (4 h post stress), compared to sham implanted fish. These results suggest that cortisol may be mediating hsp70 levels in fish tissues following times of physiological stress, and that the neuroendocrine and cellular stress responses may be functionally related in these two different species of fish.

Author Keywords: fish; cortisol; hsp70; stress response

¹ To whom correspondence should be addressed. E-mail: george.iwama@nrc.ca.

Regular Article

Evidence for an Osmoregulatory Role of Thyroid Hormones in the Freshwater Mozambique Tilapia *Oreochromis mossambicus*

M. C. Subash Peter¹, Robert A. C. Lock and Sjoerd E. Wendelaar Bonga

Department of Animal Physiology, University of Nijmegen, Toernooiveld 1, 6525 ED, Nijmegen, The Netherlands

Accepted 24 July 2000; Available online 25 March 2002.

Abstract

The existing equivocal reports on the osmoregulatory role of triiodothyronine (T₃) and thyroxine (T₄) in teleosts prompted a reinvestigation of their osmoregulatory function in the euryhaline teleost *Oreochromis mossambicus*. Evidence is presented for thyroidal involvement in hydromineral balance in freshwater tilapia. Dose- and tissue-related responses to various T₃ and T₄ concentrations were observed in the branchial and renal tissues. The branchial Na⁺,K⁺-ATPase activity, known to reflect sodium pump dynamics, increased significantly after the administration of low doses of T₃ (20 and 40 ng · g⁻¹) or T₄ (40 and 80 ng · g⁻¹). Higher doses of T₃ and T₄ (>160 ng · g⁻¹) did not change the enzyme activity, compared to sham-injected fish. Conversely, the specific activity of renal Na⁺,K⁺-ATPase decreased significantly at all doses of T₃ or T₄. Further, immunoreactive Na⁺,K⁺-ATPase in T₄-treated fish increased in branchial chloride cells and this was coupled with a significant increase in the size of chloride cells; T₄ treatment, however, did not change branchial chloride cell density. Plasma osmolality, [Na⁺], and [Cl⁻] increased, whereas [K⁺] decreased following low doses of T₃ or T₄. As expected, plasma levels of T₃ and T₄ increased significantly in a dose-dependent manner after a single injection of either T₃ or T₄. The basal levels of T₃ and T₄ were 4.45 ± 0.49 and 1.25 ± 0.26 nmol · L⁻¹, respectively. This study shows that physiological concentrations of T₃ (<10.57 nmol · L⁻¹) and T₄ (<6.64 nmol · L⁻¹) enhance branchial Na⁺ pump activity and chloride cell morphometric dynamics, favoring hyperosmoregulatory capacity in freshwater tilapia. These data are consistent with the hypothesis that thyroid hormones perform a role in hydromineral regulation in freshwater teleosts.

Author Keywords: thyroid hormones; osmoregulation; teleost fish; sodium pump; chloride cell; Na⁺,K⁺-ATPase; ion transport

¹ To whom correspondence should be made at the above current address. Permanent address: Department of Zoology, Fatima Mata National College, University of Kerala, Kollam 691 001, Kerala, India. E-mail: subash@sci.kun.nl.

Regular Article

Plasma Calcium and Stanniocalcin Levels of Male Tilapia, *Oreochromis mossambicus*, Fed Calcium-Deficient Food and Treated with 1,25 Dihydroxyvitamin D₃^{*1}

Ajai K. Srivastav^a, Gert Flik^b and S. E. Wendelaar Bonga^b

^a Department of Zoology, University of Gorakhpur, Gorakhpur, 273 009, India

^b Department of Animal Physiology, University of Nijmegen, 6525 ED, Nijmegen, The Netherlands

Accepted 10 February 1998. ; Available online 9 April 2002.

Abstract

The vitamin D metabolite 1,25 dihydroxyvitamin D₃ (1,25(OH)₂D₃; calcitriol) was injected ip (5 μg/kg^{0.75} body mass daily) into male tilapia, *Oreochromis mossambicus*, fed calcium-deficient food. Plasma calcium (total and free) and stanniocalcin levels, as well as calcium contents of vertebral and opercular bone and scales, were determined on days 1, 3, and 5. In the treated fish, total plasma calcium levels increased on days 3 and 5. Plasma-free calcium levels remained unaffected. Plasma stanniocalcin levels increased, indicating a response of the Stannius corpuscles to redress 1,25(OH)₂D₃-induced hypercalcemia. The calcium contents of bone, operculum, and scales were unchanged. It is concluded that in fish, which lack parathyroid hormone, 1,25(OH)₂D₃ is hypercalcemic and its action is independent of dietary calcium.

