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ABSTRACTS

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CASE STUDIES "INTENSIVE RAS TILAPIA FARMING"
A TACTICAL APPROACH FOR INTENSIFYING AQUACULTURE IN AFRICA

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Production of fish in closed recirculation aquaculture systems (RAS) is mostly based on production driven initiatives. On all levels of the aquaculture production chain, inefficiencies accumulate due to unforeseen harvesting results and, more importantly, irregularities on the demand side.

A more controlled environment and improved production forecast could improve the position of the fish farmer. A RAS farm design should be tailored to deliver the right number of fish of the right size on the right moment, all according to the clients' quality specifications. According to Holland Aqua, in order to be sustainable as well as successful in the industrial aquaculture sector, the main focus should be with the demand of the client.

It is Holland Aqua's experience that implementing a complete supply chain is a complex matter. However, it is also the key success factor. The Dutch agriculture and horticulture approach (highest efficiency and productivity), can also be the applied model for intensive aquaculture in Africa. For example the business strategy and implementation philosophy of the flower-industry is very useful for the development of the aquaculture sector in Africa. Building a new production industry, how did they do that?

Resources, climate and finance are key inputs for defining a feasible business case. The RAS technology should be tailored for local circumstances and demands, in order to produce fish at the lowest cost price.

There is a need for support and guidance in decision-making regarding the design and construction of RAS systems in various climate zones and locations in Africa. In this session, designs and results of several intensive tilapia RAS system business cases will be discussed, considerations will be shared and the do's and don'ts will be highlighted. Designer principles will be shared in order to meet requirements for further aquaculture development in Africa.

DNA BARCODING AND MORPHOLOGICAL IDENTIFICATION OF EGYPTIAN MARINE SHRIMP SPECIES

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Shrimp is the most important fishery traded on the world market in terms of present value. In many developing countries, this is the most profitable fishing trade. Shrimp fishing is not only a valuable food resource, but also an important economic resource in Egypt and the other developing countries. The current research work is integrating DNA barcoding with morphology-based species identification as a valuable complementary tool. Different Egyptian marine shrimp species were morphologically described and characterized according to the shape of their carapace; crest, groove and spines, the rostrum with its teeth; dorsally and ventrally, sex determination; the shape of petasma and thelycum, armed or unarmed telson and the body colour. The phylogenetic relationship of the shrimp species was studied using sequencing data from the GenBank database in part for the mitochondrial gene cytochrome oxidase (COI) subunit I subunit. Similarity search was analyzed by using BLAST to compare the obtained sequences with their counterparts and revealed high similarity (≤ 99%) for with the compared sequences in the GenBank database except for *Trachypenaeus curvirostris* (87%) and *Melicertus latisulcatus* (88%) sequence identity. Among the studied sequences for the ten shrimp species from Egypt, the GC percent was ranged from 41.5% for *Metapenaeus monoceros* and 36.9% for *Xiphopenaeus kroyeri.* Analysis of the *COI* gene sequence for the phylogenetic tree divided the shrimp species into two distinct clades that are genetically distinct from each other. This study is the first of its kind in Egypt as it provides both morphological and genetic clues for identifying such species in the Egyptian Mediterranean and Red Sea.

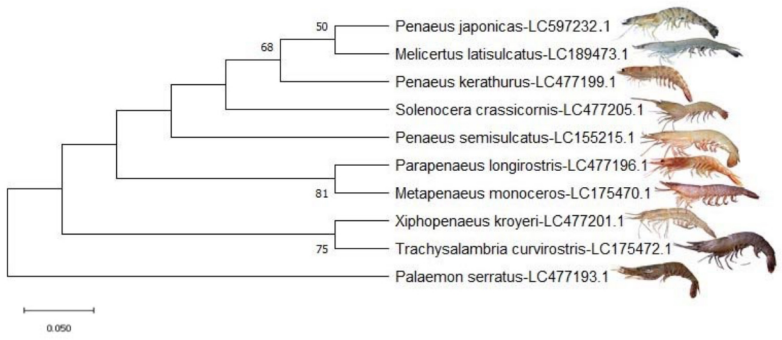

Figure 1: Neighbour Joining (NJ) phylogenetic tree for Egyptian shrimp species based on partial Cytochrome oxidase subunit I (*COI*) gene using K2P distance. The numbers above the branches are bootstrap values.

MOLECULAR CHARACTERIZATION OF USING BIOFLOC TECHNOLOGY ON GROWTH, IMMUNITY AND ANTIOXIDANT CAPACITY IN (*Litopenaeus vannamei*) UNDER INTENSIVE CULTURE

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Biofloc technology (BFT) has been presented as a sustainable shrimp farming approach capable of decreasing environmental impacts and limiting disease introduction. Bioflocs' microbial population can boost feed consumption and animal growth as well as eliminate nutrients. The cell walls of bacteria in Biofloc systems are made up of bacterial lipopolysaccharide, peptidoglycan, and B-1,3 glucan, among other components. Non-specific immune response in crustaceans, such as shrimp, is stimulated by bacterial cell wall components. As a result, bioflocs are thought to improve the immune system of shrimp that consume them as a food source. In this study, we investigated how different carbon sources (sugarcane bagasse, rice straw, and wheat bran) altered the expression of immune-related and antioxidant genes in *L. vannamei* larvae raised for 90 days. The gene expression of immune-related genes and antioxidant genes was considerably up-regulated with different carbon sources after 90 days of rearing as compared to a control group fed a basic diet. Immune-related genes (Proph, LGBP, and Trans) had higher gene expression in all biofloc treatments, with the highest expression in the sugarcane bagasse (SCB) group. The expression of antioxidant genes (SOD, GPx) increased significantly in the biofloc groups, with SOD expression increasing by (4.5-, 3.2-, and 2.5-fold changes) in SCB, wheat bran, and rice straw, respectively. In addition, the SCB group had the greatest GPx expression. Biofloc not only improves shrimp immunity, but it also improves growth, since all biofloc groups grew faster than the control group. To sum up, this study found that adding different carbon sources (sugarcane bagasse, rice straw, and wheat bran) as a direct feed to *L. vannamei* for 90 days improved shrimp immunity, growth, and reduced stress, as evidenced by underline molecular changes in expression of immune-related and antioxidant genes, and we strongly recommend the use of biofloc technology, particularly sugarcane bagasse, as a cost-effective and feasible source of carbon in shrimp farming.

Acknowledgements: The research was performed within the "Development and Research Application of biofloc Technology for increasing shrimp production in Egypt (EGY-DRAFT)" project, which is financially supported, by the Science & Technology Development Fund (STDF), Ministry of Scientific Research, Egypt. (Agreement No. 25305, Reintegration Grants). The authors are grateful for all the support.

DIETARY INCORPORATION OF ZADO® (*Ruminococcus Flavefaciens*) PROBIOTIC ENHANCES HEMATOLOGY, IMMUNE, SERUM PROTEINS, AND GROWTH RESPONSES OF NILE TILAPIA (*Oreochromis Niloticus*)

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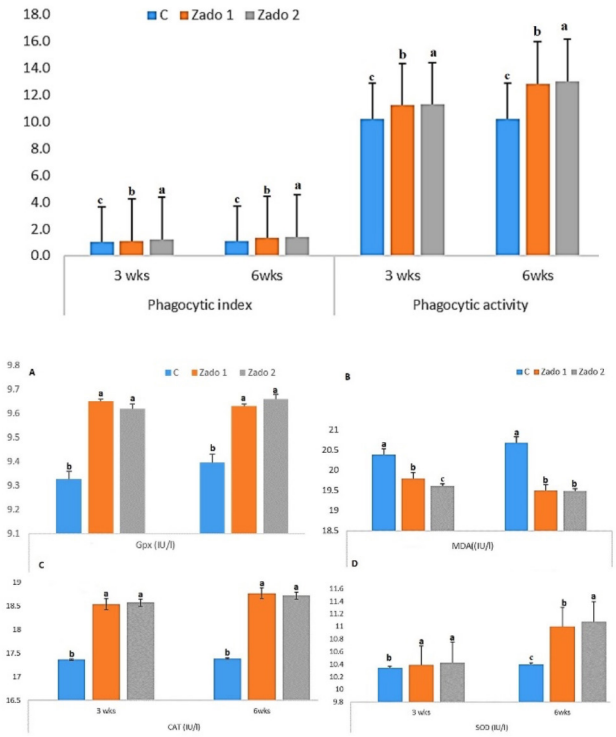
Probiotics usage in aquaculture could be a key solution to boost the overall immune and growth indices of various fish species. Various bacteria have proven positive results as probiotics for aquaculture. The current research evaluated the potential effects of Zado® (*Ruminococcus Flavefaciens* 28 × 10^4 CFU) dietary inclusion at 1 and 2 g/kg diet for 6-weeks on growth, hematological, immune, the biochemical, and anti-oxidative profiles of *Oreochromis niloticus*. Sampling was performed at the end of the third and sixth week. Fish fed with Zado® enriched diets showed ($P < 0.05$) significantly improved hematologic (MCHC, MCH, MCV, and PCV and RBCs count) and leukocytic readings (WBCs, monocytes and lymphocytes).

The immune (phagocytosis, lysozyme U/ml, and nitric oxide pmol/ml) parameters were ($P < 0.05$) markedly increased in Zado® incorporated groups (Figure 1). Biochemical parameters (globulin, albumin and total proteins; AS T and ALT) levels showed significant ($P < 0.05$) improvement at three and six weeks in Zado® groups. Serum glucose concentration was significantly higher in Zado® groups at three weeks, while was only higher for 2 g/kg Zado® at six weeks. Also, cortisol level was lower in both Zado® groups at three weeks, while was only lower for 1 g/kg Zado® at six weeks.

In addition, antioxidants Gpx, SOD, and CAT were ($P < 0.05$) significantly higher in Zado® treatments, while pro-oxidant MDA was ($P < 0.05$) significantly decreased (Figure 2).

Moreover, growth performance was also ($P < 0.05$) markedly boosted in Zado® incorporated groups compared to the control.

Conclusively, our results demonstrated that Zado® probiotic is a safe alternative for *O. niloticus* with beneficial effects on hematological parameters, immune, biochemical, antioxidants, and growth profiles.



GROWTH PATTERN AND STOCK ASSESSMENT OF JINGA SHRIMP *Metapenaeus affinis* (H. MILNE EDWARDS, 1837) (DECAPODA, PENAEIDAE) FROM THE SOUTHEASTERN MEDITERRANEAN ON THE EGYPTIAN COASTS

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A total of 1457 random specimens of newly established population *Metapenaeus affinis* were collected monthly during the period from July 2020 to June 2021 at Boughaz El-Ma'deya landing center from Abu Qir Bay (Alexandria, Mediterranean Sea, Egypt) using commercial shrimp trawlers. The study aims to shed light on the growth pattern and stock assessment of this newly established species.

Shrimp specimens were sexed and the total length (TL), the carapace length (CL) and the total body weight (Wt) were measured. According to the results of the present study, the catch varied in lengths between 5.4 cm and 16.0 cm TL and at length of 13.5 cm the population is composed of 100% females. The lengths from 9cm to 13.5cm represented 78.48% of female catches and the lengths from 8cm to 11cm represented 85.10% of the male catches. The overall sex ratio (F: M) was 1.00: 0.58 and Chi-square test reflect significant differences (X^2 =172.8; df =1; $P < 0.05$). The growth parameters were calculated for males, females and combined sexes (Table 1) where, the von-Bertalanffy's growth parameters ($L\infty$, K and t_o) were calculated from the analysis of length frequency by Bhattacharya's method. The fisheries parameters were calculated for the population (Table 2).

TABLE 1. Growth parameters of Jinga shrimp *Metapenaeus affinis* from Abu Qir Bay (Alexandria, Mediterranean Sea, Egypt) during the period from July 2020 to June 2021.

Growth parameters of *Metapenaeus affinis*			
Growth parameters	Female (n= 920)	Male (n= 537)	Combined sexes (n= 1457)
Length range	5.5 - 16.0 cm	5.4 - 13.4 cm	5.4 - 16.0 cm
Weight range	1.27 - 34.63 g	1.10 - 15.04 g	1.10- 34.63 g
CL-TL relationship	CL = -0.2634 + 0.3998 TL	CL = 0.0590 + 0.3577 TL	CL = -0.3027 + 0.4008 TL
L-Wt. relationship	Log W= 0.0040 + 3.2544 Log L	Log W= 0.0070 + 3.0002 Log L	Log W= 0.0040 + 3.2676 Log L
Condition Factor (K)	0.801 ± 0.0664	0.719 ± 0.0438	0.771 ± 0.0711
Coefficient of growth (K)	0.277	0.260	0.242
Hypothetical age at zero size (t_o)	-0.433	-0.901	-0.872
Asymptotic length ($L\infty$)	19.483	16.242	19.849
Asymptotic weight ($W\infty$)	63	30	70
Growth performance index (Q_L)	2.02	1.84	1.98
Growth performance index ($Q_{wt.}$)	0.64	0.40	0.61
Longevity by cohort no.	5	4	5
Cohort max.	10.38	10.62	11.54

The test of the allometric coefficients (b) of CL was shown negative allometry growth for males, females and sexes combined. The values of "b" for L-Wt. relationship reflect isometric growth only for males. Females and sexes combined showed a pattern of positive allometric growth.

The study of fishery parameters revealed that *Metapenaeus affinis* was still un-exploited.

Further studies were recommended in other fishing grounds for finding out of its spawning and nursery grounds in the Egyptian waters. The study of the reproductive biology for this shrimp species was also recommended.

TABLE 2. Fishery parameters of Jinga shrimp *Metapenaeus affinis* from Abu Qir Bay (Alexandria, Mediterranean Sea, Egypt) during the period from July 2020 to June 2021.

Fishery parameters of *Metapenaeus affinis*	
Total mortality (Z)	1.1339
Natural mortality (M)	0.71
Fishing mortality (F)	0.43
Annual mortality (A)	0.68
Length at first capture (Lc)	8.279
Length of recruitment (Lr)	7.147
Age at first capture (tc)	1.362
Age of recruitment (tr)	0.98
Exploitation ratio (E cur.)	0.39
The yield per recruit (Y/R)	3.04
Biomass per recruit (B/R)	7.15
The relative yield per recruit (Y/R')	0.01184
Biomass percentage (Bv%)	46.79
Lc/L00	0.4171
M/K	2.9247

THE BIOLOGICAL EFFECTS OF TURMERIC OIL ON THE IMMUNE RESPONSE AND OXIDATIVE STRESS MARKERS IN NILE TILAPIA (*Oreochromis niloticus)*

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Turmeric essential oil had been used in different experiments to study for its beneficial pharmacological and nutritional effect. However**,** its precise mechanisms as a medicinal herb in fish regarding dose and duration of application in fish diet still need much investigation. This study was carried out to investigate the effect of dietary supplementation of turmeric on immunity, antioxidant activity, and cytokines gene expression in head kidney of *Orechromis niloticus*. A total of 120 apparently healthy (55±0.52 gram) *Orechromis niloticus* were fed on diet supplemented with (0.5% and 1% turmeric essential oil /kg diet) for 15 and 30 days. Serum biochemical parameters including, serum protein fractionation, kidney and liver functional activity, immunological and antioxidant parameters, and the expression of *IL-8*, *IL-1β* and *TGF-β* were determined. The results showed that serum creatinine, serum liver transaminase (GOT), nitric oxide and lipid peroxides were significantly decreased in a concentration - dependent manner. While, serum globulins, lysoszyme activity, respiratory burst activity, hematocrit value, cytokines gene expression, total antioxidant capacity and plasma catalase were increased in time- and concentration-dependent manners. In conclusion, the results of the present study demonstrate the immunomodulatory and antioxidant roles of turmeric essential oil, which in turn improve the immune response of Nile tilapia.

VIABILITY AND FERTILIZATION RATE OF *Tor soro* SPERMATOZOA AFTER FREEZING: THE EFFECT OF EGG YOLK OF FREE-RANGE CHICKEN AS A NATURAL CRYOPROTECTANT

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Tor soro Valenciennes, 1842, is one of endemic fish in Indonesia, which is located in North Sumatera and West Java. The local name of this fish in North Sumatera is "ikan Batak", while in West Java which is called it as "ikan Kancra" or "ikan Dewa" (God Fish). Ikan Batak or ikan Kancra is usually used as traditional ceremony in North Sumatera, besides as a fish consumption in West Java. The population of this species in the natural habitat was significantly declining. Some factors involved in declining of this fish, such as over exploitation, lack of high quality of broodtock, and asynchronous gonad maturation. Cryopreservation, therefore is one of the methods to overcome this problem. Cryopreservation is a long-term storage method conducted in very low temperature. This method usually is applied for germ and embryo cells. A major factor which supporting cryopreservation is cryoprotectant. Cryoprotectant is a substance that protect the cell from ice crystallization during cryopreservation. In this study we used two types of cryoprotectants, namely methanol as a permeating cryoprotectant and egg yolk solution as a natural non-permeating cryoprotectant. Hence, the objective of present study was to determine the best combination of egg yolk solution of free-range chicken and methanol for 48 h storage of *T. soro* spermatozoa.

One level of methanol (10%) combined with six levels of egg yolk solution (0%, 5%, 10%, 15%, 20%, and 25%) were tested in this study. Fish Ringer's solution was used as an extender. The diluted sperm were equiliberated at 5 °C for 10 min. and then kept at – 10 °C for 48 h. Sperm was thawed for 1 min at 40 °C. The one-way ANOVA showed that combination of methanol with several concentrations of egg yolk solution of kampong chicken had a significan effect on spermatozoa viability and fertilization rates ($P<0.05$). The study revealed that 5% of egg solution combined with 10% methanol resulted in the highest rates of viability (82.13 ± 1.75%) [Fig. 1] and fertilization rates (92.96 ± 1.94%) [Fig. 2]. Conclusion: A 5% of egg yolk solution of combined with 10% methanol in fish Ringer's solution was the best cryoprotectant for *T. soro* spermatozoa preserved at -10 °C.

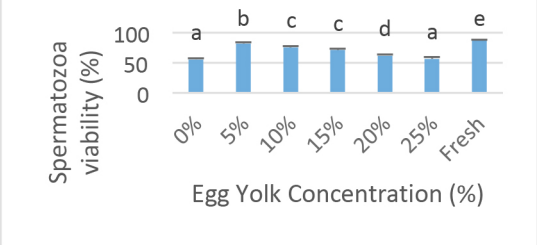

Fig. 1. Viability rate of *T. soro* spermatozoa

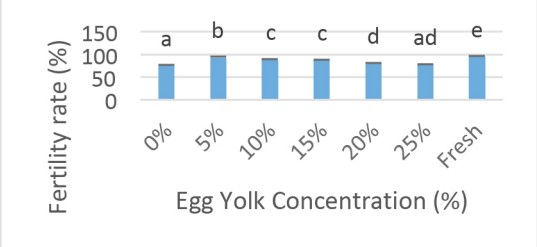

Fig. 2. Fertilization rate of *T. soro* spermatozoa

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) AND HYDROPONICS TO DELIVER HIGH QUALITY MEDITERRANEAN HORTICULTURAL

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Food products, crop and fish yields are projected to decline in many Mediterranean areas by 2050 due to climatic and other stress factors. Under semi-arid growing conditions like those found in Mediterranean regions, greenhouse crops are usually over-irrigated so that growers prevent water and nutrient shortages. In view of this, optimal greenhouse management is required to ensure unrestricted growth at a yield close to the maximum potential, while minimizing unsustainable exploitation of resources, especially energy, soil & water. The overall objective of present study is to provide the Mediterranean horticultural community with innovative tools to enable resource efficient year round greenhouse cultivation by: 1(Developing and testing a user-friendly and flexible Decision Support System (DSS) allowing smart nutrient, irrigation & climate control, and integrated pest management in greenhouses; 2(Demonstrating the potential of biological agro-ecological technologies to close the loop in Mediterranean greenhouses by validating aquaponics systems based on the combination of Integrated Multi-Trophic Aquaculture (IMTA) and hydroponics to deliver high quality Mediterranean horticultural and fish products with improved N use efficiency (NUE), and water use efficiency (WUE); 3) Providing farmers with tools for environmentally friendly integrated pest management in horticultural greenhouses. 4-Validating HortiMED technologies in low, medium and high technology greenhouses from Egypt, Algeria and Spain. 5-Achieving well-targeted communication and effective transfer of the project results to stakeholders and local horticultural community.

HortiMED project will improve: a) the sustainability in Mediterranean greenhouses and increase productive capacity by validating in real scenarios freshwater IMTA -aquaponics systems based on the integration of ecosystem services; b) Development DSS to guide farmers through advisory services on the optimal quantities of water and nutrients to be applied based on the crop requirements and the greenhouse conditions; combined with partial or full automation of the irrigation, nutrient and/or fertigation systems; c) Support the promotion of protected agricultural production systems to increase the ability of farmers in Egypt and in the Mediterranean countries to adapt to climate change effects.

HortiMED-Towards circular horticulture: closing the loop on Mediterranean greenhouses (Grant Number 1915) is part of the PRIMA Programme supported by the European Union's Horizon 2020 research and innovation programme.

GENETIC DIVERSITY OF WILD POPULATION OF *Heterobranchus bidorsalis* AND *Heterobranchus longifilis* BASED ON MITOCHONDRIA DNA *COI* GENE ANALYSIS

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Catfish *(Heterobranchus spp*.) is a major freshwater fish that are widely distributed in Nigeria waters and are gaining rapid aquaculture expansion. However, indiscriminate artificial crossbreeding of the species with others poses a threat to their biodiversity. There is a paucity of information about its genetic variability, hence this insight on the genetic variability is highly needed, not only for the species conservation but for aquaculture expansion.

In this study we tested the level of Genetic diversity, population differentiation and phylogenetic relationship analysis on 35 individuals of two populations of *Heterobranchus bidorsalis* and 29 individuals of three populations of *Heterobranchus longifilis* using the mitochondrial *cytochrome c oxidase subunit I* (mtDNA *COI*) gene sequence. Nucleotide sequences of 650 bp fragment of *COI* gene of the two species were compared.

In the whole 4 and 5 haplotype were distinguished in the populations of *H. bidorsalis & H. longifilis* with accession numbers (MG334168 - MG334171 & MG334172 to MG334176) respectively. Haplotypes diversity indices revealed a range of 0.59±0.08 to 0.57±0.09 in *H. bidorsalis* and 0.000 to 0.001051± 0.000945 in *H. longifilis* population respectively. Analysis of molecular variance (AMOVA) revealed no significant variation among *H. bidorsalis* population of the Niger & Benue Rivers, detected significant genetic variation was between the Rivers of Niger, Kaduna and Benue population of *H. longifilis*. Two main clades were recovered, showing a clear separation between *H. bidorsalis* and *H. longifilis* in the phylogenetic tree.

The mtDNA *COI* genes studied revealed high gene flow between populations with no distinct genetic differentiation between the populations as measured by the *F*ST statistic. However, a proportion of population-specific haplotypes was observed in the two species studied, suggesting a substantial degree of genetic distinctiveness for each of the population investigated. These findings present the description of the species character and accessions of the fish's genetic resources, through gene sequence submitted in Genetic data base. The data will help to protect their valuable wild resource and contribute to their recovery and selective breeding in Nigeria.

AN EVALUATION OF FISH BREEDING TECHNIQUES IN AFRICAN CATFISH- *Clarias gariepinus* (Burchell, 1822)

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Several methodological concepts on fertilization procedures of eggs during induced breeding of *Clarias gariepinus* abound. This has caused some controversy among the cat fish farmers regarding the best choice of methodology to adopt for optimal hatchability during spawning. This study was conducted to evaluate the best procedure for eggs fertilization and optimum hatchability of *Clarias gariepinus* at a reduced cost and of conservation interest. Three aquaria treatment sets were established in triplicates to accommodate different fertilization procedures. The major water quality parameters that are of interest were measured using standard methods. The weights of the broodstocks were determined using digital weighing balance and female broodstock induced using synthetic hormone (Ovaprim) at 0.5ml/Kg. The male were dissected ventrally to remove the testes which were later cut open longitudinally to juice the milt. Two mililitres of the milt was measured into three petric dish, and the two of the treatment were diluted with 5ml of normal saline solution. The fish was stripped after the response time, and 4g were stripped into three different clean petric dishes for fertilization. The eggs were differently fertilized with the graded milt (milt alone, milt mixed with 5ml saline, and milt mixed with 5ml saline). Ten mililitres of clean water was later added to the treatment mixed with 5ml normal saline. The incubation time and hatching period were recorded. The hatchling, degenerated eggs, and unhatched eggs were counted and recorded after 36 hours of incubation. All the water quality parameter fell within the NESREA recommended levels except dissolved oxygen, also all the measured water quality parameters were not differed significantly in the three treatments except the water temperature that differed significantly. Likewise all the water quality parameters varied significantly in the three aquaria set-up during the incubation period. The results further revealed direct fertilization with milt to have the highest percentage hatchability and the least unhatched eggs percentage, while the treatment with mixed milt and subsequent addition of water to the fertilized eggs recorded the least hatchability and the highest percentage of unhatched eggs, thus direct shedding of milt on striped eggs should be encourage for optimal production.

EVALUATING AQUACULTURE FARMERS RESPONSES TO CLIMATE CHANGE AND SUSTAINABLE PRACTICES IN KENYA

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The growing demand for farmed fish by underdeveloped and developing countries as a means of contributing positively towards eradication of hunger, food insecurity and malnutrition for their fast growing populations has implications to the environment. Likewise, climate change possess both an immediate and future threat to local fish production with capture fisheries already experiencing a global decline. This not only raises fundamental questions concerning how aquaculture practices affect the environment, but also how ready are aquaculture farmers to adapt to climate related hazards. This paper assesses existing aquaculture practices and approaches to adapting to climate hazards in Kenya, where aquaculture has grown rapidly since the year 2009. The growth has seen rise in aquaculture set ups mainly along rivers and streams, importation of seed and feed and intensification with possible environmental implications. The aquaculture value chain in the context of climate change and their implication for practice is further investigated, and the strategies necessary for an improved implementation of resilient aquaculture system in Kenya is examined. Data for the study is collected from interviews, questionnaires, two workshops and document analysis. Despite acclaimed nutritional benefit of fish consumption in Kenya, poor management of effluents enriched with nitrogen, phosphorus, organic matter, and suspended solids has implications not just on the ecosystem, goods, and services, but is also potential source of resource-use conflicts especially in downstream communities and operators in the livestock, horticulture, and industrial sectors. The study concluded that aquaculture focuses on future orientation, climate resilient infrastructure, appropriate site selection and invest on biosafety as the key sustainable strategies against climate hazards.

SOCIO-ECONOMIC STRUCTURES OF FISH FARMERS AND GEOSPATIAL MAPPING OF SOME SELECTED FISH FARMS IN AKURE NORTH LOCAL GOVERNMENT AREA, ONDO STATE, NIGERIA

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This study focused on socio- economic structures of fish farmers and geospatial mapping of some selected fish farms in Akure North Local Government Area of Ondo State, Nigeria. Both primary and secondary data were used to repossess appropriate information on the fish farmers' status and identify the locations of selected fish farms using Geographical Information System (GIS) applications. A multistage sampling technique was used to select the fish farmers and fish farms. The Snowball sampling method was used to get the contacts and addresses of the fish farmers.

Geographical Information System (GIS) Applications on a mobile phone was used to get the Coordinates of each fish farms. Questionnaire was administered on seventeen (17) fish farmers based on the selected fish farms. The result revealed the age ranges of the fish farmers were between 26 and 69 years. The mainstream of the fish farmers was within the economically active age range of 37 and 47 years. Fish farming in Akure North Local Government was dominated by men of which 82.35% were married and educated, 2% were single and 5.8% were divorced while only 17.65% of the respondents were not educated. It was also revealed that most of the fish farmers in the LGA were into other forms of occupation; trading, cassava farming, palm oil production, consultancy and telecommunication alongside fish farming. Only a few took fish farming as the main occupation. The major problems encountered by the farmers were lack of proper fund and cost of feed 88.24% and 58.82%, respectively. The GIS result produces series of qualitative and quantitative reference maps which are very useful to provide first-hand information on the fish farms location in the study area. This study therefore recommends, that more fish farms should be established to serve the general population within the study area. Government should create enabling environment to encourage potential investors in fish farms in the study area.

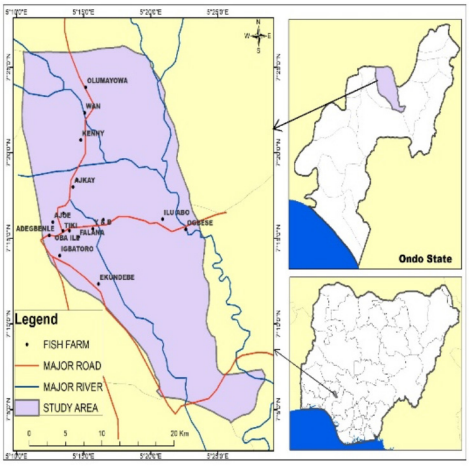

Figure 1: Maps of Nigeria, Ondo State and Akure North Local Government Source: Computed Field Survey, 2019

FEEDING HABITS AND DIGESTIVE ENZYMES IN THE GUT OF *Chrysichthysnigrodigitatus* IN OYAN DAM, ABEOKUTA, OGUN STATE, NIGERIA

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The feeding habits of 100 silver catfish, *Chrysichthysnigrodigitatus* (Lacépède, 1803) from Oyan dam were investigated. Stomach contents were identified and analyzed by occurrence methods and the prominence of Individual food items was determined by the ranking index. Only 15% of the specimens had empty stomachs while 21% had full stomach, others had stomachs in varying degrees of fullness. Sand was 11% of total volume in the stomach of *chrysichthysnigrodigitatus* species, which suggests a benthic feeding habit. The high percentage occurrence of Insects (arthropod) established *Chrysichthysnigrodigitatus* as an omnivore.

Assay was conducted to determine the distribution and specific activities of digestive enzymes in different gut regions of *chrysichthysnigridigitatus*. Amylase, lipase and protenase were present in different gut and regions at varying quantities and with specific activities. Amylase is high in the stomach, while lipase and protenase in the posterior region. There were significant differences ($P<0.05$) in specific activities of digestive enzymes. The wide distribution of enzymes in *Chrysichthysnigrodigitatus* specimen reflects its ability to digest the carbohydrate, protein and lipid portion of its food. The viscerosomatic and hepatosomatic indices were carried out for *Chrysichthysnigrodigitatus*analyzed based on the total body weight and organ weight of the fish with condition factor (K) ranging between 1.87 and 1.99 respectively. The coefficient factor of the length weight relationship, linear equation shows a correlation between weight and length, with correlation ($r=0.78$) indicating a strong association between the two variables and the regression co-efficient of determination $R^2=0.611$ indicating that 61.1% of the variations recorded in weight can be explained by length.

Table 1: Food items in the stomachs of *Chrysichthysnigrodigitatus*

Food	Frequency	% of occurrence
Detritus	14	4
Fish part	36	12
Plant	32	10
Crustacean	25	8
Insecta	42	13
Rotifera	21	7
Nematode	35	11
Arachinda	18	6
Mollusca	19	6
Scale	37	12
Sand	34	11
Total	**313**	100

PHENOTYPIC CHARACTERIZATION AND NATURAL DIET OF *Chrysichthys nigrodigitatus* IN EPE LAGOON, LAGOS STATE, SOUTHWEST, NIGERIA

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Identification of species plays a key role for the behavioural study. Different methods are used for identification but metric counts and morphometry are considered as earliest and authentic methods for the identification of species (Naymann, 1966). Meristic counts mean anything that can be counted while morphometry is the external measurement of an organism (Talwar and Jhingran, 1992). Morphological characters have been commonly used in fisheries biology to measure discreteness and relationships among various taxonomic categories.

The Phenotypic characterisation and natural diet of *Chrysichthysnigrodigitatus*in Epe lagoon were investigated between March and September 2017. The major fishing methods employed for collecting the 124 specimens were cast netting and set netting. The total lengths ranged from 15.00 to 36.3 cm (mean size 26.186 ± 0.3744 cm) while the standard lengths ranged from 10.9 to 29.4 cm (mean size 19.841 ± 0.316+1 cm).The length-weight relationship was described by the equation: Log W = a + b Log TL. The value of the coefficient of regression 'b' for this species was nearly 3 thus, indicating isometric growth. The mean condition factors ranged from 0.68 to 0.79. The food organisms consisted of phytoplankton, crustaceans, molluscs, plants materials and fish parts.

The population of males was significantly ($p < 0.05$) higher than females in the lagoon.

Length-weight relationship parameters of *Chrysichthysnigrodigitatus* from EpeLagoon, Southwest Nigeria

	n	a	b	R
Male	83	-2.32	3.14	0.95
Female	41	-1.6	2.63	0.95
Combined sexes	124	-2.09	2.98	0.95

DIETARY EFFECTS OF EXOGENOUS PHYTASE ON AFRICAN CATFISH *Clarias gariepinus* FED FISHMEAL-FREE DIET

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A study was carried out to evaluate the dietary effects of phytase on African catfish (*Clarias gariepinus*) fed fishmeal-free diet. A fishmeal-free basal diet (40 % crude protein, 6.5 % lipid) was formulated and supplemented with graded levels of phytase (0, 0.25, 0.5, 0.75 or 1 g kg $^{-1}$). The catfish (2.5 g fish^{-1} initial weight, 20 fish 30 L^{-1} stocking density) were fed either of the diets twice daily. After 8 weeks of feeding, all the catfish fed phytase (at 0.25, 0.5, 0.75 and 1 g kg $^{-1}$ levels of inclusion) supplemented diets had significantly higher final body weight (g fish^{-1}), mean weight gain (g fish^{-1}), percentage weight gain (%), specific growth rate (% day^{-1}), protein efficiency ratio and improved feed conversion ratio ($P < 0.05$). There was no significant difference observed in the condition factor, viscerosomatic index, hepatosomatic index and survival (%) of the catfish fed the test diets ($P > 0.05$). However, the whole-body composition of the catfish fed the test diets differ based on the level of phytase supplementation. The whole-body crude protein content was highest in the fish fed 0.75 g kg^{-1} phytase supplemented diet and lowest in those fed 1.00 g kg^{-1} phytase supplemented diet ($P < 0.05$). The whole-body lipid content was highest in the fish fed 1.00 g kg^{-1} phytase supplemented diet and lowest in fish fed 0.00 g kg^{-1} phytase supplemented diet ($P < 0.05$). The whole-body ash content was highest in the fish fed 0.25 and 0.50 g kg^{-1} phytase supplemented diets and lowest in those fed 0.00 g kg^{-1} phytase supplemented diet ($P < 0.05$). The histological examination of mid-intestine of the catfish fed the test diets revealed intact epithelial barriers with extensive mucosal folds into the lumen. The perimeter ratio of the catfish mid-intestine was however not significantly different after 8 weeks of feeding the test diets ($P > 0.05$). Samples are still being analysed to further established the effects of phytase supplementation on digestibility, uptake and release of nutrients (phosphorus inclusive) by the African catfish when fed phytase supplemented fishmeal-free diet. From results obtained so far, it can be concluded that African catfish (*C. gariepinus*) had improved growth performance without negative effect on somatic indices and survival when fed phytase supplemented fishmeal-free diet.

USING FUNCTIONAL FEED TO HELP OVERCOME STRESS AND PATHOGENIC BACTERIA AT THE EGYPTIAN TILAPIA *Oreochromis niloticus* FARMS

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Fish are the cornerstone of global food security and nutrition. Tilapia (*Oreochromis niloticus*) is one of the most popular fish cultured in the world based on high demand from consumers. It is also one of the most important species farmed in aquaculture as it can be grown in various agricultural systems and is omnivorous. Tilapia is particularly important in developing contexts in the world as it is inexpensive and easy for small farmers to grow for nutrition, and income. The Egyptian aquaculture sector is the largest producer of farmed fish in Africa, and tilapia is the foremost cultured species in Egypt. It accounts for approximately 67% of all cultured fish in the country.

Nowadays Egypt's tilapia farming industry faces many problems and constraints that negatively impacts progress in this area. The problems create significant decline in economic growth rates based on poor water quality and fish mortality.

Functional feeds are feeds that contain special additives to perform a special function in a specific period. The concept of functional aquafeeds represents an evolving concept in the diets of fish and crustaceans. In the design of functional feeds, a wide range of feed additives can be used to extend feed performance beyond satisfying basic nutritional requirements of the target species, to improve growth and feed utilization, but also to support the health and stress resistance of the animals.

Two types of functional feeds produced by Aller Aqua Egypt were used to counteract the suboptimal conditions of tilapia farming in Egypt. They are Aller Antistress and Support feeds, and work against temperature fluctuations and pathogens, respectively.

Research has shown that using functional feed from Aller Aqua can help prevent mortalities during summer periods, and overcome bacterial disease spread among the tilapia farms needing to improve water properties. This in turn improved the economic profitability of the farm.

ISOLATION AND IDENTIFICATION OF POTENTIAL PROBIOTICS FROM THE DIGESTIVE TRACT OF THE SHORT-SPINED SEA URCHIN (*Tripneustes gratilla*)

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The short-spined urchin, *Tripneustes gratilla* is a fast-growing, shallow water echinoid, occurring throughout the waters of the tropical Indo-Pacific. The species produces large gonads with excellent market acceptance, and is one of the most commercially important sea urchin species in countries, such as Japan. High demand has led to overfishing of natural populations prompting many countries including South Africa to explore the possibility of sea urchin aquaculture. With the increasing intensification and commercialization of aquaculture production, mass mortality during the larval stages usually associated to the presence of opportunistic pathogens is a major problem. With an increasing demand for environment-friendly aquaculture, the use of alternatives such as probiotics is now widely accepted. This study aimed to isolate and identify potential probiotics from the digestive tract of sea urchin (*Tripneustes gratilla*) to increase survival of the urchin larval phase. Nine wild-caught sea urchins were sacrificed for the isolation of potential probiotic bacteria and the digestive tract bacteria grown on selective media. A total of 250 isolates were recovered of which 27 showed antagonistic properties (zones of inhibition) against six known marine pathogens. The strains producing the top ten zones of inhibition were identified using a MALDI-TOF mass spectrometer and the Biotyper software (Bruker Daltonics MALDI-TOF biotyper RTC 3.0). Candidate probionts were capable of producing digestive enzymes (protease and amylase) with hydrolyzed skim milk and starch halos ranging from 7–28 mm. These results show that bacteria obtained from the indigenous microbiota of sea urchin could be used as probiotics in aquaculture.

Table 2: Bacterial cell concentrations based on colony-forming units (CFUs) isolated from the gut and stomach of sea urchin on various standard microbiological media.

Medium	**Stomach (CFU.mL^{-1})**	**N**	**Gut (CFU.mL^{-1})**	**N**
Marine Agar 2216e	6.35 x 10^6	21	3.46 x 10^5	14
MacConkey Agar	5.43 x 10^5	24	4.25 x 10^6	13
Mannitol Salt Agar	1 x 10^2	9	2 x 10^3	6
De Man–Rogosa–Sharpe (MRS) agar	6.04 x 10^5	17	3.46 x 10^4	11

EFFECT OF PROCESSING METHODS ON THE NUTRITIONAL COMPOSTION OF "HETEROCLARIAS" CATFISH HYBRID

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The effect of processing methods on the nutritional composition of "Heteroclarias" was analyzed. Apparently healthy samples of "Heteroclarias" with the standard mean length of 32.3±0.05cm; total length 38.7±0.56cm and weight 392.9±0.65g were obtained from a reputable farm, transported and analyzed at the laboratory of the Department of Fisheries and Aquaculture Management, Ekiti State University, Ado Ekiti. The fish were grouped and then processed (smoked, fried and oven dried). Samples of each processing method were taken for proximate and amino acids profile analysis while the organoleptic properties of the different samples were assessed within 14 days of collection. Highest crude protein content (68.38±0.27) and essential amino acids were recorded in smoked "Heteroclarias". The fish crude protein, fat and crude fiber was significantly different ($P<0.05$) in all the processing methods used. Ash content was similar in smoked and oven dried fish while moisture content was higher in oven dried fish when compared to other methods. Organoleptic analysis showed that fried fish had the best flavor. Amongst all the samples analyzed, smoked "Heteroclarias" had the best results of proximate, amino acid profile and organoleptic analysis.

Parameters	Smoked	Fried	Oven dried
Crude protein	68.38 ± 0.27^{c}	56.63 ± 0.03^{a}	65.36 ± 0.12^{b}
Fat	14.00 ± 0.00^{a}	18.98 ± 0.08^{c}	14.97 ± 0.17^{b}
Ash	13.27 ± 0.13^{a}	11.06 ± 0.04^{b}	13.57 ± 0.18^{a}
Crude fiber	2.19 ± 0.03^{c}	2.43 ± 0.07^{b}	2.91 ± 0.10^{a}
Moisture	0.43 ± 0.02^{b}	0.53 ± 0.02^{b}	0.81 ± 0.01^{a}
Nitrogen free extract	2.15 ± 0.01^{a}	10.88 ± 0.01^{a}	3.18 ± 0.01^{b}

GENDER AND CREDIT CONTROL AMONG AQUACULTURE PRODUCERS IN SOUTHWESTERN, NIGERIA

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Gender roles are significant in aquaculture production because of the benefits and limitations male and female come across in securing their livelihood for sustainable development across cultural, political, and societal settings. Studies have shown female involvement in credit use, but not on credit control among aquaculture producers in Southwest, Nigeria. Therefore, the study was aimed to determine credit use, control parameters and variables that determine credit use and control among aquaculture producers in Lagos and Oyo States, Nigeria.

Stratified sampling method was used to select cultured fish farmers in Lagos and Oyo States through the Agricultural Development Programme (ADP) zones in each state. *Clarias gariepinus* and *Oreochromis niloticus* are the major cultured fish species raised by fish farmers in both states. A total sample size of 202 respondents were proportionally selected from the membership list of the ADP zones by gender, giving male and female equal opportunities to be selected. Qualitative and quantitative data were collected through In-depth Interviews (IDIs), Focus Group Discussions (FGDs) and structured questionnaires. Data were collected on demographic characteristics of fish farmers in both states, which comprise gender, age, household size, educational level, primary occupation (PO), credit access and control by gender, as well as determinants of credit access and control between male and female fish farmers in both states. Gender Analysis Framework (Harvard Tool 2) was used to determine access and control over credit facility. Descriptive and probit regression model were used to analyse the data collected.

Majority of female fish farmers (92.3%) and male (77.9%) in Lagos State (LS), indicate fish farming (FF) business as a major source of income, but in Oyo State (OS), male (92.5% and female (69.6%) practice FF as a PO. Access to credit was reported among females (76.9%) and male (65.4%) in Lagos State (LS), with males having a higher control (34.6%) than the females (23.1%). In Oyo State (OY), although female had a higher access to credit (78.3%) and males (62.3%), males still have a higher control over credit than the females. PO (-0.294) and household size (0.169) were the significant determinants of access to and control over credit resources in both states. Significant differences exist in access and control over credit resource between Lagos and Oyo States at ($p<0.05$), and state variable was significant ($p< 0.1$), with Lagos State fish farmers having more access to and control over credit resource than Oyo State fish farmers. Gender equalities in gaining access to formal-sector credit and authority over credit resource would prevent imbalance in credit control among aquaculture producers. Therefore, the ability of male and female to have equal right over assets and privileges is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous, and sustainable world.

EFFECT OF DIETARY LYSINE DEFICIENCY ON NILE TILAPIA *Oreochromis niloticus* PRODUCTION IN FERTILIZED PONDS

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One diet containing 9.1 g lysine kg^{-1} (which is lysine-deficient) and one diet containing 13.1 g lysine kg^{-1} diet (which is lysine-sufficient) were formulated. These diets are referred to the low lysine (LowL) and balanced lysine (BalL) diet, respectively. Fish were grown in clear water aquaria or in earthen ponds. The aquaria had a water volume of 110-L and were part of a recirculation aquaculture system (RAS). In each of 4 replicate aquaria per diet, twenty 30-g (± 1.9-g SD) Nile tilapia, *Oreochromis niloticus* were stocked. The ponds had a surface area of 200 m^2, each with an independent water inlet and drain. In each of 5 replicate ponds per diet, nine hundred 17-g (± 1.6 g) Nile tilapia were stocked. The fish were fed two times daily, receiving with each feeding half of the ration of 24 g $kg^{-0.8}$ d^{-1} in RAS and 18 g $kg^{-0.8}$ d^{-1} in ponds.

In RAS, fish fed the BalL diet performed better than fish fed the LowL diet, with a higher yield (kg m^{-3}), specific growth rate (% body weight d^{-1}), nitrogen retention efficiency (%), protein efficiency ratio (g weight gain g^{-1} dietary protein), feed conversion ratio (g feed g^{-1} body weight gain), protein content and essential ammino acid content ($P < 0.05$). The percentage survival, feed intake and apparent digestibility were similar between diets ($P > 0.05$).

In ponds, the fish performed similar for both diets ($P > 0.05$) for nitrogen utilization efficiency, percentage survival, body composition and essential amino acids, and feed intake. The plankton content in the gut and plankton abundance in the water column were very similar between diets. The Pearson correlation coefficient (r) between plankton abundance and growth in fish fed the LowL diet was .76 and –.96 for phytoplankton and zooplankton, respectively, compared with .50 and .54 in fish fed the BalL diet. The contribution of natural food to nitrogen gain was 30% in fish fed the LowL diet, compared with 21% in fish fed the BalL diet ($P < .05$).

Growth performance and nutrient utilization of Nile tilapia.

	RAS				FPS			
	BalL	LowL	SEM	*p*-value	BalL	LowL	SEM	*p*-value
Survival (%)	100.0	100.0	0.00	.00	97.58	97.64	1.89	.964
Total weight at stocking (TW_0, kg m^{-3})	6.11	5.99	0.44	.723	0.08	0.08	0.01	.750
Total weight at harvest (TW_{70}, kg m^{-3})	41.98^a	31.42^b	2.46	.002	0.65	0.60	0.03	.060
Yield (kg m^{-3})	35.86^a	25.42^b	2.13	.001	0.57	0.53	0.03	.091
Initial average weight (g $fish^{-1}$)	30.57	29.98	2.17	.735	17.38	17.06	1.70	.774
Final average weight (g $fish^{-1}$)	209.90^a	157.10^b	12.32	.002	146.20	136.51	7.78	.085
AWG (g $fish^{-1}$)	179.31^a	127.11^b	10.67	.010	128.80	119.51	8.56	.125
SGR (% body weight day^{-1})	2.75^a	2.37^b	0.07	.003	3.06	2.99	0.19	.581
Feed Intake (FI, g DM $fish^{-1}$ day^{-1})	3.38^a	2.91^b	0.18	.029	1.92	1.92	0.03	.970
FCR (g dry matter g^{-1})	1.32^a	1.61^b	0.03	<.001	1.04	1.12	0.06	.089

Note: Data represented as means ± SEM ($n = 5$) corresponding means are significantly different at $p < .05$.
Abbreviations: FCR, Feed conversion ratio; SGR, Specific growth rate.

WOUND-HEALING BIOMARKER SIGNATURES IN COMMON CARP SKIN MUCUS IN RESPONSE TO *Ichthyophthirius multifiliis*

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Intensive fish farming raises the incidence of injuries and diseases. Skin mucus acts as a mechanical, physical, chemical, biological, and immunological barrier against any external stressor. Skin mucus has become a novel area of research and a true indicator of the immune status of fish. The skin mucus proteome has recently been studied in several fish species. Furthermore, the modulation of the skin mucus proteome has been investigated in response to infection, wounds, stress, or after administration of different dietary supplements. Wound healing and tissue repair are highly complex and indispensable processes to ensure the survival and health of an organism. The regenerative competence differs considerably across organs and organisms and requires the harmonized interaction of different cell types and signaling systems

Ichthyophthirius multifiliis is a ciliated protozoan parasite recognized as one of the most pathogenic diseases of wild and cultured freshwater fish. Fish skin mucus plays a significant role against invading pathogens. However, the protein-based modulation against infection with *I. multifiliis*, of host fish at this barrier is unknown. Thus, we investigated the skin mucus proteome of common carp using a shotgun proteomic approach at days 1 and 9 after *I. multifiliis* exposure.

We hypothesized that a proteomic evaluation of skin mucus from non-exposed fish against those exposed to *I. multifiliis* would facilitate the identification of specific mucus components that are involved in carp immune response to tissue damage caused by the parasite.

The aim of this study was to investigate the modulation of the skin mucus after infection with *I. multifiliis* using quantitative proteomics to provide insights into the post-transcriptional and post-translational regulation of skin mucus proteins.

We identified 25 differentially expressed proteins in infected carp skin mucus. Upregulated proteins were mainly involved in metabolism, whereas downregulated proteins were mainly structural.

This is the first proteomic analysis of infected common carp skin mucus, and it provides novel information about proteome alteration caused by *I. multifiliis*.

Furthermore, we identified novel proteins with yet unknown function in common carp following penetrating injuries such as olfactomedin 4, lumican, dermatopontin, papilin and and I cytoskeletal 18.

This analysis, therefore, represents a key for the search for potential biomarkers, which can help in a better understanding and monitoring of interactions between carp and *I. multifiliis*.

This proteomic study not only provides information on the protein-level pathways involved in fish-ciliate interactions but also could represent a complementary system for studying tissue repair.

LAND BASED AQUACULTURE PRACTICES IN AQABA; A VISION FOR PROGRESS IN JORDANIAN IMPLEMENTATION

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One of the areas of great interest to all countries in the Middle East and the Red Sea region is the development of additional food resources and the enforcement of food security. These goals can be partly attained by improving intensive farming technology, such as intensive aquaculture. Almost by definition, agriculture in this arid region has to be based on the use of as little freshwater as possible due to the limited rainfall at these latitudes. Marine aquaculture farming, or mariculture, offers an excellent solution as it is based exclusively on the use of seawater. All countries in the northern Red Sea area suffer from a deficit of seafood production and face poor fishing conditions. Jordan for example has been importing almost all of its seafood consumption (about 97%). Lately, concern has been raised regarding the effect of the fish cages on the Gulf of Aqaba fragile ecosystem. This results in an urgent need for development of alternative solutions. Land-based mariculture has the potential to provide an economic efficient and environmentally friendly food resource for all countries around the Red Sea using the technology of recirculating aquaculture systems (RAS). Such technology is advantageous in terms of its low environmental impact as up to 95% of the water is recycled. This enables lower water consumption and a more effective effluent treatment for reducing the nutrient load on the receiving water body. In environmentally sensitive areas such the Red Sea and more specifically in Jordan known for its extremely low nutrient concentrations supporting flourish coral reefs. We endeavor developing aquaculture that is consistent with the recent national regulations of which the removal of aquaculture wastes is a prerequisite to all future land aquaculture activities and development. Therefore, any water treatment solution will have to include a component addressing nitrogen as well as phosphate removal. Our primary goal toward enhancing the knowledge of environmentally friendly and economic-efficient intensive land-based marine aquaculture in Jordan was by the development of efficient and cost-effective treatment sequence for complete removal of soluble ammonia and nitrate from the effluents of intensive RAS. In addition, reduce seawater consumption in makeup water flow rate which might affect both cultured species (i.e. fish, shellfish) quality and growth parameters. Hence, the effects of operational parameters makeup water flow rates and recycling strategies was explored on cultured species growth as well as quality at low rearing water exchange rates. Using RAS in Jordan's aquaculture practices is specifically calibrated for endemic cultured fish species. This technology actually paved the road for the use of RAS in supporting sustainable marine aquaculture in Jordan's Red Sea. At the same time, avoiding direct exploitation of the limited coast and expanding in intensive land based rearing systems.

ROLES OF FACULTY OF VETERINARY MEDICINE IN AQUATIC MEDICAL TRAINING AND RESEARCH IN NIGERIA: A CASE STUDY OF UNIVERSITY OF IBADAN

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Aquaculture production is experiencing geometric growth with attendant effects, therefore, fish health training and research, with a keen interest in the concepts of diseases occurrence (an external agent, a susceptible host, and an environment) becoming important. The Faculty of Veterinary Medicine, University of Ibadan is one of the oldest in the Country and by extension, in Africa. Training of undergraduate Veterinary students started in the 1970s which is visibly reflected in the Faculty of Veterinary Medicine's prospectus of 1976-1977. The Department of Veterinary Public Health and Preventive Medicine (established in 1975) has since then taken up the training of students (Doctor of Veterinary Medicine and Postgraduates) in Fish health management.

The introduction of training on fish health was championed by Prof. Samuel Adewumi Agbede (now retired) who received his Master's degree in Aquatic Veterinary Studies from the University of Stirling in 1981. Presently, the Fish and Wildlife Unit of the Department of Veterinary Public Health and Preventive Medicine has two (2) Professors, one Lecturer Grade I and two (2) Lecturer Grade II involved in the continuous training of students and conduct of research in several areas, including Fish disease Epidemiology food safety, toxicology and indeed one health since the unit is also charged with in training of students and research into epidemiology of wildlife disease, as well. In 2014, the Department organised a Fish Health Management Workshop for all stakeholders in the Aquaculture Sector in Nigeria.

To date, over two thousand (2,000) undergraduates and three hundred (300) Postgraduate Students have passed through fish health management training and are already involved in the aquaculture sector. Some of them are into research and training, Aquatic Veterinarians (involved in the diagnosis and treatment of fish diseases), fish production, Regulatory agencies like (National Agency for Food and Drug Administration and Control (NAFDAC), Standard Organisation of Nigeria (SON), National Agricultural Quarantine Services (NAQS), among others), and entrepreneurs within Nigeria's fish food chain.

The Fish and Wildlife Unit has also attracted grants from various Funders to execute researches in the area of Evaluation for Sustainability of Aquaculture Development in Nigeria, Climate and Global Change-related Impacts, Adaptations, and Vulnerability Assessments in selected aquatic ecosystems in Africa, Investigation into residues in feral and cultured fish and their products in Nigeria,, Antimicrobial Resistance, etc. Currently, there are two grant-based researches domiciled at the Fish and Wildlife Unit of the Department of Veterinary Public Health and Preventive Medicine. These are "*Improving Biosecurity: A Science-based Approach to Manage Fish Disease Risks and Increase the Socio-economic Contribution of the Nigerian Catfish and Tilapia Industries*" , a $625,045.00 USAID grant being executed in partnership with WorldFish, Malaysia and Mississippi State University, Mississippi, USA) and "*No longer bugged by feed costs: Farming insects as sustainable and scalable Aquaculture feedstock to improve catfish (Clariidae) producers and consumers livelihoods food security in Nigeria*" a $400,000 USAID funded project being executed in partnership with Michigan State University and Departments of fisheries and Agriculture Economies.

Aquatic and Wildlife medical training and research is evolving in the University of Ibadan as the Fish and Wildlife Unit of the Department of Veterinary Public Health and Preventive Medicine is championing the creation of a full-fledged department of Aquatic and Wildlife Medicine to fully integrate all the necessary units within the Faculty of Veterinary Medicine into an holistic and comprehensive training curricula for the teaching of Aquatic and Wildlife Medicine to better prepare future Veterinarians for this rapidly evolving field. This discipline is also vital for the "One Health" research agenda, since 75% of zoonotic disease have been linked to wildlife, including fish. Additionally in a bid to cohesively propagate this field, the Faculty of Veterinary Medicine through the Aquatic Veterinarians working in the Department registered a professional association (Association of Aquatic Veterinarians of Nigeria) in 2013. The association is affiliated to the Nigerian Veterinary Medical Association (NVMA), the umbrella body of registered Veterinary Surgeons in the Country.

TEMPERATURE EFFECTS ON GROWTH, METABOLISM AND PHYSIOLOGICAL PERFORMANCE OF CULTURED CATFISH

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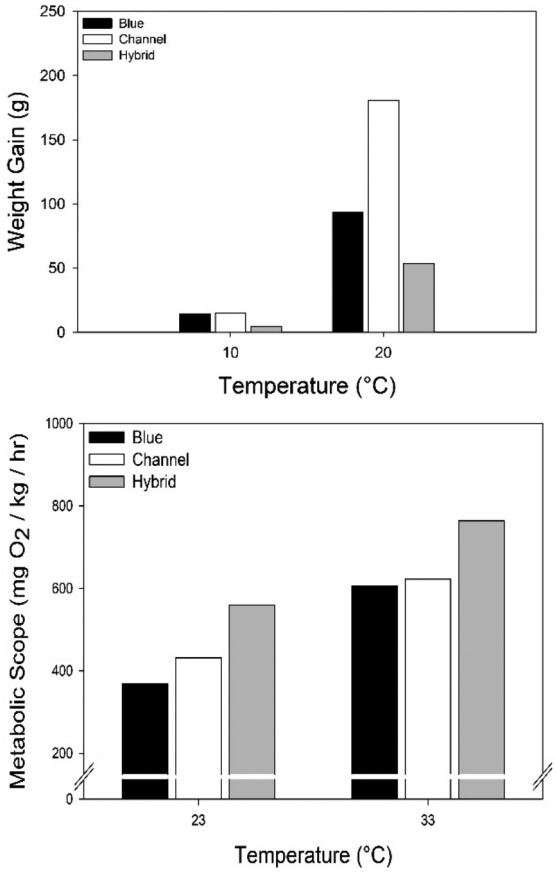
Catfish species are cultured around the world due to their high-quality muscle tissue, rapid growth and tolerance of a wide variety of environmental conditions. Catfishes are primarily distributed in warm-water regions, although they also occur in temperate ecosystems where temperatures seasonally change from cool-warm conditions. In North America, channel catfish (*Ictalurus punctatus*) and their hybrid with blue catfish (*I. punctatus* x *I. furcatus*) are commonly cultured. In earthen pond culture systems, catfish experience a wide seasonal temperature range, although a comparison among these catfish types as to optimal adaption for different temperatures has not been conducted. Therefore, juvenile channel, blue and hybrid catfish were compared for growth, metabolic rate and physiological performance in terms of swimming capacity at cool-temperatures (10 and 20°C) and at warm temperatures (23 and 33°C).

At the coolest temperature (10°C) weight gain was very limited in all catfish types, and fish had little energy evidenced by low swimming capacity. At 20°C, channel catfish had greater weight gain than blue or hybrid catfish. At 10-33°C hybrid catfish had higher standard metabolic rates and at 23 and 33°C hybrid catfish had greater metabolic scope for activity than blue or hybrid catfish. These results indicate hybrid catfish have greater metabolic capacity at warmer temperatures relating to their fast growth rates in culture ponds. At cool temperatures, all catfish types had low weight gain and little energy for additional physiological needs, although channel catfish performed better at cool (20°C) temperatures. Therefore, choice of catfish type should be taken into account depending on the temperature range of the culture region.