*1 E. Epple, C. G. Scanes, M. H. Stetson

Regular Article

Partial Cloning of the Hormone-Binding Domain of the
Cortisol Receptor in Tilapia, *Oreochromis mossambicus*, and Changes in the
mRNA Level during Embryonic Development^{*1}

M. Tagawa^{a, 1}, H. Hagiwara^b, A. Takemura^c, S. Hirose^b and T. Hirano^a

^a Ocean Research Institute, University of Tokyo, Minamidai, Nakano, Tokyo, 164, Japan

^b Department of Biological Sciences, Tokyo Institute of Technology, Nagatsutacho, Midori-ku, Yokohama, 226, Japan

^c Tropical Biosphere Research Center, University of the Ryukyus, Sesoko, Motobu, Okinawa, 905-02, Japan

Accepted 10 June 1997. ; Available online 18 April 2002.

Abstract

Cortisol is one of the central hormones in osmoregulation in fish, especially in seawater adaptation. A cDNA of 453 bp was cloned from liver mRNA of freshwater-reared tilapia (*Oreochromis mossambicus*), by reverse transcription polymerase chain reaction (RT-PCR) with primers designed for the hormone-binding domain of glucocorticoid receptors (GRs) in mammals and rainbow trout. The sequence of PCR product has 83% homology to the trout GR at the nucleotide level and 92% at the amino acid level. The PCR product of tilapia showed highest homology (74% at the amino acid level) to GR among human steroid hormone receptors, including mineralocorticoid receptor. The length of the receptor mRNA of tilapia was about 6.5 kb as determined by Northern blot hybridization. The mRNA concentration in the gills was relatively higher among various organs, the highest concentration being observed in blood cells. Signal intensity of the receptor message in the gills was stronger in fish reared in freshwater than in those reared in seawater or in concentrated (160%) seawater. During early development of tilapia, the highest concentration of receptor mRNA in the total RNA extracted from the whole egg was found just after fertilization, and its concentration decreased steadily toward hatching. The absolute amount of receptor mRNA per egg increased gradually before the initiation of cortisol production by the embryo. When embryos were transferred from fresh water to seawater 2 days before hatching, no difference was observed in the signal intensity of the receptor mRNA among embryos after 1, 2 (the day of hatching), 4, and 7 days.

^{*1} C. M. Wood T. J. Shuttleworth, Eds.

¹ Present address: Department of Fisheries, Faculty of Agriculture, Kyoto University, Kitashirakawa, Sakyo-ku, Kyoto 606-01, Japan.

Regular Article

Effects of Estradiol on the Serotonin Secretion and Turnover in the Hypothalamus of Male Tilapia, *Oreochromis mossambicus*, *in Vitro*^{*1}

Ching-Lin Tsai and Li-Hsueh Wang

Department of Marine Resources, National Sun Yat-sen University, Kaohsiung, Taiwan, 804, ROC

Accepted 26 November 1996. ; Available online 18 April 2002.

Abstract

The effects of estradiol on the secretion and turnover of serotonin in the hypothalamic fragments of male tilapia, *Oreochromis mossambicus*, were studied using a static incubation system. The quantitative analysis of serotonin and its related metabolite, 5-hydroxyindoleacetic acid, were performed by high-performance liquid chromatography with electrochemical detection. The hypothalamic fragments were incubated with 17β -estradiol at a concentration of 2×10^{-8} , 8×10^{-8} , 2×10^{-7} , 4×10^{-7} , or 4×10^{-6} g/ml. The low dose of estradiol, 2×10^{-8} g/ml, had no effect on the concentration of serotonin and 5-hydroxyindoleacetic acid or serotonin turnover in the hypothalamic incubation media. The moderate doses of estradiol 8×10^{-8} and 2×10^{-7} g/ml, increased the concentrations of serotonin and 5-hydroxyindoleacetic acid in the hypothalamic incubation media, but had no effect on the serotonin turnover. The high doses of estradiol, 4×10^{-7} and 4×10^{-6} g/ml, did not alter the serotonin concentration in the hypothalamic incubation media, but increased the 5-hydroxyindoleacetic acid concentration and serotonin turnover. These results demonstrate that the moderate dose of estradiol increases the serotonin activity by increasing the serotonin concentration, whereas the high dose of estradiol increases the serotonin activity by increasing the ratio of 5-hydroxyindoleacetic acid and serotonin. However, the serotonin concentration is homeostatically maintained in the extracellular fluid of hypothalamus under the high dose of E₂ treatment.

^{*1} O. Eichler, A. Farah, Eds.

Regular Article

Hypothalamic Regulation of the Pituitary–Thyroid Axis in the Tilapia *Oreochromis mossambicus*^{*1}

P. Sukumar, A. D. Munro, E. Y. M. Mok, S. Subburaju and T. J. Lam

Fish Neurobiology Laboratory, School of Biological Sciences, The National University, Lower Kent Ridge Road, Singapore, 119260

Accepted 15 November 1996.; Available online 18 April 2002.

Abstract

Electrolytic lesioning of the preoptic area resulted in an increase in plasma thyroxine (T₄) and reverse triiodothyronine (rT₃) 10 days later; plasma triiodothyronine (T₃) levels were not affected, so that there was also a significant decrease in the T₃:T₄, but not rT₃:T₄, ratios. No significant changes in T₄, T₃, or rT₃ levels were observed in fish with lesions in either the anterior or posterior portions of the lateral tuberal nucleus. The pituitary contents of growth hormone and the two prolactins were not affected by any lesion. This indicates that the preoptic area may play a role in the inhibitory regulation of the pituitary–thyroid axis in *Oreochromis mossambicus*, presumably by way of effects on thyrotropin secretion.

*1 R. E. Davis, R. G. Northcutt, Eds.

Regular Article

Osmoregulatory Actions of Growth Hormone and Prolactin in an Advanced Teleost^{*1}

Tatsuya Sakamoto^{a, 1}, Brian S. Shepherd^a, Steffen S. Madsen^b, Richard S. Nishioka^c, Kimmakone Siharath^c, N. Harold Richman, III^a, Howard A. Bern^c and E. Gordon Grau^a

^a Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, Hawaii, 96744

^b Institute of Biology, Odense University, DK-5230, Odense M, Denmark

^c Department of Integrative Biology, Cancer Research Laboratory and Bodega Marine Laboratory, University of California, Berkeley, California, 94720-3140

Accepted 21 November 1996. ; Available online 18 April 2002.

Abstract

To date, growth hormone (GH) is known to contribute to seawater adaptation only in salmonid fishes (primitive Euteleostei). Accordingly, the effects of homologous GH and two forms of homologous prolactin (PRL₁₇₇ and PRL₁₈₈) on hypoosmoregulatory ability and gill Na⁺,K⁺-ATPase activity in a more advanced euryhaline cichlid fish, the tilapia (*Oreochromis mossambicus*), were examined. Following adaptation of hypophysectomized fish to 25% seawater for 3 weeks, fish were given four injections of hormone or vehicle. They were then exposed to 100% seawater for 12 hr and examined for changes in plasma osmolality. Tilapia GH (0.02 and 0.2 μg/g) significantly improved the ability of tilapia to decrease plasma osmolality following transfer to full-strength seawater, in a dose-related manner. Growth hormone treatment also significantly stimulated gill Na⁺,K⁺-ATPase activity (0.5 μg/g). Both tilapia PRLs (PRL₁₇₇ and PRL₁₈₈) increased plasma osmolality in 100% seawater and reduced gill Na⁺,K⁺-ATPase activity, the effects induced by PRL₁₈₈ being more significant than those by PRL₁₇₇. Thus, GH may be involved in seawater adaptation of tilapia, a species belonging to the most advanced teleost superorder (Acanthopterygii), whereas both PRLs in tilapia are not involved in seawater adaptation.

*1 R. KirschB. Lahlou, Eds.

¹ Present address: Faculty of Integrated Arts and Sciences, Hiroshima University, Higashi-Hiroshima, Hiroshima 739, Japan.

Effect of thyroid hormones on hatching in the tilapia, *Oreochromis mossambicus*

P. K. Reddy and T. J. Lam

Department of Zoology, National University of Singapore, Kent Ridge, Singapore 0511

Accepted 10 May 1990. Available online 1 November 2004.

Abstract

Incubation of fertilized eggs of *Oreochromis mossambicus* in media containing varying doses of T₃, T₄, and phenylthiocarbamide (PTC) indicated that the thyroid hormones delayed hatching, while the antithyroid drug accelerated it. Denuded eggs were also incubated in the above media and the media were assayed at various time intervals for hatching enzyme. The thyroid hormones delayed hatching enzyme release, while PTC enhanced it. The possible role of thyroid hormones in the control of the hatching process in fish eggs is discussed.

Steroid profiles of the female tilapia, *Oreochromis mossambicus*, and correlation with oocyte growth and mouthbrooding behavior

Carol Johnson Smith¹ and Samuel R. Haley

Department of Zoology, University of Hawaii, Honolulu, Hawaii 96822, USA

Accepted 8 September 1987. Available online 22 October 2004.