ASSESSMENT OF UTILIZING AROMATIC PLANTS IN NILE TILAPIA *Oreochromis niloticus* FINGERLINGS PRODUCTION AND WATER QUALITY ENRICHMENT

Basem S. Abdelaty, Hadir A. Aly*, Mohamed M. Abdel-Rahim, Ghada R. Sallam, Mohamed A. Elokaby, Mohamed El-Hamamy and Amr Monir Helal

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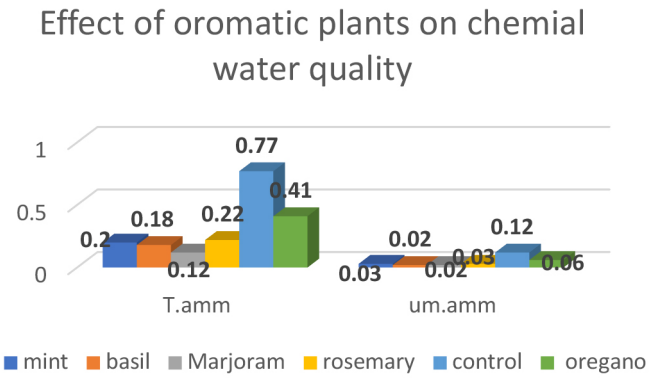
Aquaculture has becoming one of the fastest industries in the world as it provides high quality animal protein food. To cope the increasing of the progressive demand of all aquaculture products, aquacultural academics and experts must develop new schemes with low environmental impact. Moreover, the scarcity of good quality water and the land, represent a complicated challenges for improving this industry. Consequently, a symbiotic experiment between fish and plants was conducted, in a private fish hatchery in Kafr ElSheikh, to investigate the effect of both organisms on each other. The aim of this work is to achieve dual use of the water and remediate the environment in fishpond during 72 days of fish nursing.The hydroponic system was designed as Deep Flow Technique (DFT) in its simplest type. Foam panels are used to fix the plants on water pond surface. Four panels were supplied to each pond (3*8*0.8). each panel contained 10 plants (fig.1) covering about (%) of water pond surface area. The plants used in this experiment were *Mentha spicata* L. (mint) 46cm TL, *Ocimum basilicum* L. (basil) 43.5cm TL, *Origanum majorana* (Marjoram) 37cm TL, *Salvia Rosmarinus* (rosemary) TL 33cm and *Origanum syriacum* (thyme) 34.7 cm TL, obtained from a commercial plantation for 60 days. 4800 tilapia fingerlings (*Oreochromis niloticus* L.) were stocked at density of 400 fish/ pond (1.3 g wet weight). Diet used in this experiment was a commercial feed for specific species (crude protein 32) which was supplied at satiation and divided in two doses during the day (9:00 h and 14:00 h). Five treatments were conducted (4 plants and control treatment) with three replicates each. The results indicated that aromatic plants use led to water quality enhancement specially in un-ionized ammonia values. When the NH3 in control ponds was 0.12 mg/l, this value decreased to 0.02 mg/l in Basil and Marjoram with highly significant differences. In the same context, the physical parameters of water; pH, temperature, dissolved oxygen, were enhanced in all symbiotic ponds. Fish performance showed best values in case of basil followed by mint ponds, while survival rate was the best in rosemary ponds, 96.25%, without any significant differences. Significancy absence maybe due to the culture system which is extensive in this case. The best performance was achieved by mint as it grows about 200% in length. Possibly it is due to that some aromatic plants needs additional fertilizer together with ammonia. moreover, it is noteworthy that the roots of Marjoram attain noticeable growth in length which indicating that the plant produce new roots. This observation explains the remarkably low NH3 in Marjoram ponds.

Symbiotic relationship with both fish and plants has a positive influence on water quality and some aromatic plants performance. Furthermore, additional research must be taken place to evaluate the effect intensive culture on the performance of this scheme.



PASSIVE CAPTURE OF THE SILVER CATFISH *Chrysichthys nigrodigitatus* FOR DOMESTICATION, PROPAGATION AND CULTURE

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Diversification of aquaculture species for Nigeria requires the domestication of more culturable fish species. Globally, more than 500 species are farmed, including finfishes, molluscs, crustaceans and other aquatic organisms. Among the indigenous catfishes available, Nigeria is recognized for the production of the clariids. The claroteid, *Chrysichthys nigrodigitatus*, is to develop a new status from being described as a culturable species to a culture species for Nigeria. This project seeked to provide a broodstock bank of *C. nigrodigitatus* obtained from the wild and numbering >100 wild inputs domiciled at NIOMR for the purpose of producing captive bred silver catfish hatchlings for research into their growth rates in different culture environments, survival percentages and feed conversion. The whole chain of events beginning with the collection of sexually mature and ready-to-spawn pairs of the silver catfish using passive gear to grow-out rearing systems adoptable in Nigeria has been harnessed. The protocol thus described may serve as a model ready for replication and development of fresh and brackish water aquaculture.

TESTING A NEW FORMULATED FEED FOR PURPLE SEA URCHINS (*Paracentrotus lividus)* ONGROWING CULTURE

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Introduction

Purple sea-urchin aquaculture has been increasing in the last two decades but is a still challenge mainly due to the existence of different stages throughout their life cycle. Nutrition is a crucial issue for its production. The main objective of this work was to compare the performance of both artificial and control diets (macroalgae) on body growth and gonad development.

Materials and methods

Three groups of sea urchins (3.73 ± 0.39 cm test-diameter) produced at EPPO-IPMA were fed with two formulated diets and a natural diet (*Ulva sp*.) each group, for 183 days. For each treatment, three replicates of 50 individuals were constituted and kept in Hexcyl ® baskets suspended inside fiberglass tanks. The resulting growth parameters, gonadosomatic index and fatty acid profile of gonads were analyzed to evaluate to evaluate and compare the three diets.

Results and discussion

It was found that the sea urchins fed with both diets showed a higher growth compared to the control (*Ulva sp*.). Growth rates were 0.76, 0.82 and 0.39 mm/month for sea urchins fed D1, D2 and control diets, respectively. Specific growth rate (weight increase index) calculated for sea urchins fed with D2 was 0.31%, higher than D1 (0.25%) and control (0.15%). During the. No mortality was found during the experiment. At the end of the experiment, the sea urchins' gonads fed with natural food (control) had a total amount of fatty acids (absolute value of 130.9 ± 56,6 mg/g) slightly higher than those fed with formulated food, especially because of the higher content of monounsaturated fatty acids. It was found a high value of DHA observed in animals fed with ration, compared to the control. There was also a significant content of some non-existent or trace fatty acids in the diets used in the gonads, suggesting a biosynthetic activity by sea urchins (20:4 ω6, 16:4 ω3 and 20:3 ω3)

Food quality is undoubtedly an important factor for each stage of sea urchin cultivation. In this work it was found that animals fed with formulated food present a body growth significantly higher than those fed with natural food (*Ulva sp*.). The development of the gonads was greater in the ones fed with artificial feed. However, the analysis of the fatty acid profile reveals little difference in the composition of the gonads of the three treatments. This low relation suggests a greater importance of protein and glycogen in gonad development. In conclusion, the formulated diet showed great potential both in the growth and development phases of the gonads, without altering the lipid composition of the edible part.

This work has been financed through the OURIÇAQUA (Fundo Azul) project.

A GIS-BASED APPROACH TO DELINEATING THE AREAS OF A LAKE THAT ARE SUITABLE FOR CAGE FISH CULTURE

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We present a GIS-based approach to the delineation of areas that have different levels of suitability for use as tilapia cage culture sites the Kenyan part of Lake Victoria, Africa. The study area was 4,100 km^2. The method uses high-resolution bathymetric data, newly collected water quality data from all major fishing grounds and cage culture sites, and existing spatial information from previous studies. The spatio-temporal (space and season) parameters considered are water depth, water temperature, levels of dissolved oxygen, chlorophyll-*a* concentrations, distances to the lake shoreline and proximity to other constraints on cage culture development. The results indicated that the area most suitable for fish cages comprised about 362 km^2, or approximately 9% of the total area; the remaining 91% (i.e. 3,737 km^2) was found to be unsuitable for tilapia cage culture (Figure 1). We conclude that the successful implementation of this approach would need stakeholder involvement in the validation and approval of potential sites, and in the incorporation of lake zoning into spatial planning policy and the regulations that support sustainable use while minimising resource use conflicts. The results of this study have broader applicability to the whole of Lake Victoria, and other Great Lakes in the world for tilapia cage cultur.

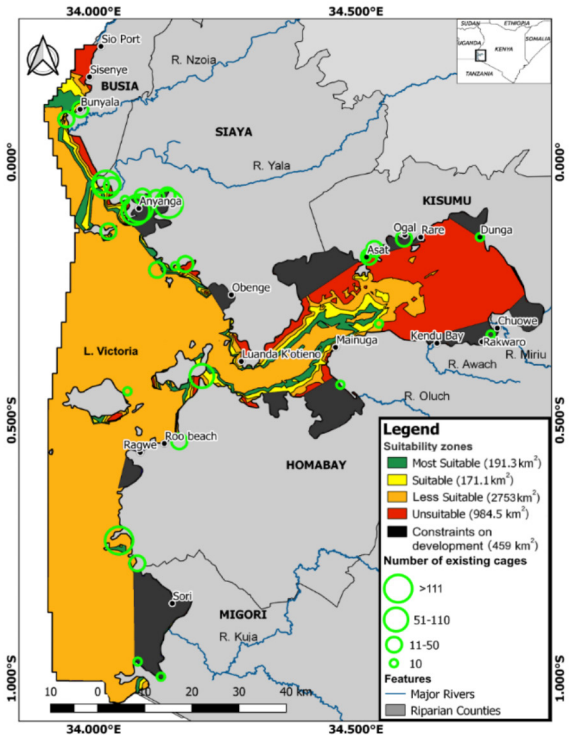

FIGURE 1 Map of Lake Victoria, Kenya, showing potential suitability for cage fish culture.

EFFECT OF FERMENTED FEED ON THE GROWTH PERFORMANCE, HEALTH CONDITION AND IMMUNE RESPONSE OF WHITELEG SHRIMP (*L. vannamei*)

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This study was aimed to evaluate the effect of fermented feed on the growth performance, health condition and immune response of whiteleg shrimp (*L. vannamei*). Whiteleg shrimp with mean initial weight 0.25 g was obtained from a shrimp hatchery in Ghallioun project, Egypt. Shrimps were fed the experimental diets up to apparent satiety at 8:00, 10:00, 12:00, 14:00, 16:00, 20:00 and 22:00 h for three weeks. The animals (150/m^3) were divided in triplicates into two groups; the groups feed on the control diets (40 % CP) and the anther group was feed on 50% of control diets in addition to fermented feed [One tonne water, 20 Kilograms of rice bran, 100 Kilograms of Molasses, 100 grams of probiotics (Sanolife PRO-W ® contain *Bacillus subtilis* was commercially purchased from INVE Company Belgium which contains 10^{11} CFU/gram used by 80 gm /Hectare in fish culture)].

The results revealed that, there were no significant differences in the water quality parameter between the control and fermented feed shrimp with higher dissolved oxygen and lower total ammonia nitrogen in shrimp that received fermented feed. A higher significant difference was reported in Copepods and Phytoplankton in shrimp that received fermented feed ($P<0.05$) and lower Total Bacterial Count (cfu/ml) and total *Vibrio* spp. (cfu/ml) in rearing water. The growth performance (Final weight, weight gain, specific growth rate and feed conversion ratio) and survival rate of shrimp received fermented feed was significantly higher than the control group ($P<0.05$). The control group showed lower lysozyme activity and phenoloxidase compared to shrimp received fermented feed.

In conclusion, using of fermented feed improves water quality, growth performance, health condition and immune response of whiteleg shrimp (*L. vannamei*).

EFFECTS OF *Eucalyptus globulus* LEAF EXTRACT ON GROWTH PERFORMANCE, FEED UTILIZATION AND BLOOD BIOCHEMISTRY OF NILE TILAPIA, *Oreochromis niloticus*

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The effects of *Eucalyptus globulus* extract in diets of Nile tilapia (*Oreochromis niloticus*) were studied. The fishes were divided into 5 groups before being fed diets supplemented with 0 percent (T 0), 5 percent (T 5), 10 percent (T 10), 15 percent (T 15) and 20 percent (T 20) of *E. globulus* extract for 12 weeks. All the groups fed *E. globulus extract* recorded significantly higher levels of protein content in the whole body. Lipid content was significantly influenced by *E. globulus* extract levels. The highest lipid content was recorded in group fed diet T 10 and was significantly higher than all other groups ($p<0.05$). The best protein efficiency ratio and feed conversion ratio were observed in groups fed diets supplemented with *E. globulus* at 5 percent and 10 percent. Hemoglobin concentration increased with increasing levels of *E. globulus extract* up to T 10. Increasing *E. globulus* extract in diets of *O. niloticus* resulted in increasing levels of Alanine aminotransferase and aspartate aminotransferase. Also, the study showed both an increase in total protein and albumin concentration as *E. globulus* extract increased in diets. There was however a significant decline in globulin content when *E. globulus* extract was increased from T 5 to T 20. The total protein serum was significantly higher in fish fed on diet containing *E. globulus* extracts when compared to basal diet. Therefore, dietary administration of *E. globulus* can promotes growth performance and increases the main hematological and biochemical parameters of Nile tilapia (*O. niloticus*) fish. This study provides new applications of eucalyptus and at the same time, promotes rational development and utilization of eucalyptus resources.

EFFECTS OF PROBIOTICS, *Bacillus Subtilis* 200 ON GROWTH, FEED UTILIZATION AND PROXIMATE COMPOSITION OF AFRICAN CATFISH, *Clarias gariepinus*

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This study was conducted to evaluate the effect of probiotics, *Bacillus Subtilis* 200 on growth, feed utilization and proximate composition of African catfish (*Clarias gariepinus*) over an 8-week period. Four experimental diets with supplemented *B. Subtilis* 200 at 0g/kg (A), 1g/kg (B), 2g/kg (C) and 3g/kg (D) were fed to *C. gariepinus* fingerlings with average initial weight of 3.47±0.95 g to apparent satiation three daily. The results showed significant difference amongst treatments with respect to final weight (FW) and weight gain (WG) ($P<0.05$). There was an increase in FW and WG as probiotic levels increased in experimental diets. Group fed diet A recorded FW and WG of 72.3±2.41 g and 68.95±3.25 g respectively, whilst group fed diet B recorded FW and WG of 77.48±2.17 g and 73.70±4.15 g respectively. Group fed diet C recorded FW and WG of 83.17±3.07 g and 79.86±2.78 g respectively whilst group D recorded FW and WG of 84.73±3.19 g and 81.27±3.05 g respectively. Feed intake ranged between 69.23±0.21 g and 77.21±0.84 g and was significantly different amongst groups ($P<0.05$). There was no significant difference in feed conversion ratio, protein efficiency ratio and condition factor ($P>0.05$). Similarly, proximate composition (ash, moisture, lipid and protein) was indifferent, irrespective of experimental diet ($P>0.05$). The result of the present study suggests that diets of *C. gariepinus* can be supplemented with *B. subtilis* 200 up to 3g/kg without compromising growth feed utilization and body composition.

GROWTH OF NILE TILAPIA *Oreochromis niloticus* ABBASSA STRAIN FED ON INSECT MEAL, FISH MEAL OR PLANT BASED DIETS IN EGYPT

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Identifying safe, sustainable and affordable fish feed stuffs is a priority within aquaculture. Insect meal has been presented as a suitable alternative to fish meal and other protein sources for omnivorous fish. However, only few trials have examined the use of insect meal within fish diets and always within the context of partial substitution of the fish meal component of the diet.

As such a preliminary study was conducted to evaluate the impact of complete replacement of fish meal with insect meal in tilapia diets. Juvenile Egyptian Nile Tilapia (Oreochromis niloticus) of the Abbassa strain were feed one of four diets and monitored over 12 weeks. One diet was a control diet utilizing Fish Meal (FM) while the other three utilized either Vegetal protein (VEG) sources only, Black Soldier Fly (*Hermetia illucens*) larvae meal (BSF), or Black Cricket (*Gryllus bimaculatus*) meal (GB). All diets were formulated to be nutritionally balanced. Overall, there was no significant effect of using insect meal within tilapia diets on feed consumption and conversion efficiency, fish survival, general health or growth. The results from this trial demonstrate that fish meal can successfully be replaced by insect meal in tilapia diets, and that growth rates and FCRs will be preserved and will be comparable to the already developed vegetable-based diets. This is an encouraging result for the development of insect-based locally sourced diets for fish rearing. The more feed ingredients can be produced or sourced locally, the greater the positive impact on the aquaculture industry and socio-economic status of farmers.

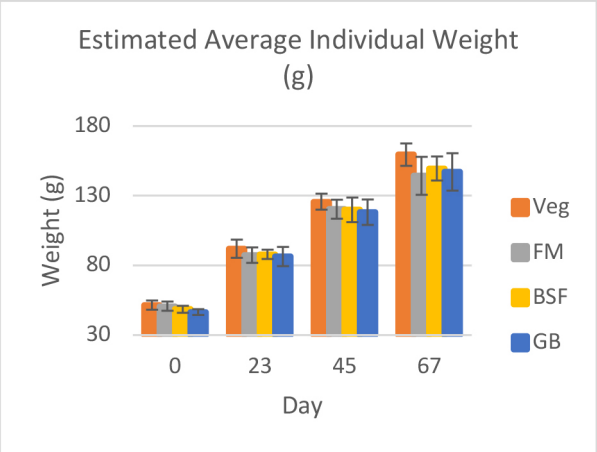
However, future trials should focus on seeing if diets can be improved by optimising inclusion rates of insects in feed formulations, it is possible that a higher rate or combination of multiple insect species might create more successful and sustainable formulations.

Table: Total survival rate, estimated average daily weight gain and feed conversion ratio of tilapia over the entire trial (standard deviation)

Diet	Survival %	average daily gain (g)	Feed conversion rate
VEG*	90.7 (4.2)	1.6 (0.1)	1.9 (0.2)
FM	91 (3.5)	1.4 (0.2)	2.2 (0.3)
BSF	86 (13.5)	1.5 (0.1)	2.3 (0.5)
GB	78 (22.3)	1.5 (0.2)	3.5 (2.7)

*N = 3, one replicate was lost due to cage failure resulting in fish escaping

Figure: show Calculated average individual weight of fish over trial period by diet with standard deviation



EFFECT OF DIFFERENT LEVELS OF CORN DRIED DISTILLER'S GRAINS WITH SOLUBLES (DDGS) AND SUNFLOWER MEAL ON THE GROWTH PERFORMANCE AND BODY COMPOSITION OF NILE TILAPIA *Oreochromis niloticus*

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The effect of different levels of DDGS and Sunflower meal were tested on the growth performance and body composition of Nile tilapia (*Oreochromis niloticus*) Abbassa strain through two experiments.

Experiment 1 evaluated the effect of three diets containing levels of DDGS (0%, 15%, and 30%) as a protein source. Triplicates of fifteen Nile tilapia fingerlings (48.8±3.67 initial body weight) were fed diets twice daily to the apparent satiation for 8 weeks in fiberglass tanks. The results showed that the tested inclusion rates of DDGS up to 30% on fish survival, fish body composition, final body weight, SGR, weight gain, feed intake, FCR, and protein efficiency were similar between all the tested diets.

In experiment 2, Nile tilapia fingerlings (49.76±1.87 initial body weight) of Abbassa strain were fed two experimental diets, control diet and 10% sunflower meal (diet 1) for 10 weeks. Each diet was fed to 4 replicate tanks. The results showed that average final weight, SGR, and FCR were similar among the treatments. Therefore, using 10% sunflower meal did not cause any adverse effect on fish growth, survival, and FCR.

Overall, these experiments confirm that in situations where soybean meal is not readily available, other protein sources such as the DDGS and sunflower meals, if available, could be used in fishmeal-free diets for tilapia. The tested diets did not affect the body composition of fish (fat, ash, moisture and protein).

Conclusion: The results showed that up to 34% of soybean meal and 80% of rice bran can be replaced by DDGS (30% in the diet) without any negative effects on the fish survival, growth and feed utilization parameters. In addition, replacing 17% of soybean meal with sunflower meal did not cause any adverse effect on fish growth, survival and FCR.

Effect of dietary DDGS and sunflower inclusion on Nile tilapia fed the experimental diets for 8 weeks.

	DDGS				Sunflower		
Parameters	0%	15%	30%	P-value	control	diet1	P-value
Survival (%)	95.6	93.3	91.1	0.898	100%	98.33%	0.355
Initial body weight (g)	47.4	47.8	51.1	0.4739	50.58	48.76	0.221
Final body weight (g)	148.2	139.1	158.6	0.3814	264.1	268.6	0.243
SGR (%/d)	1.89	1.78	1.89	0.814	2.295	2.394	0.076
Weight gain (g/fish)	100.8	91.3	107.5	0.6589	213.5	219.89	0.419
Feed intake g/fish	153.0	154.1	173.0	0.154	294.4	301.19	0.251
FCR	1.52	1.69	1.61	0.9604	1.38	1.376	0.888
PER (%)	2.2	1.9	2.0	0.6659	2.259	2.196	0.187

EFFECT OF POND MODIFICATION ON GROWTH PERFORMANCE, WATER QUALITY, HEMATO-BIOCHEMICAL PROFILE, IMMUNE-OXIDATIVE STATUS OF NILE TILAPIA

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Unlike endotherms, ectothermic species do not have the primary responses to infection which is a rapid increase in body temperature known as fever. Aquatic ectotherms modify body temperature by moving to warmer waters, this is a phenomenon known as 'behavioural fever'. Behavioural fever is defined as an acute change in an organism's thermal preference driven by pathogen recognition.

This study aimed to evaluate the effects of pond modification on water quality, growth performance, and hemato-biochemical profile, immune-oxidative status of *Oreochromis niloticus* fingerlings. Fish (0.5±0.189 g, 15000 fry/ fadan) were randomly distributed in duplicates into two experimental groups. The control group (CG), fish were reared in an earthen ponds without any modifications. The experimental group (GH), fish were reared in an earthen ponds with greenhouse (3 % of pond area) as a modifications. Greenhouse area represents 3% of the pond area; it consists of metal frame fastened at an edge of the pond by pillars and sealed with transparent UV stabilized low density polyethylene film (LDPE) of 250μm thickness.

The results revealed that fish reared in ponds modified with greenhouse effect showed an improvement in the growth performance, survival and feed utilisation efficiency ($P<0.05$). However, there was no significant effect of pond modification on water quality parameters. Hemato-biochemical parameters were improved in GH group specially RBCs, WBCs, total protein and globulin. In the same context, the fish reared under greenhouse modification showed an improvement in antioxidant parameters (SOD and CAT) and immune response (phagocytic activity, phagocytic index and lysozyme activity) compared to CG ($P<0.05$).

In conclusion, pond modification improved growth performance, water quality, hemato-biochemical profile, immune-oxidative status of Nile tilapia.

IMPACT OF COVID-19 ON FISHERIES AND AQUACULTURE IN SOUTH SUDAN

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The COVID-19 pandemic- resulted in an unsustainable fish value chain, exposing weaknesses in food production and changes in economies around the world. The effectsof climate change Fisheries and aquaculture are multiple and vary from location to location. Fisheries and aquaculture provide nutritious food for millions of people in South Sudan. all aspects of the fish supply chain are strongly affected by COVID-19 pandemic, with jobs and incomes and food security at risk. Although Covid-19 does not infect the aquatic species (Bondad-Reantaso et al., 2020) the small-scale fisheries are most affected by closed markets, no transport to markets, and therefore, fisheries cannot sell their product well; it affects the livelihood of all. Of course this also applies to aquaculture; if the market is limited, people cannot sell their harvest; also because of possible restrictions on traffic and transport. Further, some factories may keep working but generally the supply of all sort of inputs from materials to feeds are very limited and hampers the growth of fish culture if we look into transport of fingerlings from nurseries to fattening farms. Aquaculture enterprises will develop with benefit from secured input supply chain. The supply of fish on the market for poor people may benefit from an increased focus on fisheries. , COVID-19 has affected employment in fishery trade where business men and women decreased due COVID-19. In addtion COVID-19 has affected the socio- economic situation and its contribution to livelihoods in South Sudan and thus also has affected the income of fishermen. The production of captured fishery increased after/at COVID-19 while in aquaculture production in ponds decreased with lockdown effect, this could be due to closure of borders and supply of inputs like feeds, fuel, and transport. There is a great change in supply and price from fish compared to before COVID-19 while the demand for fish decreased as the price increased. Men were not affected since there is increased number of men in fish trade, while women were greatly affected as number of women traders during COVID-19 sales dropped sharply.and sales from the fisheries dropped with 60% compared to pre-COVID-19 times .and study of impact of COVID-19 on Fisheries and aquaculture,we conducted a survey among many fisheries and famers,Transparency of policy response will help build trust in future of fish value chains and Markets and development of fisheries and aquaculture in South Sudan

GENETIC DIVERSITY OF TWO SOUTHERN AFRICAN CICHLIDS *Oreochromis andersonii* and *O. macrochir* IN THE ZAMBEZI AND CONGO RIVER BASINS

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Oreochromis andersonii and *O. macrochir* are two important cichlid species native to Southern Africa. We describe their genetic population structure in the Upper Zambezi River, Kafue River, and Lake Bangweulu representing part of the Congo and Zambezi River Basins. Microsatellite genetic markers were employed to analyse the genetic population structure of the two species using 177 tissue samples.

The average allele richness of *O. andersonii* was higher in the Zambezi River (10.500) than in the Kafue River (9.583) though not statistically different. For *O. macrochir,* it was highest in the Zambezi River (11.170) followed by the Kafue River (9.781) and least in Lake Bangweulu (7.067) and their differences were significant. The gene diversity indices; gene diversity (*h*s), observed heterozygosity (*H*O), expected heterozygosity (*H*E) were high and similar in *O. andersonii* populations. However, in *O. macrochir H*E was significantly lower in Lake Bangweulu (0.678) compared to the Kafue River (0.799) and Zambezi River (0.802) populations. Population differentiation estimated by *R*ST and *D*EST revealed high differentiation in both species (*R*ST = 0.598, *D*EST = 0.777 for *O. andersonii*; *R*ST = 0.379, *D*EST = 0.710 for *O. macrochir*). The highest source of variation was among populations (84.71%) for *O. andersonii* and within populations (67.09%) for *O. macrochir*. Comparisons of population pairs revealed a close genetic similarity between the Zambezi River and Lake Bangweulu populations of *O. macrochir*. Bottlenecks were observed in both species using the Two-Phase Model (T.P.M.) indicative of a recent genetic loss or reduction in effective population size.

Though our results indicate that the populations of both species still maintain sufficiently high levels of genetic diversity in the sampled areas, the bottlenecks observed are a source of concern. We recommend a more robust study of genetic diversity of these species in all sections of these river systems and that some key conservation sites should be identified to protect the gene pool of these native species.

Table 1 Genetic differentiation estimated by four statistical properties and genetic structure (AMOVA) of *O. andersonii* and *O. macrochir*.

	Variable/ Species	*O. andersonii*	*O. macrochir*
Genetic differentiation	F_{ST}	0.076	0.135
	G_{ST}	0.076	0.125
	R_{ST}	0.598	0.379
	D_{EST}	0.777	0.710
Genetic structure	Among populations	84.71	32.53
	Among individuals within populations	4.29	0.38
	Within populations	11.00	67.09

ECOLOGYASPECTS OF WEST AFRICAN FRESHWATER CRAB *S. Africanus* IN THREE SELECTED FRESHWATERS IN AKURE METROPOLIS (NIGERIA)

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Ecological studies of freshwater crabs are crucial for the conservation of the species and habitat protection. The West African freshwater crabs, *Sudanonautes africanus,* other species contain a significant amount of nutrient. Crabs are exploited by man and other animals for food. It contains chromium which acts with insulin in the metabolism of sugar helping the body to maintain normal blood glucose level. The West African freshwater species are going into extinction, with habitat destruction due to industrialization together with the low abundance of wild population.

The ecological factors of *S. africanus* including the Length Weight Relationship (LWR) and Condition Factor (CF) collected from three different selected water habitats Rivers Ala, Elegbin, and Futa wetland areas within Akure metropolitan area was carried out from November 2020 to June 2021 were studied. Total of two hundred and seventy-five (275) crabs were collected and examined, sex ratio (male: female) was 184:91; an indication that there were more males than females in this project sites.

The bacterial isolated from *S.africanus* were scanty *klebsiella spp* while *Escherichia coli* was found prevalence at the studied sites.

A positive isometric growth form was seen at Elegbim River for the month of April (104.95), while other months shows a negative allometry growth form. The LWR (**W = aLb)** studied also indicated that freshwater crabs (*S. africanus*) under a conducive and nutrient rich environment of the project sites reach 75mm, 76mm, and 98mm (River Ala, FUTA wetlands and Elegbin respectively) in carapace length (CL).

The result gotten from this study indicates that freshwater crabs *S. africanus* available in River Ala, River Elegbin and FUTA wetlands mostly have 0.04±0.00, 0.26±0.00, 0.59±0.57 respectively and FUTA wetlands has higher condition factor.

ESSAI DE LA STIMULATION PHYSIOLOGIQUE (Hypophysation) DE L'ESPECE BROCHET *Esox lucius*, PAR LE BROYAT HYPOPHYSAIRE DE LA CARPE COMMUNE *Cyprinus carpio*

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L'extrait des glandes pituitaires est utilisé pour la reproduction artificielle de différentes espèces de poissons, ayant un intérêt économique intéressant, pour provoquer l'ovulation ou la reproduction induite. La présente étude a pour objectif de développer les techniques d'extraction de l'hypophyse de la carpe commune *Cyprinus carpio* dans le but d'utilisation du broyat hypophysaire pour la reproduction artificielle du Brochet *Esox lucius* et autres espèces.

Des pêches de récupération de la carpe commune ont été réalisées à Aguelmam Sidi Ali, le 13/07/2017. Après avoir prendre les mesures de taille et de longueur in situ, les carpes anesthésiées ont subi une ouverture du crâne pour l'enlèvement du cerveau et la récupération de l'hypophyse. Fig.1,2.

Au laboratoire de Zoologie et d'Ichtyopathologie relevant du CNHP d'Azrou, le protocole de conservation a été réalisé. Le broyat hypophysaire a été utilisé pour la stimulation des géniteurs de brochets à la station d'Azrou au moment de la campagne de reproduction 2018. Fig.3

Mots-clés : Carpe commune, extraction, Broyat Hypophysaire, induction, Aguelmam Sidi Ali.

Figure 1: Extraction de l'hypophyse de la carpe

Figure 2: Extraction de l'hypophyse de la carpe

Figure 3: Broyat hypophysaire de la carpe

PRELIMINARY DEVELOPMENT IN THE ARTIFICIAL PROPAGATION OF THE GIRAFFE CATFISH *Auchenoglanis occidentalis* (VALENCIENNES, 1840) IN CONCRETE TANKS AND EARTHEN PONDS

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To obtain a reliable and appropriate method for mass propagation of *A. occidentalis* (Valenciennes, 1840) fingerlings, different experimental trials on the artificial propagation and larval rearing will be investigated in Zambia over a 16-week period from Nov. 2021 – Mar. 2022. The experimental trials will be conducted to induce spawning using natural pituitaries from either the common carp, catfish, and/or tilapias or synthetic hormones (Ovaprim, HCG & LHRH-a). The main objective of the study will be to develop a methodology for the artificial propagation of the giraffe catfish for aquaculture development and stock enhancement in Zambian freshwater systems. This will be done by designing breeding protocols for: 1) collecting and transportation of live fish; 2) spawning of broodfish; 3) appropriate hormone and dosage inducing spawning; and 4) for the rearing of larval and nursing into fingerlings. Mitigation measures to increase productivity of the giraffe catfish larvae will be suggested. The analysis is expected to reveal as to whether the undertaking is labour intensive, technically reliable and economically feasible for an aquaculture business rearing the giraffe catfish.

Trial	Hormone administered	No. times injected	No. injected brooders
1	Ovaprim	1	10
2	LHRH-a	1	10
3	HCG	2 (12-hrs apart)	10

CULTURE POTENTIALITY OF GIFT TILAPIA BY UTILIZING LOW SALINE WATERS IN INDIA

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Introductions

In aquaculture, product demand is increasing day by day, which leads to the development of unique aquaculture production system. Low saline aquaculture - Inland saline aquaculture - is defined as land-based aquaculture using saline groundwater, occurs in several parts country including Gujarat, Andhra Pradesh, Rajasthan, Panjab, Hariyana Maharashtra, Karnataka and Tamil Nadu, etc. In India, a total of 6,744,968 ha low saline land available.

Bottlenecks and solution for low saline aquaculture

The Indian aquaculture industry is presently focusing on shrimp farming, particularly on single species, Whiteleg shrimp (*Penaeus vananmei*). But, it is not a sustainable model due to its emerging diseases which declined the production performance. On the other side, potential finfish species like Asian seabass, Milk fish, Mullet and Pearl spot have been cultured in low saline brackish waters. However, lack of seed availability and suitable feed are major bottlenecks which adversely affecting the brackishwater finfish aquaculture production. Hence, alternative species must be propagated through species diversification to utilize the low saline water resources, to make that sustainable. In this context, tilapia would be the potential species to strengthen the low saline water aquaculture production.

Potentiality of GIFT tilapia in low saline water

The tilapia species are euryhaline and it can tolerate a wide range of salinity, grow and even reproduce in saline waters. In case of GIFT tilapia rearing in low saline water, it needs to be standardized, to avoid the stress due to the salinity exposure. Based on the literature, GIFT strain showed better growth performances (daily growth rate, length gain, weight gain specific growth rate and survival) up to 15 ppt. Hence, the present review concludes that farmers can utilize low saline water to culture the GIFT tilapia in a more sustainable way.

RESPONSIBLE APPROACH TO MARINE STOCK ENHANCEMENT

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Declining marine and freshwater fisheries worldwide have increased an interest in release of cultured organisms to enhance or restore fisheries. A responsible-approach concept for developing, evaluating, and managing stock enhancement was proposed by Blankenship and Leber [American Fisheries Society Symposia 15: 167-175 (1995)] and updated by Lorenzen, Leber and Blankenship [Reviews in Fisheries Science, 18(2) 189-210,2010]. There has been wide-acceptance of the "Responsible Approach" including the grey mullet *Mugil cephalus* enhancement project under the USAID Middle East Regional Cooperation (MERC) Program, which is adapting responsible stock-enhancement technology to the Mediterranean region to help reduce fishing pressure on the wild mullet stocks.

Key components of the Responsible Approach will be discussed and include the need to (1) prioritize and select target species for enhancement; (2) develop a species management plan that identifies harvest opportunity, stock rebuilding goals, and genetic objectives; (3) define quantitative measures of success; (4) use genetic resource management to avoid deleterious genetic effects; (5) use disease and health management; (6) consider ecological, biological, and life-history patterns when forming enhancement objectives and tactics; (7) identify released hatchery fish and asses stocking effects; (8) use an empirical process for defining optimum release strategies; (9) identify economic and policy guidelines; and (10) use adaptive management .

OPPORTUNITIES TO IMPROVE TILAPIA PERFORMANCE, HEALTH, AND PRODUCT QUALITY BY ADJUSTING TRACE MINERAL NUTRITION

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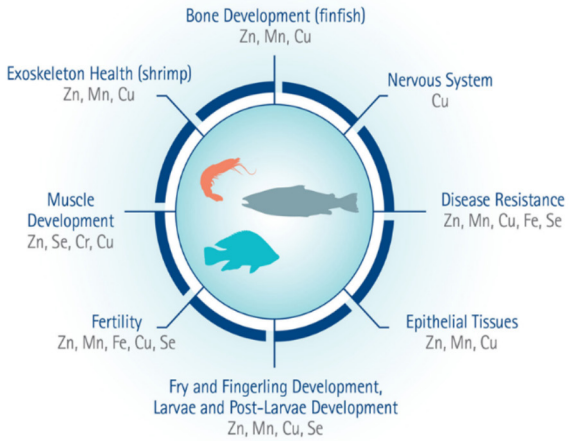
Trace minerals, such as Zn, Mn, Cu, Fe, Se and Cr, are essential for proper development of bone, muscle, nervous, and reproductive systems. Moreover, in aquatic species, as in terrestrial animals, minerals such as Zn and Cu play a critical role in the production and maintenance of epithelial tissue – as the first line of defense against microbes. Alongside Mn, Zn and Cu are of the utmost importance in wound healing, increasing the speed of the re-epithelialization processes in fish. Metal-amino acid complexes (Zinpro Performance Minerals) have proven to be more efficient than inorganic minerals in reducing skin lesions of Atlantic salmon infestated with *Caligus*, and by increasing antioxidant capacity (i.e. GPx) and barrier defenses (i.e. goblet cells in skin and intestine) in European seabass. Supplementation with Zn also increased the activity of digestive enzymes, and intestinal villi height and integrity in Nile tilapia. In channel catfish, Zn-AA complex proved to be at least 3 times more effective than ZnSO4 in meeting growth requirements in both purified and practical diets containing phytic acid, and in protecting fish against *Edwardsiella ictalurid*. Chromium supplementation proved to be equally as important in the modulation of the immune system, reducing cortisol and oxidative stress, and improving glucose metabolism, through the activation and modulation of insulin production and signaling pathway. The positive effect of Cr on growth has been shown in several fish species, such as tilapia (hybrid, Nile, red) and carp (grass, common, mirror). Cui et al. (2018) evaluated the growth response of common carp to Cr-DL-methionine (Availa® Cr) supplementation and estimated the optimal dietary Cr3+ to be 1.09 ppm. Supplementation of juvenile Nile tilapia diets with 0.5 ppm Cr, as Availa® Cr, improved final body weight and feed conversion ratio by 8 and 14%, respectively. In the same study, supplementation with 0.3 ppm Se, as Availa® Se, numerically improved final body weight and FCR by 7 and 11.4%, respectively. Highest final body weight and lowest FCR were found with the combination of 0.5 ppm Cr and 0.3 ppm Se from Zinpro Performance Minerals. Chromium supplementation in fish has shown beneficial effects related to immunological status, and metabolism of proteins, carbohydrates, lipids, and nucleic acids. Furthermore, supplementation with Zn and Cr combined seems to have a synergistic effect in controlling glycemia, thus improving carbohydrate utilization. Considering that most aquatic species, included most farmed fish, are poor users of carbohydrates as an energy source, supplementation with Cr and Zn constitutes an interesting strategy to enhance glucose utilization in order to spare dietary protein for muscle growth, increasing fillet and carcass yield. In addition, this protein sparing effect may help the aquaculture industry reduce feed costs through the utilization of cheaper dietary energy sources, such as carbohydrates.



ABALONE RANCHING IN SOUTH AFRICA RESTORES A WILD *Haliotis midae* POPULATION TO SUSTAINABLE HARVEST

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The abalone aquaculture industry in South Africa has made it possible possible to restore wild abalone populations using hatchery reared seed. We present results of an abalone ranching and stock enhancement pilot project which conducted to restore an abalone (*Haliotis* midae) population which was depleted by poaching. The South African fisheries authority granted a right to a private company to reseed an 18km ranching zone at Port Elizabeth, South Africa. Approximately 3 million seed abalone were stocked to between 2014 and 2019, with resource protection provided by private security. A research survey conducted in January 2018 indicated that on commercially seeded sites the average density increased from 0.3 abalone per m^2 in 2014 to 1.0 abalone per m^2, with the hatchery seed contributed more than 50% of the abalone found on seeded sites. Poaching fishing effort was significantly reduced by the presence of the private security and successful prosecutions of syndicates by the state. Based on a stock assessment of the resource, an initial harvest of 33 tons was granted by the fisheries authority in 2021. The key to the success of the project is the TURF (Territorial User Rights Fishery) rights system which incentivizes private sector investment in stock rebuilding by means of exclusive and secure long-term rights. The success of the model has profound implications for the management and restoration of abalone resources in South Africa.

OVERVIEW OF AQUACULTURE IN ALGERIA

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Algeria is a marine and Saharan country where central fisheries resources come from the Mediterranean Sea. Annual marine catches are estimated at 100,000 tons, and inland fisheries in dam lakes produce about 3,000 tons of freshwater fish, mainly Chinese carp (MPPH, 2019).

Algeria has a significant deficit in the production of fish from marine fisheries. The average fish consumption is 4.5 kg per inhabitant in a year (FAO, 2020). Hence, the importance of meeting the demand through aquaculture development is of paramount importance.

We present here the situation of the national aquaculture in order to target some problems that hinder or delay the achievement of the objectives defined by the Ministry of Fishing and Fisheries Productions. In particular, the issues related to the diversification of farmed species and their feeding.

The survey results show that aquaculture in Algeria has undergone several changes, passing through an activity of stocking and restocking natural and artificial water bodies. Currently, it is practiced in different production systems including semi-intensive culture in tanks, ponds, intensive production in cages, and traditional extensive production in integrated fish farming systems.

At the end of the year 2020, out of the 731 private investment projects submitted, 265 acts of concessions have been issued. There are now 86 aquaculture projects in operation, all fields combined, and 63 projects that will eventually be in operation in 2021. Aquaculture production data was reported at 5367 Metric Tons in 2020. The current aquaculture production comes from: (1) Marine fish farming offshore in floating cages practiced by private operators producing about 3236 Tons of sea bream and sea bass. (2) Shellfish farming practiced by private operators producing 107 tons of Mediterranean mussels and oysters. (3) Continental fishing by private concessionaires in dams and reservoirs, for species such as common carp, Chinese carp, pikeperch, black bass and barbel fish producing about 1600 Tons. (4) Integrated Aquaculture-Agriculture (IAA) practiced mainly in the south by agricultural farmers, for species such as Tilapia and catfish. In this context, more than 800 farmers raising fish in ponds for irrigation producing about 542 Tons of fresh fish, using the nutrient-rich water to irrigate agricultural crops.

USING ULVA MEAL *Ulva* sp IN THE FEEDING OF THIN-LIPPED GREY MULLET *Liza ramada* (RISSO, 1827) IN INTENSIVE REARING

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The Food and Agriculture Organization (FAO) of the United Nations estimates that by 2030, fish farming will have to provide two-thirds of world fish production to meet demand. However, fish farming cannot be presented as a blameless solution. The current characteristics of fish farming, like the farming of mainly carnivorous fish, have significant impacts on the environment. One of the solutions now being advocated is to diversify the species reared to move towards omnivorous fish.

This study was carried out within the framework of a project that aims to experiment a new fish farming field. It consists in experimenting the breeding of mullets in an integrated system, a local omnivorous species, less demanding in terms of protein intake and providing all the qualities required for human consumption.

We have experimented the Effect of Ulva meal, a green algae, as a replacement of soybean meal in the diet on growth performance of the thin-lipped grey mullet *liza ramada*. Experimental diets were prepared with fishmeal, soybean meal, cornflour, wheat gluten, yeast beer, lupin, stale bread and Ulva meal (*Ulva rigida*). Raw materials were obtained from commercial suppliers, except *Ulva* used (32.4% crude protein). The feeding experiment was carried out in a closed circulation system. Each diet treatment was applied to replicate four times. Groups of 18 fish individually tagged (53.8 ± 2g average wet weight) per tank (60 l) were arranged in a completely randomized design. The fish were hand-fed to satiation two times daily between 08.00 h and 18.00 h for 37 days. An industrial control diet (U_i) (EFICO Cromis 832F) and two experimental formulated diets were used: an algae-free diet (U_0) and a 20% level of raw Ulva meal (U_{20}) . The formulated diets contain 37% crude protein and 9% lipid. The 20% Ulva meal replace 20% Soybean meal.

The results showed that weight gain, final body weight (FBW) and Specific Growth Rate (SGR) did not differ significantly among groups fed on experimental diets. They had a similar average performance in specific growth rate (SGR = 1.03%/day) and feed conversion index (FCR = 1.85 and 1.92 with U_0 and U_{20}, respectively). The SGR was significantly higher in fish fed with industrial feed than with the two (2) experimental diets.

This preliminary study indicates that a 20% level of raw Ulva meal could be used in juvenile *L. Ramada* without causing any adverse effects on growth and feed utilization.

A SUCCESSFUL AQUACULTURE MODEL WITH SOCIAL RESPONSIBILITY IN AFRICA

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There was so much research done, studies conducted, model farm demonstration done to encourage the Sub-Saharan, east, middle, west & south African farmers to venture into aquaculture so that they can feed their nations. But unfortunately, most of the farming models are high capital intensive, highly technical and finally producing fish at high cost of production. We, as a responsible Danish seafood trading company have tried to demonstrate a model farming in Ghana which produces fish with basic technology, hormone free, with balanced nutrition, creating more jobs.

Cage culture in Ghana has been facing lot of issues from organized theft, high mortalities due to streptococcus, ISKNV etc. It is mostly like "cage culture is lacking both security and biosecurity safety in Ghana". At that critical situation we have invested in commercial pond farming with 2-tier system of Nursery (20% area out 1 Ha) and Grow-out (80% area out of 1 Ha) and we stocked 1 g size sex reversed fingerlings in nursery, grown them for 90 days where they have reached 90-100 g size and then transferred to grow-out ponds and grown them there for another 90-120 days. Overall, we have maximized output 3 times from a unit area. We produce 30 tons/Ha/year with an accessory aeration of 3-5 Hours in a day (2 AM to 7 AM). Effective harvest size is 400-450 g with 98-100% survival in Grow-out and 60-70% in Nursery Pond.

After ISKNV has hit Ghana in 2019 with severe mortality, we have faced mortality in nursery ponds almost loosing 90% in some of the nursery ponds, but our grow-outs were not affected which still maintained 98-100% survival. We have used some organic products, stopped hormone usage since hormone usage suppresses immunity and we have applied Darwin theory of survival for fittest at nursery stages achieving 40-50% survival compared to 5-10% survival in other farms, and achieved 100% survival in grow-out consistently in our farm. We give a maximum time of 90-120 days for fish to breed in grow-out culture where the fingerlings can attain a maximum size of 10 g by the time of harvest and that fish will be distributed to village people either for free or for nominal price.

Overall, we achieved lowest FCR, lowest cost of production, low carbon footprint, low Nitrogen emission, low phosphate emission by having control on feed and by substituting formulated feeds with natural food (plankton). Our laborious method of harvest makes theft impossible, even it happens that will be negligible quantity.

We are marching towards export of whole round tilapia to regional markets in Africa and fresh frozen tilapia fillet to rest of the western world at a on par price match with Asian products. The numbers, graphs, and technical data will be presented in full version of the paper.

FINANCING SUSTAINABLE SMALL AND MEDIUM SCALE AQUACULTURE GROWTH IN AFRICA

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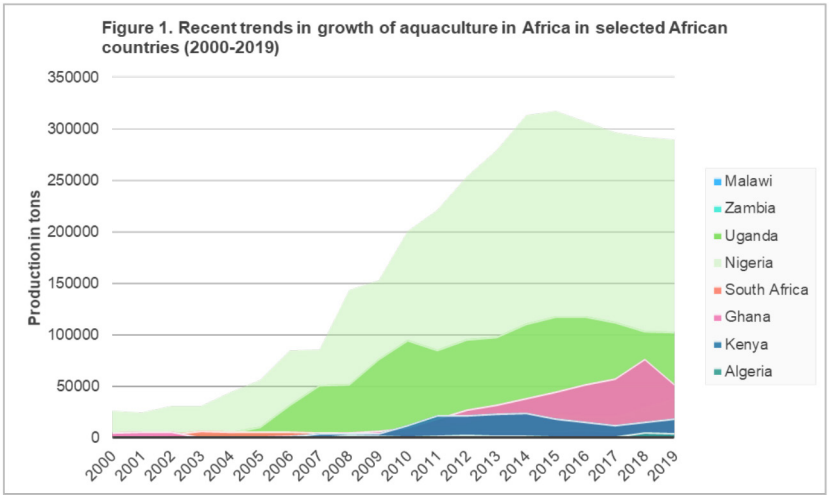
Aquaculture holds considerable potential for sustainable growth of rural economies, employment of youth and women, and food and nutrition security. Currently, small and medium-scale producers from developing countries produce most of the farmed fish and have fueled the rising growth seen in Africa in recent decades (Figure 1).

The subsistence mentality that gripped most African aquaculture at inception is waning, and, in its place, a commercial mindset spurred by an entrepreneurial environment across the value chain. Bottlenecks exist in the form of poor access to credit, lack of technical know-how, poor access to quality inputs such as genetically improved seed, quality feed, high cost of production, losses of produce due to poor infrastructure, and marketing challenges. The high cost of fish meal has led to a search for alternative sources including animal and plant based ingredients. SMEs using new technologies that utilize food wastes and biproducts to produce insect-based meal are growing in number across the continent. A few countries have initiated genetic improvement programs for provision of quality seed.

A market-focused investment model with significant profit orientation may unlock the sector and attracting investment from both the public and private sector. Diversification of products may add value, however, increasingly informed consumer markets demand prohibitive seafood quality standards alienating SMEs. Aquaculture cooperatives can bargain for affordable credit, lobby for conducive government policies, enhance specialization among members, assure better technical assistance through novel extension methods, and can find and sustain new markets that fetch better prices for fish and fish products through bulk marketing. Growing use of mobile telephony across the continent can make it easier to collect production data and disseminate market information and technical knowledge among actors across the value chain. Tackling the challenges facing SMEs to unlock the potential for resilient aquaculture growth requires appropriate government policy and regulatory frameworks and affordable financing.



A NEW BOOK: MULLET AND ITS AQUACULTURE

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A book, edited by Drs. Liao and Leaño "Mullet and Its Aquaculture" and supported by World Aquaculture Society, Asian Fisheries Society, The Fisheries Society of Taiwan and National Taiwan Ocean University, is to be printed recently. Besides the introductory paper, Forward, 11 papers are included as the following: The *Mugil cephalus* species complex, from Taiwan to the world; Review on induced breeding research and cultivation of grey mullet (*Mugil cephalus*) in Taiwan; Cryopreservation of grey mullet sperm; The pursuit of culturing mullet gold: A personal memoir; Mullet in Hawaii; mullet culture in India: Present status and future prospects; Seasonal migration and fishing technology of Lobed River Mullet "Ludong" (*Cestraeus* spp.) in Cagayan River, Philippines; Advanced development of dated grey mullets fishery in Taiwan; Past and present development of mullet aquaculture in Taiwan; Taiwan consumers' cognition and purchasing behavior for Mullet (*Mugil cephalus*) roe; and Mullet culture with leisure business. The presentation will highlight features and attractions of each paper above.

THE UTILIZATION OF PHYTASE ENZYME TO REPLACE INORGANIC PHOSPHATE IN PLANT-BASED DIETS IN TILAPIA UNDER A CAGE CULTURE SYSTEM IN INDONESIA

Rutchanee Chotikachinda, Daranee Seguin, Sirirat Chatvijitkul, Liew Chiow Yen

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The objectives of this study were to develop nutritional strategies on reducing inorganic phosphate supplementation in feed and minimizing phosphorus (P) waste from feedstuffs. Three levels of monocalcium phosphate (MCP) and microbial phytase at 2000 FYT/kg feed were applied to 75.5% plant-based control diets, which are a control diet (Diet A, 1.8% MCP), a suboptimal-P diet with phytase (Diet B, 0.9% MCP), a P-deficient diet with phytase (Diet C, 0% MCP), and a P-deficient diet (Diet D, 0% MCP). 400 tilapia with an initial weight of 262-268 g were stocked in each of 8 m^3 cages in Lake Toba, Indonesia. Fish were fed to apparent satiation twice daily over a 148-day feeding period. At the end of the feeding trial, the survival rate, biomass gain, specific growth rate (SGR), average daily gain (ADG), and feed conversion ratio (FCR) were examined. The results from the present study indicated that the suboptimal-P diet with phytase (0.9% MCP+phytase) provided good growth performance and feed utilization comparable to the control group (1.8% MCP). It suggested that the phytase application at 2,000 FYT/kg feed could release sufficient P from dietary phytate to substitute 0.9% of MCP in Diet B. However, P release from phytase was insufficient in fish fed diet C when MCP was totally removed. The growth and feed performance of fish fed diet D without inorganic P were the lowest among the treatments. It was proven that microbial phytase supplementation at 2,000 FYT/kg feed could improve P digestibility and utilization in plant-based diets to meet the fish requirement and improve growth performance. Thus, this could translate to the formula cost reduction from inorganic P substitution in the formulas and reducing P discharge from indigested phytate P from plant-based diets into the environment.

Growth performance and feed utilization of tilapia fed four dietary treatments over a 148-day feeding period.

Parameters	Diet A (1.8% MCP)	Diet B (0.9% MCP + phytase)	Diet C (0% MCP + phytase)	Diet D (0%MCP)
Initial body weight (g)	268.25±2.06	263.50±3.32	264.00±4.24	262.00±4.40
Final body weight (g)	1,200.48±20.98^{a}	1,216.53±43.46^{a}	1,132.34±33.19^{b}	1,067.41±8.19^{c}
Survival (%)	96.13±1.23	96.88±0.72	96.88±1.31	97.00±0.79
SGR (%)	1.01±0.02^{ab}	1.03±0.02^{a}	0.98±0.03^{bc}	0.95±0.01^{c}
Biomass gain (kg/cage)	354.25±7.48^{ab}	365.97±15.45^{a}	333.25±17.65^{bc}	309.34±0.42^{c}
Feed intake (kg)	634.75±19.82	632.00±11.52	632.25±16.26	635.25±13.12
ADG	6.23±0.14^{ab}	6.38±0.28a	5.81±0.25^{bc}	5.39±0.04^{c}
FCR	1.79±0.07^{b}	1.73±0.09b	1.90±0.12^{ab}	2.05±0.04^{a}

Values in a row that do not have the same superscript are significantly different ($p < 0.05$).

STATUS AND REVIEW OF MANAGEMENT PRACTICES IN ZAMBIAN HATCHERIES

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The growth of aquaculture in Zambia has seen the sector shift from subsistence production to commercialization. This has resulted in increased need for high quality, large numbers and consistent supply of fish seed. Sustainable fingerling production depends on broodstock quality as determined by the genetics, health and nutrition; better management practices (BMP's) such as proper biosecurity and diseases management, proper feeds and feeding practices, water quality management and waste disposal..

Limited information exists on the status of the hatchery sector in Zambia, including their distribution, species cultured and management practices across the various hatcheries in the country. The present study was aimed at reviewing these and assessing them against the better management practices to ascertain gaps for improvement. A countrywide survey was conducted in 2019-2020 in which information on general distribution and characterization of the hatcheries was collected. 74% of hatcheries in the country were surveyed and these were considered representative as all provinces were captured. The major cultured species from these hatcheries tilapias; *Oreochromis andersonii, O. niloticus, O. macrochir*, *O. tanganicae* and *Coptodon rendallii (*see map).

The survey indicated only 80% of the hatcheries were aware of and had some form of biosecurity measures in place while 78% had a broodstock management plan with some degree of awareness to dangers of inbreeding (86%). A 20 % non-adherence to biosecurity measures puts the industry at risk given the current threat of fish diseases in the region. A review of management practices from the current study coupled with continued awareness and capacity building of farmers, managers, extension workers and research sector through BMPs is recommended for the sustainable growth of the industry.

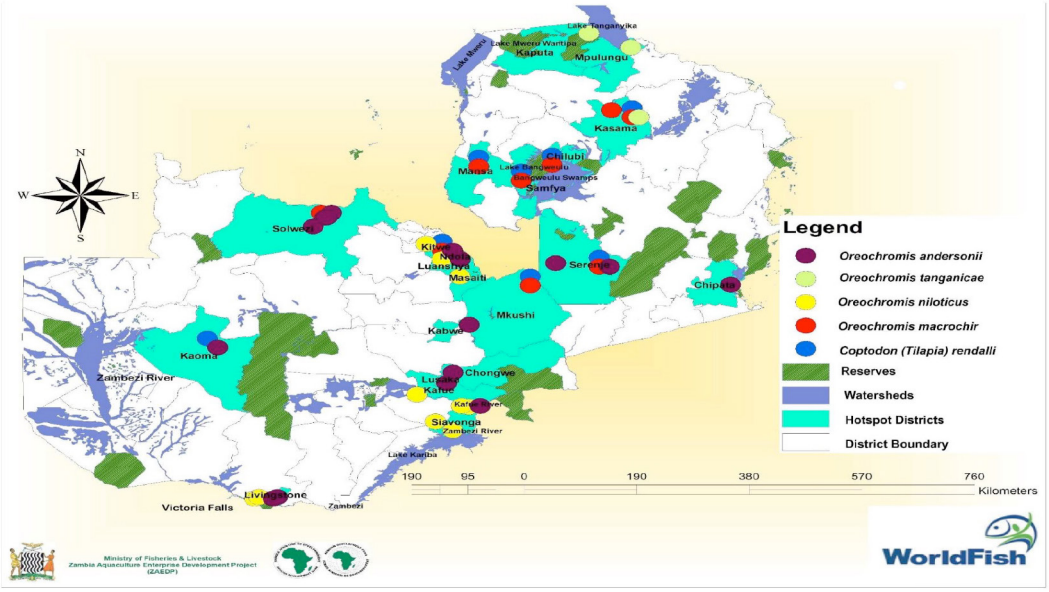

Figure 1: Map Species mapping in hatcheries in Zambia

WHY IS FISH WELFARE IMPORTANT FOR AFRICAN AQUACULTURE?

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The demand for fish is rising globally and aquaculture can provide food, livelihoods, and significant contributions to economic improvements of African countries. The controversial issue of fish welfare is now of increasing public concern in some countries, and therefore also growing importance for fish farmers. There is clear evidence and scientific acceptance that fish are sentient organisms, possessing the ability to perceive pain. Fish farming is usually associated with intensive production practices with fish being raised in captivity for most or all their life. Staff working techniques, husbandry factors and practices, handling throughout the production cycle and operations involved in slaughter can unarguably impact fish stress and welfare. Direct economic benefits of fish welfare are obvious. Fish kept under good welfare conditions are less susceptible to diseases and tend to show better growth rates and food conversion, leading to a better-quality and safer product. The potential for harmonised best practices and integration of fish welfare in international regulatory frameworks and trade agreements are at present under discussion. Inclusion of fish welfare in animal protection regulations and codes of good professional aquaculture practice should be considered for ethical, compliance and economic reasons. As the African aquaculture industry takes shape, there is the need to acknowledge, promote and potentially regulate the issue of fish welfare. This paper identifies some of the critical issues in fish culture that are relevant for fish welfare and addresses the opportunities and benefits that improved welfare conditions can represent for the development of sustainable aquaculture sector in Africa.