Abstract

Plasma levels of progesterone, 17 α -OH-progesterone, testosterone, and estradiol-17 β were measured by radioimmunoassay during the ovarian cycles of two groups of female tilapia, *Oreochromis mossambicus*. One group included females that successfully mouthbrooded fry, while the other group consisted of females in which the zygotes were either removed or swallowed within 1 day after spawning. The mouthbrooders had a longer ovarian cycle (about 40 days) and were sampled 1, 3, 5, 7, 10, 15, 20, 25, 30, 35, and 40 days after spawning. The non-mouthbrooders had an ovarian cycle of about 25 days. They were sampled 3, 5, 7, 10, 15, 20, and 25 days after spawning. Initial peaks in levels of testosterone, estradiol-17 β , and progesterone occurred later in the cycle of mouthbrooders. The first peak of testosterone and estradiol-17 β occurred at 15 days after spawning. While estradiol-17 β levels remained high, testosterone levels fell at 25 days after spawning, and increased again just prior to spawning. In the latter phase of mouthbrooding (15–25 days after spawning), the oocytes in the ovary did not increase in size, and testosterone and estradiol levels were high. During this time, estradiol may have a function other than stimulating vitellogenesis, such as an involvement (with testosterone?) in parental behavior, or protecting the oocytes from atresia. In non-mouthbrooders, testosterone, estradiol-17 β , and progesterone levels initially peaked at 10 days after spawning, then dropped at 15 days after spawning. At the end of the cycle, testosterone and estradiol-17 β levels increased again. The drop in estradiol levels is contrary to the profile seen in mouthbrooders. Also in mouthbrooders, progesterone levels did not rise until 25 days after spawning, then decreased and peaked again towards the end of the cycle. 17 α -OH-progesterone concentrations were low, with a single peak at 7 days after spawning in non-mouthbrooders, and at 40 days after spawning in mouthbrooders. There appears to be a relationship between the delayed initial peaks of the steroid hormones measured, oocyte growth arrestment, and longer-lived postovulatory follicles in mouthbrooding female tilapia.

¹ Present address: Department of Physiology, Morehouse School of Medicine, 720 Westview Drive, S.W., Atlanta, GA 30310-1495.

In vitro release of growth hormone from the
pituitary gland of tilapia, *Oreochromis*
mossambicus

Richard S. Nishioka^{a,*}, E. Gordon Grau^{b,†} and Howard A. Bern^{a,*}

* Department of Zoology, University of California, Berkeley, California 94720, USA

^a Cancer Research Laboratory, University of California, Berkeley, California 94720, USA

[†] Department of Zoology, University of Hawaii, Honolulu, Hawaii 96822, USA

^b Hawaii Institute of Marine Biology, University of Hawaii, Honolulu, Hawaii 96822, USA

Accepted 4 March 1985. Available online 11 November 2004.

Abstract

The release of growth hormone from the proximal pars distalis of the tilapia, *Oreochromis mossambicus*, was significantly stimulated by cortisol (1 μ g/ml) in an *in vitro* system. Growth hormone released into the medium and remaining in the tissue was measured by densitometry after gel electrophoresis. Neither triiodothyronine (6.7 ng/ml) nor equimolar concentrations of thyroxin altered the release of growth hormone. In combination with cortisol, triiodothyronine did not alter the effect of cortisol alone.

Androgen levels and energy metabolism in *Oreochromis mossambicus*

A. F. H. Ros*†, K. Becker‡, A. V. M. Canário§ and R. F. Oliveira*

Two studies were conducted to test the relationship between androgens and routine metabolism in the Mozambique tilapia *Oreochromis mossambicus*. In the first study, endogenous levels of plasma levels of androgens and oxygen consumption rate were measured. In accordance with expectations routine metabolism corrected for metabolic body mass, was positively correlated with the behaviourally active metabolite of testosterone, 11-ketotestosterone, but not with testosterone itself. In the second study levels of 11-ketotestosterone were experimentally elevated, which increased the lowest values of (corrected) routine metabolism, indicating a positive relationship with standard metabolism. These results show the importance of measuring reproductive hormones, and are supportive of the hypothesis that elevated levels of androgens are a costly trait.

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Affiliations

*Unidade de Investigação em Eco-Etologia, Instituto Superior de Psicologia Aplicada, Rua Jardim do Tabaco 34, 1149-041 Lisboa, Portugal, †Department of Aquaculture Systems and Animal Nutrition, Institute for Animal Production in the Tropics and Subtropics (480), University of Hohenheim, Fruwirthstr. 12, D-70593, Stuttgart, Germany and

Temperature sensitivity of skeletal ontogeny in *Oreochromis mossambicus*

M. A. Campinho*, K. A. Moutou[†] and D. M. Power[†]

Sensitivity of skeletal ontogenesis to temperature was assessed in Mozambican tilapia *Oreochromis mossambicus* and culture temperature manipulations (22, 27 and 32° C) were used to establish if age or length gave the most suitable metric for standardization. *Oreochromis mossambicus* larval growth was composed of two growth stanzas: an initial period of rapid growth, followed by a slower growth phase. Irrespective of culture temperature chondrogenesis occurred during the first rapid growth phase and ossification was initiated during the second slower growth phase. The sequence of events and rate at which ossification occurred was much more sensitive to temperature than chondrogenesis. Cumulative counts provide a useful developmental index for skeletal ontogenesis; overall, age (effective days-degrees) gave the best estimation of developmental status during chondrogenesis and the initiation of ossification, although standard length (as $\log_{10}LS$) was a better metric for completion of ossification. The timing of development of functionally important structures, such as Meckel's cartilage, the branchial arches, the centra and the cleithrum important for breathing, feeding and swimming, was well conserved at all temperatures and may be a good index of teleost developmental stages.