SOCIAL RETURN OF AQUAPONICS ENTERPRISE: A CEFOPEA-BRAZIL STUDY CASE

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The social benefits generated by aquaponics and especially those developed in social enterprises have been presented indirectly by several authors, but these manuscripts do not measure these benefits. This work aimed to measure the social return on investment in the CEFOPEA aquaponics farm located in São Paulo city, Brazil. CEFOPEA aquaponics farm runs a permanently coupled system, in a 225.37 m² of built area with 7.5 m³ of fish tanks and three hydroponics subsystems (Grow Bed-GB, Deep Water Culture-DWC, and Nutrient Film Technique-NFT). Data on disbursements and activities carried out were obtained from physical records (copybooks and invoices), digital documents (electronic spreadsheets and reports), and a semi-structured questionnaire applied to managers and employees of the farm. The social return was determined using cost-benefit analysis. The benefits generated by the aquaponics farm were classified into two items: 1- food production and 2- social services provided to the community. In food production, fish and vegetables were considered. The cash flow was prepared with a 10-year horizon. The outputs are the investment in initial fixed capital, the reinvestments in fixed capital over the horizon, and the annual operating costs. The inputs are the values of monetized social services, the value of food production, and the residual value of fixed capital. The moment zero was considered as the project implementation. The eight-month disbursement amounts (June 2019 to January 2020) were presented for one year. All the values were defined for February 2020 using the IGP-DI. The Net Present Value-NPV and the cost-relation were determined considering a discount rate of 3% per year. The NPV was regarded as the social return generated by the farm. USD 32,471.60 was the value for constructing the aquaponics farm and USD 6,315 year^{-1} for its operation. The food production was mainly fish (180.84 kg eighth.month^{-1}) and lettuce (310 units eight months^{-1}) used in the farm's kitchen and sold. Social services (visits, seminars, workshops, and courses) were the primary source of social return, with 89.61% of all benefits generated by the enterprise. The enterprise was feasible when considering that the social benefits comprise food production and social services, with a social return of USD 24,517.49.

Acknowledgment
To FAPESP (2017/50431-9, 2019/21315-6, 2018/13235-0, 2018/ 23605-9, 2019/21703-6, 2018/20463-9), to Forum Belmont (726744), to CNPq (311108 / 2017-2), to CEFOPEA-RECYCLAZARO and to Fundação Cargil.

Table 1. The Operation Cost of the CEFOPEA aquaponic farm, in dollars (USD) for February 2020, (1USD=R$4.4981).

Description	Values
Investment (USD)	32,471.60
Operation cost (USD year^{-1})	6,315.17
Benefits (USD year^{-1})	8,973.59
Food production (USD year^{-1})	932.42
Social services (USD year^{-1})	8,041.17
Social return (USD)	24,517.49
Benefit-cost ration	1.27

EVALUATION OF LEMON GRASS (*Cymbopogon citratus*) AS PHYTO-ADDITIVE IN THE DIET OF AFRICAN CATFISH (*Clarias gariepinus*) FINGERLINGS

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The dietary effects of Lemon grass (*Cymbopogon citratus*) leaf powder meal on growth performance and immune response of African catfish (*Clarias gariepinus*) was evaluated. 40% crude protein (CP) diets supplemented with 0.0g (D1), 0.5g (D2), 1.0g (D3), 1.5g (D4) and 2.0g (D5) of C. citratus leaf powder were prepared and fed to C. gariepinus fingerlings (mean weight 7.30 ±0.02g) for eight weeks. 15 *C. gariepinus* fingerlings were randomly distributed into 15 plastic tanks each representing five treatments in triplicates. Feeding was done twice daily. After the feeding trial, fish from each treatment group were challenged with pathogenic *Aeromonas salmonicida*, through intraperitoneal (I/P) injection and observed for 14 days for abnormal clinical signs and mortality. There was a significant difference ($p>0.05$) in the mean weight gain, and specific growth rate of fish fed diets with different inclusion levels of C. citratus leaf powder. There were significant differences ($p>0.05$) in white blood cells among treatments. At the inclusion level of 2.0gkg^{-1} of *C. citratus*, the best immunity against *A. salmonicida* was recorded. The result of this study has shown that *C. citratus* can be incorporated into fish feed to replace synthetic antibiotics for sustainable aquaculture.

Table 1. Growth Performance and Nutrients Utilization of *Clarias gariepinus* Fingerlings Fed Different Levels of *Cymbopogon citratus* Leaf Meal

	Dietary Treatments				
Parameters	***D1***	***D2***	***D3***	***D4***	***D5***
Initial Mean Weight(g)	7.30±0.07^{a}	7.28±0.06^{a}	7.29±0.05^{a}	7.30±0.03^{a}	7.31±0.05^{a}
Final Mean Weight(g)	52.27±4.12^{c}	52.67±5.62^{c}	43.90±1.42^{b}	43.10±2.46^{b}	35.57±0.81^{a}
Mean Weight Gain (g)	44.97±4.08^{c}	45.33±5.56^{c}	36.57±1.36^{b}	35.80±2.46^{b}	28.23±0.85^{a}
SGR (%/day)	3.51±0.13^{c}	3.53±0.17^{c}	3.21±0.05^{b}	3.17±0.10^{b}	2.82±0.05^{a}
% Survival	91.10±3.81^{a}	91.10±7.18^{a}	91.10±3.81^{a}	91.10±3.81^{a}	95.53±3.87^{a}

INFLUENCE OF WATER CHANGING FREQUENCY ON GROWTH PERFORMANCE AND NUTRIENT UTILISATION OF TROPICAL FISH SPECIES

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Fish is a major and cheaper source of animal protein and its sustainable production has been limited to aquaculture as capture fisheries has been levelled-off for almost three decades now. However, expansion of aquaculture is being challenged by resources among which water is a major one. There are different methods of culturing fish and one of the most commonly used in tank systems is stagnant-renewal method where water is changed frequently to keep the fish at optimal performance. This is mostly done arbitrarily and sometimes rely on the visual appearance of the culture water. There is limited information on how often the water changes should be conducted. This research examined the effect of water changing frequency on two major fish species cultured in Nigeria and Africa, Nile tilapia, *Oreochromis niloticus* and African catfish, *Clarias gariepinus*. The experimented water changing frequency was 50% at two days interval, four days interval and once in a week. The results showed that water change once a week is adequate for fish stocked between 10 kg/m^3 and 20 kg/m3. The water quality parameters were all within the recommended range for tropical fish culture, and only a few parameters like total dissolved solids and electrical conductivity were significantly different among the treatments. The growth performance and nutrient utilization parameters were similar in *O. niloticus*. In *C. gariepinus*, frequency of water change influenced the growth and nutrient utilization parameter, with performance increases with increased number of days of changing the water.

While further research is suggested, changing of culture water once a week is established to support improved growth performance, nutrient utilisation and well being of the fish culture. This, if adopted will reduce water usage in fish culture and increased fish production despite reduced labour and environmental friendly as the frequency of waste discharge is reduced

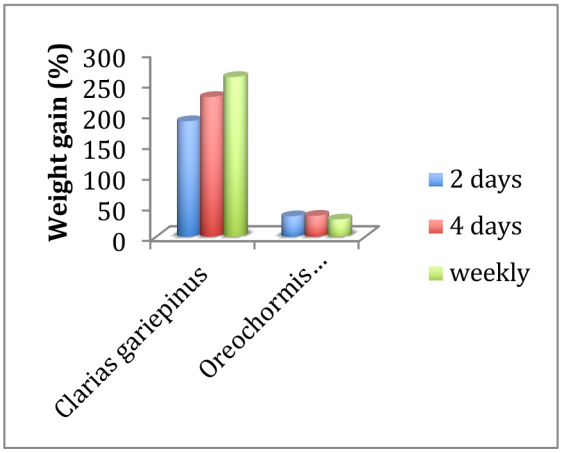

Figure 1: % weight gain of two tropical fishes reared at different water changing frequencies

DIFFERENT CARBON SOURCES AFFECT THE MORPHOLOGY AND PLANKTONIC COMPOSITIONS OF BIOFLOCS

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Biofoc technology system (BFT) is a microbial-based fish culture system that works by elevating the carbon nitrogen ratios in the culture unit. The biofloc composition, water quality and performance of aquatic animals, however, can sometimes depend on the added carbon source. Therefore, it is most likely that the carbon sources influence the microbial community in BFT. This study seeks to establish the effect of carbon sources on the structure and planktonic compositions of bioflocs.

A 21-day experiment was conducted in the wet laboratory of Universiti Putra Malaysia, using 50 L of water housed in 100 L capacity glass aquarium. Each of the 9 aquaria received 20 g of grinded fish feed (42% crude protein) at three days interval to have a similtude of aquaculture wastewater. Three different carbon sources, sucrose, glycerol and rice bran were experimented and added at carbon/nitrogen ratio of 15 in each tank with the experiment triplicated. The water quality was monitored daily and after 21 days, 50 ml of the biofloc water in each tank was collected for morphological examination, phytoplankton and zooplankton analyses using standard procedures.

The colours of the bioflocs from the different tanks were different, glycerol biofloc was greenish, sucrose biofloc tended towards reddish while rice bran biofloc was brownish in colour. The morphostructure of the bioflocs from different carbon sources as observed under microscope were different, though all the bioflocs had irregular agglomerates. The bioflocs in glycerol treatment were well dispersed. Sucrose and rice bran had aggregated structure, and it is more compacted in rice bran. The planktonic composition was also different among the different carbon sources. Phytoplankton from 18 genera and 5 phyla were observed (Figure 1). These include; Cholorophyta (*Chlamydomonas*, *Palmella*, *Micractinium*, *Oedogonium*, *Dictyosphaerium*, *Coelastrum* and *Scenedesmus*), Euglenophyta (*Astasia*), Ochrophyta (*Gonyostomum*, *Fragilariopsis*, *Amphora* and *Tribonema*), Charophyta (*Coleochaete*), Dinoflagellata (*Peridinium* and *Ceratium*) and Cyanobacteria (*Anabaena* and *Gomphosphaeria*). The phytoplankton abundance in the sucrose and glycerol treatments were higher compared to rice bran treatment. The glycerol treatment was dominated by Cholorophyta while sucrose was dominated by mixtures of Euglenophyta, Ochrophyta and Chlorophyta. Rice bran treatment had the least diverse and abundant phytoplankton with only four genera (*Anabaena*, *Gomphosphaeria*, T*ribonema* and *Dictosphaerium*). The sucrose treatment had in total of 13 phytoplankton genera while glycerol had 12 genera. The *Dictosphaerium* (Chlorophyta) was found in all treatments.

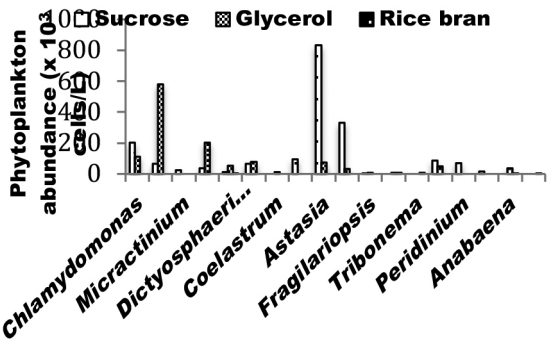

Figure 1: Phytoplantkon composition of the bioflocs

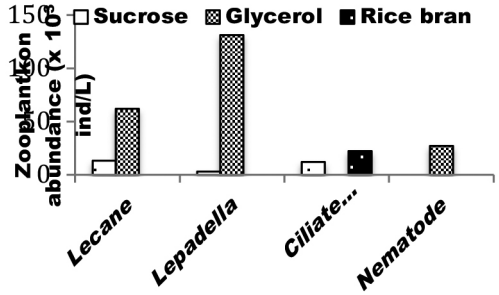

Figure 2: Zooplantkon composition of the bioflocs

In general four groups of zooplankton were observed in the biofloc treatments which include; rotifers (*Lecane* and *Lepadella*), protozoa (*Ciliate*) and nematode (Figure 2). The glycerol treatment had most abundant zooplankton from rotifers, it also had some nematodes. The sucrose treatment had both rotifers and protozoa, but rice bran treatment had only protozoa.

The results in this study indicated that carbon sources affect both the morphological structure and microbial composition of the bioflocs.

DEVELOPING SEX-REVERSED MALES BROOD FISH FOR PRODUCTION OF ALL-FEMALE PROGENY POPULATIONS OF THE GREY MULLET

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The Flathead grey mullet (*Mugil cephalus*) is a cosmopolitan marine fish. Most of its production comes from capture fisheries, yet, the aquaculture of this species, where fries are captured in estuaries and acclimated to grow out in fresh- to brackish-water ponds is becoming more and more significant, with Egypt being the major producer. Mullet females grow faster than males and ovaries of mature females are desired in the roe industry. Hence, producing all-female progeny populations is a major advantage for mullet hatcheries and producers. Only recently, steady production of mullet fry in hatcheries has become a reality. Now, it is the appropriate time to integrate genetically improved broodstock for production of all-female fingerlings. Developing such genetically improved broodstock requires understanding the sex-determination system in mullet, developing sex-reversed broodfish and developing assays to determine the genetic sex of individuals to identify sex-reversed fish. Here we report on our advancements towards developing sex-reversed males for mullet.

In mullet males and females are hard to distinguish until ready to spawn. We sampled mature fish and identified their sex based on gonad type. These fish were also genotyped by several thousands of SNP markers. We constructed a genetic map and mapped a single sex-determination genomic region. Using comparative genomics, a few candidate sex-determining gene located to this genomic region were identified. Our results corroborate two other, recently published studies, identifying the same sex-determining genomic region for several mullet populations from the Mediterranean Sea. All these studies pointed to a XX/XY sex-determination system in most populations. Thus, sex-reversed males (males with an XX rather than XY genotype) are needed as broodfish to cross with regular XX females to produce all-female (XX) progeny populations.

Developing a protocol for sex-reversal in the mullet takes time since fish mature after about two years, only then allowing to test if the natural 1:1 sex ratio was biased. Fish at early stages were fed with androgen (Methyl-testosterone) treated food. In one experiment, the control group showed a 1:1 sex ratio, whereas the treated group had 63% males, significantly more than expected, suggesting some of the males in this treated group are sex-reversed. From this group, we have fish grown under broodstock conditions.

Finally, based on the SNP markers, we developed molecular sexing assays, allowing to determine the sex of individuals based on their DNA only. By applying the molecular assays to control-group fish, we determined which genotypes are of females and which are of males. By applying these assays to fish from the sex-reversal group, some fish with testes but a female genotype were identified, in accordance to the biased sex ratio. Therefore, indeed this group included some sex-reversed males. We then, tested live fish held as broodfish by stripping and identified males. By testing their DNA, some were indeed sex-reversed. These will be soon tested as broodfish to produce all-female progeny population.

Taken together, all elements of the required methodology were developed to a stage when production of all-female groups can be tested. Further experiments are needed to tune-up the different parts of the methodology in order to allow full-scale and efficient production of all-female hatchery fingerlings, a technology that will significantly contribute to production of mullet in aquaculture and protection of the natural populations in seas.

PATHOGENS AND DISEASE EXPERIENCES IN THE AQUACULTURE OF THE YUCATAN PENINSULA, MEXICO

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México´s current aquaculture growth is 17%, an indicator above many other countries developing aquaculture. Main commodities are shrimp and tilapia, although marine finfish aquaculture has been developing since the 90´s resulting in commercial aquaculture venues in the Pacific side. Some freshwater species like basa and trout are cultured in northern and center states while tilapia is cultured all over the country (32 states). In the Yucatan peninsula tilapia is the most important cultured organism, followed by shrimp and marine finfish in the Gulf of Mexico waters. Still, a common problem facing all aquaculture ventures are pathogens and disease which at some points have caused disastrous impacts; in 2013 a red drum farm off-the coast of Campeche lost 80% of their production due to an undiagnosed outbreak of nocardiosis (Figs. 1&2). During mid 2000´s shrimp farms in Yucatan experienced the effects of ill-combined infections of Taura, white-spot disease and necrotising hepatopancreatitis which depleted the still incipient crustacean farming in the area. For over ten years there was no operative shrimp farm establishments in the whole peninsula.

Fig. 1. Ulcerative lesions in red brum *Sciaenopus ocellatus*

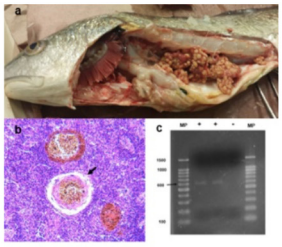

Fig. 2. Granulomatous nefrotic and histological lesion in *S. ocellatus* (a and b); positive PCR for *Nocardia seriolae* (c).

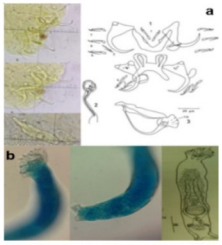

Fig. 3. Most common monogenean of tilapia in the Yucatan Peninsula: *Cichlidogyrus sclerosus* (a) and *Gyrodactilus spp.* (b)

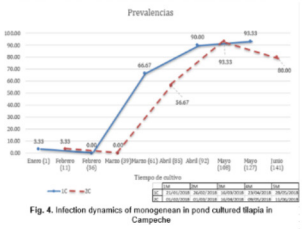

Fig. 4. Infection dynamics of monogenean in pond cultured tilapia in Campeche

Fig. 5. Skin haemorrages in tilapia due streptococcosis

Fig. 6. Streptococcosis distribution in tilapia farms in Campeche.

MANAGEMENT OF CAPTIVE BROODSTOCK GREY MULLET *Mugil cephalus* AT INSTM HATCHERY

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Grey mullet, *Mugil cephalus* fingerlings is strongly requested for extensive culture in Tunisian reservoirs. Currently they are collected in the wild in the estuaries. This production sector is essential for improving food security of inland regions. The average annual production of inland mullet production is about 315 Mt with high variations (from 195 and 466 Mt) depending to hydro-climatic conditions. This production represents 30% national freshwater fish production and play a significant socio-economic role in supporting local low-income fisherman. Obviously, a regular fingerlings supply from hatchery instead of wild catch is a requisite for the sustainability of this activity.

In the frame of the USaid-MERC project "Stock enhancement and production of the Grey Mullet fry – a sustainable choice", the INSTM is establishing a captive broodstock of *Mugil cephalus*. The fish have been captured during two summer campaigns in 2018 and 2019 from an extensive culture pond in the region of Mahres (governorate of Sfax) and from a fixed fishery at Tinja (governorate of Bizerte). Survival rate after hatchery acclimation in INSTM Monastir was 40% in 2018 and improved to reatch 70% in 2019 (table 1). This by improving transport conditions of fish (water exchange during transport, individual capture by landing net, handling in water, preventive treatment …).

A total of 70 mullet broodstock consisted by 28 females (body weight [BW] 1300 ± 218g) and 42 males (BW 655 ± 201g) were acclimated in captivity. Fish have been rearranged in three tanks of 20 m^3-tank in flow through system located in greenhouse and subjected to natural conditions of light and water temperature. Tanks are supplied with seawater at 38-42 psu salinity from the lagoon of Monastir. Fish were fed daily at the rate of 1-2 % of their biomass using a specific prepared diet enriched with dried spirulina.

During 2020 spawning season (August, September), ovarian biopsy of females revealed only the presence the previtellogenic stage with 150-200 μm oocytes and no spermiating mature males.

During 2021 spawning season, the fish with adequate size have been submitted to hormonal treatment since June (both GnRHa and dopamine antagonist for females and methyltestosterone for males) for enhancing gonadal development. Fully mature females (presence of oocyte with a diameter greater than 500 μm) and spermiating mature male (milt production) have been observed during September 2021 and final hormonal spawning injections for induction spawning are scheduled for the coming days, when adequate thermal conditions are reached.

Table 1. broodstock grey mullet *M. cephalus* captured during 2018 and 2019

Year	Fishing Trip	Number captured	Transport Density (Kg/m^3)	BW (g)	TL (Cm)	SR (%)
2018	6	73	10.6 ± 4.6	931.2 ± 326	42.8 ± 3.8	40
2019	6	68	9.5 ± 2.7	1071.1 ± 522	42.2 ± 7.4	67

SUPPORTING AQUACULTURE DEVELOPMENT ACTIVITIES

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Fish plays an important role in the nutrition of sub-Saharan Africans. Countries like Ghana are heavily dependent on fish, with consumption at 23kg per capita. Aquaculture is only in its early development phase, contributing to 1-3% of global production and needs to expand rapidly ahead of Africa's population growth.

The American Soybean Association's World Initiative for Soy in Human Health program (ASA/WISHH) has been working in Africa for the past 20 years strengthening agricultural value chains. Through funding provided by the USDA's Agricultural Trade Promotion program (ATP), ASA/WISHH has increased its scope to include aquaculture development in key West African markets including Ghana, Nigeria, and Senegal. The initiative is focused on feed management, but also provides technical expertise in fish health and diagnostics, farm design, marketing and hatchery management.

The ASA/WISHH aquaculture team has provided feed producers with extrusion training, technical assistance to clients, and feed trials. ASA/WISHH does not promote any one brand of feed but focuses on teaching farmers how to manage their feeds as it accounts for 60-80% of their direct cost. This has allowed ASA/WISHH advisors to offer objective evaluations of farmer practices and feed performance trials with the aim of making improvements.

Expectations are to see farms more data-driven in decision making and promote open knowledge-sharing amongst fish farmers for collective growth.

FIRST COMMERCIAL TRIAL OF IN-POND RACEWAY SYSTEM AQUACULTURE TECHNOLOGY IN BANGLADESH WITH *Labeo rohita*

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The first ever commercial trial of in-pond raceway system (IPRS) aquaculture technology in Bangladesh was carried out in 2020-2021. One of the most popular and commercially important species of fishes in Bangladesh *Labeo rohita* carp was stocked in a cell at the density of 11.45 kg/m^3 and at the end of 198days of production cycle harvest density was 23.31 kg/m^3 which is equivalent to 16565.76kg/ha/yr. (projected). Specific growth rate was 0.51% d and overall FCR was 1.47. Additional 692.31kg/ha, 503.85kg/ha, 1743.59kg/ha 294.87kg/ha 115.38kg/ha and 50kg/ha *Labeo rohita*, *Catla catla*, *Hypopthalmicthys molitrix*, *Aristicthys nobilis*, *Ctenopharyngodon idella* and *Mylopharyngodon piceus* were harvested from outside raceway open pond as co-cultured species. With few exceptions water quality parameters were in suitable range. Recaptured rate was 86.89%. Results show that *Labeo rohita* is a potentially suitable carp species for IPRS aquaculture in Bangladesh.

EFFECT OF DIFFERENT NITROGEN SOURCES ON CELL DENSITY, GROWTH RATE, BIOCHEMICAL COMPOSITIONS, AND FATTY ACID PROFILE OF *Nannochloropsis oculata* CULTURE

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Nitrogen is one of the most critical nutrients affecting cell growth and the biochemical composition of microalgae. The Effect of different nitrogen sources on the growth and biochemical composition of *Nannochloropsis oculata sp. (N. oculata sp.)* was investigated in this study. Five different forms of nitrogen at 0.88 mmol L^{-1} each: ammonium bicarbonate (NH_4HCO_3), ammonium sulfate ($(NH_4)_2SO_4$), ammonium nitrate (NH_4NO_3), ammonium chloride (NH_4CL), urea were all compared to F/2 media which has sodium nitrate ($NaNO_3$) as a control. The experiment lasted for 15 days under the conditions of 100 µmol photons m^2s light intensity (L/D= 24:0), salinity 25 ppt, 23± 1 °C , pH 7.5 ±0.3. Ammonium bicarbonate promoted cell density and specific growth rate (μ) achieving the highest cell density 25.27×10^6 cell/ml and 0.41 div./day after nine days while urea achieved the lowest cell density 13.58×10^6 and ammonium sulphate achieved the lowest specific growth rate 0.25 div./day. Total protein content increased significantly ($P\leq0.05$) by 38.28% in urea medium however, it had the lowest total lipid, carbohydrate, and ash 30.11%, 12.22 %, and 1.32% by dry weight, respectively. Ammonium nitrate had the highest total lipid content of 43.67%, as well as the highest total ash content of 3.77 %, total carbohydrate content increased by 19.09 % in sodium nitrate (control), whereas ammonium chloride had the lowest total protein content 19.28 %. The major fatty acids detected in different treatments were (C14:0), (C15:1), (C16:0), (C16:1n 7), (C17:1), (C18:0), (C18:1 n9), (C18:2 n6), (C20:3 n6), (C20: 4 n6), (C22:2), (C20:5 n3). *N. oculata sp.*, which was cultured by the media supplemented with NH_4HCO_3, $NaNO_3$, NH_4NO_3 and urea had higher content of Eicosapentaenoic acid (C20:5 ω3) EPA, Decosahexaenoic acid (C22: 6 ω3) DHA, while Arachidonic acid (C20: 4 ω6) increased with urea and Linoleic acid (C18:2 ω6c) increased with ($(NH_4)_2SO_4$).

Overall, our findings demonstrate that nitrogen sources can strongly influence growth and biochemical composition in *N. oculata* sp. which represent potentially interesting microalgae for aquaculture purposes.

EFFECT OF DIFFERENT PHOSPHORUS SOURCES ON THE GROWTH AND BIOCHEMICAL COMPOSITIONS OF *Nannochloropsis oculata* CULTURE

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Phosphorus is one of the most important nutritional factors which regulate cell growth and plays a significant role in most cellular processes. It is an essential nutrient element for chlorophyll synthesis it is also a key factor for lipid accumulation in microalgae and protein synthesis. The Effect of different phosphorus sources on the growth and biochemical composition of *Nannochloropsis oculata* sp. (*N. oculata sp.*) was investigated in this study. Three treatment (Mono potassium phosphate) KH_2PO_4), calcium super phosphate ($CaH_6O_9P_2$), and media without any phosphorus sources were all compared to F/2 media which has Sodium Di hydrogen Phosphate (NaH_2PO_4) as a control at concentration 36 μmol $^{-1}$. The experiment lasted for 15 days under the conditions of 100 µmol photons m^2s light intensity (L/D= 24:0), salinity 25 ppt, 23± 1 °C , pH 7.5 ±0.3. The growth of (*N. oculata sp.*) based on cell density and dry matter was inhibited in the medium with no phosphorus (5.3×10^6 and 0.71 g/l), and increased significantly in the medium with NaH_2PO_4 (16.4×10^6 and 0.95 g/l.). All phosphorus sources showed that there were significant differences ($P\leq0.05$) between all treatments media in chlorophyll a content, (KH_2PO4) was achieved the highest significant chlorophyll a content (chl a) with 4.25 mg/l followed by (NaH_2PO_4) 4.12 mg/l . Cell treated with (NaH_2PO_4) produced the highest total protein, lipid 31.14% and 46.63% by dry weight, respectively. Media without phosphorus had the highest total carbohydrate 22.48% while the lowest total lipids and total carbohydrate achieved by (KH_2PO_4) and ($CaH_6O_9P_2$) had the lowest total protein 25.90%. Our results suggest that phosphorus sources could influence significantly cell density, dry matter, chl a contents and biochemical composition of *N. oculata sp.*

Table (1): Effect of Different Phosphorus Sources on Cell density (CD), Dry Matter (DM), Chlorophyll a content (Chl a) and Biochemical Compositions of *N. oculata* sp.

Algal Growth				Biochemical Compositions		
Media	**CD ×10^6**	**DM (g/L)**	**Chl a (mg/g)**	**Protein %**	**Carbohydrate %**	**Lipid %**
KH_2PO_4	13.52±0.10 ^{c}	0.77 ± 0.017 ^{c}	4.27±0.032 ^{b}	29.11 ± 0.491^a	12.36 ± 0.221 ^{c}	36.60 ± 3.014 ^{b}
NaH_2PO_4	16.43±0.26 ^{a}	0.95 ± 0.020 ^{a}	4.86±0.020 ^{a}	31.14 ± 0.614 ^{a}	20.55 ± 1.274 ^{a}	46.63 ± 3.956 ^{a}
$CaH_6O_9P_2$	15.32±0.18 ^{b}	0.88 ± 0.010 ^{b}	4.07±0.014 ^{c}	26.70 ± 1.080 ^{b}	22.48 ± 1.406 ^{a}	37.10 ± 1.286 ^{b}
Without P	5.30±0.20 ^{d}	0.71 ± 0.010 ^{d}	3.08±0.013 ^{d}	25.90 ± 1.627 ^{c}	12.46 ± 0.191 ^{b}	45.01 ± 1.771 ^{a}

THE CORRELATION BETWEEN WATER QUALITY PARAMETERS AND CYANOBACTERIA LOAD IN NILE TILAPIA (*Oreochromis niloticus*) pond AND ITS IMPACT ON FISH HEALTH

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The present work aimed at investigating the interactions between the water quality parameters and the abundance of cyanobacteria in tilapia fish pond during the rearing period. The study was conducted at a fish farm (1.5 acre) located at the eastern shore of Qarun lake –Sinnoris – El Fayoum Governorate-Egypt. Water quality parameters and algae load were measured monthly for seven months. Water temperatures were between 21°C and 29°C along the stocking season. pH of water in the selected pond was recorded between neutral and slightly alkaline (7.25 and 8.4). dissolved oxygen (DO) recorded values were between 4.24 and 8.66 mg/l. Biological oxygen demand (BOD) was between 3.2 and 5.2 mg/l. The pond water showed low transparency between 9.5 cm and 13.5 cm. Water salinity values go through 2.7 and 6.3 PPT. Nitrate concentrations were between 2.17 and 4.845mg/l. The total ammonia ranged from 1.0 to 4.6 mg/l, while the Phosphate levels ranged between (0.39 and 1.07 mg/l). Along the monthly examination of the fish pond water from April to October a total number of 32 genera of algae were identified which varied according to sampling time. The highest algal count number was in October (43600 org. /ml) and the lowest was in June (5394 org. /ml). The average relative density of cyanobacteria to total phytoplankton was 2.5 to 11.3%. October exhibited the highest values of blue green algae counting 1067 org./ml while the lowest values were estimated on September (400 org. / ml). Liver and muscle tissue showed pathological changes in response to bad water quality as liver showed congestion in portal area and vein with necrosis in the pancreatic acini and dilatation in the central vein with inflammatory cells infiltration, while musculature showed focal aggregation of dead neutrophils and focal area of fibrosis. It was concluded that there was great correlation between different water physio-chemical parameters and algae growth in general and with cyanobacterial load with subsequent effect on general fish health.

AQUAPONICS SYSTEMS FOR REUSE WATER IN CONTINENTAL FISH FARMS : PRELIMINARY STUDY OF THE FEASIBILITY OF ITS INTRODUCTION IN MOROCCO

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The aquaculture sector continues to grow rapidly across the globe but its environmental impacts are growing as well. Considering the risks carried by classical aquaculture systems, it is necessary to develop responsible aquaculture. This is achievable by reducing the needs for water and nutrients as well as limiting waste and effluents. To this end, a shift to integrated agri aquaculture systems is a prerequisite.

Aquaponics has proven to be an effective means of recirculating aquaculture and horticulture with a decreased environmental impact. The advantages it presents earned it a growing interest worldwide as environmentally friendly expedient to achieving a larger resource productive growth.

In this context, a preliminary study of the feasibility of the introduction of aquaponic systems in continental fish farms was conducted. Thus an aquaponic system was installed. Effluents from the Silver carp (*Hypophthalmichthys molitrix*) tank are redirected to plants (lettuce, pepper, mint), instead of being discharged into the environment. Fish waste is transformed by bacteria into nutrients that can be absorbed by plants. Purified water is then returned to the fish tank. Every week, the height of each plant was measured in centimeters. Dissolved Oxygen, pH, water temperature, NO3-, NO2- and NH3 were also measured. The growth of fish was determined by measuring body weight and total length. Also, for each sampling, Feed Conversion Ratio (FCR) and Specific Growth Rate were calculated. Variation in the measurements was expressed as the mean ± S.E.

The preliminary results are encouraging. Fish and plant growth rates were remarkable: no pathological abnormality was observed in fish. The mean growth of Silver carp had significantly improved during days of the experiment at ($\alpha \leq 0{,}05$). Comparing the average initial length (15,12 ± 1,50cm) and the average initial weight (60,68±19,15g), to the final experiment results, the average final length was 18,25 ± 1,89cm, and the average weight was 85,06±20,10g. Plants grew fast with no pesticide nor fertilizer input (The height was between 2,11 cm and 4,05 cm). Furthermore, the water quality was very good (water temperature (19-22°C), PH (6-7,3).

This study showed that the application of the aquaponic system has significant influence at nitrogen reduction (NO2- (12,6%), NH3 (19,04%) and NO3- (15,1%). In light of these results, recommendations were issued aiming to nurture the development of aquaponics in Morocco in the future.

DETERMINING THE OPTIMUM LEVEL OF DIETARY PROTEIN AND FEEDING FOR IMPROVING THE GROWTH PERFORMANCE AND FEED EFFICIENCY OF JUVENILES HYBRID TILAPIA (*Oreochromis niloticus× Oreochromis aurea*) REARED IN BRACKISH WATER

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Feed quality can be measured with diet content of protein level, and feed cost can be greatly reduced if optimal dietary protein levels could be fed to the fishes. The primary goal of every researcher is to determine the optimum protein level of tilapia and increase farms' profits. Decreasing the dietary protein level had more pressure on body protein because of the dietary nutrients needed to meet the demand of tissue protein synthesis, maintenance, and metabolism, causing the fish growth reduction and enhancing mortality. In contrast, the excess protein in the fish diet leads to making new proteins and the remainder would be directed toward the deamination of amino acids to produce energy consumption; thus, increasing the excretion of ammonia in the reared ponds. Furthermore, knowledge of feeding levels is important for achieving the best growth and feed efficiency and preventing water quality deterioration due to overfeeding.

A factorial experiment 2 × 2 was conducted to inspect two dietary protein levels with two feeding rates on performance and feed use of hybrid juvenile tilapia (*Oreochromis nilotiucs* × *Oreochromis aurea*). This trial was conducted in a fish feeding laboratory, Faculty of Aquaculture and Marine Fisheries, Arish University for 6 weeks. This trial examined two dietary protein levels, 27% and 34% CP with 5% and 7% of biomass, and each treatment was in triplicate. Twelve plastic tanks (54 × 38 × 28 cm: L × W × H) were used to accomplish this work. Fishes had an average initial weight of 7.5 ± 0.16 g and were stocked at 12 juveniles/tank. Fishes were fed three times daily and 6 days weekly. The water exchange rate was about 20% of water volume/ tank every day. Water quality parameters were within the optimum limit for rearing tilapia during the experimental period (Table 1). The results showed that dietary protein levels from 27% to 34% did not significantly affect growth and feed use (Table 2). However, 7% feeding rate had significantly higher growth parameters than 5% (Table 3). Statistical analysis of the interaction between dietary protein and feeding levels showed that fishes fed at 7% as the feeding level with dietary protein at 27% or 34% was significantly higher in growth than those fed at 5% with the same diets. Also, it confirmed the significant difference in specific growth rate and survival rate of fishes fed at 7% as feeding rate with any diet protein level (Table 4). Thus, this study suggests that 27% CP with 7% as feeding rate is more for the best growth of hybrid tilapia juvenile under the same conditions of this trial.

TABLE 1. Means of water physiochemical parameters during the experimental period.

Items	Minimum	Maximum	Means	SE
Temperature	25.5	29.00	28.22	0.329
pH	7.20	8.80	8.21	0.164
DO, mg/l	5.8	7.40	6.61	0.187
ammonia, mg/l	0.03	0.15	0.08	0.011

TABLE 2. Effect of dietary protein regardless the feeding level on growth indicates:

Items	Dietary protein		SED*
	27% CP	34% CP	
WG, g	8.19	10.48	1.69
SGR, %/day	1.72	2.05	0.24
SR, %	79.14	87.51	5.86
FCR	2.50	2.14	0.17

TABLE 3. Effect of feeding level regardless the dietary protein on growth indicates:

Items	Feeding level		SED*
	5%	7%	
WG, g	6.86^{b}	11.81^{a}	0.96
SGR, %/day	1.53^{b}	2.24^{a}	0.137
SR, %	75.04^{b}	91.61^{a}	3.73
FCR	2.44	2.20	0.19

TABLE 4. The interaction between dietary protein and feeding level

Items	Dietary protein with feeding level, % of biomass				SED*
	27% CP x 5%	27% CP x7%	34%CP x5%	34% CP x7%	
WG, g	5.83^{c}	10.55^{b}	7.88^{c}	13.08^{a}	1.01
SGR, %/day	1.37^{b}	2.08^{a}	1.70^{b}	2.40^{a}	0.144
SR, %	66.68^{c}	91.60^{a}	83.40^{b}	91.62^{a}	0.11
FCR	2.72	2.28	2.17	2.12	0.24

(a, b, c) Average in the same row having different superscripts are differ significantly (P≤0.05)
*** SED is the standard error of difference**

EFFECT OF DIFFERENT LEVELS OF FEEDING DURING ACCLIMATIZATION IN HIGH SALINITIES ON GONADOSOMATIC INDEX AND SURVIVAL RATE OF ADULT RED HYBRID TILAPIA, *Oreochromis sp.*

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Red tilapia can grow and productive in a wide range of salinity water, the direct transfer from fresh water to marine water or vice versa results in fish died because severe dehydration which might impair the function of NaK-ATPase activity and is not enough to compensate for ionic exchange requirements at high salinity. The acclimatization success from fresh to marine water relates with many factor such as methods of acclimatization, temperature, fish age, salinity level and feeding. Feeding and their systems during acclimatization periods of fish are considered undetermined factors. Moreover, feeding of fish is essential to compensate for the energy consumed in osmoregulatory mechanisms and modifying the physiological case under acclimatization conditions. Therefore, it is believed that optimum feeding level has a vital role to raise the quality acclimatization and survival rate of fish.

A 15 day acclimation experiment was conducted to determine the optimum feeding level during an acclimatization period to marine water for improving survival rate and gonadosomatic index (GSI) of adult red hybrid tilapia in high salinities. Red tilapia were randomly distributed into 8 square plastic tanks with dimensions of (55 cm × 38 cm × 29 cm; L×W×H) and water volume 60 liter. Fish with an average initial weight 48.75±2.39g were stoked at 6 fish/ tank (3 male + 3 female). All tanks were provided with continuous aeration. Red tilapia were reared under natural photoperiod conditions. Fresh water was replaced with marine water for raising the salinity rate of 3.8 ppt. every day for 11 day. After this period the salinity of water was equal the salinity of Mediterranean Sea (38 ppt). This trial tested four different levels of feeding rates during fish adaptation from fresh water to marine water. The first treatment (T_1) was a control group and their fish did not feed the second treatment (T_2) fish fed with feeding rate 0.5% of their biomass, while the third treatment (T_3) and the fourth treatment (T_4) fish fed with feeding rates 1% and 2% of their body weight, respectively. Fish fed a commercial diet containing 27% crude protein (floating pellets 3mm) Table (2) Feed was offered by hand in two meals/day (9:00 a.m. and 16:00 p.m.). Water temperature, dissolved oxygen (DO) and pH, were recorded daily before adding the marine water and measured by multi parameter water quality analyzer (MULP-8C). The statistical analyses appeared significant differences among treatments and confirmed that the growth and GSI indicators are affected by different feeding levels. 0.5% (T2) and 1% (T1) as feeding rates for adult red hybrid tilapia during the acclimatization period had the best and highest in these indicators in comparison with the control treatment and T4 (table 1 and 2).

It could be conclude that the determination of feeding rate of the acclimated fish is very important to improve the acclimatization quality of adult-red tilapia. Where, the feeding rates 0.5% and 1% are suitable to mitigate the stressful conditions that accompany the acclimatization to high salinities. Also, a higher feeding level than 1% for the acclimated adult red tilapia leads to the adverse results.

Table 1. Effect of different feeding rates on the growth performance measurements of hybrid red tilapia under the salinity acclimatization conditions

Items	Feeding rates of biomass			
	0% (T_1)	0.5% (T_2)	1% (T_3)	2% (T_4)
FW (g)	50.25^{b}	53.65^{a}	52.77^{a}	50.50^{b}
FL (cm)	14.4	15.5	15.5	14.5
WG (g)	1.50^{c}	4.90^{a}	4.02^{ab}	1.75^{bc}
ADG (g/day)	0.10^{b}	0.33^{a}	0.28^{a}	0.12^{b}
RGR (%)	3.07^{c}	10.04^{a}	8.22^{ab}	3.60^{bc}
SGR (%/day)	0.20^{c}	0.63^{a}	0.53^{ab}	0.23^{bc}
FI (g/fish)	0.00	2.87^{c}	6.56^{b}	14.19^{a}

TABLE 2. Effect of different feeding rates on morphological indicates of hybrid red tilapia under the salinity acclimatization conditions

Items	Start	Feeding rates			
		0%(T_1)	0.5%(T_2)	1% (T_3)	2%(T_4)
SR (%)	100	58.00	74.00	75.00	66.00
CF (%)	1.52	1.68	1.44	1.42	1.66
GSI (%)	0.83	0.86^{ab}	0.97^{a}	1.16^{a}	0.40^{b}

Means of treatments in the same row with different superscripts letters are significantly differ (P<0.05).
SE = Standard error.

USING CLOVE AND MINT OILS AS NATURAL SEDATIVES TO INCREASE THE TRANSPORT QUALITY OF BROODSTOCK NILE TILAPIA (*Oreoccromis niloticus*)

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Providing fry for farms in the optimum time and suitable amounts with a high survival is considered one of the success factors of cultured tilapia in Egypt. Therefore, foundation hatcheries near rearing ponds encourage providing seeds before starting the production season in high quality to avoid transportation costs. The transportation of tilapia brood-stock from collection sites to the hatcheries needs to take some precautions to reduce the associated stress during transportation, such as the shock of the transportation means, a small volume of transport tanks or plastic bag, a high density, a decrease in the level of dissolved oxygen (DO), an increase in the total ammonia and carbon dioxide, and the accumulation of metabolic and organic wastes.

The present study was conducted to create a new strategy for increasing the transport efficiency of brood-stock Nile tilapia (Oreoccromis *niloticus*) using clove and mint oils for 3.5 h. The fish study was exposed to conditions simulating those normally used in transporting. This study was performed in a fish research center of the Arish University. The average initial weight of the brood-stock was 117.07 ± 09.07g (± standard error). The brood-stock was randomly distributed into 10 clear plastic aquaria (30-liter capacity) with a stocking density of one brood-stock/3.75 liter of water. The present study examined two concentrations of clove oil as a deep anesthetic for 5 min. and two concentrations of mint oil as a sedative. It includes five treatments in duplicate, which were: the control group, G1: clove and mint oil at 100 and 20 µL/L, respectively; G2: 100 and 10 µL/L of clove and mint oil, respectively; G3: 50 and 20 µL/L of clove and mint oil, respectively; and G4: 50 and 10 µL/L of clove and mint oil, respectively. Blood samples were taken before transporting from a random sample and after transporting from every group.

Using clove oil as a deep anesthetic agent at a concentration of 100 mg/L for 5 min before transport, thereafter changing the transport water and adding the mint oil at 20 mg/L achieved a high quality of tilapia brood-stock transport, with duration of 3.5 h.

This strategy recorded the best water quality, hematological parameters, and highest SR, followed by the transported brood-stock using 100 mg/L of clove oil and 10 mg/L of mint oil (Table 1 and 2). Decreasing the dose of the pre-deep anesthetic agent (clove oil) to 50 mg/L resulted in decreased transport efficiency. The transported brood-stock without the use of sedative oils has the worst parameters of water quality, blood indicators, and SR that reached 50% after 24 h of the transport.

TABLE 1. Means values of blood parameters

Items	Treatments						PSE*
	before	control	G1	G2	G3	G4	
Hb g/dl	6.55^{a}	5.30^{c}	6.20^{ab}	5.85^{bc}	5.45^{c}	5.55^{c}	0.142
Glucose mg/d	54^{f}	145^{a}	74^{e}	86d	117.5^{c}	128^{b}	9.63
Cortisol, mg/l	6.70^{c}	17.21^{a}	8.36^{c}	9.17^{c}	13.74^{b}	15.17^{ab}	1.20
AST U/l	24^{b}	68^{a}	30^{b}	25^{b}	35^{b}	28^{b}	4.55
ALT U/l	6	12.5	7.5	6	6	6.5	0.89

Means within the same row with different superscript letters are significantly different at $P < 0.05$
*, Pooled standard error

TABLE 2. Survival rate after transporting directly and after 24 hours.

parameters	Treatments					PSE*
	control	G1	G2	G3	G4	
SR, % after transporting directly	75^{b}	100^{a}	100^{a}	100^{a}	100^{a}	3.41
SR, % after 24 hr of transporting	50^{c}	100^{a}	100^{a}	87.5^{ab}	77.5^{b}	6.46

Means within the same row with different superscript letters are significantly different at $P < 0.05$.
*, Pooled standard error

IMPROVING THE GROWTH, FEED EFFICIENCY AND HEMATOLOGICAL INDICATORS OF NILE TILAPIA FINGERLINGS *Oreochromis niloticus* USING DIETARY LACTIC ACID SUPPLEMENTATION WITH DIFFERENT FEEDING SYSTEMS

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Egyptian aquaculture suffers from increasing production costs; feed cost as high as ~50% of the total production cost. Therefore, increasing utilization of feed and improving its management can help reduce production costs. Feeding management one of tools which plays a great role in reducing feed costs by avoiding overfeeding, which reduces the amount of uneaten feed, thereby maintaining water quality for as long as possible. Feeding fish at the optimal time of the day and proper frequencies may optimize growth and feed efficiency and reduce waste. Additionally dietary acidifiers improve feed efficiency and nutrient availability in various aquatic species by lowering digestive pH in the stomach and foregut, Moreover it can reduce harmful microorganisms and promote beneficial microflora colonization of the gastrointestinal tract.

A 42-day trial 2 × 2 factorial study was conducted to investigate the importance of using lactic acid (LA) as a feed additive in different feeding regimes on the performance and feed efficiency of Nile tilapia fingerlings *Oreochromis niloticus*. This study was designed to evaluate two levels of feed additives 0% and 1% LA with two feeding systems—1) half of the daily meal was given in the morning and the other half in the afternoon and 2) 3/4 of the daily meal was given in the morning and the other 1/3 in the afternoon. The average initial weight of fingerlings was 15.33 g ± 3.5 (SE); fingerlings were stocked in 12 plastic aquaria (60 liters), with six fish in each aquaria. A commercial diet of 30 % crude protein was used with a feeding rate of 3% of the biomass; the water exchange rate was 20% of the volume of the water aquaria every day. Mean values of water physicochemical parameters during the experimental period were within the recommended values for aquaculture growth and tilapia culture. Results appeared, fishes that were fed a diet containing 1% LA showed better growth performance than those fed a basal diet without LA. Moreover, there were no significant differences in feeding systems regardless of the addition of LA. The interaction between the tested factors (dietary LA and feeding system) was significantly higher for all parameters in fishes that were fed a diet containing 1% LA and given 50% of their meal in the morning, followed by fishes that were fed a diet without LA and given 75% of their meal in the morning and fishes that were fed a diet containing LA with 75% of their meal in the morning. Fishes that were fed a diet without LA with 50% of their meal in the morning had the lowest growth rate and FCR. Additionally, blood parameters improved in the same manner of growth parameters. Finally this study recommends that using 1% of LA as feed additives in tilapia feed improves the fish performance regardless the used feeding system but In the case of using a diet without LA it is preferable to feeding the fish with 75 % of their daily meal in the morning.

TABLE 1. Growth performance

Items	WG, g	SGR,%day^{-1}	FCR
Effect of adding lactic acid (LA) as feed additive			
(A1) Diet containing 1% AL	11.84±1.88^{a}	1.41±0.26^{a}	1.59±0.38
(A2) Diet without LA	7.92±0.86^{b}	1.053±0.16^{b}	2.11±0.47
Sig.	0.05	0.05	0.40
Effect of feeding system			
(B1) 1/2 of daily meal in the morning	11.10±2.24	1.346±0.29	1.92±0.55
(B2) 3/4 of daily meal in the morning	8.67±0.51	1.123±.133	1.78±0.30
Sig.	0.31	0.50	0.82
Interaction between dietary lactic acid and feeding system			
A1×B1	16.02±0.33^{a}	2.003±0.026^{a}	0.75±0.016^{b}
A1×B2	6.17±0.88^{c}	0.690±0.085^{c}	3.10±0.370^{a}
A2×B1	7.67±0.50^{b}	0.830±0.046^{c}	2.42±0.180^{a}
A2×B2	9.67±0.28^{b}	1.410±0.030^{b}	1.13±0.105^{b}
Sig	0.001	0.005	0.001

Values are means of triplicate groups in the same Colum with different superscripts (a,b.c) are significantly different ($P \leq 0.05$).

TABLE 2. Blood indicators

Items	Treatments				Sig.
	A1×B1	A1×B2	A2×B1	A2×B2	
WBC (10^9/l)	111.73^{b}	176.20^{a}	134.40^{ab}	130.21^{ab}	0.02
RBC (10^{12}/l)	2.30	2.30	2.6.00	2.10	0.50
HB (g/dl)	3.90^{b}	6.50^{a}	5.400^{a}	4.43^{ab}	0.04
Glucose (mg/d)	72.00^{b}	81.00^{a}	79.00^{a}	75.00^{b}	0.03
AST (U/l)	112.60^{b}	128.30^{a}	102.67^{b}	76.60^{c}	0.00
ALT (U/l)	31.33	35.66	35.00	34.30	0.97
Urea (mg/dl)	11.26	15.00	15.60	15.60	0.10

Values are means of triplicate groups in the same row with different superscripts (a,b.c) are significantly different ($P \leq 0.05$)

TILAPIA LAKE VIRUS (TILV): CURRENT STATUS AND FUTURE PERSPECTIVE

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Presently, tilapia is ranked among the top ten aquaculture species in terms of both quantity and value. In terms of freshwater fish production in the world, tilapia ranks third, just after silver and grass carp. It is one of the most popular farmed fish in the world as it is farmed in 78 countries, with China ranking first; Egypt is the largest producer of tilapia in Africa and the third internationally, just after Indonesia). The popularity of tilapia is reflected in the data produced by the FAO, according to which, global tilapia aquaculture production has grown from 0.3 million tons in 1987 to 5.9 million tons in 2017.

Tilapia Lake Virus (TiLV) is a globally emerging virus that leads to mass mortality in cultured and wild tilapia worldwide. The scientific knowledge about TiLV is limited, and many important questions remain unanswered. The virus was first reported from Israel followed by other countries, making it a cross-border animal disease with economically damaging effects.

Although accurate detection methods exist, there is a need for the development of more specific and sensitive diagnostic methods. Also, further studies on the pathogenesis and prognosis of the disease would help in the development of suitable preventive measures. Since farmers associated with tilapia aquaculture belong to lower-income groups, the focus is on developing cost-effective, precise diagnostic methods that do not require extensive laboratory facilities. The development of selectively bred resistant tilapias could also be a way to reduce the mortality rate.

In order to prevent and reduce the spread of the virus, much work is being focused on better screening of live fish transports at national and international borders. Along with this, good operational management practices are necessary, including the application of appropriate biosecurity measures (e.g., the proper use of disinfectants, and the quick removal of moribund and dead fish from affected ponds). In addition, since stress factors in fish play a major role in the severity of virus outbreaks, they should be reduced through appropriate management measures.

Currently, commercial vaccines are not available for TiLV prevention; however, research is ongoing to develop an effective and affordable vaccine. In addition, improved exchange of information or extensive studies on the factors associated with the field outbreaks, such as the water temperature, the pond used, the water parameters, agricultural practices, and the transport of live fish, are helpful as this could lead to appropriate control measures.

a) An outbreak of TiLV infection with high mortality, tilapia are shown floating dead at the water surface b) Clinical signs of TiLV-infected Nile tilapia showing exophthalmia, ascites and scale protrusion.

NUTRITIONAL FISH DISEASES- HOW TO AVOID

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The Aquaculture industry has witnessed an outstanding expansion during the last three decades. There has been a gradual shift from semi-intensive, low-input aquaculture practices to more intensive production systems, with increasing dependence on nutritionally complete diets, throughout the life cycle of farmed animals. This huge shift in aquaculture requires that more attention be given to aquaculture nutrition, nutritional formulation and aqua feed technology. In this regard, the nutritional requirements and feeding practices of cultured aquatic species, should be a top priority, since formulation and production of well-balanced feeds are the most important requirements for successful aquaculture. Poor feed formulation and feeding practices can lead several "nutritional fish disorders". This will likely lead to severe economic and environmental losses.

This review sheds the light on nutritional diseases of farmed aquatic organisms, including protein, lipids, carbohydrates, vitamins and minerals disorders. Endogenous anti-nutritional factors and adventitious toxic factors present in foodstuffs are also highlighted. Morphological signs of nutrient deficiency and toxicity are presented and discussed, together with disease prevention and treatment protocols.

POTENTIAL AND CHALLENGES OF HATCHERY-BASED BIVALVES AQUACULTURE IN EGYPT: AN EMERGING INDUSTRY

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Aquaculture is the largest fish source in Egypt. It represented ~ 80.5% of total fish production in 2019. Egypt is among the top ten world aquaculture producers (6th in 2019) and top in Africa with fish yields from aquaculture ~ > 1.6 million tonnes/ year. However, other than fish, only shrimp is cultured in Egypt. Egypt has no reported mollusk production from aquaculture and insignificant production from fisheries (0.24% of total fish production). Total bivalves and cockles from fisheries was 4966 tonnes at revenue value of ~149 million EGB in 2019).

Egypt represents a promising country for bivalve aquaculture as it has extended coastlines of ~ > 2000 km that have extended fishing areas of ~ 4.6 million ha for possible use as coastal farms and 65000+ feddan registered marine fish farms. This is in addition to many native and exotic commercially important bivalves with confirmed market locally and worldwide. Therefore, there is increasing interest in bivalves' aquaculture in Egypt for local market and as export commodity.

There are few capture-based clam farms in Egypt. They are based on the collection of seeds from the wild (mainly Lake Timsah, Ismailia) and growing clams to market size. The number of farms steadily increased in the last decade from one farm in 2010 to ~ 50+ farms in 2020. However, the production is still limited by disease transfer from the wild and the un-continuous seed supply to these farms, as there is no commercial bivalve hatcheries in Egypt. Bivalve aquaculture industry is promising and has bright future. It is environmentally sound kind of aquaculture, low cost as no feed needed for grow out, more profitable than fish culture, confirmed customers and market as local demand exceeds fisheries-based supply, and finally possible export markets.

Lack of the knowhow of hatchery-based bivalve aquaculture, lack of knowledge of the benefit and revenues of this industry and lack of trained personnel on bivalve hatcheries' technology and management were the main reasons for no attempted establishment of this industry in Egypt.

However, Egyptian scientists transferred the know-how of hatchery-based bivalve aquaculture from USA during the last decade. Additionally, customer discovery surveys showed promising future for the technology especially with the acceptance of the idea of converting to bivalves by marine fish farmers to solve many problems they are facing with fish aquaculture sector. The total expected addressable market for seeds from commercial hatcheries to supply only 5% of existing marine fish and bivalve farms can contribute sale value of > 277 Million EGB+ per year.

In conclusion, if established and expanded in Egypt, commercial hatcheries will increase bivalve seeds to support the production of currently existing bivalve farms and encourage investors to establish new farms supporting national seeds' demand. Developing this industry will develop and expand hatchery-experienced personnel, provide employment opportunities, especially for fishers and poor coastal communities in rural areas that represent clean areas suitable for bivalve aquaculture. To do that, collaborative effort is urgent from scientist, government, policy-makers, farmers, fishers, etc. to overcome the many constraints that will face such new industry in Egypt.

DIFFERENT REARING ENVIRONMENTAL TEMPERATURES MODULATES GROWTH, ANTIOXIDATIVE, IMMUNE AND GENE EXPRESSION RESPONSES IN BLUEGILL SUNFISH (*Lepomis macrochirus*)

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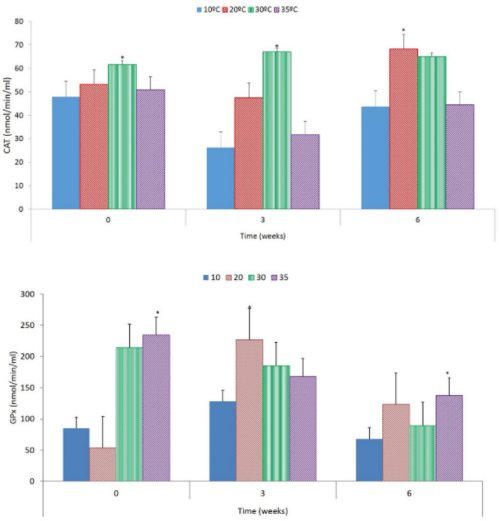
Temperature stress affects growth, physiological function, and immune function in various fish species. The current research evaluated the potential effects of different water rearing temperatures; 10ºC (10.3 ± 0.05), 20ºC (20 ± 0.06), 30ºC (29.8 ± 0.08), and 35ºC (34.6 ± 0.05) for 6-weeks on growth, antioxidative, immune and gene expression profiles of bluegill sunfish (*Lepomis macrochirus*). Sampling was performed at zero day, and the end of the third and sixth week. Growth performance (SGR and BMG) and condition factor were considerably influenced by variations in water temperature with the best performance for the 30ºC group and the lowest possible for the 10ºC group.

Temperature significantly affected the SOD, CAT and GPx activities with higher ($P < 0.05$) superoxide dismutase (SOD) in erythrocyte lysate in the 10ºC, 30ºC and 35ºC mostly pronounced at the 6th week**.** CAT activity showed most significant increase for 20ºC at 6 weeks (Fig. 1)**.** While GPx activity showed the most significant increase for 35ºC at day 0 and 6 weeks and for 20 ºC at 3 weeks (Fig. 2)**.**

The immune (lysozyme U/ml, and nitric oxide pmol/ml) parameters gave the highest increase in 20ºC groups at 6 weeks. The parameters values decreased and low (10ºC) and high (30 and 35ºC), with optimum values at intermediated temperature (20ºC). The expression pattern of immune related gene α-2-macroglobulin (A2M) gene was higher for 20 and 30ºC groups and lower in 10ºC group. Also, heat Shock protein-90 (HSP-90) was notably high for 20, 30, and 35ºC groups..

Conclusively, our results demonstrated that temperature variations markedly alter growth antioxidants, and immune profiles; with the best performance at intermediate temperatures indicating the possible usage of tested parameters as indicators for temperature changes in aquaculture.



ESTIMATION OF GENETIC PARAMETERS AND THEIR GXE INTERACTIONS BY NON-INVASIVE METHODS FOR CARCASS TRAITS ON GILTHEAD SEA BREAM (*Sparus aurata*)

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Gilthead sea bream (*Sparus aurata* L.) is one of the most important species in the Mediterranean aquaculture. In the last quinquennium, implementation of genetic improvement programs has drawn the attention of gilthead sea bream producers to maintain a sustained growth in a competitive way. Although the organization of the industrial production based on genetic criteria increases the production costs, and at the beginning shows low genetic progress rate in short term, the genetic improvements provide a tool for a continuous, cumulative and permanent growth in the industry. Thus, the main objective of the current study was to determine the additive genetic variability for biological traits (growth and carcass) in a F2 generation of PROGENSA II project (National project in Spain; Improving the competitiveness of the sector of the gilthead sea bream through genetic selection). The data provided represent an important source of information for the design and establishment of genetic breeding programs in this species.

In order to study the existence of additive genetic variability, between carcass traits and their estimated counterparts by engineering technologies or technological traits, progenies obtained from the selected bloodstocks in two research centers (PCTM –ULPGC; Canary Island, and IFAPA; Andalusia, Spain), belonging to the second generation of the genetic improvement program PROGENSA II, were tagged by Passive Integrated Transponder (PIT), and mixed at the two research centers and two Spanish companies (ADSA; Canary Island and PIMSA; Andalusia, Spain). At harvest size, fish were sampled for growth, carcass, and technological traits, these last by IMAFISH software. Pieces of caudal fin were taken and conserved in ethanol for pedigree analysis. Genotyping and parental assignment were inferred by genetic characterization of all breeders and offspring, by using the SMsa-1 multiplex PCR (Super Multiplex *Sparus aurata*), containing 11 specific microsatellite markers. Genetic parameters (heritability and genetic and phenotypic correlations) for carcass and morphology traits were estimated. Genotype–environment interactions (GxE), at harvest size, were estimated by genetic correlation between two facilities (ADSA and PIMSA).

Heritability estimates ranged from 0.09 to 0.22 for growth traits, from 0.04 to 0.35 for carcass traits, and the highest were reported by technological traits from 0.09 to 0.40 (table1). The genetic correlations for growth traits were mainly high, for carcass traits were medium, and for the technological traits were high. GxE interactions for all traits, at harvest size, were measured considering two facilities, and they were mainly medium-high for all traits, except for FHA and FHB, which were low. These data suggest that GxE interactions cannot be discarded as morphological aspects, and the new non-invasive technological traits present better additive genetic variation than biological traits, and that could lead a faster selection response to improve growth and morphology of the fish through increased accuracy of breeding values and selection response rates.

TABLE 1. Heritabilities (in bold at the diagonal, with ± standard error), phenotypic correlations (below the diagonal) and genetic correlation (in italics above the diagonal, with standard error) for growth, carcass and technological traits in gilthead sea bream, at harvest size.

	FLM	CF	Dressing %	FilletW	FilML	TaEL	FoL	FHA	FHB	FHC	FHD	FHE
FLM	**0.22±0.05**	*0.67±0.16*	*0.26±0.26*	*0.95±0.03*	*1.00±0.01*	*1.00±0.01*	*1.00±0.00*	*0.95±0.05*	*0.97±0.03*	*0.95±0.04*	*0.92±0.05*	*0.96±0.10*
CF	0.09	**0.09±0.03**	*0.67±0.36*	*0.81±0.10*	*0.65±0.19*	*0.64±0.18*	*0.56±0.21*	*0.67±0.15*	*0.68±0.15*	*0.69±0.16*	*0.71±0.18*	*0.62±0.25*
Dressing %	0.03	-0.46	**0.04±0.02**	*0.48±0.30*	*0.19±0.35*	*0.22±0.34*	*0.13±0.34*	*-0.04±0.33*	*0.11±0.32*	*0.07±0.26*	*0.25±0.26*	*0.17±0.38*
FilletW	0.85	0.45	0.16	**0.35±0.07**	*0.99±0.02*	*0.98±0.02*	*0.96±0.05*	*0.94±0.04*	*0.96±0.03*	*0.94±0.06*	*0.94±0.04*	*0.92±0.13*
FilML	0.71	0.18	0.02	0.65	**0.29±0.08**	*1.00±0.00*	*0.99±0.01*	*0.97±0.04*	*0.99±0.2*	*0.99±0.01*	*0.97±0.02*	*0.96±0.05*
TaEL	0.79	0.21	0.03	0.71	0.93	**0.29±0.07**	*1.00±0.00*	*0.96±0.03*	*0.97±0.02*	*0.98±0.01*	*0.98±0.02*	*0.98±0.05*
FoL	0.64	0.12	0.02	0.58	0.93	0.85	**0.25±0.07**	*0.96±0.03*	*0.97±0.03*	*0.99±0.01*	*0.98±0.02*	*0.98±0.03*
FHA	0.61	0.27	0.01	0.57	0.56	0.6	0.49	**0.17±0.05**	*1.00±0.00*	*0.96±0.03*	*0.90±0.07*	*0.92±0.10*
FHB	0.67	0.35	0.01	0.65	0.5	0.61	0.4	0.92	**0.22±0.06**	*0.97±0.03*	*0.93±0.05*	*0.93±0.10*
FHC	0.69	0.31	0.02	0.69	0.9	0.85	0.93	0.57	0.54	**0.40±0.10**	*0.99±0.01*	*0.97±0.03*
FHD	0.57	0.26	0.04	0.58	0.75	0.72	0.78	0.18	0.2	0.83	**0.22±0.07**	*0.92±0.07*
FHE	0.3	0.1	-0.02	0.3	0.7	0.55	0.81	0.07	-0.04	0.72	0.7	**0.09±0.04**

MOLECULAR CHARACTERIZATION OF Vibrio spp. AFFECTING FARMED *Oreochromis niloticus* WITH SPECIAL REFERENCE TO; VIRULENCE, ANTIBIOTIC SUSCEPTIBILITY, PATHOGENICITY AND HISTOPATHOLOGICAL ALTERATIONS

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Vibriosis is one of the most serious diseases affecting fish farming industry worldwide. The study aimed to identify *Vibrios* spp. causing infections and mortalities in farmed Nile tilapia, *Oreochromis niloticus*. Haemorrhages, exophthalmia, fin rot, erosions and ulcerations were commonly observed in moribund fish. Poor water quality parameters, management practices and biosecurity measures were reported in all investigated farms. Thirty eight Vibrio isolates were obtained and identified from investigated specimens using phenotypic and molecular identification methods. *Vibrio alginolyticus* was the most prevalent isolate (37%), followed by *Vibrio anguillarum* (24%), Vibrio vulnificus (18%), *Vibrio paraheamolyticus* (13%) and *Vibrio cholera* (8%). Different virulence genes were detected in all tested isolates. Vibrios exhibited resistance against some antibiotics. The highest resistance was noticed against amoxicillin and tetracycline. Pathogenicity of vibrio isolates were confirmed by experimental infection in *O. niloticus*. Challenged fish showed signs of septicemia and variable mortality with numerous histopathological alterations. Our findings highlight the risk of vibrios to farmed *O. niloticus*, point to the need of effective control and biosecurity measures to protect fish health.

GAMETOGENIC CYCLE, SEX RATIO, AND SIZE AT FIRST SEXUAL MATURITY OF *Paracentrotus lividus* FROM THE SOUTHEASTERN MEDITERRANEAN, EGYPT

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A total number of 2024 individuals of purple sea urchin *Paracentrotus lividus* was collected on monthly basis during the years 2017-2020. The specimens were collected manually by scuba diving from locations close to the coastline off Alexandria City. The main objective of this study was to describe the gametogenic cycle, sex ratio and size at first sexual maturity of *P. lividus* from the southeastern Mediterranean, off Alexandria coast, Egypt.

Four different maturity stages were recognized after histological analysis of both female and male gonads (stage I: Recovery, stage II: Growing, stage III: Mature, and stage IV: Spent) (Fig. 1). In our study, the gametogenesis cycle (stage I and II) began in Jan and reached its peak in Mar followed by a release of the mature gametes during Apr and May. Afterwards, there was a high abundance of nutritive phagocytes from Jun to Aug. Generally, the gametogenic cycle of the Egyptian *P. lividus* population off Alexandria Coast reveal two incidences of spawning where gonads become in the stage of development, maturation, ripening and spawning during late autumn and early winter and mid-winter and late spring, then they become resting and in the stage of recovering during the summer months.

The sex of sea urchins was examined by the macroscopic examination or with a smear examination, and the sex-ratio (♂/♀) was determined. The result of the chi-square test showed that there is a significant difference in sex ratio from a 1:1 ratio among different months. In the months Mar, May, Aug, Sep, Oct & Dec 1:1 sex ratio was observed, while in the months of Jan, Feb, Apr, Jun, Jul & Nov the sex ratio was in favor of the males (1: 1.2).

In order to determine the size at first sexual maturity of *P. lividus* a subsample of 416 individuals was analyzed histologically. The recovery stage was considered immature, while the remaining stages; the growing, mature and spent; were grouped and considered the mature stages. In males, the smallest observed mature individual had 19.10 mm test diameter (TD) and the calculated L50 was reached at 20 mm. For females, the smallest observed mature individual had 22.70 mm TD and the calculated L50 was reached at 20 mm. As L50 for both males and females were equal then both sexes reach maturity simultaneously. This study may help in the regulation of the fisheries of *P. lividus* to protect its natural stock from over-exploitation.

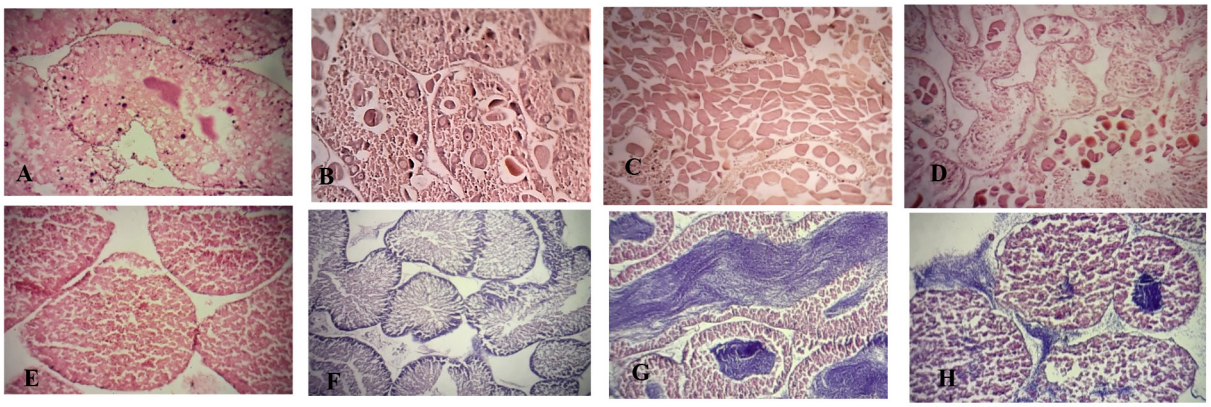

Fig. 1. Histology of the ovary (A: Recovery, B: Growing, C: Mature & D: Spent) and Testis (E: Recovery, F: Growing, G: Mature, & H: Spent) showing the four stages of maturity of *P. lividus* off the coast of Alexandria, Egypt.

STRUCTURE GENETIQUE DES POPULATIONS SAUVAGES ET D'ELEVAGE DE TILAPIA DU NIL, *Oreochromis niloticus* AU BENIN BASEE SUR LA TECHNOLOGIE *SNP* A L'ECHELLE DU GENOME

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Au cours des trois dernières décennies, l'élevage du tilapia du Nil *Oreochromis niloticus* (Linné, 1758) s'est considérablement développé dans le monde entier. Il est considéré comme l'un des poissons d'élevage les plus productifs et les plus commercialisés au niveau international. Ainsi, dans le but de proposer une souche locale performante aux acteurs de la pisciculture béninoise, des études ont été conduites afin de (i) caractériser la structure et la diversité génétique de différentes populations de *O. niloticus* collectées au Bénin et (ii) tester les performances de reproductions de cinq populations.

Au total 12 populations réparties dans les bassins du Mono, de l'Ouémé, du Niger, de la Volta, dans deux fermes d'élevage ont été échantillonnées au Bénin et une population a été échantillonnée dans un centre de recherche de l'université de Liège en Belgique. Les résultats révèlent que de toutes les populations collectées au Bénin, celle de Nangbéto du bassin du Mono reste la plus différentiée génétiquement (F_{st} from 0.091 to 0.278) comparativement aux autres populations avec un degré de consanguinité élevé (F_{is} = 0.206). Il ressort également que les populations de Gbassa, de Togbadji, de Bétérou et de la Pendjari présentent les degrés de consanguinité les plus faibles (F_{is} variant de -0.014 à 0.055).

Aussi, au vu des performances de reproduction et de croissance enregistrées, les populations de Sohoumè et de Togbadji enregistrent les meilleures performances, mais compte tenu des degrés de consanguinité enregistrés pour ces différentes populations, celle de Togbadji pourraient être un potentiel candidat pour la pisciculture béninoise.

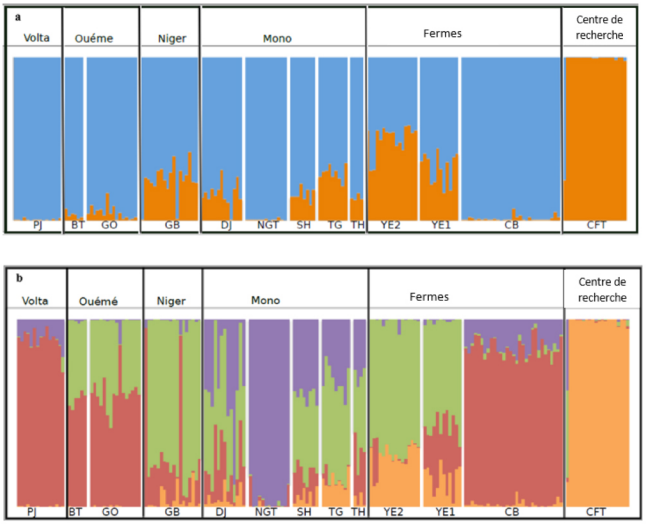

Figure 2. Résultats d'assignation de structure (a) suivant K = 2 (K1 en orange et K2 en bleu), (b) suivant K = 4 (K1 en orange, K2 en rouge, K3 en vert, K4 en violet). L'appartenance à la grappe de chaque spécimen est représentée par la composition des couleurs des lignes verticales, la longueur de chaque couleur étant proportionnelle au coefficient d'appartenance estimé.

IN VITRO ASSESSMENT OF ANTIMICROBIAL ACTIVITIES OF SOME ESSENTIAL OILS AGAINST BACTERIAL INFECTIOUS FISH PATHOGENS

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This study was performed to evaluate the minimum inhibitory concentration (MIC) of some essential oils against pathogenic bacteria strains in aquaculture. This *in vitro* trial was carried out by a micro dilution assay using liquid cultures in 96-well microplates. Eleven (11) essential oils were screened against three pathogenic bacteria including *Aeromonas salmonicida salmonicida*, *Vibrio harveyi*, *Flavobacterium psychrophylum*. Regulatory issue, environmental concerns and chemistry expertise were considered for the selection of screened ingredients.

Results showed that synthetic cinnamaldehyde (62.5-125 mg. L^{-1}), synthetic thymol (62.5-125 mg. L^{-1}) and natural oregano essential oil (125-250 mg. L^{-1}) had the lowest MIC against these three strains followed by natural tea tree and eucalyptus essential oils. From all strains tested, *A. salmonicida salmonicida* is less sensitive to active phytogenics except for synthetic thymol and cinnamaldehyde and natural oregano EO. Moreover, these three active phytogenics showed the highest antibacterial activity against all studied strains. From all active phytogenics, natural lemon and pine EOs revealed the lowest antibacterial activity with the highest MIC against three bacterial strains (4000-16000 mg. L^{-1}). Natural tea tree, lavender, eucalyptus, garlic and caraway Eos showed relative inhibition activity following bacteria strains. Overall, phenolic and aldehyde compounds tested were the most antibacterial against these three strains.

From these preliminary data, it might be interesting to combine relevant active ingredients for further in vitro and potentially in vivo trials against these pathogenic bacteria strains.

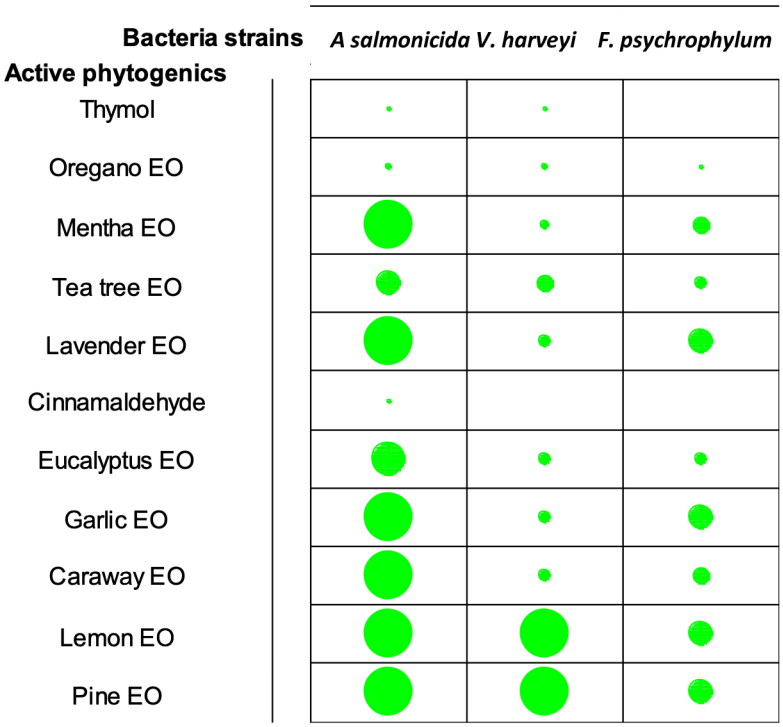

Figure 1: Minimum Inhibitory concentration of some essential oils on three (3) pathogenic bacterial strains. ***Lower is the balloon, lower is the MIC***. EO = Essential oil.

ETUDE DE LA PHYSIOLOGIE DE LA REPRODUCTION DE LA CARPE COMMUNE *(Cyprinus carpio,* L.) A MADAGASCAR : IMPLICATIONS DANS LE DÉCALAGE DE LA SAISON DE PONTE

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Sur les hautes terres de Madagascar, la carpe commune, *Cyprinus carpio,* est l'espèce la plus utilisée en rizipisciculture familiale. Parmi les producteurs locaux, un réseau d'environ 1 000 écloseries paysannes accompagnés par l'ONG APDRA Pisciculture Paysanne, assurent une production d'alevins accessible localement avec des techniques de reproduction semi-contrôlées en système extensif et ont une production de 4 000 à 10 000 alevins par producteur. Dans ces conditions d'élevage, exposées à la prédation par des insectes aquatiques et à un déficit d'alimentation exogène, la production d'alevins varie de 2 000 à 5 000 alevins.kg^{-1}.femelle^{-1}. A Madagascar, la carpe se reproduit naturellement à partir de septembre, juste au début de l'été austral, lorsque la température de l'eau atteint 22 à 25 °C. Le pic de reproduction a lieu en octobre. Ce mois coïncide normalement avec le début de la saison des pluies permettant l'arrivée d'eau dans les casiers de riz et leur empoissonnement en alevins de carpe. Cependant depuis plusieurs années, compte tenu du changement climatique, l'arrivée des précipitations est retardée de 1 à 2 mois. Dans ce contexte, des initiatives d'innovation paysanne visant à faire coïncider la production d'alevins avec l'arrivée des pluies ont été accompagnées.

Deux approches techniques ont été étudiées. La première consiste à augmenter le nombre de pontes annuelles d'une même femelle en stimulant l'ovogénèse naturelle de cette dernière. La seconde consiste à prolonger la durée de la phase de dormance des ovocytes ou la deuxième phase d'ovogenèse afin de différer la ponte. Les objectifs de cette étude étaient de 1) caractériser les pratiques d'élevage permettant de prolonger la phase de dormance des ovocytes ; et 2) d'évaluer les conditions environnementales et la physiologie de la reproduction favorisant son succès. Avec la participation de 60 pisciculteurs, un total de 420 cycles de reproduction de femelles ont été suivis entre 2017 et 2020.

La prolongation de la phase de dormance des ovocytes est bien décrite dans la littérature pour la carpe commune. En effet, une température inférieure à 17 °C permet de bloquer l'évolution des ovocytes pendant plusieurs mois avant de passer à la maturation ovocytaire puis à l'ovulation. Ce contrôle de la température en dessous de 17 °C, n'étant pas réalisable localement, les pisciculteurs ont su adapter leurs pratiques et obtenir avec succès un décalage des pontes pendant plusieurs mois à une température moyenne de 22 °C dans leurs conditions socio-environnementales.

L'utilisation de petits étangs pour stocker les femelles au début de l'hiver, facilite la gestion du stockage et la maitrise de la période de ponte. Pendant la période de stockage, les pisciculteurs évitent toute modification de l'environnement d'élevage (e.g. chocs thermiques, changement brusque de la qualité de l'eau, alimentation) qui peuvent stimuler la production de gonadotrophine responsable de la maturation finale des ovocytes et la ponte, favorisant la réussite du décalage. L'analyse multivariée des variables mesurées et l'historique des pontes a permis de démontrer, que le décalage des pontes n'est pas héréditaire chez la carpe commune. L'analyse de l'ovogénèse a permis également de mettre en évidence l'absence d'effet négatif sur la qualité des œufs et des larves issus de pontes décalées.

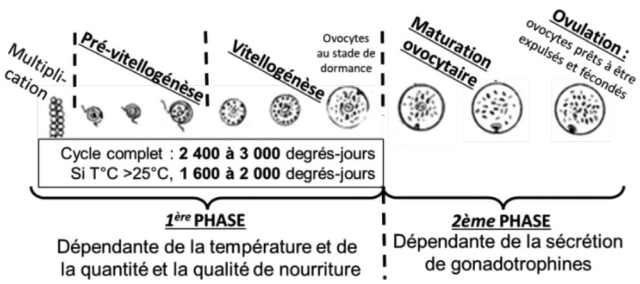

Fig. 1 : Stades de développement ovocytaire

IMPACT OF AQUACULTURE COMPACT, TECHNOLOGIES FOR AFRICAN AGRICULTURE TRANSFORMATION PROGRAM ON AFRICA'S TILAPIA SEED PRODUCTION

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Aquaculture plays an important role in food security and nutrition by providing high-quality animal protein especially for pregnant women, babies and children in the first 1,000 days. It also creates employment and sources of livelihood. Fish seed is a basic input for successful aquaculture and plays an important role in providing food and an income. However, aquaculture seed systems are confronted by many constraints including inadequate technical know-how, poor access to credit, poor quality broodstock and low survival rate (below 65%) to fingerling stage. The Technologies for African Agricultural transformation (TAAT) program funded by African Development Bank through the Aquaculture Compact led by WorldFish deployed aquaculture technologies to increase productivity in 12 African countries: Benin, Burundi, Cameroon, Cote d'Ivoire, DR Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo and Zambia.

Two selected fish breeders from each country were trained in 2018 and 2019 at the WorldFish Regional Training Centre, Abbassa, Egypt on broodstock management, mass production of mono-sex tilapia, larval rearing techniques, and feeding. Demonstration sites were identified in the selected countries and supported with improved broodstock and other quality production inputs. Step-down trainings were also conducted in the countries. Private sector fish farms and hatcheries were used to build capacity of other fish breeders to facilitate accelerated technology adoption and scaling up. The intervention to increase fish productivity and availability of quality fish seed of mono-sex tilapia produced more than128,269,800 tilapia fingerlings in the 12 countries. Mass production of fingerlings in hapa, use of probiotics, pairing brood stock ratio accompanied with Better Management Practices (BMPs) were successfully disseminated and adopted by 31,951 fish breeders as beneficiaries effectively using the technologies. The adoption of these technologies in these countries has resulted to higher survival rate of fingerlings (>90%) and increased production. To scale up the technologies, several African governments including Malawi, Zambia, Cameroon and Benin have accessed loans from multilateral donors which are made available to small and medium scale fish farms and enterprises.

Although the TAAT Aquaculture Compact has successfully overcome the challenges of tilapia seed production system in Africa, funding of long-term genetic improvement programs is necessary to maintain the path towards increased productivity of farmed tilapia.

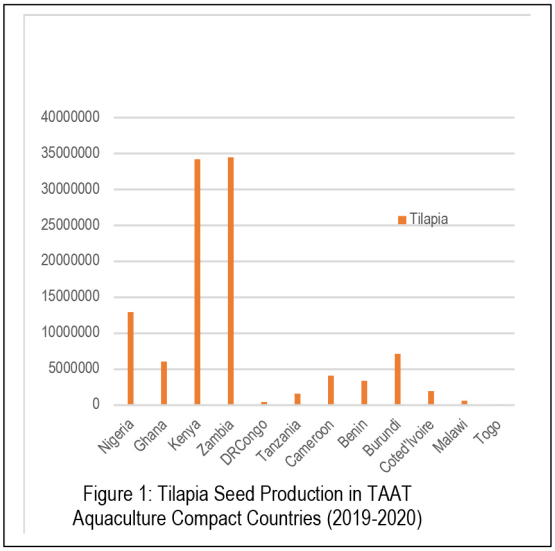

Figure 1: Tilapia Seed Production in TAAT Aquaculture Compact Countries (2019-2020)

AQUACULTURE VALUE CHAIN ASSESSMENT IN OYO STATE, NIGERIA

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Fisheries sub-sector of the Nigerian economy has potentials in addressing problems of poverty and unemployment presently confronting the nation. The sub-sector has contributed approximately US$ 2.5 billion to the country's GDP and supports about 7 million people directly and indirectly (NBS, 2014). It is a major source of protein for many poor people who could not afford meat from livestock. Despite the total available land of 1.75million hectares for aquaculture development in Nigeria, production was 311,903.00 million metric tonnes, (FDF, 2015).

The study made an assessment of the aquaculture value chains in Oyo State, Nigeria in order to provide a baseline understanding of key dynamics of the sub-sector. It provided an intermediate inventory of actors in the different segments along the value chain; considered how these various segments have changed over time, geography and what has influenced these changes.

The meso analysis methodology was used for the study. In the first stage of the survey, a rapid reconnaissance survey of different actors along aquaculture value chain (hatcheries, feed mills, feed dealers, fish farmers, fish processors and marketers) were undertaken. Information was collected from individuals or group through key informant interviews or Focus Group Discussions (FGDs) respectively. Based on data collected, aquaculture actors were classified as small, medium and large.

Results show that Ibadan and Oyo zones have the highest concentration of fish actors, followed by the Ogbomoso zone and Oke-Ogun and Ibarapa. High cost of feed especially the imported extruded feed and domestically sourced feed ingredients are major challenges to fish farmers. Although *Clarias species* are well adapted to the harsh production environment, attempts to grow all male tilapia has been successful, though restricted to reservoirs and gorge by four large scale fish farms. Majority of the catfish production is rainfed, making it impossible to do more than one cycle of cropping in a year by majority of the fish farmers. Fish processing by smoking is used as strategy to overcome the low pricing of middlemen.

In order to attain the potential of fish production in Oyo State, the WorldFish Center and other relevant institutions in Oyo State have to assist to upgrade tilapia and catfish brood stock strains for production of high-quality fish seeds for small scale fish farmers to increase fish yield under better management practices.

Table 1: Criteria for sizes of aquaculture value chain actors

Actor	Criterion	Size Category		
		Small	Medium	Large
Hatchery	Number of fish seed per annum	< 1 million	1-5 million	> 5million
Feed mill	Tons of feed produced per annum	< 240	240-600	>600
Feed dealer	Tons of feed sold per annum	<150	150-400	>400
Farmer	Tons of fish produced per annum	<100	100-1000	>1000
Processor	Tons of processed fish per annum	<10	10-60	>60
Marketer	Tons of fish sold per annum	<30	30-520	>520

Bacillus clausii: A NEW EFFICACIOUS IMMUNE-STIMULANT, GROWTH PROMOTANT, AND ANTIOXIDATIVE PROBIOTIC FOR THE WHITE-LEG SHRIMP *Litopeneaus vannmei* CULTURE

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Outbreaks of bacterial-related diseases are one of the main obstacles that impede the sustainability of the white-leg *Litopeneaus vannmei* shrimp culture in many countries. Many studies praised probiotic application in aquaculture owing to their capacity to decrease the density of pathogenic bacteria. Probiotics have mostly been recorded to enhance hematological and immunological parameters. Furthermore, they can sustain barrier function and regulate gene expression pathways. Since aquatic animals are mainly dependent on their innate immune response, this system may contribute resistance against pathogens. The feasibility of continuous and intermittent application of *Bacillus clausii* on immune, growth, and stress responses in *Litopeneaus vannmei* has been assessed before and after *Vibrio parahaemolyticus* ($_{AHPND)}$ bacterial challenge by evaluating changes over time of some immune-related gene expression; prophenoloxidase (ProPO), serine proteinase (SP), transglutaminase (TGase), lysozyme (LYZ); and superoxide dismutase (SOD).

A total of 315 *L. vannamei* weighted 0.78 g ± 0.08 (SE) were divided into three experimental groups; each group consisted of 3 replicates. Frist group (T1) was considered as a control, the second group (T2) fed *B. clausii* supplemented diet (2×10^9 CFU/kg feed) daily throughout the experiment. In contrast, the third group (T3) fed *B. clausii* supplemented diet (2×10^9 CFU/kg feed) for a week followed by a week of basal diet alternatively.

The findings before the bacterial challenge manifested that proPO of (T2) expressed significantly in 1st, 4th, 7th and 12th weeks, while ProPO of (T3) showed significant expression in 1st, 4th and 12th weeks. In (T2 and T3), SP was expressed highly in the 1st, 2nd and 12th weeks. TGase and LYZ of (T3) presented significant up-regulation in the 1st, 4th, 7th and 12th weeks. TGase of (T2) expressed in 1st, 4th and 7th weeks. LYZ of (T2) expression levels increased significantly in the 2nd, 4th, 7th, and 12th weeks. (T2) SOD was up-regulated in 1stand 4th weeks, while (T3) SOD expression levels significantly increased in 1st and 7th weeks.

Furthermore, unlike the previous study by the researchers on other Bacillus species, there was no significant difference between continuous and intermittent application of *Bacillus clausii* on immune, growth, and stress responses in *Litopeneaus vannmei*

The researchers concluded that, after induction of *Vibrio parahaemolyticus* ($_{AHPND)}$ infection, the response of most tested immune genes of two treatment groups with the two application schemes showed no significant differences, suggesting that; unlike others; the continuous use *of Bacillus clausii* as a probiotic may not exhaust shrimp immune system.

EFFECTS OF DIETARY SELENIUM NANOPARTICLES ON THE GROWTH PERFORMANCE OF AFRICAN CATFISH, *Clarias gariepinus* (Burchell, 1822)

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Abstract
This study assessed the effects of dietary Selenium nanoparticles (SeNP) supplementation on the growth performance of African catfish, *Clarias gariepinus*. One hundred and fifty (150), apparently healthy *C. gariepinus* fingerlings with the average weight of 4.69±0.10 were randomly distributed into a rectangular tank of 40x30x35cm^3 at ten (10) fish per tank. Selenium nanoparticles (SeNP) was supplemented in the fish diets at 0, 0.50g, 1.00g, 1.50g and 2.00g /100g levels in treatments T1 (control), T2, T3, T4 and T5 respectively. The experiment was in three replicates. The fish were fed for 56 days at 5% body weight twice daily at 8.00hours – 9.00hours and 16.00hours – 17.00hours GMT. The fish were weighed weekly and the feed intake adjusted according to the fish weight gain. After the feeding trials, results showed that Selenium nanoparticles supplementation significantly improved the growth performance of fish with increasing Selenium nanoparticles supplementation. Fish fed with 1.00gSe/g had the highest protein efficiency ratio (1.04 ± 0.18), weight gain (10.13g ± 0.34) and growth performance. In conclusion, this study showed that 1.00gSe/g is sufficient to ensure good nutrient utilization and growth performance of *Clarias gariepinus* fingerlings.

Introduction
Fish is an excellent source of amino acid, vitamins and high quality unsaturated fatty acid, it is a food of excellent nutritional value, providing high quality protein and a wide variety of vitamins and minerals including vitamin A and D, Phosphorus and Selenium (Agbabiaka 2014). The aquaculture industry has been globally recognized as the fastest growing food producing industry (FAO 2010). One current idea is that nanoparticles will enhance aquafeeds by increasing the proportion of fish food nutrients that pass across the gut tissue and into the fish, rather than passing directly through the fish digestive system unused (Handy 2012). Nanotechnology involves the application of materials at the nanoscale to new products or processes (Handy 2012). Among the multifaceted applications of nanoparticles in the fisheries and livestock world, reports are also appearing on enhanced efficacy of nanoscale selenium in reproduction, digestion, growth, and immunomodulation (Hassan et al 2004). It is one of those areas that many aquaculture experts are turning to (Handy 2012). Therefore, Nanotechnology and nanoparticles are increasingly recognized for their potential applications in various aspects of human and animal welfare like development of various healthcare or cosmetic products, nano-electronics and techniques for environmental remediation, and many consumer products (Ahamed et al 2010).

Selenium is a very important trace element that show significant efficiency at nanoscale level. The inclusion of Selenium in the diet of cultured fish has generated much interest as it has been found to have benefits for production, reproduction , normal growth, development and flesh quality, maintenance of fish health, in particular fish immunity(Bell and Cowey 1989). In Nigeria, the African catfish *Clarias gariepinus* is a fish of choice by fish farmers because of its biological attributes that include faster growth rate, resistance to diseases and possibility of high stocking density (Gbadamosi 2019). The fact that fish, especially African Catfish that is widely consumed is a good source of Selenium in the human diet presents an opportunity for fish farmers to produce Selenium-enriched fish for improved human health (Rayman 2012). Therefore, it is important to know the effect of selenium nanoparticles on cultivated fish species like *C. gariepinus* and the required doses for metabolism and proper body functioning. Hence this research is intended to examine the effects of dietary Selenium nanoparticles supplementation on growth performance, nutrient utilization and gut health of *Clarias gariepinus*.

Materials and Methods
Experimental site and Preparation of Experimental diet
The study was carried out at the Research and Teaching farm of the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Akure, Ondo State, Nigeria. The feed ingredients were purchased at Animal Concept, Akure, Ondo State. Selenium nanoparticles was purchased from T2Biosystems, Lexington, USA. Five isonitrogenous diets were formulated to provide 45% crude protein with increasing supplementation levels of selenium nanoparticles (0.00g/100g, 0.50g/100g, 1.00g/100g, 1.50g/100 and 2.00g/100g) designated as T0, T1, T2, T3, T4 and T5 respectively as shown in Table 1. All dietary ingredients were weighed with a sensitive weighing top balance. The ingredients were then ground to a small particle size, ingredients such as selenium nanoparticles, and vitamin premix were thoroughly mixed in the mixture to obtain a homogenous mixture. Cassava starch was added as a binder. The homogenized feed mixture was then pressed without steam

(Continued on next page)

through a mincer attached to a pelleting machine (Hobart A-200T) using a 2mm diameter die. After pelleting, the feeds were immediately sun-dried for 72 hours at ambient temperature of 27-30°C and air dried. After drying, the diets were sieved and stored prior to the start of the feeding trial. Standard and official methods (AOAC 2000) were used to carry out the proximate analyses of the experimental diets in the study.

Feeding Trials

The experimental design was five treatments with three replicates each. A total of fifteen tanks were used. Ten fish (5.61±0.04g) were randomly stocked in each tank and fed to apparent satiation twice daily for 70 days. Fish in each tank was weighed bi-weekly to measure the growth performance. Water parameters were maintained at temperature 27 - 30 °C; dissolved oxygen 6.5-8.3 mg/L and pH 6.0 - 8.5. After 70 days, fish in each tank was counted and weighed. Fish performance evaluation was measured using the following indices as described by Gbadamosi (2019). Mean Weight Gain (MWG), MWG = W_F-W_I. Where; W_F = Final weight, W_I= Initial weight. Specific Growth Rate (SGR), SGR % = Log_e Final weight – log_e Initial weight/ Culture period x100. Feed Conversion Ratio (FCR), FCR = Total Feed Intake/ Total Weight Gain. Gross Feed conversion efficiency (GFCE)**:** GFCE = 1/ FCR X 100. Protein Intake (PI), PI = feed intake x crude protein in the diet/1000. Protein Efficiency Ratio (PER)**,** PER = MWG/Mean PI.

Statistical Analyses

All data collected during the trial were tested for normality using the Kolmogorov–Smirnov test and homogeneity of variance using Levene's test. All analyses were performed using SPSS software version 13 (SPSS Inc.). All values are shown as arithmetic mean ± standard deviation.

Results and Discussion

After eight (8) weeks of feeding trials, the growth performance of *Clarias gariepinus* fed diets supplemented with varying levels of dietary nano-Se is presented in Table 2. Fish that were fed diet supplemented with 1.00g Se/g (T3) displayed significantly better growth performance ($P< 0.05$) than other dietary treatments. Selenium nanoparticles supplementation was found to contribute to fish growth performance, it significantly enhanced the final weight, specific growth rate and weight gain of fish fed 1.00gSe/kg compared to other inclusion levels. Selenium is an essential element for fish normal growth and development (Hamilton, 2004). This result was similar to that of Olson et al (2005), which reported that selenium is a structural component of the physiological antioxidant properties and it acts as a growth promoter. It clearly indicated that Se supplemented diet could improve the final weight and relative gain rate of *Clarias gariepinus,* these results were similar with the ones demonstrated by Xuxia et al (2009) on crucian carp (*Carassius auratus gibelio*). Xuxia et al (2009) concluded that Selenium nanoparticles improves adsorbing ability which result into higher proficiency in digestion and nutrient utilisation exhibited by higher absorption efficiencies in fish.

Conclusion

From this study, supplementary Selenium nanoparticles has been shown to increase growth performance of *C. gariepinus*. The results demonstrate that the weight gain, growth performance and feed utilization parameters of *C. gariepinus* were optimal with the diet contained 1.00gSeN/g. Thus, increasing demand from consumers for higher quality fish which also provides an excellent opportunity to produce fish rich in selenium. Furthermore nanotechnology may help aquaculture production by improving feed formulation and health of *C. gariepinus*.

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Table 1: Composition of the experimental diet in g/100g dry matter containing varying inclusion level of Selenium nanoparticles for *Clarias gariepinus*

	TREATMENTS				
INGREDIENTS	T1(Control)	T2	T3	T4	T5
Fish meal 70%	25.30	25.30	25.30	25.30	25.30
Soybean meal 48%	20.50	20.50	20.50	20.50	20.50
Groundnut cake 45%	23.40	23.40	23.40	23.40	23.40
Yellow maize 10%	20.80	20.80	20.80	20.80	20.80
Starch	3.00	2.50	2.00	1.50	1.00
Selenium NP (g)	0	0.50	1.00	1.50	2.00
Total (g)	100	100	100	100	100

Vitamins premix contains vitamin A (25,000,000 I.U), Vitamin D3 (2,000,000 I.U), Vitamin E (200,000 I.U), Vitamin K3 (8,000mg), Folic Acid (4,000mg), Niacin (150,000mg), Vitamin B2 (20,000mg), Vitamin B12 (10mg), Vitamin B1 (1,500mg), Vitamin B6 (12,000mg), Biotin (800mg), Antioxidant (100,000mg), Vitamin C (500,000mg). Mineral premix contains Selenium (200mg), Iodine (5,000mg), Iron (40,000mg), Cobalt (2,000mg), Manganese (50,000mg), Copper (4,000), Zinc (40,000mg), Choline chloride (600,000mg), Lysine (100,000mg), Methionine (100,000mg)

Table 2 : Growth parameters and nutrient utilization of *Clarias gariepinus* fed varying level of Selenium Nanoparticles.

PARAMETERS	T1(control)	T2	T3	T4	T5	*p*
Initial weight (g)	4.69±0.10^{a}	4.69±0.10^{a}	4.75±0.13^{a}	4.82±0.32^{a}	4.77±0.16^{a}	0.59
Final Weight(g)	11.57±0.35^{a}	12.50±0.39^{a}	14.88±0.26^{b}	12.70±0.31^{a}	11.63±0.26^{a}	0.04
Weight Gain (g)	6.88±0.36^{a}	7.81±0.41^{a}	10.13±0.25^{b}	7.88±0.14^{a}	6.86±0.31^{a}	0.039
Feed Intake (g)	15.96± 0.15^{a}	18.82 ± 0.13^{a}	19.75 ± 0.32^{b}	18.59±0.14^{a}	16.26± 0.13^{a}	0.034
FCR	2.32 ± 0.06^{a}	2.41 ± 0.08^{a}	1.95 ± 0.13^{b}	2.36 ± 0.38^{a}	2.37 ± 0.16^{a}	0.03
PER	0.84 ± 0.02^{a}	0.83 ± 0.01^{a}	1.04 ± 0.18^{b}	0.85 ± 0.17^{a}	0.75 ± 0.28^{a}	0.04
SGR (g)	1.64 ±0.06^{a}	1.71 ±0.06^{a}	2.13 ±0.34^{b}	1.75 ±0.21^{a}	1.56 ±0.50^{a}	0.04
Survival rate (%)	86.66±15.27^{b}	96.66±5.77^{c}	96.66±15.27^{c}	76.66±15.27^{a}	76.66±15.27^{a}	0.04

Figures in each row (mean ± SEM) having different superscripts are significantly different (P< 0.05).
FCR = Feed conversion ratio, PER = Protein efficient ratio, SGR = Specific growth rate.

DIETARY SUPPLEMENTATION WITH *Bacillus species* IMPROVES GROWTH, INTESTINAL HISTOMORPHOLOGY, INNATE IMMUNITY, ANTIOXIDATIVE STATUS, AND EXPRESSION OF GROWTH AND APPETITE-REGULATING GENES OF NILE TILAPIA FINGERLINGS

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This study assessed the impact of dietary supplementation of single and multi-strain *Bacillus*-based probiotics on growth performance, intestinal morphometry, blood parameters, immune-oxidative status, and transcriptomic response of Nile tilapia for 60 days.

Fish (N=150, 1.632±0.035g) were allocated into five experimental groups: 1) Control group (CG) that was fed on a basal diet; 2) Eco. 0.01%, received basal diet with 0.1 g Kg^{-1} Ecobiol; 3) Eco. 0.02%, received basal diet with 0.2 g Kg^{-1} Ecobiol; 4) Pro-F FMC 0.001%, received basal diet with 0.001 g Kg^{-1} Sanolife PRO-F FMC; 5) Pro-F FMC 0.002%, received basal diet with 0.002 g Kg^{-1} Pro-F-FMC.

Fish received Pro-F FMC 0.002% displayed higher growth performance than CG ($P < 0.05$) while Pro-F FMC 0.001% exhibited the highest intestinal weight. Sanolife PRO-F FMC supplementation improved intestinal villi length and goblet cell number while decreased inter villi space ($P < 0.05$). The best hemoglobin, hematocrit, and monocyte percent were observed in Pro-F FMC 0.001% whereas Pro-F FMC 0.002% revealed the best leukocyte, lymphocyte, and neutrophil contents. Pro-F FMC supplemented groups showed better phagocytic activity, phagocytic index, and lysozyme activity than Ecobiol supplemented groups and CG. Pro-F FMC 0.001% enrichment induced the highest up-regulation level of NPYα, AgRp-2, ghrelin and GH-1 whereas Pro-F FMC 0.002% significantly upregulated IGF-1 and IGF-2 gene expression. Eco.0.02% induced the highest up-regulation level of Orexin and Galanin gene expression.

Conclusively, dietary enrichment with single or multi strain *Bacillus*-based probiotics is likely to improve growth, immunological parameters and transcriptomic response of Nile tilapia.

COMMERCIAL SCALE HATCHERY PRODUCTION OF MULLET FRY IN ISRAEL– CHALLENGES AND SUCCESS

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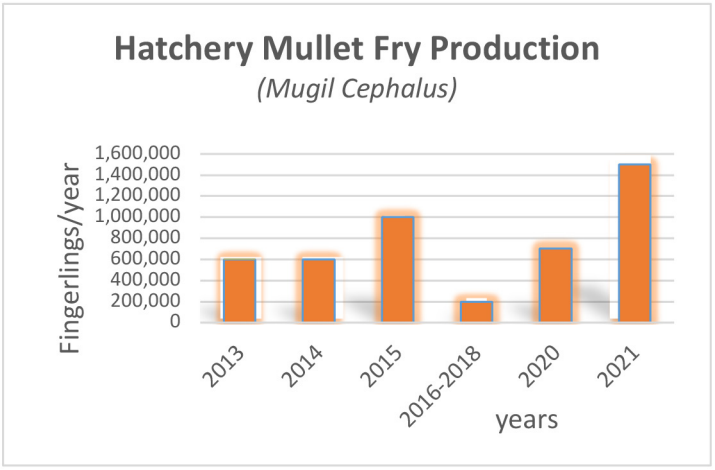
Mullet domestication is an important goal that challenged many countries and research institute for years. It is estimated that Mullet frys are being collected from the wild in several countries at a annual scale of 0.5-1 billion fingerlings. Mullet spawning and juvenile production was achieved at experimental scale in Taiwan in the 1970's and Hawaii during the 1990's, but commercialization of mullet fry production has not succeeded yet in the Middle East (ME). Egyptian and Israeli researchers studied closing the life cycle of the grey mullet in the ME in the 90's, but a stable and predicted spawning process was never achieved at that time, until Israeli researchers at the National Center for Mariculture (NCM) have succeeded to achieve hormonal control of spawning of *Mugil Cephalus*. Larval rearing protocols for mullet were also developed and included guidelines for salinity, water exchange, algal concentration, temperature, aeration, enrichment of live food, and a schedule for weaning onto dry particulate diets. This larval rearing protocol of the grey mullet includes the option of fresh water acclimation during larval development.

This protocol was transferred to several commercial hatcheries in Israel that continued to improve it and produced in the winter of 2013 about 600,000 high quality mullet fry. Recent years has brought significant progress in scaling up of these protocols to a large and commercial scale hatchery production.

During the last 3-5 years repeated production of mullet fry was achieved in Israel, resulting in a capability of routinely producing millions of fingerlings at a size of several grams, ready to be stocked in ponds and reservoirs for rearing.

At present, due to potential limitation in transportation of fry to several countries in the ME, other options of disseminating and collaborating on the capability of mullet fingerlings hatchery-based production could be considered.



USING DESALINATION BRINE FOR SEABASS (*Dicentrarchus labrax)* AQUACULTURE

Hanoch Glassner, Margarita Smirnov, Tamir Ofek, Yiftach Cohen, Benny Ron

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Israeli aquaculture as a hull, and in particular the inland fisheries has been exposed to many threat over the years. One of the main threats is water quantity, quality and price. Israel a semi-arid country suffers constantly from natural water shortage**.** In order to deal with this problem, Israel has taken several measures. Increasing the supply of desalinated water by constructing desalination facilities is one of the main measures. Nearly 90% of the desalinated water is produced in seawater desalination facilities and the other 10% come from brackish groundwater. Groundwater water operate typically contain salinity of 10–15 g L−1; those salinities make these concentrates an attractive potential water source for inland aquaculture in Israel and elsewhere. Other advantages include essentially zero water costs, potential cultivation of valuable marine species, year round convenient temperature of around 22 °C and very low pathogenic risk.

Information regarding fish cultivation in such concentrates is currently very limited. In the current work we examine the potential of rearing fish in concrete produce form a local desalination facilities. We focus on seabass as a model for saltwater fish. The research includes comprehensive chemical analysis of the incoming water, and the rearing water. These test include metal content and, water parameters such as Oxygen, Temperature, PH, Turbidity, Carbon dioxide, Ammonia, etc. Fish growth parameter such as survival, daily growth rate (SGR) and feed conversion ratio (FCR) wera collected during the season.

The brine reservoir (Picture above) was populated in mid April 2020 with 140 gr seabass fishes with 2000 fish per dunam and grown to mid-November to market weight of 450 gr. All growth parameter were the same as the local brackish water protocol (table below).

Fish	Growth period	yield per dunam (Kg)	%survival	SGE	FCR
SeaBass	207	622	89	1.36	2.21

STOCK ENHANCEMENT AND PRODUCTION OF THE GREY MULLET FRY – CODED WIRE TAG (CWT) AS MODEL OF TAGGING FISH

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The Mote project (Stock enhancement and production of the Grey Mullet fry–a sustainable choice; REG/FED/2009/021/-575) which has an overall duration of 48 months, aims to a) to evaluate and optimize stock enhancement of hatchery produced fry as a sustainable approach for mullet production in various water bodies around the Mediterranean countries; b) to advance and improve production of high quality mullet juveniles as an alternative source for stock enhancement and aquaculture production. The overall aim of the proposed project is to provide solutions for grey mullet production in aquaculture and inland fisheries through fingerling production and stock enhancement activities.

Production of mullet in aquaculture and in inland fisheries at present are solely "captured-based fry" operations that utilize dwindling natural stocks and becomes more and more restricted. Therefore the future of mullet production and sustaining these fisheries is definitely dependent on shifting from harvesting wild fry to stock to supply of "hatchery-based fry" for stocking. The Coded Wire Tag (CWT) (Fig. 1) is a well-established tagging technology that has filled a critical void in fisheries – a benign tagging method with high information content that can be used to mark large numbers of small juvenile fish, without compromising fish behavior, health or survival. Coded Wire Tags are non-transmitting and must be extracted and viewed under a low-powered microscope to retrieve the code (Fig. 2), although their presence can be externally detected with electronic detectors (Fig. 3). The present findings indicated that Because of their small size, they can be used in species or life stages that are too small for other tagging methods (i.e. there is no other tag with high information content that can be used to identify multiple batches of small fish in typical stocking events, which require multiple (often many dozens) different tag codes. Since their invention, CWTs have become the most extensively used tags for fisheries management. It is important for fish to be stocked at a time when they are able to adapt to the new environment quickly and thus learn how to forage for natural foods with minimal delay. Determining the appropriate size of fish for release requires knowledge of their potential impacts on local fish and the ecosystem in general, along with a cost-benefit analysis.

This work is a part of the USAED project outputs, " Stock enhancement and production of the Grey Mullet fry – a sustainable choice ", funded by a grant from the Middle East regional cooperation (MERC) program, U.S. Agency for International Development, Bureau for the Middle East. (Project Number: M33-038; Award Number: SIS70017GR33038).

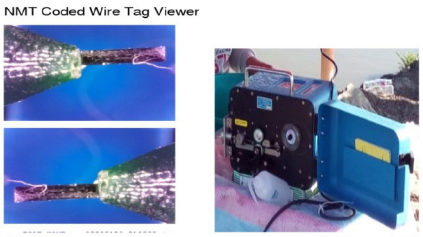

Figure 1 shows Coded Wire Tag (CWT)

Figure 2 shows identify tagging fish samples from fishermen catch.

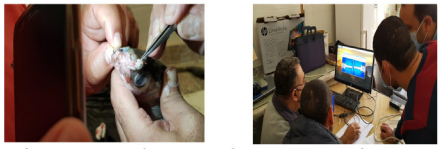

Figure 3 shows the extraction and identify (CWT) number of tagging from the Mullet head

ZONING FOR FISHERIES AND AQUACULTURE IN CAHORA BASSA, MOZAMBIQUE

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The Cahora Bassa Reservoir is in the north-western province of Tete, Mozambique, has a surface area of 2,700 square kilometres, and an east-west orientation. The reservoir and the livelihoods the water body sustain, are of enormous relevance for the economic and environmental prosperity of the province and country. The primary activity in Cahora Bassa is generation of hydroelectric power and water supply; the secondary industries are fisheries, aquaculture, tourism, and transportation.

We present a spatial planning framework based on the existing legal context, establishing zoning priorities for human activities and ecosystem sustainability based on ecological and socio-economic suitability of the system for fisheries and aquaculture (e.g. Aguilar-Manjarrez et al., 2017). The framing of zoning requirements includes constraining factors that account for the legal framework and inputs identified from the Fisheries Management Plan (160/2014), a literature review of biological considerations for the main species of fish and a multi-actor analysis. Visual representation of the spatial planning framework was developed using a Geographic Information System (GIS).

Table 1: Fishing activities and aquaculture calculated areas (km^2) by basin.

	Lake Cahora Bassa basins (km^2)						
	Garganta	Chicoa	Màgoé	Mucanha	Carinde	Mussenguezi	Zumbo
Semi-industrial	6.5	354.8	456.2	147.7	22.8	46.7	0
Aquaculture	36.5	238.3	455.1	246.6	75.0	0.6	0
Subsistence fishing	9.6	35.2	77.1	48.1	14.7	75.2	89.3
Gill net fishing	16.9	110.8	225.1	134.3	36.5	198.6	80.6
Sport and recreational	79.1	555.6	778.5	343.7	79.5	325.6	170.2

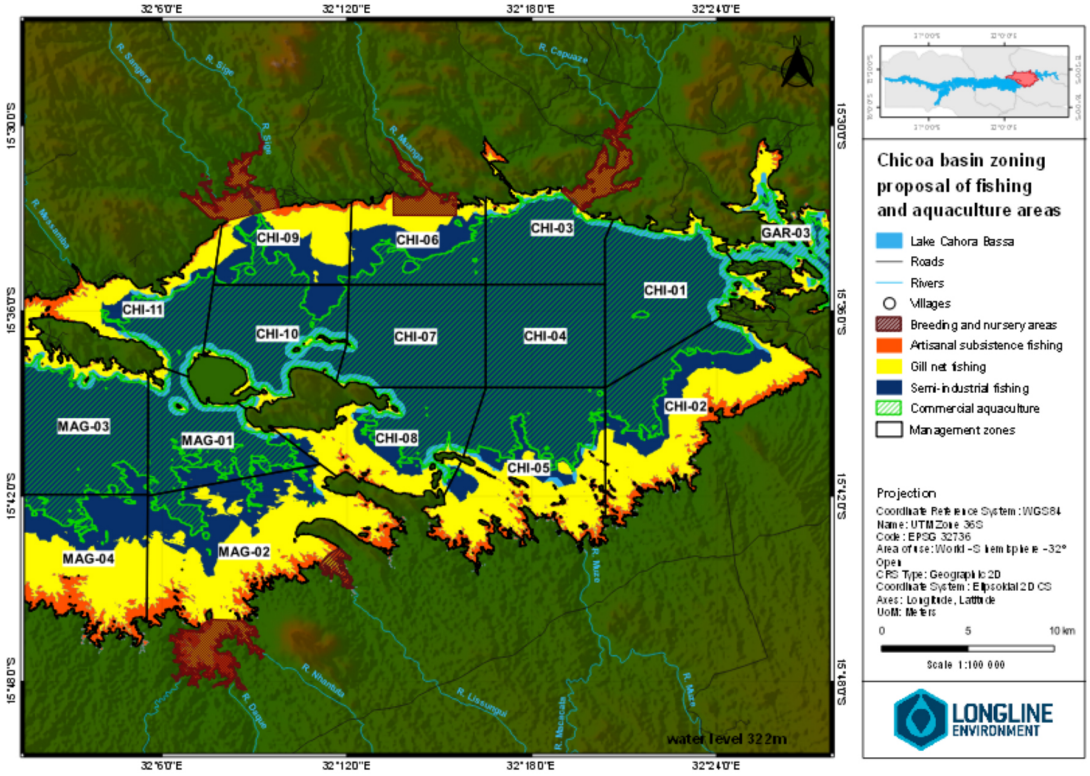

Figure 1: Zoning allocation proposal for fisheries and aquaculture in the Chicoa Basin, Cahora Bassa.

(Continued on next page)

Our framework divides Cahora Bassa into 44 zones across the 7 basins of the reservoir. Zones are defined within basins to ensure there is no cross-over among zones and management through basin-level administration. Table 1 shows the available areas per basin available for each fishing type at a water level of 322 metres above mean sea level.

The seven basins within Cahora Bassa were sub-divided into zones of similar area, with the number of zones varying per basin size. Permitted activities include: 0-5 metres water depth for artisanal fishing without boats and no gill net fisheries; 5-20 metres water depth for artisanal fisheries using boats (e.g. gill netting); >20 metres water depth for semi-industrial fisheries, with the additional limitation of minimum 500 metres distance from inhabited areas (Figure 1).

Each zone is operated through a zonal management agreement (ZMA) by a team that includes a Ministry of Fisheries representative and actors from the artisanal fisheries, semi-industrial fisheries, aquaculture, and tourism sectors. Specific ZMA areas would include the dam operator, Hidroeléctrica de Cahora Bassa (HCB), and other non-fishing stakeholders to ensure their interests are maintained, especially within the Garganta and Màgoé Basins, where power generation activities and National Park interests need to be maintained.

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Fisheries Management Plan for Fisheries in Cahora Bassa 160/2014 (*Plano de Gestão das Pescarias da Albufeira de Cahora Bassa 2014-2018, Diploma Ministerial nº 160/2014*)

SETTING SMALL SCALE FISHERIES IN FOOD AND NUTRITION SECURITY THEMES: ASSESSING CURRENT TRENDS IN SUB SAHARAN AFRICA

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Fisheries food systems provide important ecosystem services in sub-Saharan Africa (SSA), as a source of nutritious food to over 200 million people and offer avenues for countries to attain Sustainable Development Goal (SDG) 2.1. However, there is a dearth of knowledge on pathways of fish to food and nutrition security, especially in the case of inland small-scale fisheries (SSF), which are often underrepresented in research and policy discussions. We adopt a literature review method to assess how fish food systems, specifically those associated with inland SSFs in SSA relate to the four themes of food and nutrition security: availability, access, utilization and stability. The review provides a synthesis of existing knowledge about the role of inland SSF in food and nutrition security, how this role varies across the four pillars, political economic contexts (e.g. development and extent of market integration) and gender dimensions. We offer an assessment of the extent to which each of these pillars of food security have been thoroughly conceptualized and investigated in the literature, identifying important avenues for future research. We then make recommendations on research agendas to enhance sustainable contribution of inland small-scale fisheries to food security.

FOOD SAFETY CONTROLS IN THE AFRICAN AQUACULTURE

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Following three decades of legislation concerning the food safety of fishery and aquaculture products entering international trade, several dominant markets now require the establishment of functional official controls as a condition of import of these important products. This presents significant challenges for developing countries, which experience weak governance, limited technical control capacities, and limited basic infrastructure for compliance. Until now, aquaculture production in Africa has been directed mostly at domestic consumption, but some countries are now actively seeking to develop regional and international markets for their aquaculture products.