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Affiliations

*Centro de Ciências do Mar
(CCMar), Universidade do
Algarve, Campus de Gambelas,
8005-139 Faro, Portugal and [†]
Department of Biochemistry and
Biotechnology, University of
Thessaly, 26 Ploutonos Street,
41221 Larissa, Greece

Sound production during courtship and spawning of *Oreochromis mossambicus*: male–female and male–male interactions

M. C. P. Amorim*†, P. J. Fonseca‡ and V. C. Almada*

The role of sound production of the Mozambique tilapia *Oreochromis mossambicus* in agonistic and mating interactions observed during hierarchy formation and in established groups was examined. Only territorial males produced sounds, during male–female and male–male courtship interactions and during pit-related activities (e.g. dig, hover and still in the nest). Sound production rate was positively correlated with courting rate. Although sounds in other cichlids are typically emitted in early stages of courtship, *O. mossambicus* produced sounds in all phases, but especially during late stages of courtship, including spawning. It is suggested that the acoustic emissions in this species may play a role in advertising the presence and spawning readiness of males and in synchronizing gamete release.

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2002, Accepted 21 January 2003)

Affiliations

*Unidade de Investigação em
Eco-etologia, I.S.P.A., Rua
Jardim do Tabaco 34, 1149-041
Lisboa, Portugal and †
Departamento de Zoologia e
Antropologia, Faculdade de
Ciências de Lisboa, Bloco C2
Campo Grande, 1749-016
Lisboa, Portugal

Correspondence

IV. Fish culture

**An experimental study on the culture of fry of
Oreochromis mossambicus (Peters) in a peaty swamp in Sri Lanka using
cowdung and poultry manure as fertilizer^{*1}**

H. H. Costa and C. N. Keembiahetty

Department of Zoology, University of Kelaniya, Kelaniya, Sri Lanka

Received 31 May 1986; accepted 11 June 1986. ; Available online 21 August 2003.

Abstract

Growth rates of fry of *Oreochromis mossambicus* were studied in a dug-out pond in Muthurajawela swamp, which had been fertilized with cowdung and poultry waste. This swamp is characterized by waters with very low pH, low dissolved oxygen and low values of primary productivity. The addition of fertilizer increased the gross primary production from 0.18 g C/m²-day to 1.08 g C/m²-day in about 40 days, with pH and dissolved oxygen values becoming favourable for growth of fry. The average growth rate of 0.04 g/day was comparable to the growth rates attained in favourable habitats in Sri Lanka.

^{*1} Paper presented at the International Symposium on Recycling of Organic Wastes for Fertilizer, Food, Feed and Fuel, Hong Kong, August 28-30, 1985.

Oreochromis mossambicus (Peters, 1852)

Scientific Name: *Oreochromis mossambicus*

Integrated Taxonomic Information System (ITIS): 170015

Other scientific names appearing in the literature of this species:

Chromis niloticus, *Chromis mossambicus*, *Chromis niloticus*, *Chromis dumerilli*, *Chromis vorax*, *Tilapia mossambica*, *Tilapia vorax*, *Chromis natalensis*, *Tilapia natalensis*, and *Sarotherodon mossambicus* (Trewevas, 1983).

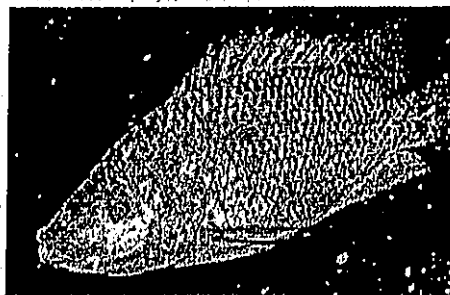


Photo by Windsor Aguirre

Common Name:

Distinguishing Features:

Jaws of sexually mature males are enlarged, making their upper profile concave. Females and non breeding males are silver colored with 2-5 midlateral blotches, and occasionally a few dorsal blotches. Breeding males have a distinct black coloration with white on the lower parts of their heads and red on the margins of their dorsal and caudal fins. In addition, males have simple genital papilla with a shallow distal notch. Typically, there are 28-31 vertebrae with a mode of 30, 15-17 dorsal spines with a mode of 16, 26-29 total dorsal rays with a mode of mode 28, 3 anal spines, and 14-20 lower gill rakers with a mode of 17-18. The pharyngeal teeth are very fine. The caudal fin is not densely scaled (Trewevas, 1983).

Similar Species:

Blue tilapia, *Oreochromis aureus*, which can be distinguished by their higher gill raker count (18-26) in the lower branch of the gill arch. Blackchin tilapia, *Sarotherodon melanotheron*, which can be distinguished by the black coloration on the underside of their chin and the gold coloration on their operculum.

Biology:

Depth: This species is usually restricted to relatively shallow waters (Bruton and Boltt, 1975). Over portions of its native range, juveniles, however, appear better adapted to inhabit deeper waters than adults (Caulton & Hill, 1973). Bowen and

Allenson (1982) reported diel movement patterns of juveniles in Lake Sibaya, Africa, with juveniles moving from shallower waters to deeper waters in response to the movements of its chief predator, *Clarias gariepinus*. Adult Mozambique tilapia move into deeper waters with the onset of colder temperatures, both over their natural range (Bruton and Bolt, 1975), and over colder portions of their non-native range (Arthington and Milton, 1986).