This paper reviews the status of development in 55 African countries of official controls for fishery and aquaculture products, using as indicators the establishment of Competent Authorities recognised by the European Commission, results of interceptions of non-compliant products in export markets and audits carried out on the relevant Competent Authorities responsible for food safety. Of these, 29 countries are Listed in Annex I (concerning fishery products) of Commission Decision and two are listed in Annex II (concerning bivalve molluscs). Only eight countries have been able to meet the EU conditions for aquaculture and 26 countries are not able to export any fishery products at all to the EU.

Potential food safety hazards of specific concern in aquaculture include residues of veterinary medicines and other treatments, environmental contaminants in fish and feed (pesticides, PCBs and heavy metals) and in the case of freshwater aquaculture, fish-borne zoonotic trematodes. The paper describes the common control and monitoring measures used by authorities to demonstrate protection against such hazards. This includes controls on distribution and use of veterinary medicines, design, and implementation of residue monitoring programmes for fish and feed, development of capacity of Competent Authorities for official controls on farms and in feed mills (based on HACCP principles) and effective systems of certification and correction of non-compliances.

Trade in live fish (including broodstock, juveniles, ova, and gametes) also introduces the risk of transmission of fish diseases. Although there is no public data to indicate the extent of adoption of Aquatic Animal Health measures, few African countries have developed the essential systems to protect against import and transmission of industry-killing fish diseases.

Incapacity to trade aquaculture products can generate a significant barrier to development, confining distribution to the domestic market even at times of high production. Since expansion of aquaculture production in many African countries is central to development policy, efforts should include the development of effective food safety (and aquatic animal health) controls to meet international requirements. In many cases there is a strong justification for such measures to be applied to all aquaculture production irrespective of the market, to protect consumers and provide a safe investment environment.

SOCIO ECONOMICAL AND WATER QUALITY ANALYSIS FOR THE IMPLEMENTATION OF A TILAPIA CULTURE (POST CONFLICT AREA) IN FLORIDA-VALLE DEL CAUCA-COLOMBIA

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Fish farming generates wealth and food worldwide (FAO, 2018). The department of Valle del Cauca (Colombia) is consolidating as one of the most conducive places for the development of this activity (Merino, 2014). However, it is necessary to obtain more technical-scientific information about this activity (Merino et al., 2013). In this valley, not only converge the ideal hydrographic and climatic conditions for fish farming, but also a strong and develop agro-industry (El País, 2017). In this sense, the possibility of expanding and diversify the economy in Florida, Valle del Cauca, becomes in an important generation of development in this municipality to reduce the rates of unemployment and violence (Guevara, 2011). Consequently, it is necessary build new productive chains such as fish farming in a place where for decades exist armed conflict. The aim of this study was to know the main environmental variables necessary to implement a tilapia culture in an artificial lake farm belonging to the "El Tamboral" association (150 beneficiary families- 2 former guerrilla). In addition, to socio-economically characterize the fish farming activity in the municipality to know processes of purchase, sale, commercialization of this species. Between March-August 2019 were realized 286 and 40 structured and close-ended interviews with 15 question to Florida´s citizens and 13 to food establishments, respectively. The people consider themselves white (58%). They consume mostly Tilapia and trout (41%) and frequently don´t eat fish because of its high cost. People don't eat fish because of its flavor and cost (25%). They like fried fish (67%). The levels of marketing and advertising of the product must be improved (40%). The restaurants mostly claimed not to sell fish (66%). Others, sell various types of fish, being the tilapia the most representative. The sale is made every day (60%). It is bought both in the supermarket and the grocery between 0.6 to 1.2U$ and restaurants sold it between 2.9 to 3.2U$. The cost for the start-up the fish farm (without workers payment), was estimated at 735U$, gain 151-200U$ per month (7-10 months-2000 alevin in 1 tank 19 x 8 x 0.5 m). Water quality was measurement. Transparency (60cm) Temperature (21.5 to 25ºC), pH (6.8 to 7.6), Conductivity (0152 to 0195), Solid Dissolved (0075 to 0096), Nitrite, nitrate and ammonium (close to 0), Total Coliforms (43000 to 54000), thermotolerant coliforms (13000 to 17000) Mercury (no detected), fats and oils (4.6 to 251). WQI index Medium level (Table 1).

Table 1. Weighing value (V_i) and quality (C_i) WQI index (Brown *et al,* 1970).

Variable	Register	V_i	C_i	$C_i * V_i$
%sat.O_2 dissolved	109.6	0.17	80	13.6
fecal Coliforms	15000	0.16	10	1.6
pH	7.3	0.16	95	15.2
(DBO_5)	3.5	0.11	60	6.6
Temperature	23.6	0.11	15	1.65
Phosphate	0	0.1	100	10
Nitrate	0	0.1	100	10
Transparency	60	0.1	30	3
Total Solid	84	0.08	88	7.04
TOTAL				**69**

EFFECT OF AMMONIA ON CARDIOVASCULAR RESPONSE, VENTILATION FREQUENCY AND OXYGEN CONSUMPTION OF MALE ADULT NILE TILAPIA (*Oreochromis niloticus*)

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In teleosts, ammonia is a respiratory gas excreted to the environment from deamination of protein. Ammonia is a toxicant, especially when present as unionized ammonia (UIA). In this study, the effects of UIA on the ventilation frequency (f_V), heart rate (HR) and resting oxygen consumption (MO_2) of adult Nile tilapia (*O. niloticus*) were investigated in a series of experiments conducted under different UIA levels at acute (1h) and prolonged (24h) exposure periods. For the acute exposure, 8 fish (497.16± 36.77g) were exposed to progressively increasing UIA concentrations of 0 (control), 0.004, 0.01, 0.035, 0.061 and 0.097 mM, by injecting pre-determined doses of ammonium chloride (NH_4Cl) stock solution into the experimental water hourly. Measurements of MO_2, HR and *fv* of the individual fish were recorded after one hour of exposure to each UIA concentration. In the prolonged exposure trial, 8 different fish (436.68 ±47.02g) fish were exposed to 0.007 mM- UIA for 24h and the same parameters as the acute exposure recorded. The results of the study showed a significant ($p<0.05$) progressive decline in MO_2, HR and f_V in response to increasing UIA levels (Fig 1). The 24-h exposure also resulted in a reduction of MO_2 and HR by 30% and f_V by 22%. It is evident from this study that Nile tilapia respond to UIA exposure by a depression in metabolic rate and cardio-respiratory work. This is in contrast to what has been described for other species, and may imply the use of a sit-and-wait strategy.

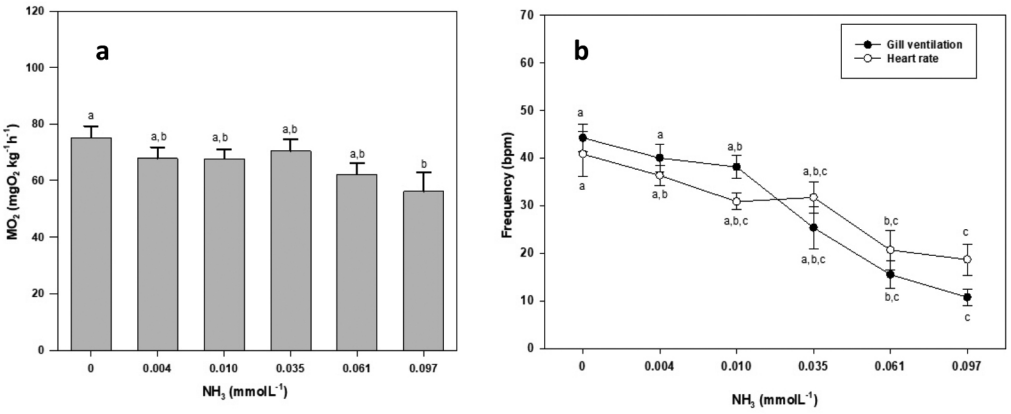

Fig.1 Effect of acute UIA on MO_2 **(a),** *fv* and HR **(b)** of O. *niloticus* at 26ºC. Among treatments, MO_2 varied significantly (P=0.03). Highly significant differences (P< 0.001) were also observed between treatments for Vf and HR respectively, different superscripts indicate significant differences between treatments, n=8

DRIED SEAWEED (*Sargassum ilicifolium*) AS AN ADSORBENT FOR PHOSPHOROUS REMOVAL FROM AQUEOUS SOLUTION (AS SHRIMP FARM WASTEWATER)

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Aquaculture is a source of significant amounts of wastes, which generally leads to deterioration of water quality. Removal of phosphorous (P) from aquaculture wastewater is an important environmental challenge. In the present study, efficacy of dry sea weed (*Sargassum ilicifolium*) to remove water P was investigated under laboratory conditions. Several levels of medium pH (3.5-10), initial Pconcentration (0.015-0.45mgL^{-1}), contact time (7-60min), particle size (0.5-5mm) and the sea weed particle concentration (10-40gL^{-1}) have been monitored. The results showed a high efficiency of the sea weed to remove water P under different conditions (83.1-97.7% P removal). Among the tested pH, 3.5 had the lowest P removal. P removal linearly increased along with time progress. The lowest P removal was observed in the lowest initial P concentration (0.015mg/L), however, there was no significant difference among the groups with initial P concentration of 0.15-0.45 mg/L. P removal in 10g/L sea weed concentration was significantly lower than those of 20 and 40g/L. P removal significantly increased with decrease in sea weed particle size. Regression analysis showed that the weight of factors to remove P from the medium was as follow: particle size (β = -0.659)> particle concentration (β = 0.427)> time (β = 0.227)> initial P concentration (β = 0.190)> medium pH (β = 0.113). In conclusion, dry *S.ilicifolium* is capable to efficiently remove P from wastewater at aquaculture-relevant concentration. The P removal capability of the sea weed markedly increases by decrease in particle size and increase in particle concentration in medium.

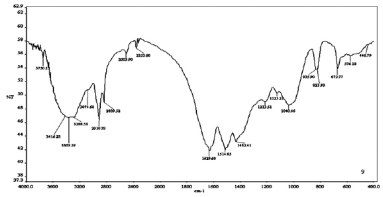

Fig. 1. FTIR spectrum of the seaweed (*S. ilicifolium*)

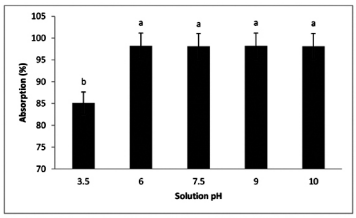

Fig.2: Effect of initial pH solution on P absorption of seaweed. Different letters mean significant difference among the treatments.

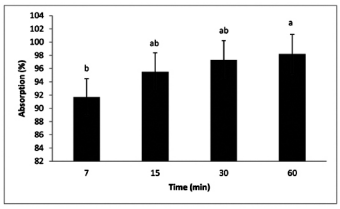

Fig. 3: Effect of contact time on P absorption of seaweed. Different letters mean significant difference among the treatments.

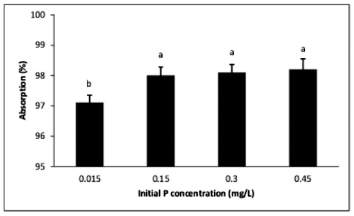

Fig. 4: Effect of initial P concentration on P absorption of seaweed. Different letters mean significant difference among the treatments.

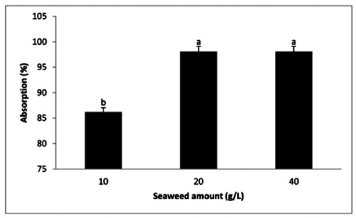

Fig. 5: Effect of seaweed amount on P absorption of seaweed. Different letters mean significant difference among the treatments.

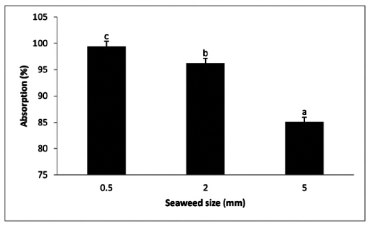

Fig. 6: Effect of seaweed size on P absorption of seaweed. Different letters mean significant difference among the treatments.

THE REPRODUCTIVE PERFOMANCE OF THREE POPULATIONS OF *Oreochromis andersonii* (CAUSTELNAU, 1861) BROODFISH

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More than 50% of fish farming in Zambia grow the exotic *Oreochromis niloticus,* However, *O. niloticus* is a threat to the conservational status of the local strains, whose effects range from hybridization, competition, and predation. To protect local species and for the sustainability of the industry, an indigenous species needs to be promoted for culture in Zambia, presently many authors have suggested *O. andersonii* as the most adequate alternative for culture in Zambia. in order to produce adequate fingerlings needed by the growing aquaculture industry in Zambia, there is need to learn the reproductive biology of the species and its various strains.

Three different Populations were used in the present study including the National Aquaculture Research and Development Centre (NARDC), which had been at the station for more than 10 years. The Supper Upper Zambezi and Luangwa populations all collected from their respective river systems in the wild. The fish were then conditioned for 6 *months*, being exposed to same management regime and water environment, after which they were paired in breeding hapas (2m x 1m) in a ratio of 1:1 for spawning.

The result of the present study showed that the NARDC population gonadal somatic index (GSI) and Gonadal metric ratio (GMR) were significantly higher ($P<0.05$) compared to the wild Luangwa and Supper Upper Zambezi populations. However, no significant differences were detected in other parameters such as fecundity and hatchability across the three populations. The percentage of spawning females per population varied, the Wild Luangwa population had more females that spawned followed by NARDC and Supper Upper Zambezi.

The study reviewed that, there are very little variations across the three populations examined in the study, we also conclude that despite the wide hydro-geographical origin of the three populations, they have not diverged significantly from one another to reach an extent were the differences that might be present in genotype to be actively expressed in the phenotypes considered in this study. This indicates that no population could be superior to the other and as such all populations of *O. andersonii* will perform similar under same environment and management.

Table 1: Mean ± SE of gonadal somatic index (GSI), Gonadal metric ratio (GMR), relative fecundity, batch fecundity and Hatchability.

	Populations of *Oreochromis andersonii*		
REPRODUCTIVE PERFOMANCE	**NARDC**	**SUPPER UPPER ZAMBEZI**	**LUANGWA**
GSI	2.26 ± 0.215^{b}	1.64 ± 0.25^{a}	1.85 ± 0.42^{a}
GMR	$27.433.41^{b}$	18.49 ± 2.61^{a}	12.62 ± 2.69^{a}
Relative Fecundity	4.25 ± 0.382^{a}	6.38 ± 1.384^{a}	4.00 ± 0.773^{a}
Batch Fecundity	546.42 ± 61.23^{a}	361.75 ± 76.651^{a}	356.67 ± 58.794^{a}
Hatchability %	0.85 ± 0.11^{a}	0.96 ± 0.19^{a}	0.98 ± 0.006^{a}

Different letters in the same row represent significant difference ($P<0.05$).

SEEDING OF YOUNG TAGGED MULLETS IN TUNISIAN RESERVOIRS: PRELIMINARY RESULTS

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In the frame of the "Grey Mullet Stock Enhancement" work package of the MERC – USAID project we used local wild fry grown within experimental freshwater facilities of INSTM.

Small (0.1-0.2g) wild mullets were captured from delta rivers and acclimated at INSTM's freshwater hatchery where they were maintained in 500 L tanks (1000 to 1200 fry/tank) and were fed compound diets (8-10% of the biomass) until reaching the required size (4,5 cm) for tagging with CWT. A total of 12370 tagged fish have been released within three lakes (Kasseb, Lebna & Smati) allowing acceptable stocking densities; containing enough water (country was suffering drought conditions in the last 4 years); and in which there "should" be collaboration opportunities with local fishermen for fish capture. For the seeding program, we selected different treatments applied with replications. Treatments consisted inshore *versus* offshore release; no anesthesia *versus* MS-222 or clove oil anesthesia; oxygen peroxide treatment before release.

Up to date, 80 tagged fish have been obtained from fishermen. Biometry and tag number were identified for each fish. Data were compared by ANOVA. The averaging recovery rates (i.e., number recaptured/number released) between release batches, release lake, and experimental treatment, were Arcsinus (square root (X)) transformed. Only data concerning Kasseb and Lebna lakes (for which we had enough samples) were statistically analyzed.

As expected for mullets coming from the wild, captured tagged fish showed a mixed population consisting in 56% *Mugil cephalus* and 44% *Liza ramada*. All biometric indicator (LT, weight & K) appeared higher within samples of Lebna lake compared with Kasseb lake (Table 1). As all the fish came from the same juvenile cohort, this suggests better conditions (thermal, nutritional, …) in lake of Lebna.

Lebna lake is considered a low depth (max. about 10 m), tempered (near the sea) lake. It has a surface of 650 Ha for 30 M.m^3 volume and it has a surrounding region strongly urbanized with intensive agriculture. Contrastingly, Kasseb lake is considered an inland (30 km from the shore) deep lake with much cooler conditions in winter. It has a surface of 430 Ha for 82 M.m^3 volume (2.7 folds the volume of Lebna) and it has a surrounding region weakly urbanized with poorly covered mountains. The highly distinct growth performances are suggesting the necessity of developing a typology of exploited lakes for optimizing priorities of seeding operations.

Data analysis in relation to fish lots and experimental treatments did not evidence any benefit of offshore release or anesthesia during fish transportation. Other treatments (SAR, boosting, wild/captive juveniles…) might be studied for further optimization.

Table 1. : Biometry of captured tagged fish of Lebna and Kassed lakes for the automnal fishing campain of 2020.

	Lebna		Kasseb
Weight (g)	**1546 ± 95**	**>**	**872 ± 33**
Total Length (cm)	**52,2 ± 1,2**	**>**	**46,9 ± 0,7**
K (Fulton incex)	**1,09 ± 0,05**	**>**	**0,85 ± 0,02**
Observations	**25**		**36**

Data are mean ± 95% confidence

ADDRESSING EXPORT BARRIERS FOR SOUTH AFRICAN AND NAMIBIAN SHELLFISH – THE TRADE FORWARD SOUTHERN AFRICA PROGRAMME

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Trade Forward Southern Africa (TFSA) works to increase opportunities to trade, overcome nontechnical barriers to trade in goods, and improve export performance in the region while facilitating trade with the United Kingdom as it exits the European Union.

Farmed abalone, oysters and mussels in South Africa and Namibia have traditionally been consumed locally or exported to the Far East. With growing production, competition in traditional markets and the impact of Covid-19, this sector realized the need to access new international markets, particularly European markets. During 2020 a TFSA pilot phase set out to identify barriers to export. This was followed in 2021 with the implementation of several initiatives to address these barriers.

The European Union (EU) regulations pertaining to the import of farmed bivalves and gastropod molluscs was studied and analyzed. Using this information, a database of the South African and Namibian laboratories capable of providing the diagnostic tests and analyses required for compliance to these regulations, was developed. In this, the testing requirements for organoleptic characteristics, hazardous substances, as well as marine microbes and biotoxins were matched to accredited laboratories.

With assistance from MegaPesca in Portugal, the latest guideline resources on compliance to the EU regulations were collected and used to develop a "*compliance pack*" for farmers, as well as for the competent authorities in the respective countries. The work was expanded into a review of the officially documented shellfish monitoring programmes in both South Africa and Namibia, taking note of the latest EU requirements.

During the TFSA work a critical shortage of essential skills in the identification of potentially harmful algal blooms (HAB's) was identified. The Intergovernmental Oceanographic Commission's (IOC's) Science and Communication Centre on Harmful Algae at the University of Copenhagen were approached, and an arrangement made to provide training in this area for South Africa and Namibia. It is hoped that this training will be concluded in 2022.

The TFSA inputs to eliminate export barriers culminated in a "*roadmap toward compliance*" for both countries. This roadmap has been documented and disseminated to the sector and authorities with the view to better equipping all parties to deal with barriers to the export of their products.

ADVANCING AQUACULTURE IN EAST AFRICA: THE TRUE-FISH PROJECT

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TRUE-FISH PROJECT
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Despite the rapid growth of the aquaculture sector in the Lake Victoria basin, several structural constraints remain prevalent, including limited access to finance and commercial networks, inadequate high-quality fish seed and feed, lack of skilled operators, lack of policy coherence, limited access to genetically improved strains, poor management of fish diseases, unstainable management of the basin's Aquatic Genetic Resources (AqGR), and unsustainable utilization of biodiversity.

These constraints informed the creation of TRUE-FISH; a programme funded by the European Union (EU) through the East African Community (EAC), which is overseen by the Lake Victoria Fisheries Organisation (LVFO). The Food and Agriculture Organisation (FAO) of the United Nations (UN), WorldFish and Landell Mills are providing expertise as implementing partners. TRUE-FISH has an estimated value of just over 10 million Euros and will be implemented between 2019 and 2025. The focus is on the Lake Victoria basin in Kenya, Tanzania, and Uganda, but the aquatic animal health and biosecurity components will be extended to other EAC Member States.

The overall objective of TRUE-FISH is to contribute to the development of competitive, gender equitable and sustainable commercial aquaculture to improve the economic development and sustainable management of natural resources in the Lake Victoria basin. The sub-objectives relate to, (i) improving access to commercial networks for aquaculture-related businesses, (ii) increasing the availability and quality of skilled workers for the development of aquaculture-related businesses, and (iii) improving the sustainability and biosecurity of regional aquaculture production systems.

Landell Mills is addressing sub-objective (i), which includes the establishment of an East African Aquaculture Exhibition and Conference (EAAEC), the strengthening of business linkages, and support to aquaculture associations. Sub-objective (ii) sees the FAO upgrading and formalising aquaculture training, as well as strengthening linkages between training institutions and with aquaculture business operators. The FAO and WorldFish are jointly addressing sub-objective (iii), which includes the strengthening of aquatic animal health management, the zoning of Lake Victoria for sustainable cage culture development, and improved information on AqGR to support sustainable development of aquaculture together with protection of biodiversity through a better understanding of the genetic make-up of commercially farmed fish in the region.

This paper has been prepared to showcase the progress that has been made in TRUE-FISH to advance aquaculture in East Africa and coincides with TRUE-FISH facilitating 8 representatives from aquaculture associations in the region to attend the Aquaculture Africa 2021 Conference. This opportunity will see these representatives networking with global leaders in aquaculture, learning from the experience of others, and taking this knowledge back to East Africa for implementation towards advancing aquaculture.

THE ECOLOGY AND BIOLOGY OF *Oreochromis mossambicus* TO INFORM INLAND FISHERIES DEVELOPMENT IN LAKE FLAG BOSHIELO, SOUTH AFRICA

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In South Africa, many water reservoirs support livelihoods for many rural communities through inland fisheries. However, the sector is not properly developed and managed. With the country under enormous pressure to implement strategies that will aid in the alleviation of poverty and creation of jobs. The country have recently identified inland fisheries as a priority area for social and economic empowerment.

However, to achieve a sustainable inland fisheries sector, a scientific informed strategy for sustainable management of fish stocks in these reservoirs is an urgent requirement. The strategy should use information derived from biological and environmental research to provide sustainable management advice. Hence research aimed at the ecology and biology of potential fisheries species is necessary

Monthly fish surveys were conducted from February 2016 to April 2017 using composite gill nets were conducted in Lake Flag Boshielo. The overall mean CPUE calculated was 1.7±0.04 kg/100 m net/hr (Figure 1). Length-at-50% sexual maturity was 16.6 cm TL (Figure 2). The asymptotic length was calculated to be 40.4 cm TL and the age-at-zero-length at 0.249 yr (Table 1).

To ensure the sustainability of small formal fisheries in Lake Flag Boshielo targeting *O. mossambicus*, the management of the fishery will have to ensure sustainable utilisation of fish stocks over time.

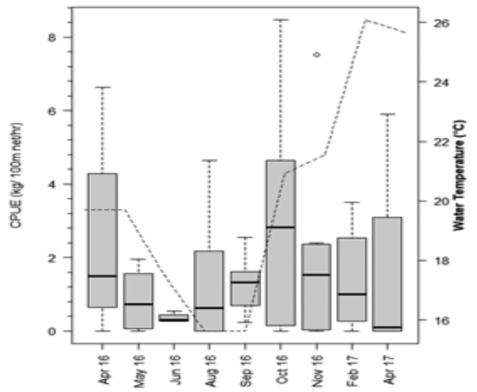

Figure 1: The catch-per-unit effort for *O. mossambicus* sampled in Lake Flag Boshielo.

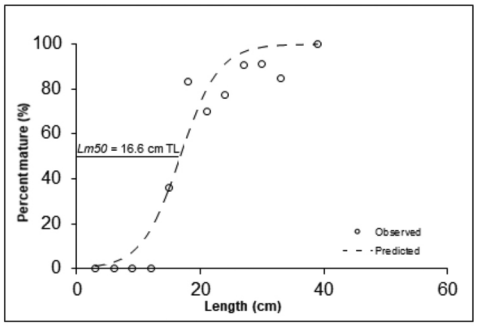

Figure 2: Length-at-50% sexual maturity of *O. mossambicus* sampled in Lake Flag Boshielo.

Table 1: Von Bertalanffy growth parameters, Standard Error (SE) and 95% confidence intervals for *Oreochromis mossambicus*.

Parameter	Estimate	SE	95% confidence
K (Brody growth coefficient; yr^{-1})	0.239	0.002	[0.991, 1.087]
L_∞ (asymptotic length; cm)	40.365	0.163	[34.670, 44.500]
t_0 (age of zero length; yr)	0.249	2.337	[0.190, 0.301]

EFFECT OF DIFFERENT WASTE SUBSTRATES ON THE GROWTH, DEVELOPMENT AND PROXIMATE COMPOSITION OF BLACK SOLDIER FLY (*Hermetia illucens*) LARVAE

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Black soldier fly larvae (BSFL) is considered as an alternative sustainable protein source for pigs, poultry and fish feed as well as a means of converting and utilization of organic waste. To achieve these roles, it is necessary to develop appropriate culture methods and understand their growth on different feeding substrates. This study therefore investigated the effect of three different substrates on the growth, development and proximate composition of BSFL. Feeding substrates mainly from Hotel Wastes (HW), Market Wastes (MW) and mixture of Market and Hotel Wastes (MHW) were used separately for the BSF culture. Efficiency of BSFL to consume different substrates and reduce the waste load to manure was also investigated. HW was found to be more attractive to the BSF eggs (5.90kg) but not significantly different ($P>0.05$) to MW substrate which had 5.34kg. MHW had the lowest production of (4.53kg) which was significantly different ($P<0.05$) to HW and MW. In evaluating the efficiency to digest the waste load, it was observed that younger larvae of 3 days old were able to consume and reduce the waste load faster within 4 days than larvae of 6 days' old that took 9 days to reduce the same amount of waste load. Larvae fed on HW was seen to take a shorter time (7 days) to develop into pupae with significance difference for all treatments ($P<0.05$). BSF larvae of 0.019 kg subjected to HW grew faster to a final weight of 0.68kg while MHW and MW production was lower with 0.567kg and 0.41 kg respectively. All treatments were seen to be significantly different ($P<0.05$) on the production of the final weight of BSFL. The study concludes that the larvae reared in MHW substrate is a better option to grow BSF larvae compared to MW and MHW due to its high crude protein content of 51.57%, ($P<0.05$).

Table 1: showing mineral content and proximate composition of BSF larvae fed on Market Waste (MW), Hotel waste (HW) and Market and Hotel Waste (MHW) substrates.

Parameter (% dry matter)	Market waste (MW)	Hotel waste (HW)	Market and Hotel waste (MHW)
Crude protein	46.52±0.55	45.29±0.52	51.52±0.01
Calcium as Ca	3.30±0.06	3.15±0.03	3.50±0.01
Crude fiber	4.92±0.01	4.12±0.01	4.02±0.01
Crude Ash	10.08±0.01	9.03±0.02	9.55±0.02
Moisture	50.05 ±0.01	54.78±0.02	51.06±0.02
Energy (DM) Kcal/kg	3,924.18 ±0.01	3,801.89±0.00	3,847.06±0.01

SUSTAINABLE LIVELIHOOD OF WOMEN IN FISHERIES VALUE CHAIN IN AKPAKA AREA ONITSHA LOCAL GOVERNMENT AREA ANAMBRA STATE NIGERIA

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Sustainable fisheries have supported the livelihoods and food security of communities for millennia, playing an essential role in local economies and food security.(FAO 2020).The sustainable livelihood of women in fisheries value chain in Akpaka area of Onitsha, Anambra state Nigeria was determined by a study of the socio economic assessment of the women in the study area .The population of women was forty (40).Data collection was through administration of 40 structured structured questionnaire and scheduled interview of the women in the study area. Strength, opportunities, aspirations, and results (SOAR) analysis was used in the deduction of the strengths, opportunities, aspirations and expected results from the responses to the questionnaire and interview discussions, as shown in Table 1.1: The SOAR analysis matrix.

The study area is a fisheries landing site on the bank of the river Niger where the fishermen sell the captured fishes to the women. The women process and sell the fish to consumers. It was concluded that providing the means for these women to achieve their aspirations as expected results will go a long way in ensuring the sustainable livelihood of the women in the fisheries value chain. This could be achieved through:

- Ø Empowering the women financially through a microcredit scheme.
- Ø Providing adequate and clean environment for the women to work.
- Ø Providing them with more environmental friendly smoking kiln for processing fish.
- Ø Sending fisheries extension officers to train and update the women on modern skills in fish processing, preservation and marketing of their productions.

Table 1.1 the soar Analysis table.

STRENGTHS	**OPPORTUNITIES**
Age of women	limited opposition
High level of literacy	successors
Basic skills and experience	location of the market
Household number	Available fish value chain
Cooperative Societies	Increase in income
Financial independence	Overcoming challenges
Fisheries extension officers	Improvement of security
Increase in sales	
Modern processing equipment	
Secure business environment	
ASPIRATIONS	**RESULTS**

SURVIVAL AND SOME PRO AND ANTIOXIDANT ACTIVITIES OF *Clarias gariepinus* FRY FED STRAINS OF *Lactobacillus fermentum* SUPPLEMENTED DIET CHALLENGED WITH *Aeromonas hydrophila*

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The use of live microbes as probiotics in improving the health and wellbeing of humans and animals have been extensively studied however the use of those isolated from food products in aquaculture especially fry production is limited in the literature. *Lactobacillus fermentum* strains BCS27 and F4S8 isolated from fermented food products were included in a basal diet at a concentration of $3x10^9$, $6x10^6$ and $9x10^3$CFU/ml/100g of feed respectively. The concentrations were presented as L1T1, L1T2, L1T3 for BCS27 and L2T1, L2T2, L2T3 for F4S8. At the same time, positive and negative controls contained no bacteria isolate and oxytetracycline at 100mg/kg of feed, respectively. These feeds were fed to 3 days old *Clarias gariepinus* larvae for six weeks. A pathogenic *Aeromonas hydrophila* was used to challenge the six weeks old fry and monitored for 2weeks. The survival rate was significantly higher (above 65%) in all the treatments compared with the positive control (42%), see Figs 1 and 2.

The oxidative stress assay showed increased activity of Superoxide dismutase (SOD), Glutathione Peroxidase (GPx), Glutathione (GSH) and increased Total Protein in the frys fed *L. fermentum* strains compared with the positive and negative control. The controls had higher activity in Malondialdehyde (MDA) and Nitric Oxide (NO) but was not significantly different ($p<0.05$) from all the other treatments. It could be concluded that *L. fermentum* strains BCS27 and F4S8 isolated from fermented food product could improve the antioxidant activity, disease resistance and survival of *C. gariepinus* fry.

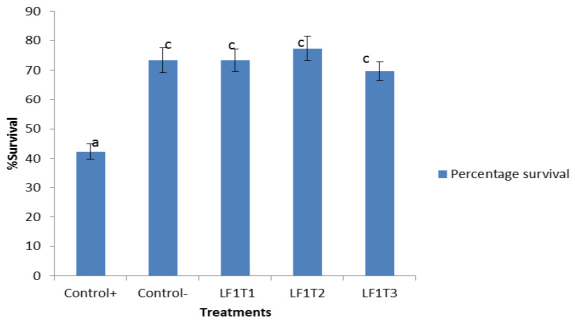

Fig 1. Showing percentage Survival of *C. gariepinus* fry fed with *L. fermentum* strain BCS27 supplemented feed challenged with *A. hydrophila* . Bars with the same alphabet are not significantly different at $p<0.05$

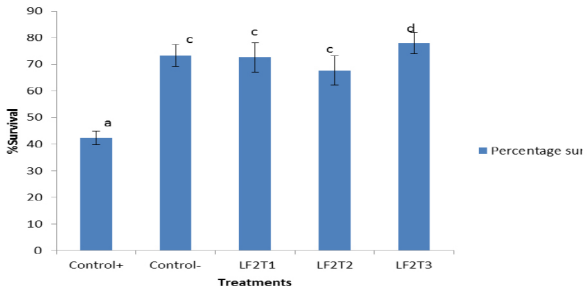

Fig 2. Showing percentage Survival of *C. gariepinus* fry fed with *L. fermentum* strain F4S8 supplemented diet challenged with

MITIGATION OF EXTREME HEATWAVE STRESS IN FISH THROUGH DIETARY MANIPULATION: THE CASE OF EUROPEAN SEABASS *(Dicentrarchus labrax)*

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Extreme climatic events have an impact on all living organisms, including fish. The purpose of this study was to assess the growth, hemato-physiological, and immune-antioxidant stress responses of European seabass, *Dicentrarchus labrax* fed four different dietary supplements, followed by ambient extreme heatwave (32°C) exposure.

For 56 days, fish were fed diets supplemented with vitamin C and E, propolis, phycocyanin, and β-glucan, along with a control diet, followed by 15 days of extreme ambient warm exposure. The results showed that fish fed propolis had better growth performance and survival than fish fed diets supplemented with vitamins C, E, and phycocyanin.

During extreme warm exposure, serum osmotic parameters (Na+, Cl-, and K+), glucose, and cortisol levels were significantly higher in fish fed on control and β-glucan supplemented diets compared to fish fed on propolis, vitamins C, E and phycocyanin supplemented diets ($p<0.05$). On day 15 of extreme warm stress, serum triglycerides, cholesterol, and protein levels were significantly higher in fish fed on propolis, vitamins C, E and phycocyanin supplemented diets compared to other diets. On days 7 and 115, serum metabolites (blood urea nitrogen, creatin, and lactate levels were significantly increased in control and β-glucan diets ($p<0.05$). Cellular enzymatic activities [AST, ALT, GPT, GOT, and LDH) were comparatively lower in fish fed propolis and vitamins C and E supplemented diets during days 7 and 15 of extreme heatwave stress. On days 7 and 15 of extreme heatwave exposure stress, HSP70mRNA was significantly ($p<0.05$) upregulated in the muscles and kidneys of fish fed on control and β-glucan supplemented diets compared to fish fed on propolis, vitamins C, E and phycocyanin supplemented diets ($p<0.05$), while Igf1 showed downregulation.

Most of the repeatedly measured parameters indicated that diets supplemented with propolis, vitamins C & E, and phycocyanin provide improved acclimation potential during ambient extreme warm exposure (32°C).

AMELIORATIVE EFFECT OF LYCOPENE ON GONADS, SEX STEROID AND THYROID STATUS IN MATURING TILAPIA *Oreochromes niloticus* DURING HARNESS® EXPOSURE

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The current work aimed to (1) study the impact of Herbicide Harness® used for weed control on the reproductive performance and thyroid status of maturing tilapia (*Oreochromes niloticus*), and (2) examine the potential role of the natural antioxidant lycopene administration in relieving Harness® adverse effects. Maturing male and female tilapia were divided into five experimental groups as follows: group 1 (control) received no treatment, group 2 was exposed to Harness® (10 µm /L), group 3 was supplemented with 10 mg lycopene/kg bodyweight and exposed to 10 µm /L of Harness®, group 4 was exposed to 100 µm Harness®/L, and group 5 was supplemented with 10 mg lycopene/kg body weight exposed to 100 µm Harness®/L, for 2 weeks. Thereafter, blood samples were taken from the four experimental groups and the control fish group; to evaluate biochemical parameters, catalase (CAT), superoxide dismutase (SOD), and total antioxidant capacity (TAC). In addition, serum testosterone (T), estradiol (E2), triiodothyronine (T3) and thyroxin (T4) were detected, also gonadal and thyroid follicles sections were assessed. The results showed that the antioxidants enzyme activity was affected by Harness® exposure as TAC significantly decreased ($P > 0.05$), while SOD and CAT activity significantly increased ($P > 0.05$) when compared to the control. The T and E2 levels for both male and female fish were significantly dropped ($P > 0.05$) in response to Harness® exposure. Adding lycopene supplement returned both SOD and CAT close to the control levels and significantly ($P > 0.05$) improved the level of T in both male and females with no influence on E2 levels. For the thyroid axis, both T3 and T4 levels diminished with the higher dose of Harness® (100 µm /L) while lycopene administration returned both T3 and T4 close to the normal levels. Harness® exposure induced number of histological alterations and degenerative changes in testicular, ovarian and thyroid follicles tissues. The findings showed that Harness® induce endocrine disruption for both sex steroids and thyroid axis, while lycopene administration decreased Harness® Oxidative stress, alleviated its endocrine disparaging effects and improving histological configuration of gonadal and thyroid tissues.

FOSTERING OPPORTUNITIES TO ENHANCE AQUATIC VETERINARY EDUCATION

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Since 2006, WAVMA has supported the global development of a veterinary task force with expertise in a wide range of aquatic animals and specialties. The specific objectives of WAVMA are to: *(1)* serve aquatic veterinary practitioners involved in multidisciplinary backgrounds, supporting and sustained members, and the aquatic sectors they serve; *(2)* identify, foster and strengthen professional interactions among aquatic medical practitioners and other international organizations; *(3)* advocate for, develop guidance on, and promote the advancement of the science, ethics and professional aspects of aquatic animal medicine within the veterinary profession and a wider audience; and *(4)* optimally position and advance the discipline of aquatic veterinary medicine, thus to promote practicing aquatic veterinary medicine in all countries. Since 2019, the WAVMA Education and Students Committee (ESC) has been actively working to dispense complementary training to aquatic veterinarians and veterinary students around the world. ESC is composed of volunteers and currently organized in three subcommittees, each chaired by a dedicated WAVMA regular or student member. The ESC Student Chapters Support Subcommittee provides guidance for the establishment of Student Chapters at veterinary universities around the world, monitoring their activities, and manages the assignation of Mini-Grants to established Chapters. Student Chapters provide a unique opportunity for veterinary students to receive additional education through lectures and practical activities on unconventional topics, and network with professionals in the field. This exposure has enabled veterinary students fully appreciate the roles of an aquatic veterinarian in the various domains associated with the wellbeing of aquatic animals within the framework of the UN Sustainable Development Goals (SDGs) and One Health. The WebCEPD subcommittee runs the Continuing Education and Professional Development (CEPD), with webinars given by experts from various fields. In 2021, the ESC achieved its goal of conducting one webinar per month, attracting a great audience. Live webinars are open to anyone interested at no cost. However, the recordings of webinars remain available for free to WAVMA members only, and upon a fee payment for non-members. Upon the completion of a short knowledge and skills assessment (KSA), Continuous Education (CE) credits can be obtained. The Student Support subcommittee is devoted to increasing accessibility to externship and internship opportunities for veterinary students around the world. This is done through announcements on the WAVMA website and virtual meetings organized for young veterinarians, such as the student panel series "A Sea of Opportunities" where career paths and other formative experiences are shared. Students and recently graduated veterinary members are also encouraged to apply for the John L. Pitts Aquatic Veterinary Education Awards Program, which enables awardees to gain expertise in aquatic veterinary medicine. For regions of the world where the aquaculture industry has grown much faster than the capacity for aquatic animal health management and biosecurity control could have been established, such as Africa or Southern East Asia, WAVMA provides great opportunities for rapidly bridging the gap in exposure, practical knowledge, and skills for veterinary students, and practicing aquatic veterinarians through its numerous programs and resources, in addition to those provided by the ESC.

INTERVENTIONS TO REDUCE DRIVERS OF BACTERIAL FISH DISEASES IN AQUACULTURE PRODUCTION SYSTEMS THROUGH MULTI-STAKEHOLDER COLLABORATION

Irene Naigaga, Nelly Isyagi, Mugimba Kizito, David Kahwa, Sophia Nagadya and Susan

Nakayiza PhD – Makerere University

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Aquaculture in Uganda is growing tremendously with the government promoting sustainable commercialization. However, this has come with expansion and intensification of production systems and increased live fish movement due to trade, leading to increased risk of disease outbreaks. In addition, Uganda's human and infrastructural capacity in fish disease diagnosis and response is limited. Previous related research has focused parasites mainly in wild hosts with limited research on bacterial, viral and fungal diseases, their epidemiological factors, disease prevention and control. The need to build disease early warning systems, improve diagnosis and response in case of outbreaks, and strategies to reduce disease occurrence/emergence are now necessary. Multistakeholder engagement and collaborating using a One Health approach has been recognized globally as a best practice of disease control and prevention strategies that recognizes the interconnections among humans, animals, environment as well as the economic, cultural and physical factors that influence health. This study incorporated the One Health approach in fish health management taking into account the assessment of pathogens of bacterial pathogens of Public Health concern; ascertaining the epidemiology of transmission of these pathogens on farm and between farms; and drivers of disease emergence, recommendations for best fish health management practices and on farm biosecurity measures, and multistakeholder interventions to reduce fish disease emergence.

A cross sectional study was used to generate both qualitative and quantitative data. Two commonly farmed fish species, namely, *Clarias gariepinus* (catfish) and *Oreochromis niloticus* (Nile tilapia) were sampled from ponds, and cages from 79 fish farms in 9 sub counties in Wakiso district, Uganda. Over 500 fish samples were collected, and visibly lesioned fish examined and fish tissue including, the kidney, liver, spleen, gills, and brain were ascetically dissected from each fish. Physico-chemical water quality specifically temperature, dissolved oxygen, pH and conductivity were measured from each pond/cage/tank in-situ. In addition, a questionnaire was administered to the farmer or farm manager to collect information of the disease occurrence and how they manage disease at each fish farm. This was to assist in explaining the difference in the fish husbandry practices among fish farms where disease was witnessed vs fish farms where fish diseases were not found. Thus recommendable husbandry practices would be conclusively recommended to fish farmers and practices that predispose fish to diseases would be communicated and reformed.

Fish lesions included skin discoloration, hemorrhages, ulcerations and abscesses, exophthalmia, and granulomas in the internal organs. Two major pathogenic fish bacteria types were identified and included; *Aeromonas* species and *Edwardsiella* species. Some of the disease drivers identified during the study included, poor hygienic measures, Limited preventive measures of fish health management practices, lack of record keeping, lack of extension services; limited knowledge of fish behaviors and fish health, poor sources of fish seed, and self-medication. Fish farmers, feed producers, academia, government service providers will be convening in two weeks-time to be sensitized on the results from the study, and collectively design interventions to reduce the drivers of exposure to and or the spread of bacterial pathogens in aquaculture and improve fish productivity. This multistakeholder workshop will be the first of its kind to come together for this purpose. Results with this workshop will shared at the Africa Aquaculture Conference AAFRAQ 21 during the Aquatic Animal Health Session..

BREEDING PATTERN OF *Oreochromis niloticus* (Linnaeus, 1758) (Pisces: Cichlidae) VERSUS NATIVE CONGENERIC SPECIES, *Oreochromis macrochir* (Boulinger, 1912) IN THE UPPER KABOMPO RIVER, NORTHWEST OF ZAMBIA

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Investigating the determinants of reproductive biology of fishes is an essential component of fisheries research. Breeding patterns were investigated to determine the impact of exotic *Oreochromis niloticus* on the native congeneric *Oreochromis macrochir* in the upper Kabompo River in the northwest part of Zambia. Gonado-somatic index and sex ratio was used to investigate the breeding patterns in both invaded (where *O. niloticus* is present) and uninvaded (where *O. niloticus* is absent) sections of the river. Results showed that the overall gonado-somatic index means for both sexes of *O. macrochir* in both sections were similar. For *O. niloticus* in invaded section indicated all year reproduction through reduced spawning in May-June, but with increased spawning activity in February-March. In *O. macrochir*, males and females were found breeding in both December and February-March months, as for the month of June no reproduction was recorded. Sex ratio (females: males) was 1:1.3 and 1:1.7 for *O. niloticus* and *O. macrochir* respectively, and both significantly deviated from the sex ratio of 1:1 (χ^2=8.42 and 9.37; p<0.05). *Oreochromis niloticus* was the most abundant fish caught 221(63.5%) than *O. macrochir* 127(36.5%). Our study has revealed that *O. niloticus* was able to spawn in across all sampled months with 23% higher breeding population than *O. macrochir*, might explains the suppression in the abundance of native *O. macrochir*. Due to the superior breeding patterns of *O. niloticus*, fisheries and wildlife and aquaculture practitioners need to make contingency plans to either alleviate its effects or harness its benefits even further downstream of the Kabompo River.

DUTCH AQUACULTURE EXPERTS: EXPERTISE IN SUSTAINABLE AQUACULTURE AND RECIRCULATION TECHNOLOGY

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The DAE (Dutch Aquaculture Experts) is a partnership between the most qualified and sophisticated aquaculture companies and research institutes in the Netherlands.

The Netherlands is a pioneering country in terms of developing a modern, sustainable and profitable aquaculture industry. For example, the development and implementation of recirculation aquaculture technology (RAS) is largely the result of Dutch aquaculture expertise.

The DAE is a one-stop platform combining the knowledge and experience of 16 Dutch companies and consultants. The DAE provides integrated aquaculture solutions for customers all over the world, including design & construct, training and research. Expertise ranges from feed, genetics and breeding to rearing systems and processing.

The presentation will show some examples of projects and will provide an insight into the aquaculture expertise in the Netherlands.

DNA BARCODING APPLICATION IN STUDY OF ICTHYO- BIODIVERSITY IN RIVER INDUS AT TAUNSA BARRAGE, PAKISTAN

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Fishes show great diversity among all vertebrates. Proper identification of fishes is of great importance in evaluation of biodiversity. Morphometric method is one of the popular and oldest methods for identification of fishes. This method is now complemented with genetic identification method due to limitations of morphometric method. This new taxonomic methodology is an emerging trend in Pakistan. Molecular taxonomy as compared to morphometric taxonomy improves knowledge on the early life stages which could be useful for both taxonomists and zoo technicians. With the growing population water, food and other resources are exploited greatly. This puts pressure on the aquatic environment and demands suitable conservation efforts. Purpose of present study is to apply DNA barcoding technique for identification of ichthyo-fauna of Indus River at Taunsa barrage. Present study involves Cytochrome C Oxidase1 gene for molecular identification of fish fauna of this region. This study resulted in total of 150 barcodes, which were differentiated into 30 taxonomically recognized species, 26 genera and 12 families. The mean length of all the sequences was 667 base pairs. The results were compared with the available literature of freshwater fish species in the River Indus. The average conspecific, congeneric and confamilial Kimura2 parameter (K2p) distances were .001%, .033% and .184% respectively. Biodiversity is shown by the clear differences in interspecific and intraspecific distances which are also found in the present work. From these results it is concluded that DNA barcoding can be used for biodiversity studies in different water bodies with positive results.

Table1. Kimura 2- parameter (K2P) distance of various fish taxonomic levels.

Genetic distance (K2P percent)								
	Comparison within				Comparison between			
Taxonomic level	Min (%)	Max (%)	Mean (%)	SE (%)	Min (%)	Max (%)	Mean (%)	SE (%)
Species	0.000	0.003	0.001	00008	0.000	0.081	0.041	0.021
Genera	0.000	0.073	0.033	0.051	0.000	14.598	9.486	3.352
Family	0.047	0.347	0.184	0.077	0.002	0.401	0.228	0.058
Order	0.000	7.088	2.686	2.41	----	----	----	----

GENETIC PARAMETERS FOR GROWTH RATE IN THE FOURTH GENERATION OF SELECTIVE STRIPED CATFISH (*Pangasinodon hypophthalmus*) IN VIETNAM

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The objective of this study was to estimate genetic parameters of G4 generation, phenotypic and genetic correlations between several traits, harvest body weight, harvest standard body length, specific growth rate, daily weight gain, and survival at harvest in striped catfish (*Pangasianodon hypophthalmus*). A nested mating design was used to generate G4 generation with 189 full-sib families (from 124 sires and 157 dams). The data set in the G4 generation consisted of 5,506 records for predicted harvest body weight at harvest. Model validation by model fitting (for random effects) concluded the final statistical model that was used to analyze the data for the traits under investigation. The best model was that which contained random effects of additive genetic and common environment and fixed covariates of the number of days from spawning till tagging (*tagage*) and the number of days from tagging till the harvest (*growage*), respectively. A univariate model was used to estimate variance components, while the bivariate model was used to determine genetic correlations using the same model.

High heritability estimates were obtained for body weight (0.49-0.61) and harvest standard length (0.43-0.65), which means that harvest body weight proved heritable to utilize the information on the selected candidates. The variation of harvest body weight explains most of the variation of harvest standard body length, and the two traits are genetically positively correlated (r_g=0.92-0.94), which permits the efficient indirect selection for standard harvest length *(HL)* through direct selection for harvest body weight *(HW)*. Daily weight gain had a very high correlation to both harvest body weight and harvest standard length (r_g=0.9-1), respectively. The specific growth rate, on the other hand, had very low correlations with both harvest weight and standard body length at harvest (0.06-0.04), respectively. The common full-sib effect regarding harvest body weight was high (0.27±0.07) and highly significant (P<0.05). Response for both estimated and realized in the current study provides valuable information for breeding programs of *Pangasianodon hypophthalmus*.

EFFECT OF *Bacillus* SPECIES ON LETTUCE GROWTH AND ROOT ASSOCIATED BACTERIAL COMMUNITY IN A SMALL-SCALE AQUAPONIC SYSTEM

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The integration of probiotics in aquaponic systems is a strategy for mitigating environmental impacts and for promoting sustainable agriculture. In order to understand the role of probiotics in aquaponics, we investigated the effect of a commercial probiotic mixture of *Bacillus subtilis* and *B. licheniformis* on the growth of lettuce (*Lactuca sativa* L.) under deep-water culture integrated with Mozambique tilapia (*Oreochromis mossambicus)*. We determinedplant growth, water quality parameters, leaf mineral analysis, and assessed the influence of a probiotic mixture on the microbiota. Bacterial communities were analysed by high throughput 16S rRNA gene sequencing. Compared to the control systems, the addition of the probiotic *Bacillus* significantly increased the concentration of nitrate and phosphate in deep water culture solution. In both the growth trials, the F_v/F_m, the mean shoot dry weight and the mean fresh weight of the harvested shoots from the *Bacillus* treatment were significantly higher than those observed for the control plants. Higher concentrations of phosphorus, potassium and zinc in the lettuce leaves were found in systems that received the *Bacillus*. Although differences were observed at the phylum level, Proteobacteria and Bacteroidetes were predominant in both the *Bacillus*-treatment and the control systems. At the genus level, however,the communities present in the two types of systems were heterogeneous with *Bacillus*-treated systems containing significantly higher numbers of *Chryseobacterium*, *Bacillus*, *Nitrospira*, *Polynucleobacter* and *Thermomonas*. The results indicate that *Bacillus* supplementation can effectively alleviate nutrient deficiencies, improve water quality, and modify the composition of bacterial communities in aquaponic systems.

TABLE 1 Growth of 'Locarno' lettuce cultivar under in deep-water culture solution in the control and *Bacillus* treatment for two crop cycles. Data are means ± standard error (SE) of 32 plants for each crop cycle and for each treatment. * indicate means were significantly different at $P < 0.05$.

Variables	**Growth trial 1**		
	Bacillus treatment	Control	*P*-value
Initial plant mass (g plant^{-1})	3.51 ± 0.005	3.50 ± 0.09	0.29
Shoot fresh weight (g plant^{-1})	24.84 ± 0.18	20.07 ±0.02	0.001*
Root fresh weight (g plant^{-1})	1.58 ± 0.004	1.06 ± 0.009	0.07
Height gain of plant (cm plant^{-1})	20.93 ± 1.66	20.24 ± 0.64	0.74
Absolute growth rate (g day^{-1})	0.77 ± 0.005	0.59 ± 0.0	0.0008*
F_v/F_m	0.83 ± 0.007	0.71 ± 0.01	0.01*
CCI	2.20 ± 0.09	2.06 ± 0.05	0.30
Shoot dry weight (g plant^{-1})	0.76 ± 0.03	0.55 ± 0.006	0.02*
Root dry weight (g plant^{-1})	0.104 ± 0.004	0.09 ± 0.005	0.07
	Growth trial 2		
	Bacillus treatment	Control	*P*-value
Initial plant mass (g plant^{-1})	4.62 ± 0.05	4.63 ± 0.01	0.70
Shoot fresh weight (g plant^{-1})	33.08 ± 1.36	25.57 ± 0.53	0.03*
Root fresh weight (g plant^{-1})	2.11 ± 0.04	1.65 ± 0.05	0.02*
Height gain of plant (cm plant^{-1})	29.32 ± 0.69	20.31 ± 0.14	0.006*
Absolute growth rate (g day^{-1})	1.02 ± 0.05	0.76 ± 0.02	0.03*
F_v/F_m	0.82 ± 0.04	0.72 ± 0.01	0.03*
CCI	2.46 ± 0.03	2.41 ± 0.004	0.30
Shoot dry weight (g plant^{-1})	1.47 ± 0.031	0.85 ± 0.01	0.001*
Root dry weight (g plant^{-1})	0.24 ± 0.01	0.14 ± 0.01	0.02*

EFFECT OF UREA TREATED SUGARCANE BAGASSE ON GRASS CARP (*Ctenopharyngodon idella*)

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A 90 days experimental trial was conducted to evaluate the effect of urea treated sugarcane bagasse on the growth, gut microflora and digestive enzymes of grass carp (*Ctenopharyngodon idella*). Fish were fed at 3% wet body weight with experimental feeds having 0% (CTRL), 0.7% (T1), 1.4% (T2) and 2.1% (T3) urea each having two replicate tanks. Results revealed that fish fed on 2.1% urea treated sugarcane bagasse (T3) showed significantly higher ($P<0.05$) growth as compared to T2, T1 and CTRL. The feed conversion ratio (FCR) and specific growth rate (SGR) were also significantly higher in T3 fish group that were followed by T2, T1 and CTRL groups. Proximate analysis of fishes showed that level of crude protein (CP) was significantly higher in T2 than other groups and crude fat (CF) level was significantly higher in T1 fish that was followed by T2, CTRL and T3 fish group. The percentage level of dry matter was significantly higher in T3 fish and ash percentage was significantly higher in T2 fish than T3, T1 and CTRL group. Amylase and Lipase concentration was significantly higher in T2 fish group than T3, T1 and CTRL. Protease concentration was significantly higher in T3 that was followed by T1, T2 and CTRL fish groups. The presence of *Lactobacillus fermentum* was confirmed in T1, T2 and T3 fish groups. Overall the results shown that urea treated sugarcane bagasse can be used as a feed ingredient for *C. idella* and has no adverse effect on the nutritional value of fish.

ESTIMATES OF COMBINING ABILITY ON GROWTH TRAITS IN A FULL DIALLEL CROSSES OF THE THREE STRAINS OF *Oreochromis Macrochir* (BOULENGER, 1912)

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The study was conducted to evaluate the combining abilities of the growth traits resulting from a complete diallel crosses of the three strains of *Oreochromis macrochir* from Chambeshi, Kafue and Luapula rivers conducted at Misamfu Aquaculture Research Station in Zambia.

A complete diallel cross was used to evaluate combining abilities, reciprocal effects and maternal effects in a randomized complete block design. The fry from the diallel cross were held in 1m *x* 1m *x* 1.3 m hapas installed in 600m^2 earthen pond, stocking density of 250 fry/hapa. Fry were stocked at mean weight of 0.04g (±0.001) across all treatments, and the study lasted for 70 days.

The results showed significant differences (P<0.05) in FBW, SGR% and SL. Best general combining ability (GCA) of strains on final weight was Luapula (0.180±0.022) followed by Chambeshi (-0.009±0.009) lastly Kafue with a highest negative value (-0.172±0.018).

The best specific combining ability (SCA) for final body weight was Chambeshi *x* Kafue or Kafue *x* Chambeshi (-0.350±0.028) followed by Chambeshi *x* Luapula or Luapula *x* Chambeshi (-0.379±0.013). The reciprocal effects and maternal effects were not significantly different (P>0.05) for the three strains. The Luapula strain is recommended for genetic improvement program for it showed better growth and general combining ability.

IDENTIFICATION OF GHOST NETS IN VLORA BAY, SOUTH ADRIATIC SEA

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Ghost nets (abandoned or discarded fish nets) deposited in Vlora Bay are the problem for the fisherman from several years ago. The ghost nets stuck in the object as ships and aeroplane drowned from the Second War in Vlora Bay localised in South Adriatic Sea. The fishing gear nets lost during fishing activities due to obstacles, grounding dangers or particularly adverse weather and sea conditions. Usually made from synthetic, non-degradable fibers, the nets continue to trap and entangle large numbers of animals – including precious juvenile fish and turtles, smothering vital habitats and their eco-systems. The overall objective of ADRINET Project in period 2018-2020, was to improve a joint coastal management system and create governance plans to preserve biodiversity and coastal ecosystems inside the Programme area. The project includes investments in technology, to map fishing routes and monitor sea from ghost nets. We indentified the locations of ghost nets lost through basic information of the fisherman's in the fishing area of Vlora Bay, Adriatic Sea. Participation in this survey were fisherman and divers from this area that identified from the interviews the 5 problematic sites of Vlora Bay that deposited the ghost nets. These data using underwater inspection equipment, such as remotely operated vehicle (ROV).Allowing fishermen to eliminate ghost nets and easily acquire biodegradable and selective fishing nets that had so far been available at an affordable price only in neighboring countries.

PERFORMANCE EVALUATION OF TILAPIA SPECIES: THE CASE OF *Oreochromis niloticus* AND *Oreochromis andersonii* IN ZAMBIA

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Governments in Southern Africa in partnership with research and development agencies have put forth initiatives to improve some of the indigenous species (the Kafue Bream, *Oreochromis andersonii* in Zambia, *O. shiranus* in Malawi and *O. mossambicus* in Mozambique and South Africa) through Genetic Improvement Programs (GIPs). However, data on performance for the popular *O. niloticus* alongside these other key indigenous species is still limited. In Zambia, *O. niloticus* contributes up to 69% of the total national aquaculture production, followed by *O. andersonii* especially in commercial establishments. In the present study, performance of these two major contributors to the Zambian aquaculture production; *O. niloticus* and *O. andersonii* sourced from different hatcheries and fed a commercial feed was evaluated over a period of 175 days in a controlled environment. The fish were all subjected to the same single feeding regime and management throughout the experimental period.