Salinity Tolerance: Over their native range Mozambique tilapia occur in freshwater and estuaries along the coast, tolerating a broad range of salinities (Trewevas, 1983). However, they prefer estuarine waters (Dial and Wainright, 1983). Brock (1954) reported successful spawning in seawater under artificial conditions. Mozambique tilapia may be able to spawn in salinities of up to 30 ppt and survive in salinities of up to 40 ppt (Robins in Courtney et al., 1974). Knaggs in Dial and Wainright (1983) reported breeding in salinities of up to 34.5 ppt in California. In Florida this species is well established both in fresh water ponds and brackish water estuaries, whereas in Texas it appears more restricted to fresh waters. (Courtney et al., 1974; Hogg, 1976, Shafland and Pestrak, 1982; Dial and Wainright, 1983).

Temperature Tolerance: *O. mossambicus* does not tolerate temperatures below 10°C, which appear to be a limiting factor over its native range (Trewevas, 1983) and in Gulf of Mexico drainages (Shafland and Pestrak, 1982). In Lake Sibaya, Africa, Bruton and Bolt (1975) reported seasonal movements to deeper waters during the cold season and to shallower waters in the warm season, with colder temperatures limiting the length of the breeding season. In tropical waters Mozambique tilapia breed throughout the year (Neil, 1966; De Silva and Chandrosoma, 1980). Shafland and Pestrak (1982) suggested a northern limit in Florida just south of Gainesville, for Mozambique tilapia based on a lower lethal temperature of 9.5°C estimated under laboratory conditions. However, they may venture further north through the use of thermal refuges, as has been the case with other cichlids such as the blue tilapia, *Oreochromis aureus* (Dial and Wainright, 1983, Hubbs et al., 1978). Lee et al. (1980) reported temperature tolerance down to 12 °C in fresh waters and 11° in brackish waters of Florida.

Reproduction and Fecundity: According to Bruton and Bolt, 1975. The Mozambique tilapia is a mouth brooder. Males construct nests in areas of sparse to moderately dense vegetation. Females mouth brood the young. There have been a few reports of males mouth brooding young (Bruton and Bolt, 1975; Arthington and Milton, 1986). Maturation appears to usually occur between 150 and 160 mm in females and between 170 and 180 mm for males (Hodgkiss and Hanson, 1978; Arthington and Milton, 1986). De Silva and Chandrasoma

(1980) reported males maturing at 200-275 mm in Sri Lanka, with the percentage of mature males increasing dramatically above 275 mm.

Nests in Lake Sibaya, Africa were located at depths ranging from 41 cm to 8.5 m, and had diameters ranging from 20 cm to 142 cm. Eggs are fertilized within the nests and then carried off to deeper waters for maturation by the female. Incubation ranges from 20-22 days, and maturation of ova takes two weeks. Fry are released in shallow waters by females once they have reached a length of 9-10 mm. Release of fry appears to also be associated with cues relating to rainfall.

Although males are highly aggressive during the breeding season, under natural conditions most interactions appear to be ritualized, normally without serious injury resulting (Bruton and Bolt, 1975). Neil (1966), however, reported that although rare, fighting among males was very violent, with serious injury and even death occurring, among introduced tilapia in Hawaii. The white coloration on the head and red on the fins of breeding males is used in territorial and breeding displays (Trewavas, 1983).

Females may lay anywhere from 50-1780 eggs, varying according to the locality and the size of the female (Trewavas, 1983). Hodgkiss (1978) recorded a maximum of 1,754 eggs for the largest (25 cm) female caught from 38 examined in Plover Cove, Hong Kong. De Silva and Chandrosoma (1980) reported 360-1775 eggs per female in Sri Lanka. Arthington and Milton (1986) reported a mean of 2107 eggs for fish introduced in an artificial lake of Australia. Bruton and Bolt (1975) suggested that females may produce three or four broods per year in one breeding season in Lake Sibaya, Africa. Over tropical portions of its range, breeding occurs throughout the year (De Silva and Chandrasoma, 1980; Neil, 1966).

Very little information exists on the breeding of Mozambique tilapia in the Gulf states. However, they may compete for nesting areas with native fishes such as centrarchids, as has been reported for other cichlids (Courtney et al., 1974). Given the relatively cold water temperatures in the winter, their breeding is probably seasonal in the Gulf.