Table 1: Mean ± standard deviation of body weight at harvest (g), daily growth coefficient (DGC) (g/day), specific growth rate (SGR) (g/day) and Food Conversion Ratio (FCR) for the four species-hatchery combinations ("strains"). N is sample size with body weight assessed for individual fish while DGC, SGR and FCR were assessed by tank.

Species-Hatchery "Strain"	Body weight		DGC		SGR		FCR
	N	Mean±SD	N	Mean±SD	N	Mean±SD	Mean±SD
O.andersonii- ML	72	73.8 ± 38.5[b]	4	0.017±0.010[b]	4	0.021±0.002[b]	1.75±0.09[a]
O.andersonii- PL	76	65.2±31.5[b]	4	0.016±0.010[b]	4	0.020±0.001[b]	1.78±0.17[a]
O.niloticus- CL	68	178.5±74.7[a]	4	0.025±0.020[a]	4	0.026±0.001[a]	1.20±0.10[b]
O.niloticus- PL	77	187.8±73.6[a]	4	0.026±0.010[a]	4	0.026±0.000[a]	1.05±0.04[b]

CHANGING NUTRIENT REQUIREMENTS DURING THE TROPHIC SHIFT FROM LARVAL CARNIVORY TO JUVENILE OMNIVORY IN GREY MULLET *(Mugil cephalus)*

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The flathead grey mullet is a catadromous species where the larvae are strict carnivores. On the other hand, juvenile fish become omnivorous during their migration to a more hypersaline, estuarine environment. This requires that mullet adjust their biosynthetic and digestive capacity, which affects their dietary requirements. Our group tested different levels of dietary DHA (0.7, 0.9 and 1.2% DW diet) at two salinities (15 and 40 ‰) on juvenile mullet DHA synthesis. Fish exposed to 15 ‰, increased DHA synthesis through a series of desaturation and elongation steps that were regulated by transcription factors (PPARα and SREBP-1) resulting in similar growth among treatments. However, at 40‰ mullets displayed a significant ($P < 0.05$) dietary DHA dose-dependent response on weight gain (Fig. 1), while the expression of the transcription factors was ca. 50% lower. These results suggested that dietary levels of DHA can be reduced during grow-out of farmed juvenile mullet, provided the salinity is lowered to 15‰.

NCM studies testing 3 rotifer taurine levels (1.1, 4.4, 6.4 mg g^{-1}) on 3-12 dph larvae, found a significant ($P < 0.05$) taurine dose-dependent growth response in 12, 19 and 44 dph (Fig. 2) demonstrating the far-reaching effect of rotifer taurine on post-larvae and juveniles. On the other hand, when older juveniles were fed different dietary taurine levels (0, 0.5, 1.0 and 2.0% DW diet), only the 0.5% treatment elicited a better ($P < 0.05$) growth performance, while there was a marked ($P < 0.05$) up-regulation of liver cysteine sulfinic acid decarboxylase (CSD). This is the main rate limiting enzyme in taurine biosynthesis and suggests that mullet juveniles have the capacity for endogenous taurine production as they move towards taurine-poor estuarine waters.

The most effective weaning diet also reflects changes in digestive capacity as the mullet larvae develop into juveniles. Therefore, three weaning dietary treatments (herbivorous, carnivorous, and omnivorous) were tested in 24 to 53 dph juveniles. The omnivorous weaning diet resulted in the best fish growth ($P < 0.05$), which may be tied to high gut production of both α-amylase and proteolytic enzymes. Moreover, the herbivorous diet delayed fish gut maturation and mucosal absorption reducing growth, while hydrolysates in the carnivorous and omnivorous diets may have increased these parameters. Taken altogether, this study recommends that mullet weaning and grow-out feeds should be designed for omnivorous feeding.

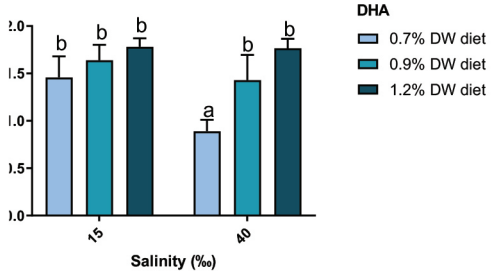

Fig. 1 Effect of diet DHA and salinity on non-density affected weight gain in 89 dph fish

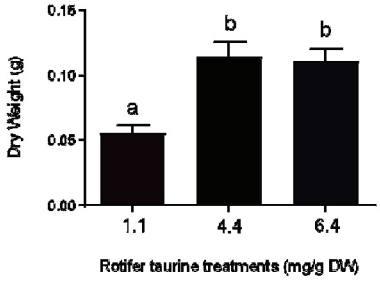

Fig. 2 Effect of rotifer taurine on growth in 44 dph fish

ASSESSMENT OF THE EFFECTS OF CAPTIVITY ON FIRST SEXUAL MATURITY OF WILD-CAUGHT AND HATCHERY-PRODUCED MULLET (MUGIL CEPHALUS)

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In fish, puberty (= first sexual maturity) is susceptible to multiple, interacting environmental cues. As a result, farming conditions may have varying influences on the age of pubertal onset causing precocious puberty in some species or delayed and even completely blocked puberty in others. Therefore, this study aimed at characterizing pubertal development in cultured grey mullet (*Mugil cephalus*), an important fish candidate for domestication and aquaculture production.

Two stocks of grey mullet were compared: wild-caught (WC; Apulia, Italy) and hatchery produced (HP; National Center for Mariculture, Eilat, Israel) grey mullet, both subjected to captive conditions consisting of ambient seawater salinity (40 ppt; Gulf of Eilat, Red Sea) and photo-thermal regime. The age of the fish was estimated based on their scales. Growth performance and gonadal development were monitored in 2- and 3- year old fish (2y and 3y).

Our results revealed that in both groups all 2y fish had immature gonads. The majority of age 2y females had ovaries with late perinucleolar stage oocytes as the most advanced oocyte stage, however, some of these fish still had ovaries constituting mainly by oogonia intermingled with small groups of early perinucleolar stage oocytes. Yet, HP females had significantly larger oocytes than WC specimens. Testis from an immature age 2y HP specimen showed small seminiferous lobules. Only spermatogonia, along with somatic cells were visible. Gonad section from a 2y HP intersex showed the presence of all stages of spermatogenesis. Scattered perinucleolar stage oocytes were visible, indicating that both WC and HP, had immature testes. Following 3y age category revealed that WC females were larger and heavier than cognate males. Although not significant, the HP grey mullets appear to exhibit a similar trend. Gonadosomatic index (GSI) values in 3y HP females and males were significantly higher than those of the WC of the same age. Undifferentiated gonads were found in 20% of WC fish compared to 5% in the HP fish. While only 33% had reached vitellogenic oocytes level, 54% of the HP females reached this level of development. Males exhibited a significant difference in development: while 100% of the WC males showed first stages of spermatogenesis, 67% of the male population in the HP group produced mature sperm. HP females, sampled during October (spawning season, under our natural conditions), reached maturity and ovulation. Their GSI exceeded 15%. Interestingly, approximately 50% of the HP females' GSI exhibited markedly developed gonads with GSI values ranging between 10-20% while all the others were lagging far behind, having GSI values between 0.2 to 0.3 %. GSI values in WC females were also divided into 2 sub groups and found to be significantly lower than those of the hatchery produced females (1-6% and <1% respectively). Males also exhibited two GSI groups pattern, higher GSI values were exhibited by HP fish (1.5%-2.75% and <1% compared to 0.2-0.5% and <0.15%) . Suggesting hierarchy plays a major role affecting gonadal development in mullets.

In summary, The 3 yr old HP mullet females and males exhibited enhanced gonadal maturation as compared to that of the WC captive-reared fish, probably as a result of domestication.

STUDIES ON BONE DEFORMITY IN EARLY DEVELOPMENTAL STAGE OF NILE TILAPIA *Oreochromis niloticus* INDUCED BY ENVIRONMENTAL CONDITIONS

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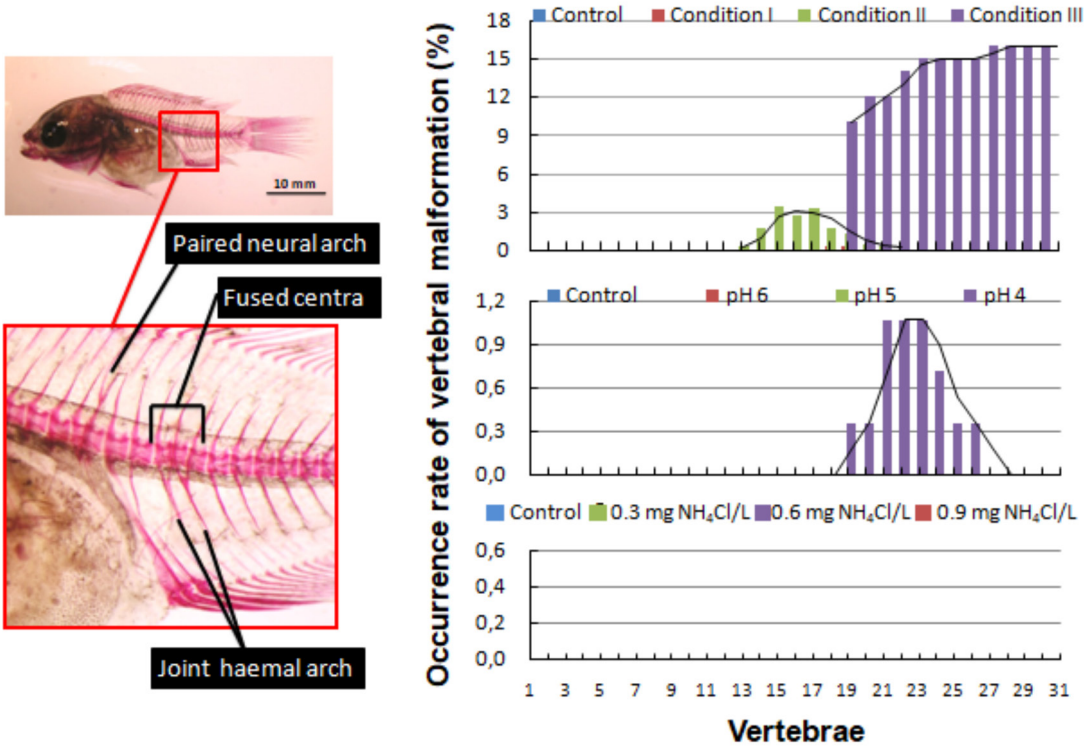
Malformations represent an economic problem due to a lower market value of the products, an increased expenditure on food, a limited growth, supplementary labor for sorting and general handling as well.

Hence, there is significant interest in addressing the potential causes of these deformities. The main purpose of this study is to understand the effects of incubation into hypoxia (low oxygen concentration), acidic pH and high level of ammonia on various early life stages of Nile tilapia with regards to the occurrence of spinal malformation.

Double staining with alizarin red and alcian blue revealed higher incidence of vertebral deformation with fry incubated in hypoxia within 39-45 hours post fertilization or hpf (Condition III) compared to these of 27-33hpf (Condition I) and 33-39 hpf (Condition II). In similarity with the incubation in acidic condition, abnormalities such as paired neural arch, fused centra or joint haemal arch were commonly observed from the 19th vertebrae onward.

These results showed that only a deprivation of oxygen during somitogenesis lead to spinal deformities. However, as the ammonia analysis by spectrophotometer indicated a concentration of 0.03± 0.01 mg NH_3-N/L, 0.09 ± 0.02 mg NH_3-N/L and 0.17 ± 0.02 mg NH_3-N/L within our last experiment, it is suggested to increase the concentration of NH_4Cl in order to witness more relevant data.



EFFECT OF GRADED INCLUSION RATE OF A LOCALLY PRODUCED PEANUT *Arachis hypogaea* MEAL IN EXTRUDED FEED ON THE GROWTH OF CARP *Cyprinus carpio* AND TILAPIA *Oreochromis niloticus* FARMED IN THE ANALAMANGA REGION IN MADAGASCAR

Le Reste Guillaume*, Andriantsoa Mamy, Andriniaina Henri, Desprez Damien, Godard Léo, Randriarilala Fanomezantosa, Rakotoambinina Samuel, Rakotoasimbola Lovasoa, Rakotomavo David, Mauny Frédéric, Delord Sylvain

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Progressive intensification of the carp and tilapia aquaculture in Madagascar leads to the increasing use of fish feeds. Locally available feeds can be imported or produced in Madagascar. As a part of the PADM project, a trial has been launched to evacuate the feasibility of producing fish feeds with raw materials available in the Analamanga Region.

Based on analysis performed on samples of the locally available ingredients gathered in 2019, a trial was designed to test the effect of graded inclusion of a peanut meal (PM). This raw material was rich in interesting nutrients (protein and lipids) and affordable but it is known to contain antinutrient factors and is highly susceptible to mycotoxins contamination.

A range of 3 feeds with increasing PM levels was formulated (Feed A=5% PM ; Feed B = 10% PM ; Feed C = 15% PM). Feeds were manufactured on a commercial extruder managed by a local feed meal. Feeds were used in 2 carp farms and 2 tilapia farms. Farmers were advised to distribute the feeds to different ponds (3 meals/day). Ponds were stocked with the same density. Weight gain were measured monthly. Carps and one tilapia group were fed for 150 days. The other tilapia group one for 190 days. Final harvest enable us to calculate the following parameters: survival, weight gain, daily weight gain and feed conversion ratio (FCR).

Fish fed with Feed A are generally showing better results than fish fed the Feed C. Feed B tends to give intermediary results but we cannot observe any clear dose effect response. Results analysis is complicated by the fact that the parameters measured differ a lot between farms. Our results also provide information on the nutritional composition of raw materials available in the Analamanga. We also analysed aflatoxins in the different batches of feed produced

Raw Material	Feed A	Feed B	Feed C
Soybean Meal	50	50	49
Cassava starch	10	10	10
Corn	10	10	10
Peanut meal	**5**	**10**	**15**
Wheat bran	8,59	6,89	5,8
Wheat meal	8	7,14	5,8
Fsh meal	4,22	2,22	1
Palm oil	1,43	0,98	0,5
Premix + MCP	2,39	2,39	2,51
Methionine	0,37	0,38	0,40

Table 1: feed formulas

Feed	Feed A	Feed B	Feed C	Feed A	Feed B	Feed C
Farm	Carp 1	Carp 1	Carp 1	Carp 2	Carp 2	Carp 2
FCR	3,05	3,42	3,43	2,93	7,73	5,48
Survival (%)	100	98,5	100	100	65,4	76,4
Yield (kg/hectare)	1 233	1 100	1 097	2 462	1 304	1 100
Feed	**Feed A**	**Feed B**	**Feed C**	**Feed A**	**Feed B**	**Feed C**
Farm	Tilapia 1	Tilapia 1	Tilapia 1	Tilapia 2	Tilapia 2	Tilapia 2
FCR	2,51	1,46	2,46	4,52	3,79	4,89
Survival (%)	100	88,7	85,7	71,3	85,7	88,6
Yield (kg/hectare)	5 450	5 460	3 253	1 875	2 920	1 981

Table 2: Growth, Survival and Yield in the different ponds

EFFECTS OF GRADED LEVELS OF CITRUS EXTRACTS IN FEED ON GROWTH, BLOOD PARAMETERS AND SURVIVAL OF NILE TILAPIA *(Oreochromis niloticus)* BEFORE AND AFTER A CHALLENGE WITH *Aeromonas hydrophila*

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Plant secondary metabolites are more and more commonly used as functional additives in aquafeeds. Such a process is driven by the market demand for natural products. Citrus extracts are among the most studied extracts for aquaculture. The present study was undertaken to study the effect of graded inclusion levels of a standardized citrus extract in the feed of Nile tilapia.

The Aquaculture Laboratory team of the Federal University of Vale do São Francisco held a trial with 360 Nile tilapia juveniles (mean initial weight = 12.8 ± 0.17 g). After a two-week acclimatization period, fish were divided into 6 groups containing 3 replicates each, where each group received a specific diet. Feeds used in this trial contained different doses of Nor-Spice AB® (Nor-Feed, France): 200 ppm, 400 ppm, 800 ppm, 1,600 ppm and 3.200 ppm (Control, NS200, NS400, NS800, NS1600, NS3200 respectively). Growth parameters were recorded after 60 days. Blood sample were taken on 8 fish in each tank after 60 days.

At the end of this trial 30 fishes of each treatment have been selected to be experimentally infected with intraperitoneal injection of locally available strain of *Aeromonas hydrophila* (inoculation with 0.2ml of a $1*10^{-7}$ CFU/ml solution). Mortality of the fish were then analyzed for 8 days.

Results show a positive effect of the increasing inclusion of NSAB on growth. FCR is influenced with the highest dosage inclusion rate.

Blood analysis show the product increases total protein, cholesterol and hemoglobin. Survival after the challenge with *A. hydrophila* was also positively influenced by the increased inclusion rate of the citrus extract.

Our results demonstrate the positive effects of the graded inclusion of a standardized citrus extract on zootechnical and hematological parameters when fed to juvenile Nile tilapias grown in unchallenging conditions. They also underline its interest when fish are challenged with a pathogenic bacteria

	Control	NS200	NS400	NS800	NS1600	NS3200
Weight gain (g)	61,67 ± 0,94^{b}	65,01 ± 0,98^{ab}	65,48 ± 0,98^{ab}	70,40 ± 2,4^{ab}	72,46 ± 1,39^{a}	62,95 ± 1,84^{ab}
Feed Cons. (g)	88,47^{b}	94,01^{ab}	96,48^{ab}	99,79^{a}	99,81^{a}	95,71^{b}
FCR	1,43^{ab}	1,44^{ab}	1,47^{ab}	1,42^{ab}	1,37^{a}	1,52^{b}

	Control	NS200	NS400	NS800	NS1600	NS3200
Total protein (g/dl)	3,67 ±0,33^{b}	3,74 ±0,38^{ab}	3,79 ±0,31^{ab}	3,52 ±0,23^{b}	4,64 ±0,27^{a}	4,41 ±0,19^{ab}
Cholesterol (mg/dl)	128,72 ±9,21^{b}	119,64 ±10,5^{b}	133,31 ±9,69^{b}	179,01 ±5,67^{a}	167,76 ±6,03^{a}	159,54 ±7,96^{a}
Hemoglobin (g/dl)	13,35 ±1,27^{b}	15,67 ±1,11^{ab}	14,9 ±1,19^{ab}	15,19 ±0,78^{ab}	17,82 ±1,10^{a}	16,82 ±2,19^{ab}

INTEGRATED AQUACULTURE IN WEST AFRICA: AN ECOLOGICAL INTENSIFICATION LED BY FAMILY FARMERS IN A MARKET ORIENTED STRATEGY

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The modalities of the integration of a marketable fish production conducted by smallholders in the lowlands of the West African forest area have been studied. First, it should be pointed out that the motivation for fish farming of these smallholders is at the origin of a dynamic of dam pond construction, built using their own resources. This fish farming development leans on first core group of farmers who received close and long-term technical support.

Integrations are selected and analyzed. On the scale of the production pond, polyculture based on tilapia (*Oreochromis niloticus*) and Heterotis (*Heterotis niloticus*) illustrates the possibility of combining two animal husbandry practices. Another technique widely used in Guinea and Côte d'Ivoire is the integration of floating rice into dams: this combination of plant cultivation and fish offers mutual benefits. In Guinea, the practice of pig farming on the edge of the pond, in connection with the recent development of palm kernel meal production, is also an interesting case to point. Finally, in Côte d'Ivoire, on the periphery of dam ponds and downstream, different types of crops are grown to benefit from the security of water supply: market gardening, irrigated rice, tree nurseries, etc.

These integrations increase the sustainable multiplication of the agriculture-aquaculture interfaces and thus constitute an interesting means of ecological intensification. They benefit from the great flexibility of family farms, particularly in terms of the predominantly manual labour force. On another level, these integrations reflect an adaptation to the opportunities of the various territories.

Their analysis refers to the need to collect observations at different scales: the husbandry cycle, the livestock system (fishponds), the farming system (family farm), the lowlands, the local agricultural network and more generally the agrarian system (territory). The multitude of these scales renders the overall assessment complex. This explains why benefits of this small-scale fish farming are often poorly described and quantified, or even neglected, despite their great importance and potential.

Theses forms of integration of fish farming should be encouraged. Collaborative approaches supporting smallholder innovation within territories are a tool for their promotion. Support for national development policies is also a lever for action, as in the case of Guinea, which has made this smallholder integrated fish farming, a strategic priority in the fight against food and nutritional insecurity and one of its contributions to limiting global warming.

AGROECOLOGY FOR SUSTAINABLE AQUACULTURE IN A CONTEXT OF GLOBAL CHANGES – ASACHA GDRI-SUD (2021 – 2025)

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With production constantly increasing over the past 30 years, and now ahead of fisheries production for seafood, aquaculture has become a major issue for development and food security, particularly in tropical regions where the impacts of global change are most felt. In South-East Asia as in Africa, the increase in demand for cultured fish is leading to an intensification of farming practices. Despite the very different contexts, aquaculture practices in both regions need to evolve towards greater sustainability. Such evolution is obviously an environmental challenge, but is also an economic and nutritional challenge for many rural families. Increasing sustainability in aquaculture is intended toward innovative agroecological practices, mobilization of ecological functionalities, optimization of natural processes (ecological intensification) and common and efficient management of resources and sanitary risks.

The ASACHA GDRI-Sud (https://asacha-gdri.com/) aims to facilitate agroecological transition of aquaculture in the South promoting scientific multidisciplinarity at the service of the sustainability of aquaculture in a context of global changes. ASACHA GDRI-Sud is situated at the interface of issues related to food security, sustainability of aquaculture production systems, and training, thus responding to 8 SDGs. These issues call upon many complementary disciplines that interact in a complex framework, and are at the heart of the program that the AQUABIOS team of ISEM is developing with its partners in the South and the North.

ASACHA GDRI-Sud aims to i) structure scientific activities between the numerous disciplines involved with the partners from the South and the North, ii) strengthen South-South relationships, by federating academic and socio-economic actors on the issues of sustainability and agroecological transition of aquaculture, and iii) intensify training in the South on these aspects. Thus, the aims of the group is to improve integration of knowledge and skills acquired by scientists and stakeholders in tropical aquaculture. The group aims also to develop a shared approach for the development of ecological intensification and the promotion of a greater ecosystem integration of aquaculture in the various socio-ecological contexts.

Network (7 Southern Countries - 25 institutions)

Members of African & Asian network	Multidisciplinary collaborations France
CAMBODIA: FiA, ITC, RUA	• UMR ISEM – AQUABIOS team • APDRA Pisciculture paysanne (ONG) • University of Montpellier • INRAE - UMR 1069 SAS • UR Recycling and Risk • UPR AIDA • UMR Selmet
INDONESIA : RIFAFE, RIFB, MCFAD	
MADAGASCAR : DRZVP - FOFIFA	
VIETNAM : FAS - VNUA, Fac. of Fisheries VNUA, NLU, CAF-CTU	
GUINEA : ANAG	
IVORY COAST : CRO, UAO, INP-HB, IPNETP, UJLOG	
SENEGAL : IUPA - UCAD	

AQUACULTURE SKILLS AUDIT IN KWAZULU-NATAL

Mafuyeka, Sipho, Deon; Robertson-Andersson, Deborah, Vivienne & Salie, Khalid, .Universities of KwaZulu-Natal and Stellenbosch, respectively.

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South Africa has 26 Universities, 10 of which offer aquaculture or marine biology studies (FAO, 2016). However, the total number of aquaculture professionals produced compared to professionals of other sectors is too little. Aquaculture is one of the growing food production sectors in the world, yet, the RSA aquaculture sector has performed below its potential and remains a minor contributor to the GDP. (FAO, 2016).

Currently, there is very limited literature available on aquaculture skills requirements for aquaculture sector in South Africa. Since the skills needs of the freshwater aquaculture sector are unknown or undocumented, it is difficult to develop suitable training material/courses for the sector. A semi-structured questionnaire was administered to farmers and officials. The main objective of this study was to investigate both current and future skills that will be required by the fresh water aquaculture sector in KZN. These included both worker and farmer skills.

The study found that KZN Department of Agriculture and Rural development employs only one aquaculture professional and that 2 farmers out of 10 had tertiary qualifications in agriculture. This study concluded that two factors can be attributed to under performance of the fresh water sector, namely: lack of formal aquaculture skills qualifications and poor knowledge transfer. Consequently, without a comprehensive aquaculture skills development and knowledge transfer agenda, gaps in aquaculture skills development and knowledge transfer will continue.

ASSESSMENT OF HEAVY METALS POLLUTION IN SEAWATER AND SEDIMENTS IN THE ARABIAN GULF, NEAR DAMMAM, SAUDI ARABIA

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Anthropogenic activities, urban and industrial wastewaters, and the usual disintegration of rock from physical, chemical, and biological stresses are the main cause of heavy metals in seawater and sediments worldwide. Five different sampling locations were selected after an initial survey of the Dammam region Seawater study area, and sediment samples were procured in triplicate from each location to assess the level of selected heavy metals pollutions in the Arabian Gulf, Dammam, Saudi Arabia. Be, Cr, Ni, Cu, As, Se, Ag, Cd, Pb, Hg, Co, Zn, Fe, Mn, Sr, and Mo were detected using "inductively coupled plasma mass spectrometer (ICP-MS)." The pH ranges from 7.91±0.26 -8.22 ± 0.38 in stations 4 and 3, respectively. Surface seawater's electrical conductivity values ranged from 71788±28.52 to 75680 ± 42.92 µS/cm at stations 4 and 3. The minimum and maximum concentration of total dissolved solid was observed as 49524 ±50.25 and 54786 ±66.95 mgL^{-1} in sites 4 and 3, respectively. The level of these metals fluctuated among the sampling sites. The highest concentration of these heavy metals was recorded from sampling site 4 and minimum in location 1. The average level of these metals in water samples were recorded Sr > Cu > Se > Zn > As > Mn > Fe > Ni > Mo > Hg > Co > Cr > Ag > Cd > Pb and Be, respectively. The average level of these metals in sediment samples were recorded Fe > Sr > Ni > Mn > Cu > Cr > Zn > Pb > Ag > As > Mo > Co > Se > Hg > Be and Cd, respectively.

It has been concluded that the pollution stress was not very high except Tarut Island compared to other sampling sites. The average level of these metals in water samples were recorded Sr > Cu > Se > Zn > As > Mn > Fe > Ni > Mo > Hg > Co > Cr > Ag > Cd > Pb and Be, respectively. The average level of these metals in sediment samples were recorded Fe > Sr > Ni > Mn > Cu > Cr > Zn > Pb > Ag > As > Mo > Co > Se > Hg > Be and Cd, respectively. The concentration of As, Hg, Cd, Cr, Cu, Fe, and Sr was high, alarming, particularly in the Dammam area. This critical situation warrants the attention of the country's Environmental Protection Agency and other stakeholders to devise strategies to overcome the current situation to ensure the supply of aquaculture products for human consumption.

EVALUATION OF THE EFFICACY OF SALINOMYCIN/AMPROLIUM (SAL/AMP) LOADED CHITOSAN NANOPARTICLES ON THE MYXOSPORES OF *Myxobolus cerebralis*, THE CAUSATIVE AGENT OF SALMONID WHIRLING DISEASE

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Myxobolus cerebralis, is the causative agent of salmonid whirling disease which results in higher economic losses. In our investigation, we studied the effects of Amprolium (Amp.), Salinomycin and Amproulium (Sal/Amp), chitosan nanoparticles (CNs), Amprolium-loaded chitosan nanoparticles (Amp- CNs), and Salinomycin + Amprolium-loaded chitosan nanoparticles (Sal/Amp- CNs) on the infectivity of myxospores of *Myxobolus celebralis* in vitro and in vivo. Preparation of the chitosan nanoparticles has been done by using the ionic gelation method and loaded with different drugs.

In the in vitro study, Myxospores were obtained from 60 clinically diseased rainbow trout. The myxospores have been divided into 6 groups each of them incubated with 3 different concentrations of the treatments at the 3-time interval (12,24,48 hr) except the un-treated group which serves as a control. Each group of spores has been analyzed using a light microscope. The strongest effect was found to be after 48hr. The percentage of dead and defective spores were 15±8.6% normal,61± 9% amp.,61.7±2.9% Sal/Amp, 65.3±0.6%CNs, 63±2.6%CNs-Amp, and 66±2.6%CNs-Sal/Amp. We tested the cytotoxicity effect of the chosen concentration of each treatment using the Alamar blue cytotoxicity essay on two different types of cell lines (EPC and BF2) for 72hr. Treatments were found to be safe for both cell lines. The effect of different treatments for the chosen concentration and incubation time has been evaluated using a fluorescent microscope (FDA and PI staining) and Transmission Electron Microscope (10000 spore/group for each technique). Sal/Amp-CNs and Amp-CNs showed the strongest effect regarding the alteration in spores' morphology and dead spores counting. Followed by CNs- treated group, then Sal/Amp and Amp. While the non-treated group shows normal morphology and dead spores counting.

On the other hand, in the in vivo study, *Tubifex tubifex* were infected with four different groups of myxospores (Sal/Amp CNs -treated spores, CNs-treated spores, Sal/Amp -treated spores, non-treated spores). The worm was sampled for Conventional PCR and qPCR at 3-time intervals (1st month, 2nd month, 3rd-month post-infection). All groups were found to be infected with light infection after the 2nd month with slight differences between the 2nd and 1st months.
The 3rd- month PCR and the final filtration are in progress.

IMPROVED GROWTH PERFORMANCE OF NILE TILAPIA *Oreochromis niloticus* JUVENILES USING A PHYTOGENIC FEED ADDITIVE

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Nile tilapia (*Oreochromis niloticus*) is one of the most aquacultured fish species worldwide, mainly due to its rapid growth performance and market value. However, as occurs in other farmed species, growth performance, feed efficiency and disease resistance are usually challenged by stressful situations derived from common culture practices. Phytogenic feed additives (PFA) have been demonstrated to be potential tools to improve production performance.

Three studies were conducted to determine the efficacy of a new phytogenic feed additive (saponins, spices and essential oils) on Nile tilapia juveniles growth performance and feed efficiency. Diets were formulated to contain different levels of Syrena® Boost (0, 200 & 400 mg/kg) and fed for 8 weeks to Nile tilapia juveniles in triplicates. Experimental tanks were 100 L & 350 L tanks, depending on the study.

After 8 weeks of dietary PFA supplementation, similar results were obtained in all three studies. In the first one, fish fed the different levels of the product showed a 11.6% & 9.7% increase in weight gain, 6.4% & 6.2% increase in specific growth rate (SGR) and 7.6% increase in total feed intake, depending on the dose, without compromising feed conversion ratio (FCR), compared to fish fed with the control diet. In the second study, fish fed PFA supplemented diet showed a significant ($p \leq 0.05$) increase of weight gain compared to fish fed the control diet by 7.2%, an increase in SGR by 6.7% and a significant ($p \leq 0.05$) improvement in FCR by 6.9% compared to fish fed the control diet. In the third trial, fish fed PFA supplemented diet showed a significant ($p \leq 0.01$) increase in feed intake by 6 & 6.2%, an increase in weight gain by 9.6% & 9.9% and a significant ($p \leq 0.05$) improvement in SGR by 4.8% & 7.9%, depending on the dosage.

In summary, these studies indicate the benefits of supplementing Syrena® Boost, a specific formulation of selected phytogenics, being efficient to promote tilapia growth performance, to stimulate feed intake and to optimize feed conversion ratio. All this supporting Syrena® Boost as an ideal phytogenic product to enhance the profitability of tilapia production in a cost-effective way.

SUCCESSFUL LARVICULTURE OF THE GIANT AFRICA FRESHWATER PRAWN *Macrobrachium vollenhovenii* IN CAMEROON

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The African River prawn *Macrobrachium vollenhovenii* is the largest of the local Palaemonidae prawns along the Cameroonian coast and an important target species for fisheries and aquaculture. A preliminary study on larviculture of this species was carried out at the IRAD-AQUASOL hatchery in Kribi, Cameroon.

Berried females *M. vollenhovenii* were obtained from the Lobe and Lokoundje Rivers in the Southern Region, typical Lower Guinea rainforest streams. The larval rearing system consisted of a single recirculation system of four 65 L cylindrical plastic containers connected to a submerged biological filter container (65 L). Experiments were conducted three times in the same condition, with two batches of larvae reared separately in duplicate per experiment, at a density of 40/L, temperature 26°C, and salinity 16‰. Larvae were fed from 1 day after hatching until metamorphosis to postlarvae (PL) with newly hatched *Artemia* nauplii, three times daily at the rate of 5 nauplii per mL water.

The number of newly hatched larvae per female body weight unit was not affected by the female size and ranged between 531 to 1349 larvae g–1. The six batches succeeded from hatching to metamorphosis, and the 11 distinct larval stages described for *M. rosenbergii* were found. Larvae in all the batches developed more or less at the same pace up to stage V. However, a clear difference in the timing of appearance of the developmental stages was observed between batches and individuals of the same batch during the subsequent stages. The transition from stage V to stage VI and from stage IX to stage X was longer than the passage to other stages and seems to be the critical rearing period of *M. vollenhovenii*. From day 20 onward to sampling, the larval stage index (LSI) showed that larval development of the batch 1 was significantly faster than for all other batches (Table 1). The time for first appearance of postlarvae was variable between batches (41–74 days), and batch 1 larvae passed through metamorphosis within a shorter span of time (41 days). Survival up to postlarvae was variable among batches, ranging between 3%–9%, and was better in batch 1 (9.31 ± 1.09). This result is the first recorded success in larviculture of *M. vollenhovenii* in Cameroon.

Table 1. Offspring quality parameters of different females of *M. vollenhovenii*

Parameters	**Broodstocks**					
	F1	**F2**	**F3**	**F4**	**F5**	**F6**
LSI at day 10	4.0±0^{a}	3.7±0.49^{b}	4.0±0^{a}	3.7±0.47^{b}	4.0±0^{a}	4.0±0^{a}
LSI at day 20	**5.3±0.47^{a}**	5.0±0^{b}	5.0±0^{b}	5.0±0^{b}	5.0±0^{b}	5.0±0^{b}
LSI at day 40	9.9±0.88^{a}	7.0±1.03^{b}	6.3±0.79^{c}	6.4±1.10^{bc}	7.3±1.21^{b}	8.0±1.23^{d}
PL appearance (days)	**41±1**	70±0	**74±1**	69±1	67±1	63±0
Survival rate up to PL (%)	**9.3±1.09**	3.8±0.22	3.4±0.30	3.2±0.22	2.9±0.30	4.9±0.60

ASSESSMENT OF CAUSATIVE AGENTS IN ICE ICE DISEASE IN *Kappaphycus Alvarezii* AND RELEVANT MOLECULES FOR PROLIFERATION OF ALGAL PATHOGENS IN ZANZIBAR ISLANDS

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The aim of this research was to assess causative agents in Ice Ice disease in *Kappaphycus Alvarezii* and relevant molecules for the proliferation of Algal Pathogens in Zanzibar Islands, the collection of diseased seaweed was collected from Unguja (Bweleo and Muungo) and Pemba (Tumbe and Chokocho) during wet and dry season. Bacteria isolates were collected and identified using 16s rRNA gene, and pathogenicity experiment was conducted for 10 days, The study also collected farmed sponges from Paje Zanzibar for extraction of antibacterial compounds for testing their use in inhibiting pathogenic bacterium in seaweed *Kappaphycus Alvarezii*. The results showed that 110 isolated were obtained from 10 genus of bacteria namely *Bacillus, Vibrio, Psychobacteria, Paracoccus, Cobetia, Pseudoalteromonas, Halomonas, Shwanella, Photobacterium and Burthilderia* and the causative agents were *Vibrio mytilii, Cobetia litoralis, Psychrobacter nivimaris, Photobacterium angustum, Pseudoalteromonas issachenkonii, Cobetia Litorallis, Paracoccus marcusii, Fictibacillus nanhalensis, Bacillus Indicus* and *Pseudoalteromonas issachenkonii were positive causative agents* furthermore, *Bacillus velezensis, Exiguobacterium mexicanum,* showing epiphytic diseases.

Their was no acitivity for antibacterial from callyspongia sp. Against all pathogenic bacteria

Figure 1: Seaweed *Kappaphycus Alvarezii* with Ice Ice Disease

INITIATIVES IN WIND ENERGY FOR WELL WATER EXTRACTION IN KENYAN RIPARIAN LANDS

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Wind energy is a green and renewable source of energy that can compete effectively in increasing world of electricity market. The initial capital investment in wind energy goes to the machine and other supporting infrastructure. Wind energy can be used to generate underground water for use domestically and in aquaculture in Riparian communities to beef up food security in our society. Water flow in wetlands ecosystems can be irregular and of limited supply in many Riparian livelihoods, furthermore water from streams and rivers is becoming scarce. Therefore, using wind energy to tap underground water can provide livelihood to Riparian communities. Underground well water extraction can provide continuous water supply and effectively close the gap of clean water, shortage for Riparian farming and general use. A mathematical model of a wind turbine is essential in understanding the behaviour of wind over its region of operation. Modelling also enables control of wind turbines performance in Riparian areas. Through this initiative we expect to provide clean continuously flowing water for many households in aquaculture. Furthermore, there are reduced incidences of water borne diseases hence Riparian communities can engage in aquaculture and other farming enterprises using wind energy and healthy waters from wells extraction**.**

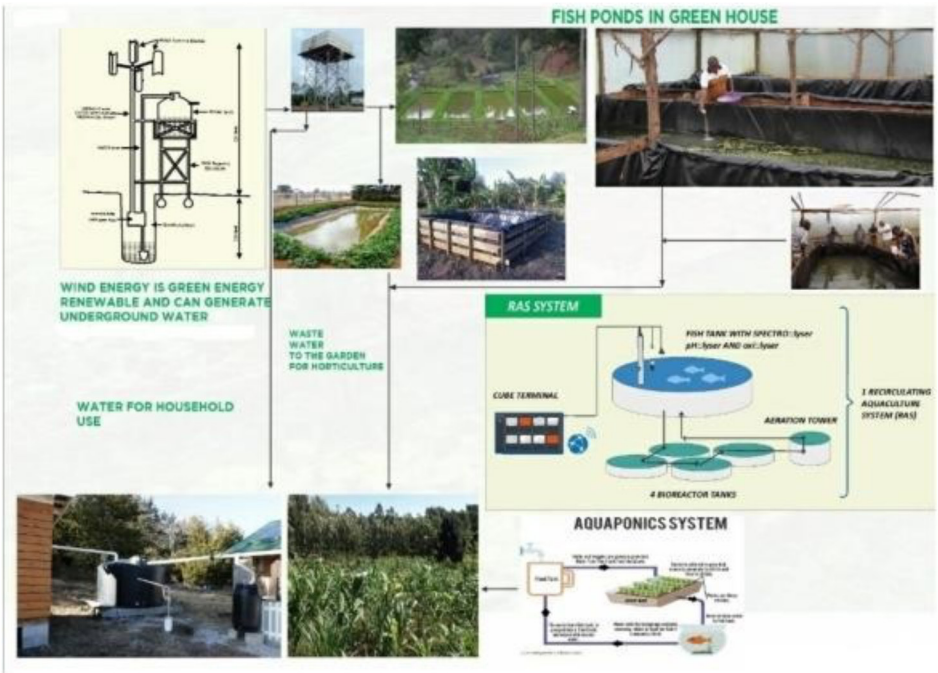

Figure 1. Aquaculture Initiatives in riparian parts of Kenya

BIOSECURITY IN FISH CULTURE

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One of the most important negative impacts of fish culture is the fact that farmed fish are more susceptible to disease agents than their wild counterparts due to the artificial conditions posed by intensive rearing. However, the natural sources of fishes are becoming poorer because of pollution and unmanaged fishing of many immature fish.

Adverse environmental situations may acutely or chronically stress fish health, altering some of their biochemical parameters and suppressing their innate and adaptive immune responses. These drastic impacts are manifested in the high fish mortality from acute infections and the lowered growth rate and food conversion in the chronically diseased ones with the end result of decreased fish production outcome. Nowadays, the main objective of fish pathologists is not only directed to overcome the infectious outbreaks appear, but also how to prevent the spread of diseases in the different fish culture systems in order to produce a safe and cheap good quality animal protein for human consumers. To fulfill this important issue, microbial epidemiological studies for the different available fresh water and marine water environments suspected to be sites for fish production are urgently required.

EFFECT OF DIETARY *Clostridium autoethanogenum* PROTEIN ON GROWTH, BODY COMPOSITION, PLASMA PARAMETERS, AND HEPATIC GENES EXPRESSION RELATED TO GROWTH AND AMPK/TOR/PI3K SIGNALING PATHWAY OF THE GENETICALLY IMPROVED FARMED TILAPIA (GIFT) JUVENILES

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This study investigated the effect of dietary *Clostridium autoethanogenum* protein (*Ca*P) on growth, whole-body composition, plasma parameters, and hepatic genes expression related to growth and AMPK/TOR/PI3K signaling pathway of the genetically improved farmed tilapia (GIFT: *Oreochromis niloticus*) juveniles. The fish (initial weight of 0.7 ± 0.05 g) were fed with diets containing *Ca*P at 0 g/kg (Control, diet 1), 50 g/kg (Diet 2), 100 g/kg (Diet 3), 150 g/kg (Diet 4) and 200 g/kg (Diet 5) to partially replace mainly soybean meal in triplicates. After 8 weeks feeding trial, the growth was significantly ($P < 0.05$) improved by dietary *Ca*P compared with the control. Whole-body crude lipid increased in the fish group fed over 50 g/kg *Ca*P ($P < 0.05$). Plasma triglycerides (TG) was significantly ($P < 0.05$) elevated by dietary *Ca*P protein at 200 g/kg. *Ca*P supplementation significantly ($P < 0.05$) up-regulated the mRNA expression of the growth-related insulin-like growth factor-1 (IGF-1). 50 g/kg and 100 g/kg dietary *Ca*P improved the phosphorylation and protein levels of the eukaryotic initiation factor 4E binding protein 1 (4E-BP1) and ribosomal protein S6 Kinase 1 (S6K1), and the phosphorylation of the adenosine monophosphate-activated protein kinase (AMPK) compared with the control diet. The phosphorylation level of the phosphoinositide 3-kinase (PI3K) was lowered by 200 g/kg *Ca*P compared with the control. The pyruvate kinase (PK) mRNA level was significantly ($P < 0.05$) up regulated by 100 g/kg *Ca*P; while glucose 6-phosphatase (G6Pase) mRNA expression was downregulated by 150 g/kg and 200 g/kg *Ca*P compared with the control ($P < 0.05$). The mRNA expression of fatty acid transport protein 5 (FATP5) was significantly downregulated by 100-200 g/kg; peroxisome proliferator-activated receptor alpha (PPARα) was significantly down-regulated by 50 g/kg; while fatty acid synthase (FAS) was significantly up-regulated by 150 g/kg and 200 g/kg *Ca*P compared with the control ($P < 0.05$). The results further showed that GIFT juveniles fed with dietary *Ca*P could regulate whole-body energy homeostasis through the AMPK signaling pathway. Therefore, *Ca*P could successfully be used as a novel and sustainable protein in juvenile GIFT diets.

Table 1: Growth and nutrient utilization of GIFT juveniles fed diets with dietary *Ca*P

	Dietary treatments					SEM
Parameter	**Diet 1 (Control)**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	
IBW (g)	0.67	0.68	0.69	0.69	0.69	0.00
FBW (g)	16.11^{a}	21.11^{b}	21.75^{bc}	22.41^{bc}	23.12^{c}	0.68
WGR (%)	2247.09^{a}	3024.89^{b}	3068.71^{bc}	3162.16^{bc}	3261.89^{c}	98.49
SGR (%/day)	5.63^{a}	6.15^{b}	6.17^{b}	6.22^{b}	6.28^{b}	0.06
SR (%)	98.89	97.78	100.00	100.00	100.00	0.48
FCR	1.29^{a}	0.99^{b}	0.96^{b}	0.97^{b}	0.94^{b}	0.04
FI	1.24^{a}	0.96^{b}	0.93^{b}	0.94^{b}	0.91^{b}	0.03
PER	2.73^{a}	3.55^{b}	3.56^{b}	3.57^{b}	3.42^{b}	0.10

Table 2: Whole-body composition of GIFT tilapia fed varying levels of dietary *Ca*P

	Dietary treatments					SEM
Parameter (g/100g)	**Diet 1 (Control)**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	
Moisture	74.83	75.04	74.29	73.44	73.44	0.24
Protein	15.04	14.48	15.04	14.92	14.47	0.09
Lipid	5.92^{a}	5.92^{a}	6.28^{b}	6.83^{b}	6.87^{b}	0.13
Ash	3.37	3.52	3.63	3.46	3.54	0.05

(Continued on next page)

Table 3: Plasma parameters of GIFT tilapia fed different levels of dietary *Ca*P

Parameter[1]	Dietary treatments					SEM
	Diet 1 (Control)	Diet 2	Diet 3	Diet 4	Diet 5	
TP (g/L)	20.70	21.92	22.26	23.06	22.09	0.43
ALB (g/L)	12.97	11.30	12.47	12.87	12.56	0.28
TG (mmol/L)	37.80[a]	39.39[a]	44.64[a]	45.70[a]	54.43[b]	1.55
Glu (mmol/L)	5.87	5.49	6.42	6.58	6.35	0.15
TC (mmol/L)	2.73	2.89	2.79	3.03	3.18	0.06
ALT (U/L)	27.39	20.56	24.80	27.60	17.48	1.95

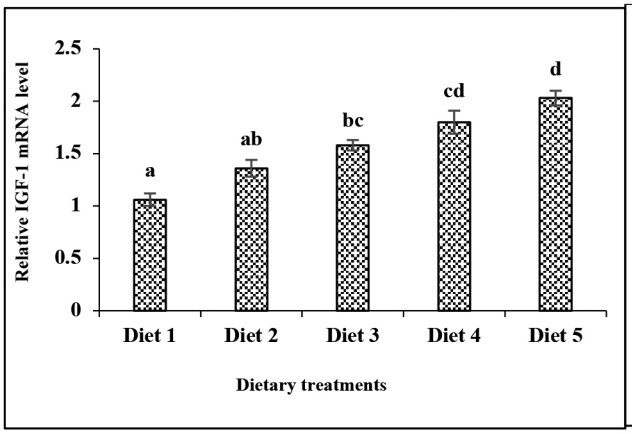

Figure 1: Relative mRNA expression of hepatic insulin-like growth factor-1 (IGF-1) in GIFT juveniles fed diets with *Ca*P

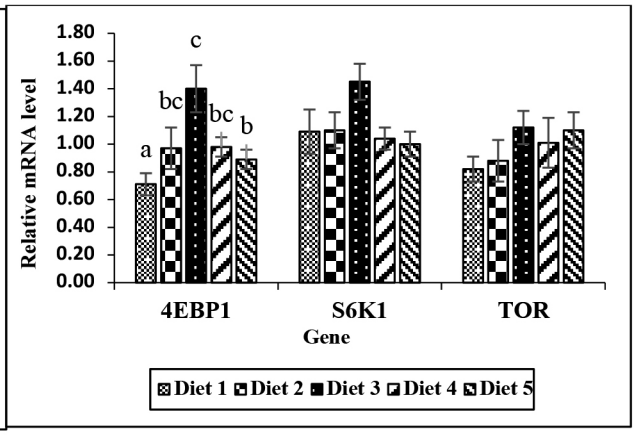

Figure 2: Relative mRNA expression of hepatic genes related to protein synthesis in GIFT juveniles fed diets with *Ca*P

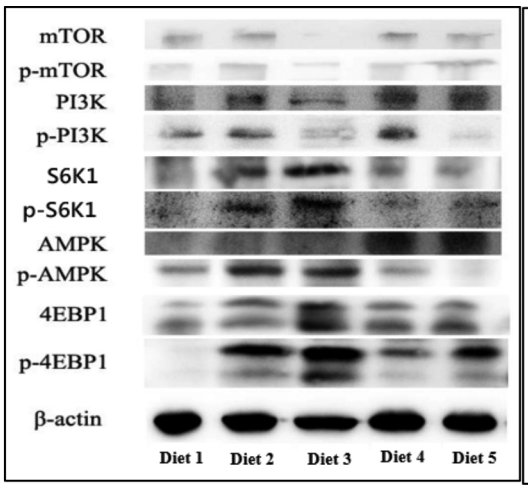

Figure 3: Protein and phosphorylation levels of some selected hepatic genes related to protein synthesis and glucolipid metabolism of GIFT juveniles fed diets with *Ca*P

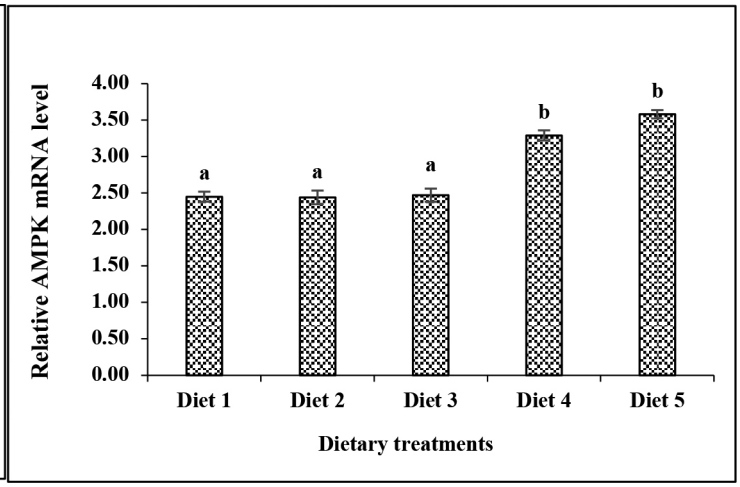

Figure 4: Relative mRNA expression of hepatic monophosphate-activated protein kinase (AMPK) in GIFT juveniles fed diets with fed diets with *Ca*P

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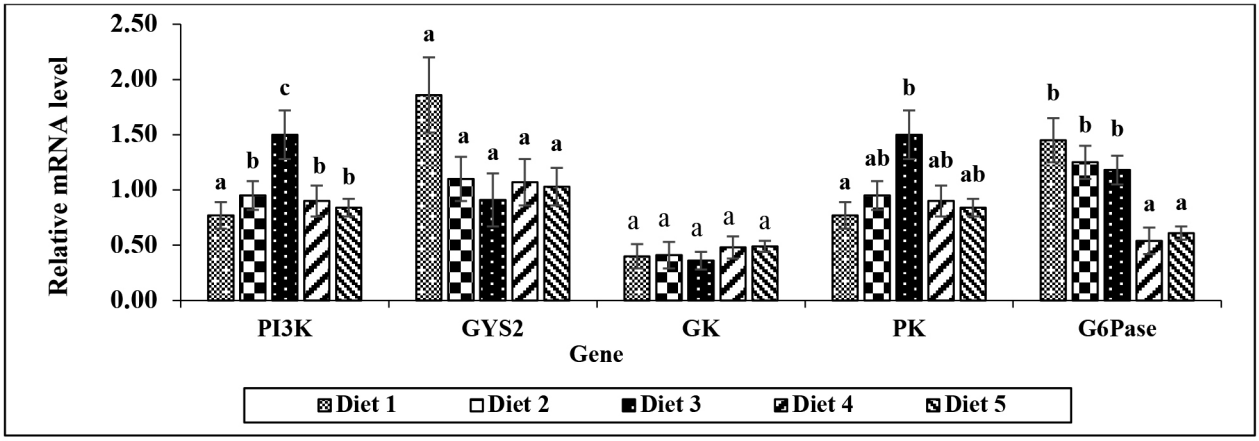

Figure 5: Relative mRNA expression of some selected hepatic genes involved in glucose metabolism of GIFT juveniles fed diets with *Ca*P

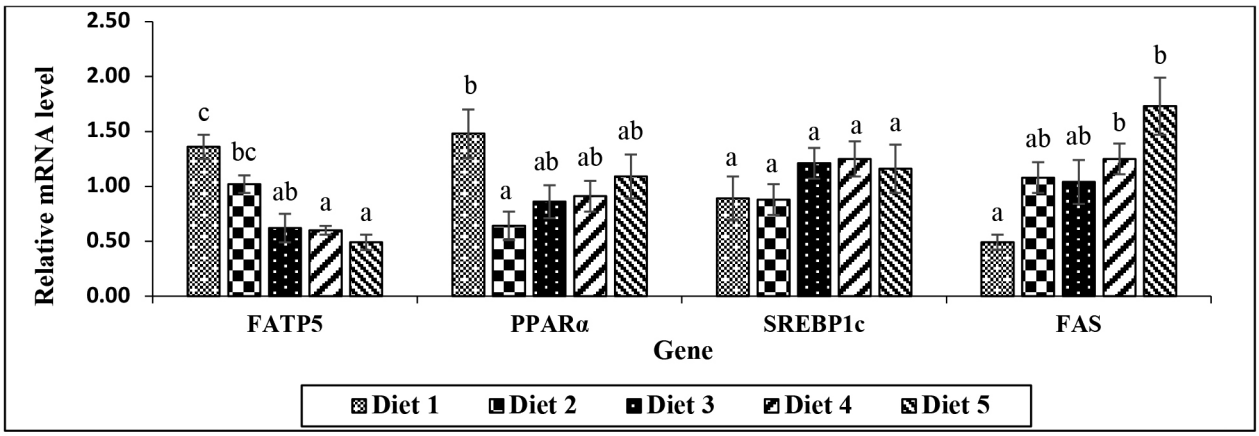

Figure 6: Relative mRNA expression of some selected hepatic genes involved in lipid metabolism of GIFT juveniles fed diets with CaP

EFFECT OF REPLACING FRESHWATER SHRIMP MEAL *Caridina nilotica* PROTEIN WITH A MIXTURE OF PLANT PROTEIN ON GROWTH, APPARENT DIGESTIBILITY, AND ECONOMIC RETURNS OF NILE TILAPIA *Oreochromis niloticus* L

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This study aimed to evaluate the effects of substituting varying levels of a plant protein mixture (PPM) with freshwater shrimp meal (FSM) on the growth, digestibility, and economic returns of Nile tilapia. Monosex male *O. niloticus* fingerlings (initial mean body weight, 28 ±0.01 g) were simultaneously cultured in cages installed in an earthen pond (for growth and economic returns studies) and tanks (for apparent digestibility assessment) for a period of 180 and 60 days, respectively. The PPM was made of 50% soybean meal, 25% sunflower cake, and 25% cotton seed cake. Replacement of FSM was done at 25%, 50%, 75% and 100% of the dietary protein and the diets labelled D1, D2, D3 and D4, respectively. The test diets were compared with a control diet containing (D0, 0% PPM). After 6 months of feeding, the fish fed on diets D0 and D1 did not differ ($p>0.05$) in growth performance. Fish weight gain decreased significantly ($p<0.05$) as the levels of PPM increased. Apparent digestibility of crude protein decreased significantly ($p<0.05$) with increasing inclusion levels of PPM in the diets with diet D0 recording the highest digestibility followed by D1 and D2 although D0, D1 and D2 were not significantly different from each other ($p>0.05$). Diet D0 and D1 were not significantly different ($p>0.05$) hence cost benefit analysis showed that D1 was economically viable than D0. In conclusion, PPM could partially replace FSM up to 25% without adverse effects on growth performance.

TABLE 1: Growth performance of *O. niloticus* fed on a mixture of plant proteins.

Experimental groups	**D0**	**D1**	**D2**	**D3**	**D4**
Rate of FSM substitution	**0%**	**25%**	**50%**	**75%**	**100%**
Initial length (cm)	11.11 ± 0.00^{a}	11.11 ± 0.00^{a}	11.11 ± 0.00^{a}	11.11 ± 0.00^{a}	11.11 ± 0.00^{a}
Initial body weight (g)	28.11 ± 0.01^{a}	28.11 ± 0.01^{a}	28.11 ± 0.01^{a}	28.11 ± 0.01^{a}	28.11 ± 0.01^{a}
Final mean body weight (g)	140.33 ± 3.27^{b}	130.18 ± 2.89^{b}	103.18 ± 2.03^{a}	99.20 ± 4.12^{a}	89.91 ± 2.33^{a}
Weight gain (%)	399.2 ± 1.79^{c}	363.1 ± 1.87^{bc}	267.1 ± 1.51^{b}	252.89 ± 1.28^{b}	217.3 ± 1.45^{a}
Daily weight gain (g)	0.68 ± 0.04^{c}	0.61 ± 0.06^{bc}	0.45 ± 0.04^{b}	0.42 ± 0.03^{b}	0.36 ± 0.07^{a}
Specific growth rate (% day-1)	2.38 ± 0.25^{c}	2.16 ± 0.27^{bc}	1.59 ± 0.22^{b}	1.51 ± 0.21^{b}	1.31 ± 0.18^{a}
FCR	1.63 ± 0.14^{a}	1.69 ± 0.14^{a}	1.75 ± 0.23^{b}	1.78 ± 0.20^{b}	2.08 ± 0.48^{c}
Condition factor	1.73^{a}	1.76^{a}	1.77^{a}	1.68^{a}	1.84^{a}
Survival (%)	99 ± 1.12^{a}	97 ± 1.22^{a}	99 ± 0.98^{a}	98 ± 1.28^{a}	97 ± 1.14^{a}

Values with the same superscript across rows are not significantly different ($p<0.05$). Values are expressed as mean ± SEM). D0=Control diet; D1=25% fishmeal replacement; D2=50% fishmeal replacement; D3=75% fishmeal replacement; D4=100% fishmeal replacement

REVIEW OF AQUACULTURE, GOVERNANCE AND DEVELOPMENT OF SMALL-SCALE AQUACULTURE IN THE IORA REGION

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Aquaculture has been around for millennia but only started to contribute significantly to the global food supply and rural livelihoods about 30 years ago. Whereas aquaculture provided just 7% of fish for human consumption in 1974, this share had increased to 26% in 1994 and 54% in 2018 with 114.5 million tonnes of production, and it is expected to increase by 62% by 2030 (FAO, 2020).

The Indian Ocean Rim Association (IORA) 23 members states represented together 26.2 million tonnes of aquaculture production, representing 17% of the world volume production in 2018 . The development of aquaculture in the IORA region is also recent, the production multiplied almost 6-fold over the past two decades to represent almost USD 39 billion to IORA members states economy in 2018 (FAO). Analysis of the type of aquaculture and species used show the predominance of small- scale aquaculture and the ascendancy of 6 species, over the 80 cultured, representing 80% of the Indian Ocean production (in volume).

All member states of IORA are not at the same development stage of their aquaculture, five countries alone represent 69% of the Association's production and some countries have almost no aquaculture activities. The member states can be shared into three thematic categories:

a. "Mature aquaculture sector development": countries where the aquaculture sector represents more than 30% of national fisheries products with important sector development and dynamism.
b. "Emerging aquaculture sector": countries still have low or no aquaculture production but with an important potential for development. In these countries, the aquaculture sector remains nascent and with low levels of production even if some timely development can be noticed.
c. "High technical aquaculture development": Some members of IORA have chosen to develop aquaculture species with high value (based on their national market or for export). This form of aquaculture requires infrastructure and important technical and technological skills.

This disparity has several roots causes, from size of the country and its population, areas suitable for aquaculture, traditional social structure in rural areas, development approaches, market dynamisms and accessibility and experiences of aquaculture production. The different experiences between members of IORA offer opportunities to share lessons learnt on the approaches of aquaculture development, the drivers, the successes, and the pitfalls.

From an analysis of past experiences, some key requirements for sustainable and viable projects can be observed. Five requirements can be discerned:

a. Good environment for aquaculture development and governance;
b. Structures and inputs for small-scale aquaculture development;
c. Knowledge and technology – Strengthening human capacity and communication;
d. Support for business investment and economic development;
e. Sustainability approach.

The promotion of sustainable aquaculture development in the implementation of the IORA Action Plan (2017-2021) focuses on sustainable aquaculture practices, focussing on rural and coastal communities in IORA MS, including SIDS and LDCs and will be showcased in the presentation.

SYNERGISTIC EFFECTS OF THE SOAPBARK TREE, *Quillaja saponaria* AND VITAMIN E ON WATER QUALITY, GROWTH PERFORMANCE, BLOOD HEALTH, GILLS AND INTESTINE HISTOMORPHOLOGY OF NILE TILAPIA, *Oreochromis niloticus* FINGERLINGS

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This study aimed to evaluate the synergistic effects of *Quillaja saponaria* (QS), and Vitamin E (VE) on water quality, fish performance, and health of *Oreochromis niloticus* fingerlings. Fish (N=120, 12.75±0.289 g) were randomly distributed in triplicates into four experimental groups. (1) the control group (CG), fish received a basal diet; (2) the *Quillaja saponaria* group (QS), fish received a basal diet containing 300 mg kg^{-1} QS extract; (3) Vitamin E group (VE), fish received a basal diet supplemented with 400 mg kg^{-1} VE; and (4) QS/VE group, fish received a basal diet supplemented with a mixture of 300 mg kg^{-1} QS extract and 400 mg kg^{-1} VE. Fish fed experimental diets (30/6, protein/lipids ratio) for 60 days.

Results revealed a significant decrease of total ammonia nitrogen and unionized ammonia in fish fed QS/VE, VE, and QS compared to CG. Fish provided QS and/or VE showed a significant improvement in growth and feed utilization indices compared to CG (P<0.05), with the best results in QS/VE group. QS and/or VE's dietary supplementation did not improve hematological parameters. However, a significant improvement of serum analyses (total protein, albumin, globulin, A/G ratio, cholesterol, and triglycerides) was recorded in fish fed QS and/or VE compared to CG with the best values in QS/VE. Digestive enzyme activity (lipase, amylase) and oxidative parameters (SOD, CAT) were significantly increased with QS and/or VE dietary supplementation, and the best findings were recorded in QS/VE. Gill necrotic tissues were alleviated in fish fed QS or/and VE. The intestinal health (villi length, villi surface area, and goblet cells count) showed a significant improvement by dietary QS or/and VE, with the best findings in fish received QS/VE.

In conclusion, QS and/or VE's dietary supplementation improves water quality, fish performance, blood health, gills, and intestine health of Nile tilapia.

Table 1. Growth performance and feed utilization of fish fed experimental diets for 60 day

	CG	QS	VE	QS/VE
Initial body weight (g)	12.88±0.285	12.81±0.298	12.73±0.386	12.84±0.278
Final body weight (g)	42.93±0.692^{c}	47.52±0.397^{b}	46.12±0.464^{b}	50.02±0.393^{a}
Body weight gain (g)	30.22±0.898^{c}	34.89±0.545^{b}	33.29±0.566^{b}	37.39±0.416^{a}
Total feed intake (g)	41.97±2.121	42.21±1.051	42.17±1.257	41.57±1.006
Specific growth rate (% /day)	2.032±0.060^{c}	2.213±0.044^{b}	2.137±0.044^{b}	2.296±0.029^{a}
Final Length (cm)	13.62±0.321	13.48±0.290	13.39±0.268	13.80±0.236
Condition factor (K)	1.699±0.061	1.940±0.104	1.921±0.073	1.902±0.076
Survival rate (SR %)	93.33±3.333	96.67±3.333	96.67±3.333	96.67±3.333
Feed conversion ratio	1.389±0.136^{a}	1.210±0.014^{b}	1.267±0.033^{b}	1.112±0.021^{c}

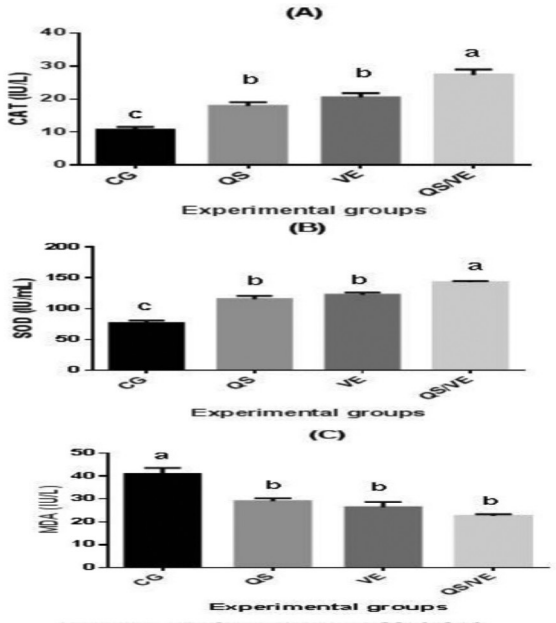

Figure1. Oxidative status of fish fed experimental diets for 60 days.

Quillaja saponaria AND/OR *Yucca schidigera* AMELIORATE WATER QUALITY, GROWTH PERFORMANCE, IMMUNE-OXIDATIVE STATUS, DIGESTIVE ENZYMES, INTESTINE AND GILLS HISTOMORPHOLOGY OF NILE TILAPIA, *Oreochromis niloticus*

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This study aimed to evaluate the synergistic effects of *Quillaja saponaria* (QS) and *Yucca schidigera* (YS) on water quality, growth performance and health of Nile tilapia. Fish (n=120, 11.97±0.497 g) were randomly distributed into four experimental groups in triplicates. (1) Control group (CG), fish received basal diet; (2) *Yucca schidigera* group (YS); fish received basal diet and 0.11 mL/m^3 per week *YS* extract in water; (3) *Quillaja saponaria* group (QS), fish received basal diet supplemented with 300 mg kg^{-1} *QS* extract; (4) Mixed group (QS/YS), fish received basal diet supplemented with 300 mg kg^{-1} *QS* and 0.11 mL/m^3 per week *YS* extract in water.

Results revealed an improvement of water quality parameters in QS/YS, YS, and QS compared to CG ($P \leq 0.05$). Fish received QS and/or YS showed higher growth performance and lower feed conversion ratio than CG ($P \leq 0.05$), with the best findings being reported in QS/YS. Using QS and/or YS improved gill health, increased intestinal villi length, and goblet cell number compared to CG ($P \leq 0.05$). Lymphocytes, total protein, globulin, and lysozyme activity were increased, while cholesterol, triglycerides, glucose, and creatinine were decreased in fish received QS and/or YS compared to CG ($P \leq 0.05$), with the best results being observed in QS/YS. QS and/or YS supplementation increased lipase, amylase, superoxide dismutase, catalase while reduced malonaldehyde activity compared to CG, with the highest activity being recorded in QS/YS.

Conclusively, Nile tilapia received QS and YS prompted synergistic effects that improved water quality, growth performance, immune-oxidative status, digestive enzymes, gills and intestine histomorphology.

Table 1. Water quality analysis of fish exposed to experimental treatments for 60 day

	CG	QS	YS	QS/YS
Dissolved oxygen (mg/L)	4.984±0.129^{b}	5.105±0.139^{ab}	5.385±0.182^{ab}	5.618±0.122^{a}
Temperature (°C)	26.81±0.399	26.80±0.406	26.57±0.351	26.91±0.435
pH	7.950±0.065	7.775±0.053	7.842±0.079	7.867±0.084
Total ammonia nitrogen (mg/L)	0.618±0.190^{a}	0.445±0.082^{a}	0.112±0.033^{b}	0.107±0.033^{b}
Unionized ammonia (mg/L)	0.035±0.0001^{a}	0.017±0.0001^{b}	0.005±0.0001^{c}	0.005±0.0001^{c}

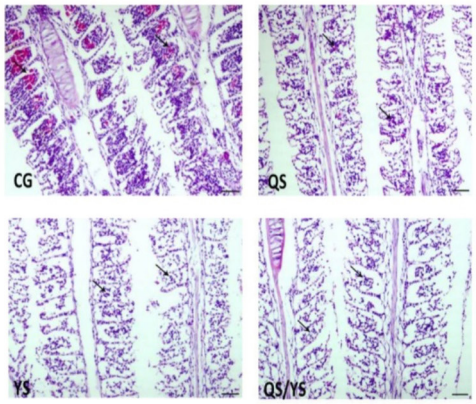

Figure1. Gills histomorphology of fish exposed to different experimental treatments for 60 day.

EFFECTIVENESS AND COST-BENEFIT OF IN WATER PROBIOTICS IN TILAPIA FARMING: ON FARM TRIAL

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The aim of this study was to evaluate the effectiveness and cost-benefit of water probiotics (Sanolife PRO W) in tilapia farming. Six earthen ponds (2100 m^2, 6500 fish each, 20±2.21 g/fish) were used. Ponds were randomly allocated for the treatment and control, 3 ponds each. A water probiotic "Sanolife PRO W- INVE aquaculture Belgium", a blend of *Bacillus Subtilis* and *Bacillus Licheniformis* $5x10^5$ cfu/g, was add to the treatment ponds at a rate of 30 g per pond (50 g/feddan) every 2 weeks for 8 months, according to the manufacturer instructions.

The results revealed an improvement in the water quality especially total ammonia nitrogen and unionised ammonia in treated ponds ($P<0.05$). Final body weight, weight gain and feed conversion ratio were significantly ($P<0.05$) improved in fish treated with Sanolife PRO W. Furthermore, the fish received in water probiotic showed significant increase in total fish sales and relative percent of return ($P<0.05$). The morphometric analysis of intestine showed significant improvement in the absorption capacity in fish treated with Sanolife PRO W in form of increased villi length, villi width and goblet cell number compared to control group($P<0.05$).

In conclusion, using of in water probiotic (Sanolife PRO W) improved farmed water quality, Nile tilapia performance, feed utilization efficiency, total fish sales and relative percent of return.

Table 1: Effect of in water probiotic (Pro W) on water quality of tilapia earthen ponds

Parameters	Optimal conditions	Control group	Pro-W group	*P*-value
Temperature (°C)	24-32	28.03±0.632	28.06±0.626	0.9753
Dissolved oxygen (mg L^{-1})	> 3	5.356±0.306	5.517±0.322	0.7192
Salinity (ppt)	0-3	1.817±0.036	1.839±0.044	0.6952
pH	7-9	8.744±0.033^a	8.850±0.023^b	0.0124
Total ammonia nitrogen (mg L^{-1})	< 0.5	0.168±0.006^b	0.123±0.007^a	0.0001
Unionized ammonia (mg L^{-1})	0	0.048±0.003^b	0.040±0.003^a	0.0359

Means within the same row with different superscripts are significantly different (P<0.05).

Table 2: Effect of in water probiotic (Pro W) on growth performance of Nile tilapia in earthen ponds

	Control group	Pro- W group	*P*-value
Final body weight (g)	222.4±1.074^b	278.2±5.967^a	0.0008
Weight gain (g)	202.4±1.074^b	258.2±5.967^a	0.0008
Feed intake (g)	335.0±19.10	367.3±31.58	0.4302
Feed conversion ratio	1.654±0.019^b	1.422±0.014^a	0.0006

Means within the same row with different superscripts are significantly different (P<0.05).

DETERMINATION OF HEAVY METALS FROM BANANA BY_PRODUCT IN NILE TILAPIA (*Oreochromis niloticus)*; HEALTH RISK ASSESSMENT FOR CONSUMERS

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Introduction: The food gap in animal protein had already increased as the world's population has grown, aquaculture is one of the most important sources of animal protein for overcoming the gap (Galappaththi, Aubrac, Ichien, Hyman, and Ford, 2020). Nile tilapia (*Oreochromis niloticus*) is one of the most commonly used species in intensive farms thanks to their high growth rate, disease resistance, and low trophic feeding levels. (Furuya et al., 2008).

Though fish feed composes around 50% of the production cost (Mzengereza et al., 2014), therefore the use of alternative foods that meet the nutritional requirements of animals, without altering the quality of diet is important. The alternative component used in our study is banana by-product under the name of circular economy which is an industrial model aims to eliminate waste through a higher design (Ghisellini et al. 2016. Sometimes these plants contain heavy metals, which are considered dangerous to fish and therefore humans as final consumers. This led us to the aim of the study which is to determine the content of heavy metals in experimental diets with different inclusion of banana byproduct in Tilapia and the cascading effects on human health as final consumer.

Materials and methods: One hundred and ninety-two tilapia (*Oreochromis niloticus*) (5 g initial body weight) had been distributed among 12 glass tanks of 50 l of fresh water using a Recirculated Aquaculture System (RAS) in the facilities of the Technological Science Park Foundation (FCPCT) of the University of Las Palmas de Gran Canaria (Canary Islands, Spain). Fish had fed over the experimental diets three times per day 6 days per week, until apparent satiation, for 3 months. Sampling was made monthly to measure the parameters of weight, total size and furcal size, two fishes of every tank were collected for the heavy metals and pesticides determination. Four isocaloric and isoproteic diets will be developed: one of them will be a commercial diet of the specie under study, and other three including increasing percentages of the raw material of banana tallo obtained in the processing phase (5,10 and 20 %). For the health risk different parameters had been calculated such as Target Hazard Quotient (THQ) and Hazard Index (HI).

In addition, the Carcinogenic Risk of As measured in this study. Also, the Estimated Daily Intake (EDI) and Maximum Safe Consumption (MSCA) were determined.

Table 1. Target Hazard Quotient (THQ), Estimated Daily Intake (EDI) (mg/kg BW/day), for both consumptions (ng/g WW), and Maximum Safe Consumption (MSC) (kg fish WW/day), (x 10^{-1}), based on the Contents of heavy metals of Tilapia fed experimental diets.

element	treatment	Con wet/w	THQ*1^{-10}	EDI*1^{-10}	MSC
AS	control	0.2314	1.136	0.329	0.091
	D1	0.2796	1.373	0.397	0.075
	D2	0.2023	0.993	0.287	0.104
	D3	0.2421	1.189	0.344	0.087
Hg	control	0.0516	0.152	0.073	0.678
	D1	0.0605	0.178	0.086	0.579
	D2	0.0547	0.161	0.078	0.639
	D3	0.0540	0.159	0.077	0.648
Cd	control	0.0003	0.000	0.000	258.649
	D1	0.0002	0.000	0.000	292.447
	D2	0.0003	0.000	0.000	240.173
	D3				
Pb	control	0.0041	0.002	0.006	67.520
	D1	0.0141	0.005	0.020	19.809
	D2	0.0075	0.003	0.011	37.398
	D3	0.0108	0.004	0.015	25.920

Table 2. Hazard Index values (HI) for heavy metals (ng/g WW) of Nile tilapia fed experimental diets.

treatment	HI
control	0.129
D1	0.156
D2	0.116
D3	0.135

Table 3. The carcinogenic risk of arsenic (As-CR) (ng/g WW) (x 10-1) of Nile tilapia fed experimental diets.

element	treatment	As-CR *1^{-10}
AS	control	0.0005
	D1	0.0006
	D2	0.0004
	D3	0.0005

Results: As shown in Table 1 and 2 for toxic elements the THQ values and. HI values were far below 1 in all diets indicates that using banana raw material as a feed with different concentrations as a diet for Tilapia are safe for human consumption. The (EDI) for the elements, Cd and Pb element was found lower than the established Reference Doses (RfD). The Maximum Safe Consumption shown in Table 1 showed that (Cd and Pb) had the highest amounts that a person of 70 Kg can safely consumed. The As Carcinogenic Risk (As-CR) was below the highest established acceptable risk level of 10-4 (Table 3). This suggests that if a person of 70 kg takes 9.94g of these fish each day, 365 days per year and 56 years, the additional risk of developing cancer would not be entirely excluded.

EFFICACY OF CODED WIRE-TAGGING AS A TOOL TO ENHANCE THE STOCK OF GREY MULLET IN WADI EL-RAYAN LAKE AS ENCLOSED WATER BODIES

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Fish stocking and culture-based fisheries are valid management practices compensating the shortfalls of catch in overfished systems. Improving the survival of fish to be stocked–pre-conditioning and acclimatization to prevailing conditions in the receiving water body potentially improves their survival. Determining the appropriate size of fish for release requires knowledge of their likely impacts on native fishes and the ecosystem in general, together with a cost–benefit analysis. In the present study 16000 mullet, *Mugil cephalus* (11.41±0.04 cm) (10.5 ±0.8 g) tagged with the magnetic wire codes were used. Two nursing treatments were carried out to determine the influence of re-stocking nursing mullet fry on the enhancement of the stock of grey mullet in Wadi El-Rayan Lake as enclosed body. In the first treatment (T_1) grey mullet was tagged with coded wire-tagging in the earthen pond and nursing for 21-days then release in the Wadi El-Rayan Lake. While, in the second treatment (T_2) grey mullet was release immediately to Wadi El-Rayan Lake after the tagging with coded wire-tagging. Monthly samples were collected from the Lake periodically to follow up the growth performance over 716-days. The results showed that grey mullet survival (%) recorded 81.4% and 71.88% for T_1 and T_2, respectively. Mullet resulted in higher growth rate, length and weight either any fish sample date verses previous sample or between initial restocking mullet fish (Table 1).

The present findings indicated that it is important for fish to be stocked at a time when they are able to adapt to the new environment quickly and thus learn how to forage for natural foods with minimal delay. Determining the appropriate size of fish for release requires knowledge of their potential impacts on local fish and the ecosystem in general, along with a cost-benefit analysis. This work is a part of the USAED project outputs, " Stock enhancement and production of the Grey Mullet fry – a sustainable choice ", funded by a grant from the Middle East regional cooperation (MERC) program, U.S. Agency for International Development, Bureau for the Middle East. (Project Number: M33-038; Award Number: SIS70017GR33038).

Table (1) growth performance of tagging mullet which were restocked in Wadi Al-Rayyan Lakes, Fayoum Governorate .

	Total length (cm/fish)	Total weight (g/fish)	Weight Gain (g/fish)
14/04/2019	5.10	6.30	-
30/05/2019	11.5	16.3	10.00
23/12/2019	25.80	164.82	148.52
16/01/2020	26.5	172.47	7.64
16/03/2020	30.1	257.11	84.65
14/06/2020	31.50	350.72	93.61
1/11/2020	32.5	442.27	91.55
11/2/2021	33.24	476.68	34.41

REPLACEMENT OF FISHMEAL BY ANTARCTIC KRILL MEAL IN DIETS OF EUROPEAN SEA BASS *Dicentrarchus labrax:* EFFECTS ON GROWTH PERFORMANCE, FEED UTIZATION AND LIVER METABOLISM

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A sustainable growth of the aquaculture sector implies the use of sustainable novel raw materials as replacement of the traditional fish meal (FM) and fish oil (FO) ingredients. This fact will lead to the development of functional diets as part of a management strategy to reduce the effects on fish growth performance and health derived from low FM/FO dietary contents. In this sense, krill meal (*Euphausia superba*) may be a potential candidate to potentiate fish growth and health status.

European sea bass (*Dicentrarchus labrax*) were fed a commercial relevant diet with either a 15% fishmeal content (KM0) or the same diet substituted by 30% (KM5) or 50% Antarctic krill meal (KM7.5) for 12 weeks in triplicates. Diets were isoproteic (45%) and isolipidic (18%).

At the end of the feeding trial, growth performance, liver morphology, liver proximate composition and fatty acid profile, as well as liver lipid metabolism related genes were evaluated. After two months of supplementation, krill meal-supplemented fish presented increased feed intake ($p<0.05$), regardless of the dietary level. However, feed conversion ratio (FCR) was only significantly lower ($p<0.05$) in fish fed the KM7.5 diet. At the end of the feeding trial, fish fed KM-based diets presented increased ($p<0.05$) final weight, final length, relative growth, specific growth rate (SGR) and improved FCR, irrespective of the KM dietary level. Livers of European sea bass fed the experimental diets presented similar ($p>0.05$) biochemical composition and fatty acid profile. Despite the similar content of liver lipids, fish fed KM diets presented a healthier liver morphological profile. Hepatocytes of KM fed fish presented lower vacuolization levels, better alignment of the hepatocyte nuclei along the sinusoidal lines, and in general lower sings of steatosis. Liver gene expression results revealed a down regulation of the *3*-hydroxy-3-methylglutaryl-coenzyme A reductase *(hmgcr)* and delta-6-desaturase (*fads2*) expression, when fish were fed the KM7.5 diet compared to fish fed the KM0 diet. Besides, a significant negative correlation between the gene expression levels of *hmgcr, fads2* and KM dietary levels were observed. On the other side, fatty acid binding protein 7 (*fabp7*) and KM were significantly positively correlated.

Altogether profiling KM as a potential growth and health promoter in European sea bass fed low fish meal and oil diets.

CAPTURE BASED AQUACULTURE OF TARPON *Megalops atlanticus* IN NIGERIA: ASSESSMENT OF CARCASS NUTRITIONAL CHARACTERISTICS AND POND WATER QUALITY PARAMETERS

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Atlantic Tarpon *Megalops atlanticus* is a large, elopomorph fish found in coastal and inshore waters of the tropical and subtropical Atlantic Ocean. Under natural conditions, Tarpon occur in a variety of habitats ranging from freshwater lakes and rivers to offshore marine waters during their life cycles, and serve as economically important recreational fish species in many countries.

In Africa, Tarpon play a major role in the commercial artisanal fisheries along the Eastern Atlantic coastline areas (from Mauritania to Angola), especially in Nigeria where it is considered as highly priced food fish among the locals. Despite the existence of localized capture based farming for Tarpon in the coastal communities of Nigeria, information on nutritional characteristics, growth patterns, habitat and water requirements and other relevant data concerning its production in captivity is lacking. This study was conducted to provide baseline information on suitability of the fish for human consumption and for enhancing its aquaculture production.

The analyses were done in nine Tarpon farms in three coastal communities of Ilaje Local Government Areas of Ondo State, Nigeria. The assessed farms used dug-out ponds with static water conditions for culturing or fattening tarpon juveniles obtained from the wild and fed with trash fish or shrimps. Collected fish specimens were evaluated for carcass dressing and proximate analysis. Water samples in each of the assessed ponds were also analyzed

The results show that *M. atlanticus* are raised in a wide range of brackish/marine water conditions. Pond-raised *M. atlanticus* may serve as food fish due to their high dressing percentage and appreciable amount of macro-nutrients observed in this study.

Table 1: Physico-chemical parameters of water samples from *M. atlanticu* farms

Parameters	Range
Temperature (ºC)	26.9 – 27.2
Transparency (cm)	12.51 – 17.80
pH	6.57 – 7.24
Conductivity (mg/l)	366.29 – 420.65
Total dissolved solids (mg/l)	185.61 – 214.43
Dissolve oxygen (mg/l)	7.25 – 9.68
Nitrate (mg/l)	1.47 – 3.15
Ammonia (mg/l)	0.51 – 0.97
Salinity (mg/l)	15.36 – 44.91

Table 2: Carcass and proximate analysis of pond-raised *M. atlanticus*

Parameter	Fish weight range		
	0.7 – 1.0 kg	**0.4 – 0.6 kg**	**0.1 – 0.3 kg**
Number of fish analyzed	12	19	15
% dressing (with head)	92.25	91.84	91.32
% dressing (without head)	68.23	67.54	67.13
Proximate composition			
Moisture	70.03	71.16	71.82
Ash	3.61	3.31	2.96
Protein	18.55	17.38	17.31
Fat	7.18	7.02	6.91
Nitrogen free extract	1.63	1.03	1.02

TROPHIC FUNCTIONING OF INTEGRATED RICE-FISH FARMING IN MADAGASCAR: INSIGHTS FROM STABLE ISOTOPES ($\delta^{13}C$ & $\delta^{15}N$)

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Integrated rice and fish farming (IRF) with aquatic animal aquaculture (i.e. rice-fish farming) is an ingenious agricultural system that produces fish and rice within the same plot using the same amount of water, while benefitting from synergistic effects. Indeed, fish such as common carp (*Cyprinus carpio*, L.) influence nutrient dynamics through consumption, excretion and bioturbation, which ultimately benefit the rice. However, the potential of IRF to address challenges related to food security and to alleviate poverty is constrained by the small fish yields obtained in traditional Malagasy systems (from 50 kg ha^{-1} $cycle^{-1}$ to 350 kg ha^{-1} $year^{-1}$, on average). Fish yields could be improved by increasing natural productivity through organic fertilization. However, high biodiversity in rice field suggests complex trophic interactions which may affect ecosystem functioning as well as ecological intensification of aquatic food production. Trophic dynamics of IRF systems were thus studied in extensive irrigated rice plots stocked with common carp in Madagascar. Fish feeding behavior was assessed by analyzing stable carbon and nitrogen isotopes of fish and natural food sources.

Stable isotope signatures of 45dayold carp fry introduced into rice plots ($\delta^{13}C$ = 18.8‰ ± 0.5‰, $\delta^{15}N$ = 9.3‰ ± 0.6‰) revealed that they had been fed chicken egg yolk and corn meal, in accordance with local practices. However, after a 100day growing period in experimental rice plots, ^{13}C and ^{15}N depletion was observed for 145dayold carp, indicating a change in feeding sources. Under extensive conditions, common carp that fed on rice roots, sediments and suspended particulate organic matter (i.e. plant debris and detritus) had a larger trophic niche (3‰^{2}) than 45dayold carp (1.2‰^{2}).

Overall, common carp feeding behavior and the trophic food web in the IRF system confirms that increasing natural productivity through organic fertilization (e.g. rich in nitrogen, carbon and phosphorus), instead of synthetic fertilizers and feeds, should help increase natural productivity and enhance ecological intensification of both rice and fish production. However, further research is needed on the contribution of insects, weeds and zooplankton to the common carp diet, as well as studies integrating native species from multiple trophic levels.

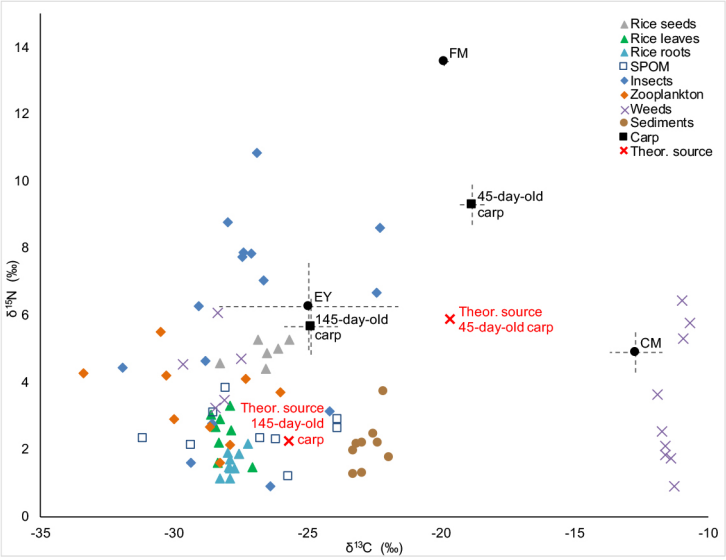

Fig. 1: Mean isotopic signature ($\delta^{13}C$ & $\delta^{15}N$) of common carp, theoretical food source and trophic compartments collected from extensive rice plots

INCREASING FRY SURVIVAL IN NATURAL FOOD-BASED CARP (*Cyprinus carpio,* L.) HATCHERIES IN MADAGASCAR: AN EXOGENOUS FEED EXPERIMENT

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In Madagascar, fry shortage is one of the major constraints of fish farming development. Large hatcheries fail to sufficiently supply fish growers with fry due to little road development and remoteness of production areas. Thus, farmers mainly rely on small scale hatcheries selling their production in the neighbourhood. After hatching, carp fry are usually reared in rice fields or ponds of 100 – 10 000 m² and rely almost completely on natural productivity. However, this system suffers from large mortalities at the larval stage, resulting in the harvest of few thousand marketable carp fry despite the high natural fecundity of female carp. Two hypotheses were made, based on participatory research with farmers, suggesting i) feed shortage and, ii) predation by invertebrates and other aquatic fauna, as the main drivers. Regarding the first hypothesis, it was thus expected that feeding carp fry would significantly increase the survival rates and fish growth.

An on-farm experiment was conducted during two breeding campaigns in which the effect of a soybean and maize flour combination (SM) and commercial fry feed were compared to a control treatment without exogeneous feed inputs. Commercial feed used in the experiment (LFL®, tilapia starter fry feed) consisted of 43% proteins and 6.5% lipids content while the SM feed was estimated to reach a 30% protein content. Fish were fed twice a day by the fish farmer throughout the 45 d of the experiment. Feeding was stopped and postponed in case no fish feeding activity was observed to avoid waste. The three treatments were replicated in a total of 15 small scale hatcheries within the two breeding campaigns, where farmers acted as research technicians for all activities. The experiment was completed by a carbon and nitrogen stable isotopes analysis in order to characterize the food web relationships between carp fry, feeds and the aquatic fauna collected at harvest.

Fry production reached 5±8, 15±16 and 22±19 individuals/m² in the control, the SM and commercial fry feed treatments, respectively. Thus, compared to the control treatment, exogenous feed supplement increased fry survival. A difference between SM and the commercial fry feed was not confirmed by statistical analysis probably given high standard deviation. No difference in carp fry size was observed between the three treatments, although a bigger size for the fed fry was expected. However, stable isotopes suggested little contribution of the exogenous feed to the overall food web over the 45 d of experiments. Our study confirmed the opportunity to increase fry survival rate for small scale hatcheries in Madagascar through feed supplementation. However, although exogeneous feed improved fry production, its contribution and assimilation by carp fry is called into question and will require further investigation.

CHARACTERIZATION AND FARMERS' PERCEPTION ON AQUATIC FAUNA PREDATION IN MADAGASCAR SMALL-SCALE FRY HATCHERIES

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In Madagascar, common carp fry (*Cyprinus carpio*, L.) are produced in rice fields or ponds of small-scale hatcheries. These hatcheries suffer from small yield production despite the high fecundity of common carp. Two hypotheses were made, based on participatory research with farmers, suggesting i) feed shortage and, ii) predation by invertebrates and other aquatic fauna as the main drivers. For the latter hypothesis, a characterization of the aquatic fauna, their trophic interactions and farmers' perception was provided. Most of small-scale hatcheries in Madagascar are located in the countryside, without a setup to avoid the introduction of invertebrates and other aquatic fauna, such as tadpoles and other fish species, through flying, crawling or through the water supply. In the hatchery, they compete for food or act as predators, therefore threatening fry production.

Insects were collected in 16 hatcheries in 2019. Their frequency and density were measured and life cycles studied in order to assess the risk displayed by each taxa. Farmers' perception of the risk displayed by each taxa was then evaluated through surveys with a total of 42 respondents. Lastly, characterization of the food web relationships was jointly performed in an experiment assessing the first hypothesis on feed availability through carbon and nitrogen natural stable isotopes.

The results showed that the dominant group are *Amphibian* larvae (tadpoles), *Notonecta* (backswimmer), *Odonata* larvae (dragonfly larvae), *Coleoptera* adult/larvae (diving beetle), and *Gambusia* (mosquitofish). According to farmers, the most troublesome group are diving beetle larvae, dragon fly larvae and *Nepa* (water scorpion) due to their predation behaviour on fish larvae and fry as well as backswimmers by predation on fish eggs and during larval stage. Tadpoles are not considered as predators but as a highly competitive group for natural productivity and fry feed. The marbled crayfish (*Procambarus virginalis*) is also considered as a pest by some hatcheries given their burrowing behaviour resulting in water leakage of ponds. Farmers' perception was in general in accordance with literature with respect to aquatic fauna behaviour and life cycles. However, depending on the species, tadpoles may also be considered as predators as suggested by the stable isotopes analysis. Aquatic fauna identified in Madagascar small-scale hatcheries are also commonly found in waterbodies of other tropical countries. An exception is the marbled crayfish which is present in Madagascar but not yet in other tropical areas. Thus, the current study helped to identify the main groups of aquatic pests to be targeted in order to improve common carp fry production in Madagascar. Several methods are already adopted by farmers to supress troublesome aquatic pests but none seems to yield a satisfactory result yet. However, the use of larvae protection such as happa nets is a sustainable method, avoiding ecological negative impacts on insects' populations. Further research is needed to characterize tadpole species and trophic behaviour.

PINPOINTING POTENTIAL BIOCONTROL PATCHES IN FRESHWATER SYSTEMS: REGIONAL MODELING OF PARASITES AND PARASITE-CARRYING SNAILS

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Fish farms in Northern Israel (NI) suffer from parasitic trematodes with a complex life cycle which attack fish, causing slow growth rates and higher mortality. The trematodes transmit through freshwater snails, including: local species (*Melanopsidae* and *Theodexus*) found in natural springs; invasive species (*Thiara scabra; Tarebia granifera*; *Pseudosuccinea columella*) and overabundant local species (*Melanoides Tuberculata*), found in huge numbers in the fish farm vicinity.

The variety of regional water transport systems is suspected to impact the dispersal abilities of the snails, ranging from undisturbed flow to man-made trenches and pumps. Within these combinations, the complex system of parasite-carrying snail populations can be classified according to ecological metapopulation models.

Fish farms integrate pesticides and prawn biocontrol against snails, being easier targets than trematodes. The prawns, *Macrobracium rosenbergii,* voracious snail predators, have proved to be successful, yet limited to the single fishpond.

We aim to utilize the local potential of the prawn biocontrol on a regional scale, which requires a deeper understanding of the snail metapopulation structure and trematode hubs. Thus, we surveyed six representative freshwater tracks in NI to find potentially influential spots for prawn biocontrol against parasite-carrying snails in this spatially explicit system.

The survey focused on the snail populations from the sources to the fishponds (Fig.1), while also testing middle points in which the water system changed (i.e., from undisturbed flow to concrete trench). We screened snails from each sample point for parasitic trematodes, using general trematode 18s primers, to find trends in snail infection rates along the tracks. We will discuss the change in snail population structure, and trematode presence along the representative water tracks, and the ongoing efforts in fitting the best suiting metapopulation model to each of the tracks.

This survey will be an important base for further regional biocontrol efforts, and could possibly serve as a template for other areas attempting to use biocontrol against the same parasitic cycle or invasive snails.

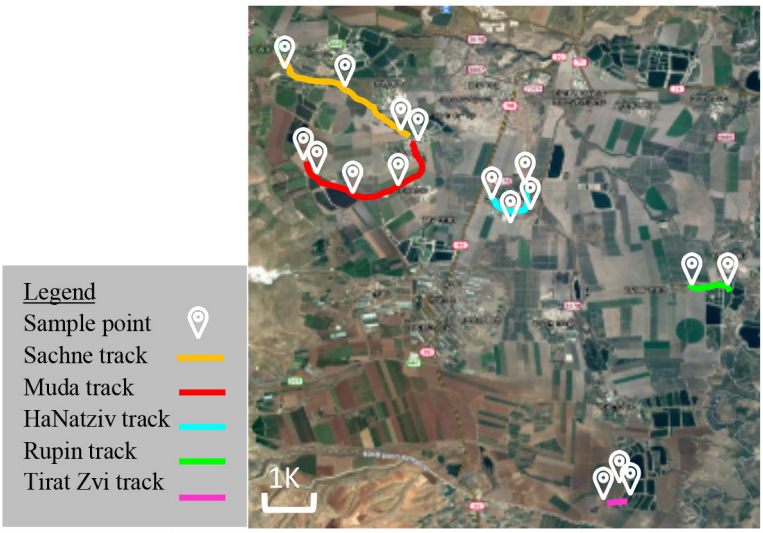

Figure 1: Area of research and survey tracks.

DESERT LAND-BASED AQUACULTURE AND OFFSHORE MARICULTURE RECENT INNOVATIONS AND DEVELOPMENT DIRECTIONS IN ISRAEL

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As other North Africa – Middle East countries, Israel desert is covering more than half of its land, therefore lacking freshwater, but has an excess to two marine environments: the Mediterranean and the Red Sea. The removal of cage fish farms from the north tip of the Red Sea a dozen years ago, reduced significantly mariculture production in Israel and forced the sector to cope with two challenging development opportunities: 1. Arid inland based aquaculture and mariculture using pumped Red Sea water, 2. Offshore based mariculture in the Mediterranean Sea.

Following a 100 ton/year pilot of sea bream (*Sparus aurata*) in RAS and the development of effluent nitrogen removal through bacterial and algal procedures, we promote a large scale program for land based mariculture parks in the Arava\Araba valley. An innovative denitrification process in anoxic reactors is planned to provide a central water treatment plant for the parks users. Macro algae rearing units was tested and now is scaled up to remove nitrogen fluxes from other seawater users (such as desalination plant) to reduce efficiently the total nitrogen loads to the Red Sea.

Few brackish water ornamental fish farm and a large scale indoor RAS in arid areas are irrigating olive plantations or growing lattes in an aquaphonic setup. In these areas and others, high sun radiation is captured by solar panels installed over roofs or open ponds water surface, increasing income and improving water quality parameters.

On the East Mediterranean front, the Israeli coast is exposed to rough oceanographic conditions reaching to 7-8m significant wave heights. After more than 20 years of trails two submersibles cage technologies are operational in farms of 200-700 ton/year scale, proving technical feasibility that reflects the need for scale up to 1,000-5,000 ton/year farms. Governmental maritime spatial planning allocated polygons and now putting emphasis on solutions for operational piers.

Commercial and governmental efforts are also promoting completion domestication of mullet (*Mugil cephalus*), grouper (*Epinephelus aeneus*) and recently Atlantic Bluefin Tuna, aiming to further expand Israel's capacity as marine fingerlings supplier to neighboring countries and offering species to be grown in offshore cages. The National Center for Mariculture (NCM) research institute is leading the tuna domestication project.

An additional important sector is micro and macro algae culture of several species that is carried out mainly by commercial companies, supported by several research institutes. The major production of algae's is taking place in southern Israeli desert, utilizing biotechnological innovations to acquire high value extracted materials. Recent initiatives are also looking at large scale macro algae culture in the open sea in relation to mitigate climatic change.

STOCK ENHANCEMENT AND PRODUCTION OF THE GREY MULLET FRY – A SUSTAINABLE CHOICE. A MERC PROJECT

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An international research and development project on stock enhancement and hatchery production of grey mullet *Mugil Cephalus* was approved and financed by the Middle East Regional Cooperation (MERC) program of the USAID. The consolidation of the international team occurred during the AQUAMED project funded by the EU, that promoted coordination of aquaculture research around Mediterranean countries.

The mullet project group included partners from Morocco, Tunisia, Egypt and Israel and coordinated by a partner from Mote Marine Laboratory, USA. During the pre-proposal phase also a representative of an Algerian institute joined the project.

In several Mediterranean countries, and mainly in Egypt, the grey mullet (*Mugil cephalus*) is a major species. Mullet production is principally based on inland fisheries in lakes and lagoons stocked with wild fry (caught in the sea). Grey mullets cannot complete their reproductive life cycle in these water bodies and therefore their restocking is based on fingerlings produced elsewhere. Currently the only source for mullet fingerlings in middle eastern countries are the declining wild populations. Restrictions on capturing wild fry are imposed in Egypt and other regional partners, posing concern for food security. Recently controlled and stable reproduction and larval rearing procedures were developed for grey mullet, partly in the framework of a previous MERC projects, opening possibilities for hatcheries to produce fry for aquaculture and for stock enhancement.

The present project goals are: a) to evaluate and optimize stock enhancement methods of hatchery produced fry as a sustainable approach for mullet production in various water bodies around the Mediterranean countries; b) to advance, improve and disseminate production of high-quality mullet juvenile hatchery production as a sustainable alternative source for wild caught juveniles.

During the project kickoff meeting in Malta (2017) the project partner were trained in tagging procedures allowing the use of similar experimental methodology of stocking mullets in lakes in Egypt, Tunisia and Israel. A second training course for students and technicians on mullet reproduction and larval rearing was given in Aqaba (2018) brought together 30 participants from partner countries and Jordan.

The project aims to promote the production of hatchery produced mullet fry for aquaculture and stock enhancement activities, through strengthening regional collaboration of ME and other regional partners.

WHAT TYPES OF MACRO-ORGANISMS FOUL SEAWEED FARMS? CASE STUDY OF ZANZIBAR, TANZANIA

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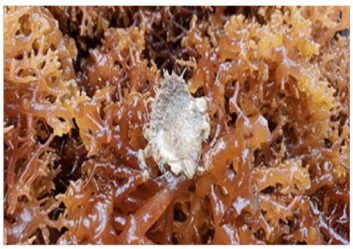
Seaweed farms worldwide face the challenge of fouling from macrophytes and macrobenthos, which can cause significant damage to the farmed seaweed. Some macrophytes, such as *Ulva* (formerly *Enteromorpha*) and *Hydroclathrus* spp can cause mortality of the farmed seaweed through overgrowth of the thallus, especially when the swathe is >50% of the seaweed thalli. Seaweed farms in the Zanzibar archipelago in Tanzania, have experienced such challenges caused by macro-fouling. For example, at Bweleo village farmers have abandoned their farms in 2019-20, due to a serious loss of their seaweed crop through fouling, particularly by *Gracilaria* and *Hydroclathrus*. Information on the species diversity and extent of the fouling problem, however, is lacking. A study on the types of macro-organisms fouling *Eucheuma* and *Kappaphycus* seaweed farms in Zanzibar was, therefore, conducted during August – October 2020 and February-March 2021.

The study concentrated on a seaweed farm in Muungoni, SW Coast of Zanzibar, as part of a larger study on seaweed farm biosecurity. Three replicate areas on the farm were used to collect data on the fouling organisms during the harvesting of the seaweed, i.e., after a full 45-day growth cycle. Macro-fouling organisms were collected by hand, placed in sealed containers and identified to the lowest possible taxonomic group using field guides. The macro-fouling was observed to cover 40-60% of the cultivated seaweed lines. Twenty-four species of macroalgae were identified. The majority of species consisted of brown algae and some species were directly attached to the farmed seaweed, in addition to the cultivation lines. Seven species of seagrasses and 7 types of macrobenthos, some attached to the seaweed were also identified. Further investigations are now in progress to determine if the regular removal of this macro-fouling will increase the productivity of the seaweed farms in Tanzania.

Species type	Number of species
Chlorophyta	6
Rhodophyta	6
Phaeophyceae	12
Cyanophyta	1
Seagrasses	7
Macrobenthos	7

Fouling by various macro-algae on *Kappaphycus*

Padina attached to *Eucheuma*



Oyster attached to *Kappaphycus*

CHALLENGES OF THE SEAWEED INDUSTRY IN TANZANIA AND THE ROLE OF THE GLOBALSEAWEEDSTAR PROJECT

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The seaweed industry in Tanzania employs about 30,000 farmers (80% of whom are women) and has improved the livelihoods of the coastal people. Production is c. 12,000 MT per year of the red eucheumatoid seaweeds *Eucheuma denticulatum* (10,000 MT), *Kappaphycus striatus* and *K. alvarezii* (2,000 MT) in the order of decreasing production. Varieties of these species were imported from the Philippines for commercial cultivation. The industry is, however, challenged by changes in the environment (linked to climate change). These changes have badly affected the seaweed production and farmers livelihoods throughout Tanzania. In the past 10-15 years, the seaweed industry has been badly hit by ice-ice disease and epiphyte (especially *Neosiphonia*) outbreaks. Seaweed production has decreased by 20% from 16,000 MT in 2012 to the current (2018) 12,000 MT.

The GlobalSeaweedSTAR Project, funded by UK Research and Innovation, is working in collaboration with the University of Dar es Salaam, to address these challenges in four categories: 1. Diseases and epiphyte identification; 2. Biosecurity to minimise the spread of disease and epiphytes; 3. Breeding to enhance resistance to disease, including studying the genetic diversity of imported and native eucheumatoids and exploring the possibility of propagating native varieties for commercial production; and 4. Socioeconomic resilience - studying how resilient the farmers are to the challenges facing the industry. The project aims to produce best practice guidelines and to disseminate these to farmers, government, and other stakeholders to enable the sustainable development of this industry in Tanzania. Some results of the project will be presented.

THE DETERMINANTS OF INCOME FROM FISH FOR MEN AND WOMEN FISH FARMERS IN THE SOUTHERN PROVINCE OF MALAWI

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This paper focuses on how gender affects income differentials for men and women in aquaculture in the Southern province of Malawi. It is important to understand these gender differences and disparities in the aquaculture sector because disparities between men and women particularly differences in income, result in women being relegated further into 'positions of poverty' (Weeratunge et al., 2010:406). More than a fourth of people employed in the fisheries and aquaculture sector in Africa are women (Rajaratnum et al., 2016). But it is becoming increasingly apparent that benefits and opportunities are not equitably distributed across gender and socio-economic classes (Kruijssen et al., 2018; Morgan et al., 2016). Descriptive statistics and multivariate linear regression across married women, single women and men were used.

Findings: (see table 1). Land size positively determines income from fish farming for men, married women, and single women. Household size negatively determines fish income received by married women. Selling to neighbors and friends (coded as 1 and the others as 0) has a negative impact on incomes received by married women and single women at 95% confidence level. Pond ownership (coded as 1 for yes) by married women have a higher probability of increased. Education level significantly and positively influences the level of fish income earned by men and single women. Experience in fish farming positively influences the income received from fish farming by single women. Ability of single women to make household decisions by themselves positively influences the income they earn from fish farming. Age is negatively significant for men. Younger men have a higher likelihood of earning more from fish farming. Extension visits positively impacts fish revenue earned by men The more extension visits a man receives, the more likely he will have increased income from fish farming. Market distance negatively affects the income earned from fish farming by men.

Dependent variable: Income	**Married Women**		**Single women**		**Men**	
	Coef.	P>|t|	Coef.	P>|t|	Coef.	P>|t|
Market distance	1900.93	0.43	-399.2	0.93	-7468.33	0.04
Res_Age	-96.04	0.94	-793.65	0.67	-3918.69	0.03
Res_Education Status	1001.1	0.80	18195.17	0.02	-13883.8	0.03
Household Size	-14045.7	0.02	15489.15	0.12	8904.95	0.33
Land Size	214.8	0.00	227.64	0.00	668.18	0.00
Farming_years	-424.64	0.83	6989.74	0.04	-519.32	0.86
Stocking Density	7738.33	0.28	2360.6	0.8	-3089.52	0.74
Pond ownership (1=Yes; No=0)	79651.3	0.08	-99553.88	0.31	115946.9	0.19
Cooperative	-24553.47	0.45	-90216.61	0.25	-61936.35	0.42
Fingerlings_Category	-504.2307	0.98	13709.73	0.77	-65923.3	0.15
Fish Market category	-48146.29	0.50	-98536.94	0.04	12114.38	0.80
Extension visits	891.54	0.75	5338.885	0.31	9197.84	0.00
Household decision making (self=1, Others=0)	-35857	0.15	340198.6	0.00	-4504.50	0.94

THE POTENTIAL OF INSECT MEAL IN IMPROVING FOOD SECURITY IN MALAWI: AN ALTERNATIVE OF SOYBEAN AND FISHMEAL IN LIVESTOCK FEED

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It is reported that fish contributes 70% of the animal protein intake in Malawi. This maybe currently lower as per capita fish consumption is reported to have declined by 58% from 14 kg/person/year in the 1970s to 8.12 kg/person/year in 2014. The situation is posing a serious national nutrition problem if not put under control. This led Malawi Government and other stakeholders to promote fish farming to supplement fish from capture fisheries on the market. Currently Malawi Development Cooperation (MALDECO) Aquaculture is a prominent commercial aquaculture company in Malawi with just above 6,000 small-scale farmers. Feed is a challenge due to high prices of soybean and imported fishmeal. Most fish small-scale farmers use maize bran to feed their fish and this is nonviable as it results in low yield and abandonment of fish farming by most farmers.

This study seeks to provide information in search of a solution to address feed challenges in the fish sector. Literature review was conducted on approaches being used by fish farmers and current efforts to resolve these and used to outline the road map for solving livestock feed challenges at household level in Malawi. It was observed that through use of waste from farm yard, farmers can culture insects which have high protein content than soybean and highly digestible than fish meal. Insects can deal with environmental pollution by utilising waste. Incorporation of insect meal in fish feed can replace soybean and fish meal hence turning around fish industry in Malawi by making it more productive. The dream of making fish products adequately available on market may rely on potential of incorporating insect meal in fish feed.

Insect inclusion in fish feed has a potential of increasing fish consumption per capita in Malawi hence food security. However, challenges to solve are food acceptancy, food safety issues and legislation which can be dealt with by coordination of government, industry and academia.

A CALL FOR WOMEN INCLUSIVENESS IN FISH VALUE CHAIN IN MALAWI

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Gender disparities have a long history in most parts of the world. The United Nations (UN), African Union (AU), African Development Bank (AfDB) and Southern African Development Community (SADC) among others are striving to eliminate gender disparities in Africa. Malawi is a signatory to both international and regional conventions, treaties, declarations and protocols enforcing the rights of women and children. At national level, Malawi has a strong legal and policy frame work for human rights which includes gender related rights. However, due to poor implementation, monitoring and policing of these legal and policy frameworks has resulted into gender disparities remaining a challenge to date even in fisheries sector.

Women have low participation in fish value chain there by weakening the economic and nutritional value of fish at household, community, and regional levels. At the moment there is a serious decline of fish consumption per capita from 14 kg per person per year in the late 1990s to about 5.4 kg per person per year in 2017 hence posing a serious national nutrition problem as fish contributes about 40% of total animal consumed in Malawi. Women are involved throughout the fish value chain, however, more participation is done in fish processing and marketing though into as much as men. Limited women participation is observed on the actual fishing although at the moment only 2% of women are gear owners. Several interventions are being made to increase women participation in the fish value chain in Malawi. Dispersed cases of child labour were as well observed across the fish value chain but requires proper quantification. Both *Nsomba Mchuma* Project and World Fish Centre are as well advocating for a climate smart technology designed to trap warm air inside and dry the fish faster, even during rainy weather in a clean environment without any from dust and houseflies. The technology is reducing deforestation as there is now no need to cut down trees carelessly which were formerly used to smoke the fish. The technology will greatly enhance fish value chain in Malawi. Women are believed to benefit from this technology even more as it tackles the fishing processing and trading nodes where more women participation is in fish value chain.

Among others, there is a need to develop a Fisheries Gender Strategy which should be in unison with the National Gender Policy and the current fisheries regulations. At the same time the said strategy should be well monitored and policed to ensure its implementation adherence by stakeholders.

EFFECTS OF SEAWEEDS *Chaetomorpha crassa* AND *Ulva rigida* AS FEED ADDITIVES ON THE GROWTH PERFORMANCE AND BODY COMPOSITION OF NILE TILAPIA (*Oreochromis niloticus*) FINGERLINGS

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With increased investments in aquaculture, challenges of inadequate fish feeds have necessitated the identification of suitable alternatives for fish meal, wheat and corn in fish diets to take care of the protein needs of farmed fish. Seaweeds are receiving attention as suitable alternative protein sources for farmed fish. In a 12-week feeding trial, the effect of 2 seaweed supplimented meals (*C. crassa* and *U. rigida*) on growth performance and body composition of Nile tilapia fingerlings was investigated. This was the first attempt to utilize seaweeds *C. crassa* and *U. rigida* as feed supplements for Nile tilapia in Kenya. The experiment was done in hapas placed in earthen ponds in four replicates for each treatment. The fish were fed to apparent satiation with fish meal supplemented with various levels of *C. crassa* and *U. rigida* meals (5%, 8%, 10%, 20% and 30%). A diet without seaweed served as a control. Determination of carcass nutritional composition was done at the beginning and end of experiment. Fish weight and length was taken for each treatment every two weeks.

The highest weight gain was observed in fish fed the 8% *U. rigida* and *C. crassa* supplemented diets while, the lowest weight gain was recorded in the 30% *C. crassa* supplemented diet. There were significant differences ($p<0.05$) in specific growth rate, feed conversion ratio and protein efficiency among the treatments. Protein utilization tended to decrease in the groups fed the seaweed meals at the highest supplementation level of 30%. Carcass lipid levels increased with increasing levels of *U. rigida* and *C. crassa* meals. The results suggested that both seaweeds *U. rigida* and *C. crassa* meals could be used in small percentages in tilapia diets.

Table (a & b): Body composition of *O. niloticus* (L) fed the experimental diet supplemented with *U. rigida* and *C. crassa*

	Initial	C	Ur5	Ur8	Ur10	Ur20	Ur30
Moisture%	71.3±0.47	70.7±0.82	70.9±0.13	72.3±0.33	71.4±0.21	70.1±0.29	71.4±0.76
Protein%	18.9±1.51	18.8±0.93	19.3±0.93	19.31±0.21	19.2±0.91	17.8±1.21	17.2±1.3
Lipid%	3.7±0.31	8.6±0.81	8.7±0.61	12.4±0.43	12.6±0.31	14.7±1.3	14.5±0.21
Ash%	3.7±0.51	3.5±0.11	3.1±0.31	3.7±0.17	3.5±0.51	3.6±0.34	3.6±0.47
Fibre%	3.2±0.23	3.1±0.15	3.3±0.17	3.4±0.67	3.3±0.73	3.4±0.13	3.4±0.21

(b)

	Initial	C	Cc5	Cc8	Cc10	Cc20	Cc30
Moisture%	71.3±0.47	70.7±0.82	67.5±0.15	63.8±0.36	64±0.57	65.3±0.51	68.5±0.32
Protein%	18.9±1.51	17.8±0.93	19.0±0.2	19.2±0.51	18.8±0.2	16.3±0.61	16.2±1.2
Lipid%	3.6±0.31	8.6±0.81	9.9±0.27	11.7±0.43	11.8±0.11	10.9±0.31	9.3±0.9
Ash%	3.8±0.51	3.5±0.11	3.6±0.1	3.7±0.21	3.9±0.42	3.7±0.59	3.5±0.33
Fibre%	3.1±0.23	3.1±0.15	3.8±0.93	4.2±0.33	4.1±0.33	3.8±0.42	3.5±0.14

SOCIO-ECONOMIC DETERMINANTS AND PROFITABILITY OF SMALLHOLDER AQUACULTURE FARMERS IN MALAWI: DOES WHO YOU SELL TO MATTER?

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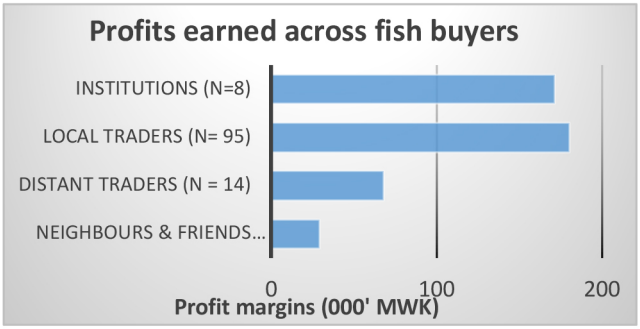
In Malawi, both capture fisheries and aquaculture production cannot meet the current demand for fish. The current undersupply of fish provides an economic opportunity for domestic aquaculture industry to thrive and meet the fish supply gap as well as ease the pressure on wild fish stocks. To grow the small-scale aquaculture, sustained economic returns from smallholder engagement is key. A myriad of factors influences profitability levels of aquaculture enterprises. Previous studies have mainly focused on technical and environmental factors (Phiri et al., 2018; Dickson et al., 2016). Socio-economic factors may equally affect smallholder profitability; these factors have however been largely ignored in previous aquaculture studies.

This paper explores socioeconomic determinants affecting profitability among smallholder aquaculture farmers in Malawi, providing empirical evidence on how buyers influence profits earned by farmers using a randomly selected sample of 375 fish-farming households in Malawi. Descriptive statistics and log-linear multivariate regressions were used. Operating profits were assessed across buyers and a regression performed with socio-economic factors.



Dependent variable = log operating profits	Coefficient	Std. Err.	P>t
Socio-economic factors			
Fingerlings source (1=recycling)	0.00	0.15	0.98
Loan access (1=Yes)	-0.04	0.16	0.81
Buyer type (1=neighbors/friends)	-0.55***	0.16	0.00
Group membership (1=yes)	-0.03	0.16	0.84
Pond area (m^2)	0.00***	0.00	0.00
Household Size (Number)	-0.03	0.03	0.42
Education level (years)	0.07***	0.02	0.00
Age (years)	0.01*	0.01	0.09
Market distance (km)	-0.01	0.01	0.54
sex (1=female)	0.13	0.15	0.40
Extension visit (Number)	0.02*	0.01	0.09
Nonfarm activity (1=yes)	-0.11	0.15	0.46

Key findings:

Majority of the farmers (66.5%) sold fish to neighbors and friends. Less than 5% sold to distant traders and institutions.

Farmers selling to local traders earned the highest gross profits (MWK 180,000), lowest profits were earned from neighbors and friends (MWK 29,000).

Selling to neighbors and friends had a significant probability of decreasing profits from fish farming.

Large pond area significantly increased the probability of earning more profits.

Higher education and age levels increased probability for higher profits.

Increased extension visits positively influenced profits.

Conclusions and recommendations

Smallholder market linkages to traders and institutions for increased profits.

Expansion of extension programme for increased trainings, mentoring and coaching to smallholders

Integrating youth into aquaculture at an early stage to gain experience in aquaculture.