Trophic Interactions: In general, Mozambique tilapia are omnivorous, feeding on whatever is available, although they seem to show some preference for detritus and plant matter. Over their natural range, Mozambique tilapia appear to be primarily detritivorous, with diatoms playing an important role in their nutrition (Bowen, 1979; Trewavas, 1983). Bruton and Bolt (1975), however, reported differing diets among adults from different parts of Lake Sibaya. Feeding on filamentous algae, phytoplankton, zooplankton, vascular plant fragments, insects, crustaceans and small fish has also been reported (Neil,

1966; Bruton and Bolt, 1975; Trewevas, 1983, De Silva et al., 1984). In artificial lakes of Sri Lanka, where Mozambique tilapia support a substantial fishery, De Silva et al. (1984) found populations in different lakes to differ markedly in their diets. These ranged from almost exclusively detritivorous, to primarily herbivorous and even primarily carnivorous. Reports of Mozambique tilapia opportunistically feeding on other fish are common (Neil, 1966; Bruton and Bolt, 1975; Trewevas, 1983).

Growth: Males grow faster and become larger than females (Bruton and Allanson, 1974; Bruton and Bolt, 1975). Like most cichlids, optimal growth occurs near 30°C (Price et al., 1985). However, growth rates vary depending on food availability and habitat quality (Bruton and Allanson, 1974; Bowen, 1979; Arthington and Milton, 1986). Over their natural range, several cases of stunted populations have been documented (Bruton and Allanson, 1974; Bowen, 1979). Bruton and Allanson (1974) believed this to be an adaptation to harsh environments. They reported average breeding size of Mozambique tilapia in food limited waters of Lake Sibaya, Africa, to be 100 mm in females and 120 mm in males, with the smallest breeding female found 68 mm and the smallest breeding male 104 mm. A maximum size of approximately 260 mm for the population was reported. Bowen (1979) attributed the stunting observed in Lake Sibaya, to the poor protein content of the diet of Mozambique tilapia. On the other hand, high growth rates of fish reaching 350 mm in 8 months were reported in brackish waters conditions by Hickling in Trewevas (1983).

Maximum Size:

The Mozambique tilapia typically grows to about 380 mm (Trewevas, 1983). Coke (in Bruton and Allanson, 1974) reported a maximum size of 432 mm at Inyamiti pan, in Africa. In the Gulf, Mozambique tilapia typically grow to 140-220 mm SL with a maximum reported of 360 mm SL (Lee et al., 1980).

Distribution:

This species naturally occurs along the eastern coast of Africa, in the lower Zambezi and its tributaries and eastward-flowing rivers and coastal lagoons southward to the Bushman's River, near Port Elizabeth, South Africa (Bruton and Bolt, 1975).

In the Gulf of Mexico ecosystem, Mozambique tilapia are established in Texas, where they are abundant in the San Antonio Area (especially around the San Antonio zoo), Bexar county, in the San Marcos River, Hays county, and in the Potters Creek Park area of Canyon Lake (Brown, 1961; Hubbs et al., 1962; Whiteside, 1975). Additionally, museum records exist for Caldwell and Limestone counties. They are abundant in Dade, Brevard, Indian River, and Hillsborough counties, Florida, each of which apparently represents an independent

introduction (Courtney et al. 1974). Additionally museum records exist for Alachua and Palm Beach counties. This species also occurs in Alabama (Lee et al., 1980).

Collection Records

Interest to Fisheries:

Current Status of this Species in the Gulf of Mexico Ecosystem:

This species was stocked in Alabama by the Alabama Department of Conservation for aquatic plant control and potential use in aquaculture (Smith-Vaniz, 1968, Lee et al., 1980). It escaped and was intentionally released by the Texas Game and Fish Commission from hatcheries in the upper San Marcos River, Hays county, Texas. It also escaped and was intentionally released from the San Antonio Zoo in Bexar county (Brown, 1961; Howells, 1992; Hubbs et al., 1992). In Florida it escaped from fish farms, was released by recreational aquarists, and probably transplanted between counties by local fishermen for fisheries purposes (Courtenay and Robins, 1973; Courtenay et al., 1974; Hogg, 1976; Lee et al., 1980, Dial and Wainright, 1983).

Its status in Alabama is uncertain, as stocking programs have been discontinued. It is well established in Texas and locally common in the fresh waters of Bexar and Hays counties, where it has probably contributed to the displacement of native faunas (Hubbs et al., 1992). This species was reportedly introduced into San Marcos River and Canyon Reservoir, Comal county. However, populations there appear to be currently represented by a hybrid Mozambique tilapia - blue tilapia form (Howells, 1992). In Florida this species is well established in fresh and brackish waters in several counties across the state, south of Gainesville. Shafland (1996) reported possible hybridization between Mozambique tilapia and blue tilapia in canals of Dade county.

Mozambique tilapia continue to expand their range throughout the Gulf of Mexico ecosystem (Courtney et al., 1991).

Potential Impacts:

The extent of the impact of the Mozambique tilapia on native assemblages in Gulf drainages remains unclear. This species probably competes with native fishes such as centrarchids for nesting areas (Courtenay et al., 1974). Because of its aggressive breeding habits, where abundant, it may alter community structure (Neil, 1966; Bruton and Bolt, 1975). In addition, Mozambique tilapia may opportunistically feed on a number of different food items and hence have the potential to compete with a broad array of native taxa. Where common, such as in the estuarine waters of Florida, they may lower local

biodiversity, through competition for trophic resources and direct predation. Hubbs et al. (1992) expressed special concern for native faunas of stenothermal springs in Bexar county, Texas.

Recommendations:

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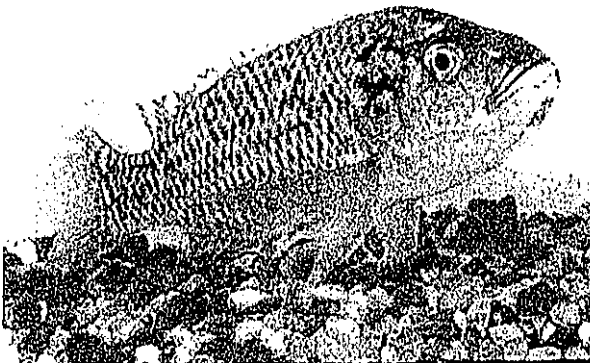
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Attachment 3

New Strains of Mozambique Tilapia

Mozambique Tilapia (*Oreochromis mossambicus*)

black mossambica female



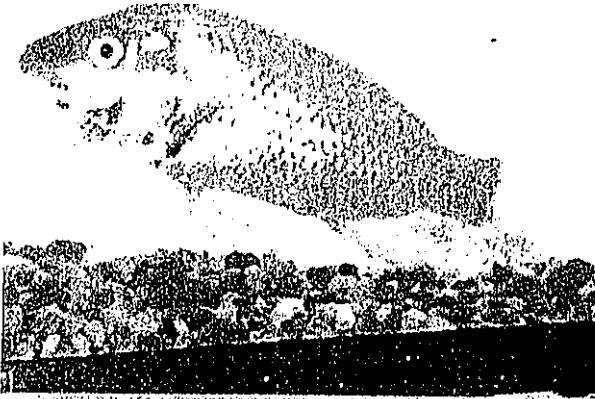
black mossambica male



Oreochromis mossambicus has still admirers who research and develop the fish for farming. It is now increasingly used as an F1 hybrid, where crosses with *O. hornorum* result in nearly 100% male offspring. This is a very desirable trait as mixed populations of tilapia breed profusely and perform poorly as a result. The development of coloured strains of *O. mossambicus* (see pictures below for orange mossambicus and red mossambicus) has enabled cross checking of the breeding program. All fish resulting from the crossing of an orange mossambicus and a grey hornorum, are copper coloured. The appearance of any orange or grey fish in the stock means that the parent fish were incorrectly sexed and the offspring are not necessarily all male.

The process of all male production involves using a female mossambicus and a male hornorum. The mossambicus possesses XX chromosomes and the hornorum male, ZZ chromosomes. As the Z chromosome exerts a dominance over the X, the resulting offspring are all ZX i.e. male.

orange mossambica female

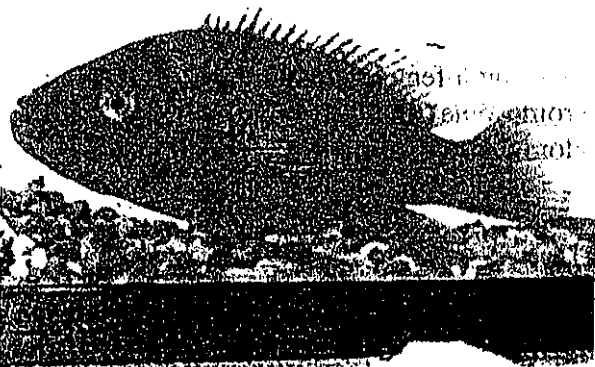


orange mossambica male

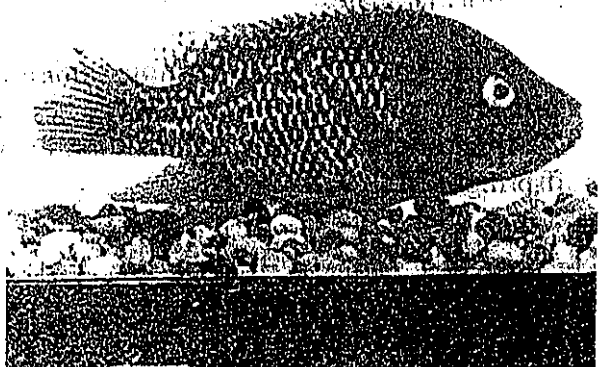


The coloured strains of mossambicus have enabled tilapia to be marketed in many areas where, in its natural colour form it would not be acceptable. The bright colours are perceived by many consumers as the colouration of a marine fish, and therefore a desirable one to consume; this is in contrast to the natural, rather drab olive green colour, which highlights it as a freshwater fish and reduces its market value.

red mossambica female



red mossambica male



Attachment 4

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