DEVELOPMENT OF BACTERIOPHAGE COCKTAILS AS DISEASE BIOCONTROL AGENTS FOR IMPROVED AQUACULTURE PRODUCTIVITY, FOOD AND NUTRITION SAFETY IN GHANA AND UGANDA (SAFEFISH PROJECT)

Jesca Nakavuma*; John K. Walakira; Samuel P. Wamala; Deus Kamya; Stephen Alafi; Raphael Hans Lwesya; Martha Nalweyiso; Claire M. Mugasa; Maureen N. Mayanja; Evans Agbemafle; Deborah Narh Mensah; Etornyo Agbeko; Isaac Okyere; Susan Damanka; and Martha Clokie

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Aquaculture is promoted globally to address dwindling capture fisheries, but challenges including bacterial diseases exist and impact on productivity. Existing fish health management strategies, including prophylactic and therapeutic antibiotic use, have shortcomings. Irrational drug use contributes to antibiotic resistance and residues in fish. Thus, alternative disease control approaches, such as use of bacteriophages, are urgently needed. Bacteriophages are viruses that infect specific bacteria. An on-going African Union funded project, Safefish, is implemented in Ghana and Uganda with aims to develop bacteriophage cocktails as fish disease biocontrol agents for integrated fish disease management and minimized antibiotic use, for improved aquaculture productivity among tilapia farmers, in Ghana and Uganda.

Methods: Fish, pond water and sediment; as well as fish feed samples were collected from selected tilapia farms in a survey that covered the different regions of Uganda. Prevalent bacteria were identified and tested for susceptibility to selected antibiotics. Bacteriophages against three most encountered fish pathogens were isolated evaluated their lytic activity by host range and stability at selected physicochemical conditions.

Results: Various Gram-negative pathogens were detected in pond sediments, pond water, fish feed and fish obtained during a survey. The most common encountered were *Aeromonas* ssp (up to 36%), *Edwardsiella* spp (up to 24%) and *Klebsiella* spp (up to 23%). High occurrence of MDR and antibiotic resistance was encountered (Fig.1). Aeromonas- specific bacteriophages analysed indicated up to 65% host range; stability at 20 – 50°C and 60% and 70% survival at -20°C and 4°C, respectively.

Conclusion: High occurrence of AMR augments the need for alternatives to antibiotic use in fish disease management. Bacteriophage analyses on-going to select candidate for formulation of cocktails for use on tilapia farms.

Acknowledgement: Funding agency - European Union and African Union; Conference organisers, WAA

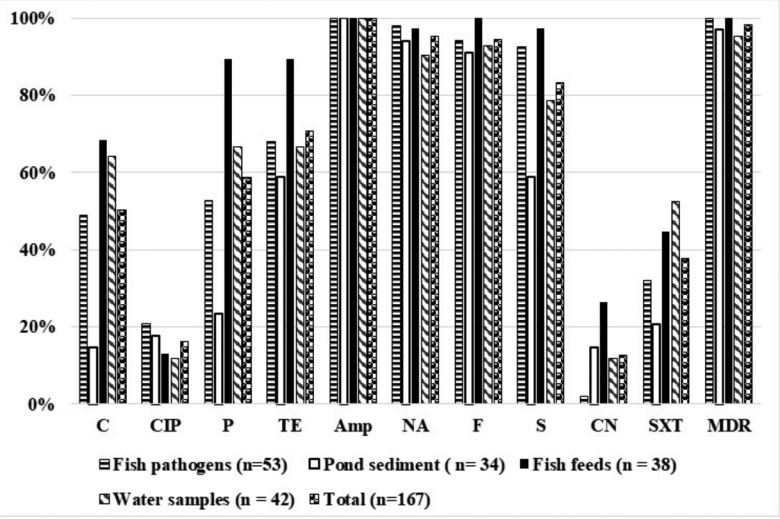

Fig.1: Frequency of drug resistance among the Gram-negative fish pathogens

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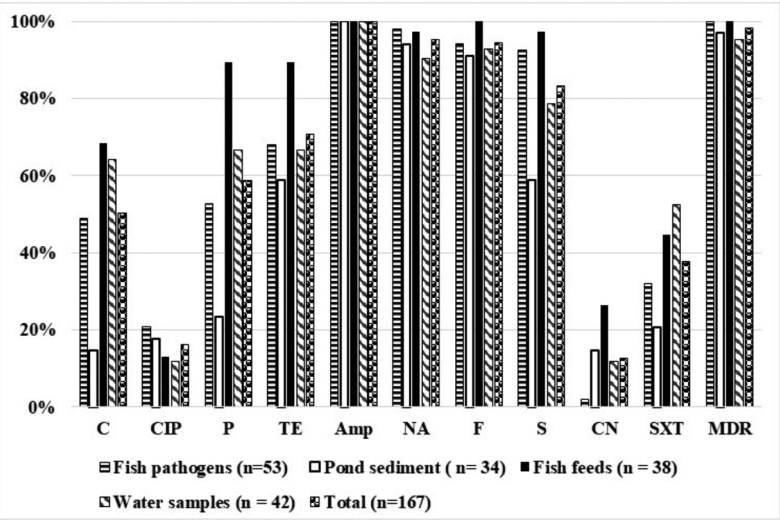

Fig.1: Frequency of drug resistance among the Gram-negative fish pathogens

DETECTION OF FUNCTIONAL SNP MARKERS IN RAINBOW TROUT (*Onchorhynchus mykiss*) FROM NEXT GENERATION SEQUENCING (NGS) DATA

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Rainbow trout (*Onchorhynchus mykiss*) is one of the most important freshwater aquaculture fish in Iran. It is necessary to development available molecular marker associated with genetic variation in maturation for *O. mykiss*. In this study, 52 novel SNP markers for *O. mykiss* were discovered for functional markers, and validated based on transcriptome sequencing with the Illumina Hiseq2500 platform and most of variants cause synonymous mutations in protein. The observed and expected heterozygosities ranged from 0.177 to 1.000 and 0.239 to 0.638, respectively. The minimum allele frequency (MAF) ranged from 0.166 to 0.489. Among these SNP loci, twenty two loci showed significant departures from the Hardy–Weinberg equilibrium after Bonferroni correction ($p < 0.05$) and significant linkage disequilibrium was found. These data provide valuable transcript sequence and functional marker resources for the quantitative trait locus (QTL) identification. The SNP markers would be used in genetic studies helping economic performance improvement and management of this species.

EFFECT OF *Plucea odorata, Piliostigma reticulatum* AND *Guiera senegalensis* LEAVES POWDER ON GROWTH, IMMUNITY RESPONSE AND RESISTANCE OF NILE TILAPIA (*Oreochromis niloticus* LINNAEUS, 1758) AGAINST *Aeromonas hydrophila* INFECTION

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The use of medicinal plants would boost growth, improve immunity and resistance against *Aeromonas hydrophila*, a major pathogen in tropical aquaculture. The effect of *Pluchea odorata* (L.) Cass., *Piliostigma reticulatum* (DC.) Hoscht and *Guiera senegalensis* (J. F.) Gmel. leaves powder, collected in Senegal, on growth, immune response and resistance of Nile tilapia (*Oreochromis niloticus* Linnaeus, 1758) against experimental infection of *Aeromonas hydrophila* was studied.

Five experimental diets containing different contents of the above-mentioned plants, namely C (control diet or 0% plant), 1% P (1% *P. odorata*), 2% P (2% *P. odorata*), 1% M (1% *P. odorata* + 1% *P. reticulatum* + 1% *G. senegalensis*) and 2% M (2% *P. odorata* + 2% *P. reticulatum* + 2% *G. senegalensis*), were produced using a basal formulated diet (32% protein, 9% lipids and 10.7% ash). Five hundred and twenty-five (525) Nile tilapia fingerlings with an average initial weight of 22.23± 3.6 g were randomly distributed in 15 aquaria (250 l/aquaria) at a density of 35 fish per aquarium. The fish were reared in triplicate and fed the experimental diets twice daily for 28 days. Growth (average weight gain (AWG), feed conversion ratio (FCR), specific growth rate (SGR)), survival (SR) and non-specific immunity (NBT, bactericidal activity and plasma lysozyme) parameters were assessed prior to the experimental infection, which was conducted at 12 days.

No significant differences were observed for growth and survival parameters and plasma lysozyme activity between diets at the end of the feeding period (28 days). 2% M significantly improved NBT compared to the control. The bactericidal activity of plasma increased with the level of plant inclusion. The survival rate after experimental infection with *A. hydrophila* did not change after 12 days of observation.

The mixture of 2% *P. odorata*, 2% *P. reticulatum* and 2% *G. senegalensis* included in the basal diet was able to stimulate bactericidal activity and NBT in the plasma of *O. niloticus* during the 28 days of feeding.

DETERIORATION OF NEWLY HATCHED LARVAE AND POTENTIALITY OF REARING LARVAL AND POST-LARVAL STAGES OF EUROPEAN SEA BASS *Dicentrarchus labrax* IN STRESSED GROUND MARINE WATER THROUGH MANAGING WATER SYSTEMS

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The National Institute of Oceanography and Fisheries (NIOF) at El-Anfoushy depends mainly on seawater (SW) from the Eastern Harbor in its marine fish hatchery for marine fish aquaculture. On the other hand, the El-MAX facility which is not located directly on any marine SW source provides an alternative source of water: groundwater (GW) for the marine fish aquaculture. Although the EL-MAX facility provides a new source of water for aquaculture, the properties and suitability of its GW for marine fish production and larval rearing is still under examination. Groundwater from the El-Max facility was used in comparison with SW in two different water systems: a running flow-through system and a static system for assessing their potentiality in European sea bass *Dicentrarchus labrax* aquaculture. The current research studied brood stock spawning, egg incubation, larval and post larval rearing until 60 days post hatch (dph) in both marine water types and rearing systems.

The results revealed that *D. labrax* brood stock did not spawn in GW while spawning and hatching was 95-100% for eggs held in SW. Yolk-sac larvae that were transferred to GW tanks suffered high mortality that extended to the newly mouth opened larvae until 7th dph in which the larvae in GW showed normal viability and survival as those in SW tanks. The results of the current research revealed that by 60 dph the marine water source in combination with the water rearing systems significantly affected post-larvae survival (fig. 1), final weight, and composition (total lipid, total protein and fatty acid profile) but did not affect the growth in length.

The results of the current study do not recommend GW water from El-MAX facility for *D.labrax* brood stock spawning. Urgent need for more research is required for enhancing GW with nutrients or new technologies should be considered to accommodate early larval rearing stages, especially newly hatched larvae. Authors suggest using stressed GW in the EL-MAX facility in *D. labrax* larval rearing starting from the 7th dph while applying a running water system to achieve better larval survival and quality.

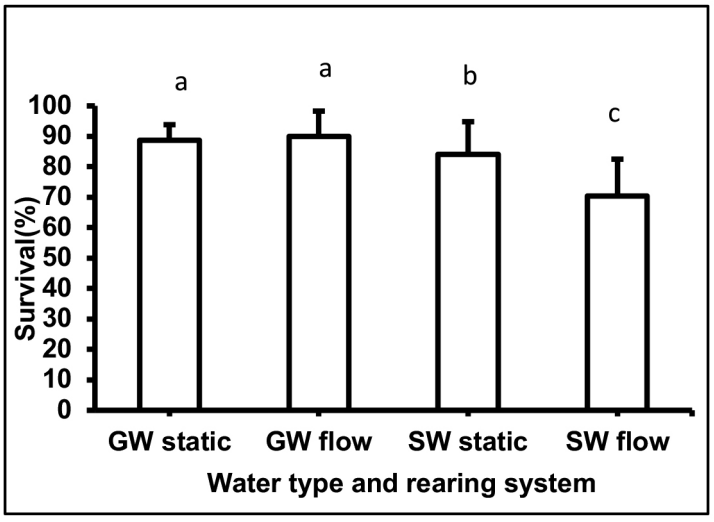

Figure 1: Survival of *Dicentrarchus labrax* larvae at 60 dph reared in groundwater (GW) or seawater (SW) in static or flow-through of water. Values are mean + SD (n = 3 replicate tanks). Superscripts show statistical differences among treatments (ANOVA, P > 0.05). GW = groundwater and SW = seawater.

COULD AQUACULTURE BE THE SILVER BULLET FOR KENYA FISHERIES GROWTH?

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Globally, aquaculture production with an annual growth rate of 8.6%, is the fastest growing food sector that has been doubling every decade for the last 50 yrs. Aquaculture production in Africa is undergoing a major revolution change and its huge potential for fish farming due to suitable areas and paradigm shift by governments to towards food security and economic empowerment of its population. The Sub-Saharan countries that include Kenya have registered momentous aquaculture growth and now accounts over 90% of the total production in Africa.

Kenya has created policies and strategies to enhanced aquaculture production that saw production increase from below 1000 mt to over 24 000 mt in a span of about 5 years. By the year 2030, the country hopes to increase national production by 10% annually; increase per capita fish consumption from 4.75 to 10 kg/capita/year; increase employment opportunities in the fisheries and aquaculture sectors from 80,000 to approximately 2.0 million; and increase farmed fish production to 100,000 mt.

This projected increase is in contrast with decline in capture fisheries from over 200 000 mt in the late to below 150 000 mt in the recent past. It is thus envisioned that aquaculture in the country could be the next frontier in terms of fisheries production. The paper discusses challenges, opportunities and strategies the government has put in place to increase aquaculture production.

EFFECT OF FERMENTED CORN PROTEIN CONCENTRATE ON GROWTH PERFORMANCE, HAEMOCYTE COUNTS, HISTOLOGICAL STRUCTURE OF HEPATOPANCREAS AND INTESTINAL CONDITION OF PACIFIC WHITE SHRIMP *Litopenaeus vannamei*

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This study evaluated the suitability of commercially produced fermented corn protein concentrate (FCPC) known as MOTIV® (Cargill's IP Product), in replacing fishmeal (FM) and/or poultry by-product meal (PBM) on growth and health performances of the Pacific white shrimp *Litopenaeus vannamei*. A 60-day feeding trial was conducted to evaluate the effect of five iso-nitrogenous and iso-lipidic diets containing 0 % FCPC (control), 7.5% FCPC and 1.5% Krill meal (KM) to replace the use of 9% of FM (FCPC 1), 7.5% FCPC and 1% KM to replace 2% poultry by-product meal (PBM) and 6.5% FM (FCPC2), 7.5% FCPC to replace 3.5% PBM and 4% FM (FCPC3) and 7.5% FCPC to replace 7.5% PBM (FCPC4) on growth performance, total haemocytes count, lysozyme activity, body composition, resistance on acute salinity change, total number of bacteria and histomorphological condition of the hepatopancreas of Pacific white shrimp *Litopenaeus vannamei*. At the end of the growth trial, the dietary treatments significantly affect the growth performance of shrimp with better growth obtained in shrimp treated with FCPC compared to the control treatment. For the non-specific immune system, the inclusion of FCPC had significantly improved the lysozyme activity of *L. vannamei* but no significant effect to the total haemocytes counts. Total numbers of bacteria were lower in the hepatopancreas of shrimp fed on FCPC diets compared to the control treatment. In addition, FCPC diets increased survivability of shrimp acute salinity stress compared to the control group. Our findings suggested that FCPC could be used as an alternative for a sustainable approach to replace FM and/or PBM in shrimp diets to have better growth as well as enhancing stress resistances and increasing antibacterial responses of shrimp through enhancing the lysozyme activities in *L. vannamei*.

DIETARY PHENYLALANINE (Phe) REQUIREMENT OF FINGERLINGS AFRICAN CATFISH *Clarias gariepinus* (Burchell, 1822)

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Phenylalanine (Phe), an indispensable aromatic amino acid (AAA) is required for normal growth and metabolic processes, and it is the sole precursor of tyrosine. Since phenylalanine can be converted to tyrosine in an irreversible reaction, its insufficiency in diets will reduce growth performance and physiological functions. Hence, the study determined the dietary phenylalanine requirement of African catfish with a known or fixed level of tyrosine.

Table 1: Performance of African catfish fed different levels of dietary Phe

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Initial	6.19 ±0.09^{a}	6.12±0.07^{a}	6.04±0.00^{a}	6.06±0.04^{a}	6.12±0.05^{a}
Final	27.83±2.50^{bc}	29.13±1.11^{bc}	32.70±1.02^{c}	20.6±2.21^{ab}	15.84±1.20^{a}
WG	21.65±2.45^{bc}	23.01±1.05^{bc}	26.66±1.02^{c}	14.5±2.24^{ab}	9.71±1.16^{a}
SGR	1.87±0.10^{bc}	1.95±0.03^{c}	2.11±0.04^{c}	1.51±0.14^{b}	1.18±0.09^{a}
FCR	1.81±0.13^{ab}	1.61±0.04^{a}	1.45±0.07^{a}	2.07±0.30^{ab}	2.49±0.52^{b}
PER	1.46±0.16^{ab}	1.73±0.04^{b}	1.93±0.09^{c}	1.40±0.22^{ab}	1.21±0.22^{a}
Cholesterol	83.5 ± 1.84^{c}	58.6 ± 0.80^{bc}	54.6 ± 0.40^{bc}	29.4 ± 0.00^{ab}	21.0 ± 0.81^{a}
Protein	56.38 ± 2.72^{a}	56.87 ± 3.13^{a}	65.08 ± 0.97^{b}	62.9 ± 1.19^{ab}	62.0 ± 2.17^{ab}
RBC	2.90±0.17^{a}	3.30±0.20^{ab}	3.60±0.24^{b}	3.70±0.10^{b}	3.70±0.10^{b}

WEANING FRY OF THE AFRICAN BONYTONGUE (*Heterotis niloticus*) TO PARTICULATE DRY FEED DIETS

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A major challenge to the commercial culture of Bony tongue (*Heterotis niloticus*) is low larval survival rates due to lack of suitable weaning diets. This study evaluated the survival and growth performance of *H. niloticus* fry weaned at 40 days after hatching (DAH) to three locally formulated diets (D) of different crude protein content (CP); D1: CP-41%, D2: CP-43%, D3: CP-45%, compared with a commercially available fry feed(Raanan) D4: CP-48%, and a group that was fed with live Artemia as a control. Eight hundred and ten (0.60 ± 0.17g) *H. niloticus* fry raised in the laboratory on *Artemia* nauplii were randomly distributed into 9 (3x3) tanks with 54 individuals per tank. The 3 experimental diets were daily fed at 10% of total body weight/ tank for 21 days. At the end of the trial, the mean weights (g±sd) of the juveniles were 1.00 ±0.58, 1.75±1.10, 2.00±3.20 for the 3 test diets, respectively and 1.80 ±0.20, and 3.60±0.20 for the commercial diet and the control, respectively. The survival rate differed significantly between the treatments ($p<0.0001$) with the control having the highest rate of (88.3%) followed by the commercial diet (21.6%) while the locally formulated diets had poor survival rates; 0.6%, 4.9%, 3.0% respectively. During co-feeding with *Artemia* nauplii the mortality was very low (<7%) for all the test diets during the first 7 days, however mortality increased sharply from the second week when the fish were solely on their respective test diets. The results indicated that the fry of *H. niloticus* will require well balanced particulate diets to enhance growth and survival. Further investigations on the protein to lipid ratios will be experimented in subsequent trials to evaluate its effect on the survival and growth performance for this species.

ANTIBACTERIAL POTENTIALS OF SKIN MUCUS EXTRACT OF AFRICAN LUNGFISH AND AFRICAN CATFISH FROM THREE MAJOR LAKES OF UGANDA

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Background
The skin mucus layer of fish is endowed with biologics that offer a first line of immune defense against pathogens. This study evaluated the antibacterial activity of extracts from skin mucus of two fresh water fish; *Protopterus annectens* (African lungfish) and *Claris griepinus* (African catfish).

Method
A 10% acetic acid extracts of the 24 *P. annectens* and 24 *C. griepinus* sourced from Lake Victoria, Albert and Kyoga were ultra-filtered using 5 kDa 5kDa molecular weight cut-off ultrafiltration membrane. The antibacterial activity was later determined using Agar Well Diffusion method utilizing *Staphylococcus aureus* (ATCC 25923) and *Escherichia coli* (ATCC 25922). Later, the profiles of the extract was determined using a 15% Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE).

Results
Results indicate that extractive yield was influenced by Lake ($F_{2,18}$=528.65, $p<0.05$), fish species ($F_{1,18}$=88.20, $p<0.05$) and the interaction between the two factors ($F_{2,18}$=49.65, $p<0.05$). *P. annectens* produced higher yield (29.89±0.35 %, $p<0.05$) compared to *C. griepinus* (25.22±0.35 %); concentration 7.05±0.33 µg/mL). Lake Kyoga fish gave the highest peptide yield (44.67±0.61 %, $p<0.05$). All the peptide extracts studied exhibited antimicrobial activity on *E. coli* and *S. aureus*. However, peptides from *C. griepinus* were more active on both *E. coli* (Zone of inhibition [ZOI], 15.00±0.58 mm, $p<0.05$) and *S. aureus* (ZOI, 11.67±0.33 mm, $p<0.05$) as compared to those from *P. annectens* (*E. coli* ZOI, 12.00±0.58 mm; *S. aureus* ZOI, 11.33±0.33 mm). Generally, *E. coli* was more susceptible to extracted peptides compared to *S. aureus*. The most active extract was approximately 4 kDa in molecular weight.

Conclusion & Recommendation
The finding of this study points out that skin mucus of *P. annectens* and *C. griepinus* are potential sources of antimicrobial peptide candidates, however, further studies are still needed especially to identify the actual peptide-residues responsible for this observed activity.

EFFICACY OF *Ocimum gratissimum* (SCENT LEAF) POWDER AS ANAESTHETIC AND ITS EFFECT ON THE HAEMATOLOGY OF *Clarias gariepinus* JUVENILES

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Intensive nature of aquaculture have subjected farmed fish to a number of stressors due to handling proceedures and transportation from hatcheries to final stages. These stressors have most often been responsible for high mortalities recorded, hence hindering the growth of fish farming. Anaesthetics are used in aquaculture, fisheries and biological researches, as a way to minimize hypermotility during handling and transportation to reduce stress and mortality. Previous studies have reported the use of some plant materials to anaesthetized various fish species including *C. gariepinus* This studies aimed to investigates the efficacy of *Ocimum gratissimum* as anaethetic and determine its effects on some haematological parameters of *C. gariepinus* juveniles.

Fresh leafs of *O. gratissimum* were obtained from within the university campus, identified, air dry for 5 days and blended to powder. The experimental treatment were prepared from a stock solution of 2g in 10 litres of water (200mg/l) into five concentrations (0, 50, 100, 150 and 200mg/l) in 20 litres of water. Stages of induction and recovery were monitored and recorded using a stop watch. Blood was ollected by severing the caudal peduncle into Ethylene Diamine Tetra acetic Acids (EDTA) for the analysis of various hemaetological parameters using standard methods.

The result revealed that *O. gratissimum* caused anaesthesia which was concentration dependent. Induction time (min) reduced with increase in concentration while recovery increases as induction time reduces (Table 1 and Figure 1).

Haematological parameters showed some slight changes exspecially at higher concentration however some were not significant ($p > 0.05$). the mean values of red blood cells, haemoglobin, pack cell volume, mean cell haemoglobin, mean cell haemoglobin concentration, basophile, eosinophile and neutrphile were decreasing with increased concentration of clove powder. Others such as white blood cells, platelets and lymphocytes increased with concentration (Tables 2 and 3). Fish exposed to 150mg/l cause induction shows that RBC, Hb and PCV were not significantly ($P > 0.05$) from those exposed to 50mg/l which were however not different from the control (0.0mg/).

The observed behavioural changes including initial hypermotility, hyperventilation, loss of equilibrium and no reaction to handling suggest the fish were immobilised (anaesthetized) by the plant material. This was in line with the reports of several researchers who used anaesthetics on fish during handling and transportation Slight changes in the haematological parameters reported in this study corroborates with the studies of many other researchers who have use plant materials as anaesthetic Minimal changes in RBC, Hb and PCV recorded on fish exposed to 150mg/l which were not different ($P > 0.05$) from the control but induces anaesthesia in 6.22 mins shows it is an ideal concentration. However, researchers have reported a 48 hours reversal to the haematological paramters of fish exposed to clove powder. Further research will be required to investigate the effects of *Ocimum* of the biochemical paramters of *C. gariepinus*.

Table 1: Induction and recovery time (min) of of *Clarias gariepinus* juveniles' exposure to *Ocimum gratissimum* powder anaesthetic for 30min.

Concentration (mg/l)	**Induction**		Recovery	
	Induction 1	Induction 2	Recovery 1	Recovery 2
0	-	-	-	-
50	26.61 ± 2.34	-	-	2.82 ± 2.44
100	11.12 ± 1.54	15.26 ± 0.81	1.26 ± 1.38	4.43 ± 0.36
150	4.16 ± 2.36	6.08 ± 0.34	2.35 ± 2.14	6.76 ± 2.18
200	1.24 ± 4.56	3.22 ± 1.26	4.81 ± 0.19	11.67 ± 1.44
Mean with the same superscript are not significantly different at $p < 0.05$, Induction1 (loss of equilibrium), induction2 (deep anaethesia), recovery 1 (regain equilibrium), recovery2 (normal swimming).				

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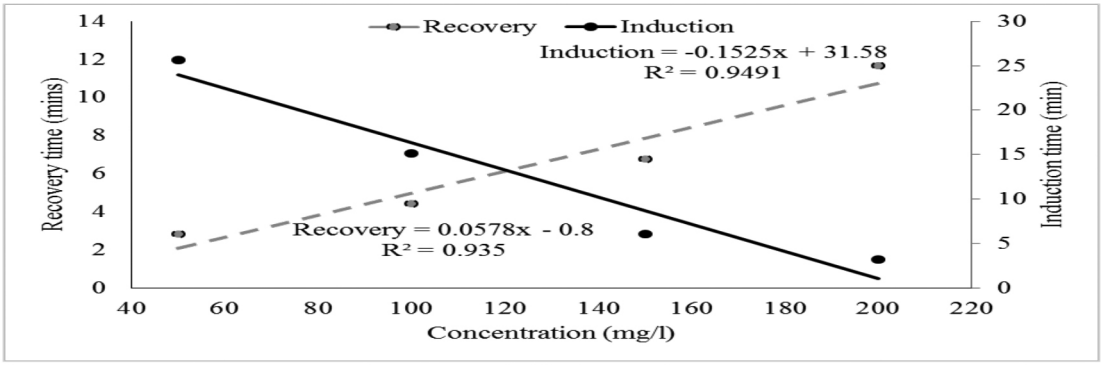

Figure 1: Relationship between Induction, Recovery time (mins) and Concentration (mg/l) of *O. gratissimum*

Table 2: The mean values of selected haematological indices of *Clarias gariepinus* juveniles' exposure to *Ocimum gratissimum* powder anaesthetic for 30min.

Conc. (mg/l)	Haematological parameter							
	RBC (10^{12} cells/L)	WBC (10^{9}cells/L)	Hb (g/l)	Plt	PCV (%)	MCV (fl)	MCH (pg)	MCHC (g/l)
0.00	8.34±1.05^{a}	30.95±1.79^{c}	10.34±0.70^{a}	58.77±1.07^{c}	38.05± 3.20^{a}	66.30± 1.92c	21.17±1.92^{c}	30.84±1.28^{a}
50.00	7.06±0.08^{ab}	33.12±4.30^{c}	9.26±0.34^{ab}	61.82±1.71^{bc}	33.97±1.58^{ab}	67.88±2.49bc	23.38±0.58^{bc}	28.38±1.98^{ab}
100.00	6.82±0.70^{ab}	42.47±0.87^{b}	8.86±0.19^{bc}	70.63±1.46^{b}	30.32±1.27^{bc}	78.69± 5.73^{c}	24.60±0.65^{b}	27.87±2.22^{a}
150.00	5.93±0.90^{bc}	50.07±1.41^{a}	7.99±0.54^{bc}	77.00±3.05^{ab}	28.64±0.34^{bc}	93.76± 4.80^{a}	26.44±0.82^{ab}	26.59±0.78^{a}
200.00	4.80±0.33^{c}	52.87±2.36^{a}	7.31±0.80^{c}	98.14±4.93^{a}	26.17±1.34^{c}	102.52±4.53^{a}	28.70±1.28^{a}	25.31±1.08^{c}
Mean with the same superscript are not significantly different at p< 0.05, Conc.= concentration, PCV = packed cell volume , RBC= red blood cell Hb = haemoglobin, MCV =mean cell volume MCH= mean cell haemoglobin MCHC= mean haemoglobin concentration, WBC =white blood cell, Plt = platelet..								

Table 3: The mean values of selected Differential white blood cell counts of *Clarias gariepinus* juveniles' exposure to *Ocimum gratissimum* powder anaesthetic for 30min.

Conc. (mg/l)	Differential white blood cell count (%)				
	Neut	Lymp	Baso	Mono	Eosin
0	14.71± 1.92^{a}	56.25± 1.40^{b}	4.88± 0.20^{a}	5.99±0.32^{b}	8.07±0.17^{a}
50	13.74± 1.48^{a}	58.02± 1.49^{ab}	4.74± 0.36^{a}	7.01±0.14^{b}	7.66±0.44^{ab}
100	12.18± 0.60^{bc}	59.40± 1.78^{ab}	4.31± 0.31^{a}	7.92±0.53^{b}	6.61±0.36^{ab}
150	12.11± 0.83^{bc}	59.82±1.42^{ab}	3.95± 0.10^{ab}	9.08±0.05^{ab}	5.98±0.48^{ab}
200	10.79± 0.31^{c}	65.44±1.91^{a}	3.07± 0.77^{b}	10.27±0.85^{a}	4.14±0.42^{b}
Mean with the same superscript are not significantly different at p< 0.05, Conc.= concentration, Neut = neutrophil Lymp= lymphocytes Baso = basophil, Mono = monophil, Eosin = eosinophil,					

HAEMATO-IMMUNOLOGICAL RESPONSE AND ANTIOXIDANT ENZYMES ACTIVITY OF *Clarias gariepinus* FINGERLINGS FED DIETS CONTAINING *Acalypha wilkesiana* LEAF EXTRACT

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A major factor limiting fish production is regular outbreak of diseases. This usually constitute substantial monetary loss, either directly or indirectly by increasing production cost through investment lost to dead fish; cost incurred on treatment and slowed fish growth during period of recovery of diseased fish (Mzula *et al*., 2021). The use of antibiotics which is the conventional means of treating diseased fish is being discouraged because of its negative impacts such as the potential development of antibiotic resistant bacteria, suppression of immune system, bioaccumulation of toxic residues and their bio-magnification up the food chain (Vignesh *et al*., 2011). The significance of other more sustainable health management strategies including the use of medicinal plant has thus been better realized.

The present study investigated the effects of varying dietary levels of *Acalypha wilkesiana* leaf extract on growth, haemato-immunological and antioxidant enzyme activities of *Clarias gariepinus* fingerlings. 150 fingerlings (6.07 ± 0.02g) of *Clarias gariepinus* were randomly stocked in fifteen tanks and fed isonitrogenous (40% crude protein) diets containing 0% (diet 1), 0.25% (diet 2), 0.5% (diet 3), 0.75% (diet 4) and 1% (diet 5) of *A. wilkesiana* leaf extract for sixty three days. At the end of the experiment, diet 3 significantly ($p < 0.05$) increased weight gain (34.66 ± 2.76g) and the specific growth rate (3.02 ± 0.11%/day) relative to the control group (Table 1). Feed conversion ratio and protein efficiency ratio were however similar ($p > 0.05$) in the control and other treatment groups. Significantly ($p < 0.05$) lower white blood cell count was recorded in the group fed diet 5 when compared with those of diets 1-3. The serum aspartic aminotransferase was significantly ($p < 0.05$) higher in the group reared on diet 3 when compared to the control group. Serum total protein and its fractions (albumin and globulin) were not significantly ($p > 0.05$) influenced by dietary treatment. The respiratory burst activity and total immunoglobulin ranged between 0.73 ± 0.04 – 0.80 ± 0.05 and 0.09 ± 0.01 – 0.13 ± 0.01 g/dL respectively and did not differ significantly ($p > 0.05$) across dietary groups. Serum superoxide dismutase (SOD) and reduced glutathione (GSH) significantly ($p < 0.05$) increased in all treatment groups compared to control, while there were no significant ($p > 0.05$) difference in serum malondialdehyde (MDA). It was concluded that addition of 0.5% *A. wilkesiana* leaf extract in the diets of *Clarias gariepinus* fingerlings can improve their growth and health status.

Table 1: Growth, antioxidant enzymes and malondialdehyde activities of *Clarias gariepinus* fingerlings fed experimental diets

Parameters	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**
Weight gain (g)	29.55 ± 0.17^{ab}	32.35 ± 2.42^{ab}	34.66 ± 2.76^{b}	31.77 ± 1.23^{ab}	26.68 ± 0.58^{a}
SOD	1.10 ± 0.01^{a}	1.55 ± 0.18^{b}	1.92 ± 0.14^{b}	1.70 ± 0.15^{b}	1.76 ± 0.12^{b}
GSH	10.39 ± 0.14^{a}	13.97 ± 0.13^{b}	15.67 ± 1.12^{b}	16.97 ± 1.19^{b}	14.60 ± 1.26^{b}
MDA	4.85 ± 0.85	5.78 ± 0.41	5.65 ± 0.66	5.83 ± 0.30	6.19 ± 0.55

GENDER ANALYSIS OF FISHERS ALONG ASEJIRE LAKE

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Gender analysis was used to identify gender norms, pattern of resource use and power relationships in fishing communities in and around Asejire Lake. The study revealed that the roles of women and men are deeply integrated, but unequal, especially in relation to assets, workload, leadership and decision-making. Gender equality in fisheries and aquaculture can bring many potential benefits including higher fish productivity and household incomes, as well as positive nutritional outcomes. One hundred and fifty well-structured questionnaires were administered to the respondents. Descriptive statistics was used to analyze the socioeconomic characteristics of fishers while Inferential Statistics; t test for significant difference and Chi-square : Test for significant relationship at 5% level of significance. It is shown from the analysis that 30.7% of the respondents fall within the age 40 – 49 years, 62% were male, 57.3% were married, 29.3% of the respondents passed through Technical Education, 76.7% declared their household head to be male, 56.7% of the respondents have been fishing for the past 1 – 10yrs, with 50% having a household size of 1 to 5 persons. The main source of credit was from personal savings with 72% of the respondents getting over ₦100,000. Baskets were the most owned fishing gear with the majority of the respondents catching more fish at night. The most abundant fish species were the catfish and tilapia species with 64% of the respondents catching more tilapia than catfish. In the study area, more women (60%) own boats and finance fishing expedition while 33% men were in charge of actual fishing activities. There are little or no government policies favoring gender. The constraints faced by the respondents chiefly were lack of government assistance/intervention in the water body, inaccessibility to credit facilities and high cost of fishing equipment. The test is significant at 5% level of significance with the correlation coefficient of 0.65 which shows the extent of relationship existing between the socio-economic characteristics and the challenges. Gender analysis should be carried out on fishing settlements across the nation to help in designing policies and programs that would favour all involved parties boosting production, reducing poverty and enhancing nutrition security for millions of fish-dependent households.

GENDER ANALYSIS OF FISHERFOLKS IN THE COASTAL COMMUNITIES OF DELTA AND BAYELSA STATES, NIGERIA

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Gender issues in coastal and marine environment have exposed deep social inequalities among users of the natural resources such as patriarchy, cultural norms, under-representation in decision making and unequal access to material, social and natural resources. The research thus assesses the gender status of fisherfolks in the coastal communities of Delta and Bayelsa States.

A multistage sampling technique was adopted using structured questionnaire to collect information from 240 fisherfolks from both states. Data was analysed using the Harvard analytical framework, the descriptive statistics, multiple response and regression.

The descriptive result revealed majority of fisherfolks were permanent fishers with mean age of 40.65±10.65 for Bayelsa State and 47.12±11.60 for Delta State. Bayelsa State fisherfolks were majorly of the Hausa tribe (51.7%) and the Delta State were more of the Igbo tribe (33.3%). The tested hypothesis revealed that socioeconomic parameters were significant at 1% in the both States while the multiple response showed the existence of inequality in decision making at the household level. The productive and community activities been majorly dominated by men fisherfolks. However, it was observed that in Bayelsa State men were marginalization in all measures of inequality except in control over some resources and benefits.

The interlink between fisherfolks and gender issues would be a right place for policy making and interventions in the fisheries sectors of these states. This would contribute to meeting the SDG's "no poverty' and "gender equality" by 2030. Support from the government through policy intervention and gender sensitive training should be administered equitably.

A STRATEGIC POLICY FRAMEWORK FOR AQUACULTURE EDUCATION IN KENYA

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This policy framework aims to strengthen Kenya's aquaculture education programmes for improved academic training in Universities and Vocational Aquaculture Training Institutions. It is in line with the Comprehensive Africa Agriculture Development Programme (CAADP) of the African Union and New Partnership for Africa's Development (NEPAD) agenda. The recommendations take into consideration the regional aspiration contained in East Africa Community (EAC) Vision 2050 Agenda, in which Member States aspire to become middle-income countries, Kenya's Vision 2030 blueprint and Kenya's "Big 4 Priority agenda" (2017-2022) focusing on food and nutrition security. The framework aims to tackle some of the perennial challenges in the aquaculture educational landscape including; limited knowledge, skills and innovative capacity to operationalize and commercialize technological advancements in fish production such as culture systems, fish breeding and genetics; fish nutrition, health management and post-harvest technologies. Specifically, the higher/university and technical vocational education training institutions are currently offering theoretical knowledge with minimal practical "hands-on" skills due to inadequate infrastructure. On the other hand, the advisory by extension service providers is insufficient to promote the adoption of new farming Technologies, Innovations and Management Practices (TIMPs). This policy framework recognizes that educational and vocational training reforms in the aquaculture sector will improve fish husbandry skills, thereby resulting in increased productivity, revenue generation and higher economic growth for sustainable development. It includes perspectives from the aquaculture labour market, alumni and extension service providers. Data was gathered via mixed methods using semi-structured interviews, site visits and a multi-stakeholder engagement in various Counties in Kenya. Results indicated that employers from both public and private sectors were moderately satisfied with their employees' knowledge and skills. There was inadequate practical training and capacity-building opportunities for on-site and lifelong learning. The academic staff in universities offering fisheries and aquaculture had PhDs in different areas of specialization but had a high workload leading to low engagement with the industry. Operationalization of this policy framework will lead to efficient training of aquaculture graduates, which will lead to improved production of aquaculture in Kenya.

BLACK SOLDIER FLY (*Hermetia illucens*) LARVAE MEAL AS A SOYBEAN MEAL REPLACEMENT IN DIETS FOR NILE TILAPIA (*Oreochromis niloticus*) REARED IN EARTHEN PONDS

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This study investigated the effect of replacing soybean meal (SBM) with black soldier fly larvae meal (BSFLM) on the growth performance, carcass body composition and profitability of Nile tilapia (*Oreochromis niloticus)*. Three isonitrogenous (30% crude protein) diets containing BSFLM in varying proportions of 0% ($BSFLM_0$), 50% ($BSFLM_{50}$), and 100% ($BSFLM_{100}$), were formulated to replace SBM. A commercial diet ($COMM_0$) sourced from the local market was used as a positive control. Male sex-reversed *O. niloticus* juveniles of mean weight 20.88± 0.16 g were stocked in 12 cages each at a density of 12.5 fish m^{-3}. Fish were hand fed at 5% of the body weight twice a day (1000 and 1600hrs) and thereafter adjusted to 3% and 2.5% for 6 months. The diets had significant effects on the final body weight, body weight gain (BWG), specific growth rate (SGR), feed conversion ratio (FCR), survival rate and condition factor (K) ($P < 0.05$). The best growth performance and feed utilization was recorded in fish fed on $BSFLM_{100}$. The diets had significant effects on body composition and amino acid profiles of the experimental fish ($P < 0.05$).

An increase in BSFLM led to a significant decrease in crude protein, ash and dry matter of the fish carcasses with an increase in amino acids concentration. The carcass of the fish fed on $BSFLM_{100}$ exhibited significantly highest values ($P < 0.05$) for methionine (5.0%) and lysine (56.3%) (essential amino acids) and alanine (8.9%), cysteine (8.0%) and proline (14.7%) (non-essential amino acids). Results from the partial enterprise budget analysis indicated that the total cost of feeding Nile tilapia $BSFLM_{100}$ had significantly reduced and had higher gross profit compared to the conventional commercial feed ($P < 0.05$). This translated to positive return on investment for the feed containing 100% inclusion rate of BSFLM as a replacement of soybean meal therefore making BSFLM a highly sustainable and cost effective alternative protein ingredient in fish feed as it improves growth performance and feed utilization.

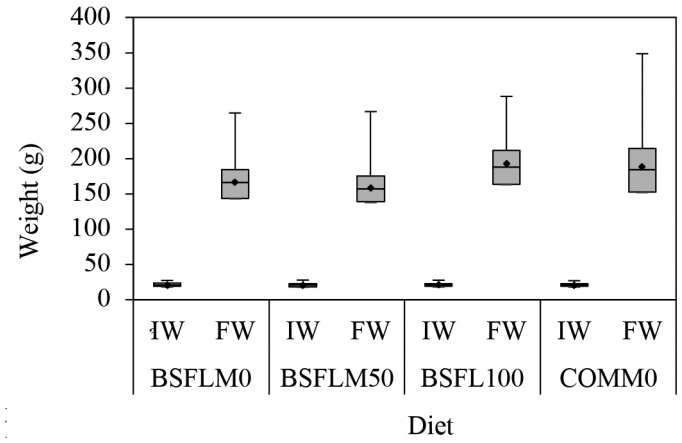

Figure 1: A box plot showing the initial (IW) and final weight (FW) of *O. niloticus* fed on diets with different levels of black soldier meal and a commercial diet

PREVALENCE, PATHOGENICITY AND GENOTYPES OF AEROMONAS SPECIES IN THE GUT OF AFRICAN CATFISH *Clarias gariepinus (*BURCHELL, 1822*)* AT POST *Aeromonas hydrophila* CHALLENGE PERIOD

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Clarias gariepinus specimens often survive disease outbreak on farm, making way to hypothesize resilient strains. We investigated prevalence, pathogenic nature and strains of Aeromonas in the gut of survivor *C. gariepinus* at post *Aeromonas hydrophila* challenge period to understand the possible implications of such survival.

Randomly selected six gut samples of unchallenged(C) and the *A. hydrophila* challenged but survived (Ch) *C. gariepinus* (8.00±0.02g) were assessed for differences ($p<0.05$) in total counts of bacteria(TBC), Coliform, *E. coli*, Salmonella, Shigella, Vibrio, Staphylococcus, Pseudomonas, and Aeromonas species. Aeromonas isolates were assessed for reaction (+ve) to none of haemolysis, gelatinase, and DNAse pathogenicity tests (0.00%pathogenic- NP) or all (100.00%pathogenic-P). Np and P in C and Ch were analysed for phylogenetic cluster of 16S Ribosomal RNA gene nucleotide sequences.

The TBC ranged $2.02\pm0.63x10^6$(C) - $2.32\pm0.65x10^6$(Ch). Significantly, bacteria count (10^4cfu/g) ranged 0.58±0.93 (Pseudomonas sp.)-1.55±0.87 (Coliform)-C, 0.58±0.53 (Pseudomonas sp.) - 1.83±0.58 (Aeromonas sp.)-Ch. Coliform, *E. coli*, Vibrio and Aeromonas were higher in Ch than C while Salmonella, Shigella, and Staphylococcus species were higher in C than Ch. 100.00%C-sourced Aeromonads were NP (denoted NPCS); 27.78%Ch-sourced Aeromonads were NP (denoted NPChS), while 72.22%Ch-sourced Aeromonads reacted (+ve) to 33.33-100% P tests (denoted PChS). Phylogenetically, 66.66%NPChS linked *A. salmonicida* vouchers, 33.33%NPChS linked *A. sobria.* 33.33%PChS linked *A. hydrophila,* but diverged from 66.66%NPCS. 66.66%PChS linked *A. veronii*; while 33.33%NPCS outlied to link *Lactobacillus helveticus* voucher.

Gut of the *Aeromonas hydrophila* challenged but survived *C. gariepinus* has increased Aeromonas flora including pathogenic and non-pathogenic *Aeromonas* strains. The pathogenic *A. hydrophila* strain (PChS) was of relative small proportion (33.33%) in the gut of the challenged specimens indicating the survived C. *gariepinus* has tendencies to resist flourishing of the pathogenic strain.

ADOPTION OF WATER QUALITY MANAGEMENT TECHNIQUES AMONG FISH FARMERS IN SOUTH-WESTERN NIGERIA

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Aquaculture has significant contribution to increased fish production but poor management of water quality could threaten sustainability of aquatic ecosystem, aquaculture and fish production. For water management planning, this study investigated the proportion of fish farmers adopting water quality management techniques (WQMT), reasons for non-adoption, as well as sources of information for water quality management among fish farmers in an aquaculture hub, south-western Nigeria.

Structured questionnaires was utilized to collect data on WQMT adoption, reasons for non-adoption and effective innovation communication media from 150 fish farmers (50 from each of Lagos, Oyo and Ogun states) in Southwest Nigeria.

Respondents had 45.96 ±1.28 years mean age, mostly had tertiary education and were aware of indigenous (94.0%) and modern techniques- Recirculating Aquaculture System-RAS (75.4%), water test kit (98.0%) Bioflocculation (40.1%), Phytoremediation (38.0%), Aquaponics (0.7%), Remote Sensing and Geographic Information System-RSGIS (9.3%). Adoption ranged from 0.0% (RSGIS, Phytoremediation, Aquaponics) to 40.7% (indigenous methods-mainly water exchange). Source of information on WQMT ranged from voluntary extension agents-VEA (0.7%) to formal extension services (16%). Reasons for non-adoption of WQMT was mainly multiple (68.6%respondents).

In conclusion, awareness and adoption of modern WQMT- Bioflocculation, Phytoremediation, Aquaponics, Remote Sensing and Geographic Information System were low. The multiple challenges responsible for this could be solved through increased extension services. There is the need to improve awareness on and participation of voluntary extension agents among grassroot fish farmers in south western Nigeria.

ROLES OF WOMEN IN SMALL SCALE FISHERIES IN OSUN STATE: ENHANCING HOUSEHOLD BENEFITS AND LIVELIHOOD IMPROVEMENT

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This research study was undertaken to examine the household benefits and livelihood improvement as a result of women's roles in fishery activities. This descriptive survey employed the use of questionnaire as means of data gathering. Multistage sampling was used to select 120 respondents from the study area. Data collected were analysed using descriptive and inferential statistics. Finding shows that majority of the women fishers are still in their youthful and active productive years, and over 80% are literate and married. Majority, 80% and 85% of the women fishers engaged in fish processing and marketing respectively, and also 68.3% engaged in actual fish production. Women involvement in fishery activities has resulted in the generation of considerable level of income which is above the current minimum wage of ₦30,000 on monthly basis as well as daily income of $2.44 per day and $73.17 monthly which indicate that they live above global poverty line index of $1 per day. Thus, due to the significant contributions of fishery business to the household benefits of women fishers and in order to improve their livelihood activities, there is need to provide access to physical and capital resources for business expansion and growth that will in turn result in nutritional sustainability.

Introduction

Women occupy a critical position in every link of the value chain in small-scale fisheries, though they are best known as processors and marketers of fish and other fishery products. The perception of the gender-segregated division of labour, that is men fishing and women processing, has shaped the generalized approach in supporting development initiatives for small-scale fisheries. This approach sees men as fishers, and women as processors and marketers of fishery products (Bene & Merten, 2008). However, this generalization has made governance of fishery sector blind to other valuable inputs of women to the sector. In fact, women roles can and should go beyond post-harvest and marketing. However, the lack of utilization of their additional contribution has deterred women's participation in fisheries resource management and policy decision-making (Arenas & Lentisco, 2011).

According to Olufayo, 2012, women have been reported to play diverse roles in fishery sector, they take part majorly in fishing, processing and marketing. Women according to Odili et al. (2012) spend prolong hours daily in fishing related activities for which they receive very little or no assistance from NGOs or other organizations. They are directly and vigorously involved with their capital in the coordination of the fisheries chain, from production to sale of fish. Their role is however not limited to fish processing and marketing but include participation in actual production in most types of aquaculture brackish-water or freshwater fishpond. They participate in various stages of fish farm development (planning, construction and actual operation) and in fish feed formulation. Adequate participation of women in small-scale fisheries has been perceived as a factor that will create opportunity for improving livelihood that will be of immense benefit to the household in Nigeria (Nlerum and Bagshaw, 2015).

Despite the enormous contributions of womenfolk in the fishery sector, they usually lack representation in fisheries associations and fisheries management bodies, they are usually excluded from decision-making, particularly for the type of decisions that directly affect the resource they depend on. With such a striking absence of women in decision-making bodies at all levels, it is easy to understand household livelihood improvement opportunities which this study is focused on. This study focused on the following objectives;

i. To examine the level of women participation and roles in small scale fisheries.
ii To investigate how women participation in small scale fisheries has contributed to the improvement of their livelihood activities.
iii. To determine whether women participation in small scale fisheries can enhance their household benefits.

Methodology

Osun State is one of the land-locked states of the Federal Republic of Nigeria. It covers an estimated area of 8,062 square kilometers. The State runs an agrarian economy with a vast majority of the populace taking to farming. It is limited to freshwater fisheries. Pond fish culture in the area dated back to the time of the colonial masters (Olasunkanmi, 2010). Osun state, according to the state Department of fisheries is divided into six fisheries zones. Multi-stage sampling method was used in selecting the respondents used for the study. Simple random sampling method was adopted in selecting 50%, i.e. 3 out of the 6 fishery zones in the study area, after which 40 female fish farmers were randomly selected from each of the selected zones to give a sample size of 120 respondents. Structured questionnaire were administered and data collected were analyzed using descriptive and inferential statistics.

(Coninued on next pae)

Results and Discussion

Table 1: Demographic Characteristics of Respondents

Variable	Frequency	Percentage %
Age (Years)		
≤ 20	9	75
21 – 30	16	13.3
31 – 40	45	37.5
41 – 50	24	20.0
51 – 60	17	14.2
≥ 61	9	7.5
Total	120	100
Level of Education		
No formal education	21	17.5
Primary	39	32.5
Secondary	42	35.0
Tertiary	18	15.0
Total	120	100
Marital status		
Single	23	19.2
Married	52	43.3
Divorced/Separated	30	25.0
Widow	15	12.5
Total	120	100

Source: Field survey 2021.

The above table reveals the demographic information of respondents. Age distribution shows that majority, i.e 37.5% were within 31 – 40 years, follow by 20.0% who were within 41 – 50 years, only 7.5% were below 20 years, 13.3% were within 21 – 30 years, 14.2% were within 51 – 60 years, and 7.5 % were above 61 years. This is an implication that majority of the women fishers are still in their youthful and active productive years. This corroborated Babagana and Mohammed, 2020 who affirmed that most of the women who engaged in fishery activities are very active because they are still young. Over 80% of the women fishers are literate with level of education ranging from primary to tertiary education. This will be of greater advantages to the fishery sector development especially in the area of innovation or technology adoption. This study further reveals that majority (43.3%) of the women in fishery sector are married, 25.0% are divorced/separated, and another 12.5% are widow, while only 19.2% are single. This indicates that majority of women fishers are responsible to their household either as a support to their husband or as provider in the case of widow or divorced/separated. Thus, they engage in fish farming as a means of survival.

Table 2: Fish farming activities of respondents

Variable	Frequency	Percentage %
Mode of operation		
Full time	42	35.0
Part time	78	65.0
Other occupation		
Agricultural occupation	42	35.0
Non-agricultural occupation	36	30.0
Cultural system		
Monoculture	68	56.7
Polyculture	52	43.3
Tenure Arrangement		
Purchase	36	30.0
Lease	69	57.5
Inheritance	15	12.5
No of Ponds		
1 – 3	72	60.0
4 – 6	39	32.5
7 – 9	7	5.8
10 – 12	2	1.7
Species of fish cultured		
Tilapia	22	18.3
Catfish	46	38.3
Both	52	43.3
Years of fishing experience (Years)		
≤ 5	36	30.0
6 – 10	72	60.0
11 – 15	12	10.0
Fishery activities involved in		
Fish production/management	82	68.3
Fish processing	96	80.0
Marketing	102	85.0
Feed preparation	12	10.0
Breeding	28	23.3

Source: Field survey 2021.

(Coninued on next pae)

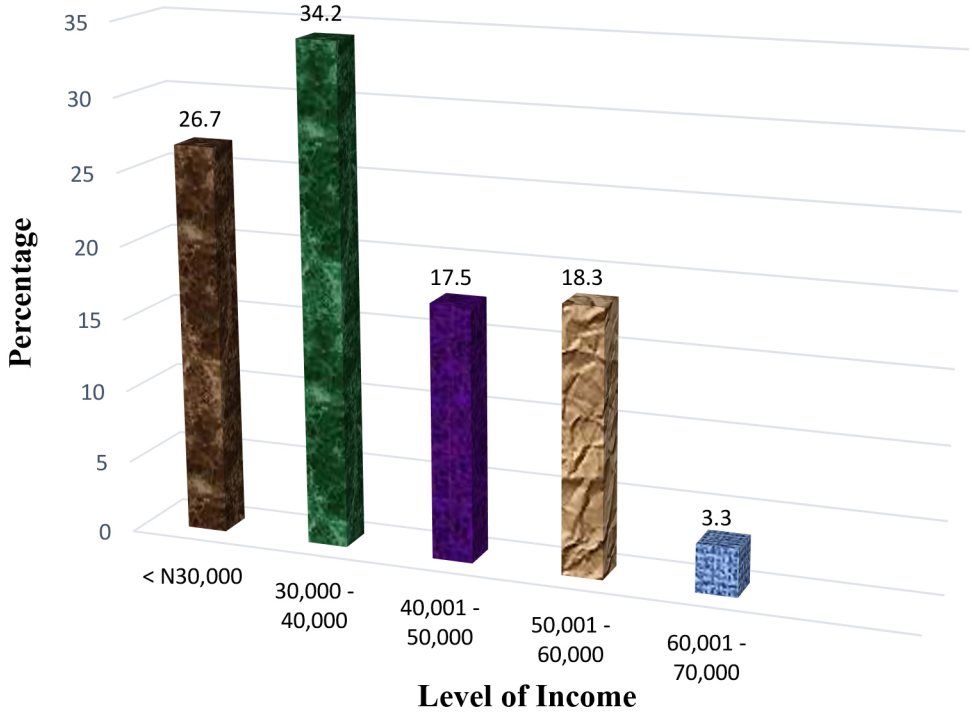
The table above reveals the faming activities of the woman fishers. This shows that majority, (65.0%) of the women fishers are on part-time bases, meaning that they engage on other businesses which is either agricultural or non-agricultural occupations. This categories of women fishers also see fish farming as a veritable venture that they can venture into as a means of diversifying their livelihood and obtaining additional income for their household benefits, while 35.0% of them engaged in fishery business on full time and solely as means of generating income. So they invest all their capital in fish farming to operate on large scale in order to generate reasonable amount of income. The study further reveals that majority (80.0% and another 85.0%) of the women in fishery business engaged in fish processing and marketing respectively. 68.3% also engaged in direct fish production which including culturing and management of fishes in an enclosures such as earthen ponds, concrete and plastic tanks e.t.c, while few of them, 10.0% engaged in feed preparation or production, and 23.3% in breeding. This is supported by Cliffe and Akinrotimi, 2015 who affirmed that womenfolk engaged in processing and marketing of fishes, leaving actual fishing for men.

Table 3: Household benefits from fish farming

Benefit from fish farming	Frequency	Percentage %	Rank
Income generation	116	96.7	1st
Access to proteinous food	102	85.0	2nd
Pride	32	26.7	3rd

Source: Field survey 2021.

Fig 1: Monthly income from fish farming



Source: Field survey 2021.

This above table reveals the household benefits from fish farming. This shows that income generation ranked 1st, follows by household access to proteinous food, while considerable number of women fishers also derive prestige or gain recognition of being in-charge of their fishery business, which makes them contributors to the welfare of their family, this direct involvement in fishery activities has contributed to a feeling of being recognized, included and respected. Also, the study reveals in figure 1 above that only 26.7% of the women fishers earned less than ₦30,000 which is the current minimum wage for the federal staff, while majority, i.e over 70% earned between ₦30,000 and ₦70,000 on monthly basis from their fishery business. This means they earned minimum of $2.44 per day and $73.17 monthly which is an indicators that they lived above the global poverty line which is 1 US Dollar per day. This implies that women involvement in fishery activities is economically rewarding and could serve as means of reducing poverty and food insecurity. This is in line with Raji and Omowumi, 2006, and Babagana and Mohammed 2020 who both confirmed that fishers cannot be regarded as poor because they have an average daily income that is above 1 US dollar which stands as global poverty index.

(Coninued on next pae)

Table 4: Livelihood improvement indicators

Livelihood indicator	Frequency	Percentage %
Access to capital	68	56.7
Access to market	72	60.0
Access to infrastructure	62	51.7
Improved standard of living	78	65.0

Source: Field survey 2021.

This table reveals livelihood improvement indicators. This shows that majority (65%) of the women fishers have access to improved standard of living as a result of the financial gain which lead to food security and good health of the fisher households. Also, 60% claimed access to market, 56% have access to capital and 51.7% claimed access to infrastructure all of which serve as great advantage for business expansion and growth. Therefore, there is an indication that there will be an improvement in livelihood activities of fisher women if all these opportunity can be properly channeled to build assets in the fishery industries.

Table 5. : Bivariate analysis of relationship between women involvement in small scale fisheries and Household benefits

Women involvement in small scale fisheries*Household benefits	r	p	N	Decision
	0.823**	0.000	120	significant

**. Correlation is significant at the 0.01 level (2-tailed).

The above table reveals the analysis of relationship between women involvement in small scale fisheries and Household benefits. This shows that there is significant relationship between women involvement in small scale fisheries and Household benefits ($r = 0.823$, $p = 0.000$), that is, the involvement of women folks in small scale fisheries has contributed to the enhancement of household benefits. This is corroborated by Nlerum and Bagshaw, 2015 who affirmed that women in the fishery business found it to be economically rewarding as well as having access to nutritious proteinous food.

Conclusion

The findings of this study as well as that of other studies revealed that women play highly significant roles in the fishery industries. This involvement of women folks in the fishery business has resulted in some household benefits which include access to reasonable level of income that equally contributed to the welfare of the farm family, as well as building enough capital asset for business expansion and growth. Therefore, in order to further improve the livelihood of the women fishers there is need to provide physical and capital resources as means of boosting business capacity as well as improving standard of living and nutritional sustainability of the nation.

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NEGATIVE EFFECT OF ECTOPARASITE BURDENS ON THE CONDITION FACTOR FROM FARMED TILAPIA *Oreochromis niloticus* IN THE YUCATAN, MEXICO

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Nile tilapia (Oreochromis niloticus Linnaeus, 1758) is one of the most important aquaculture species in the world, and, when introduced, the ectoparasites of Nile tilapia have followed. Currently, farmers worldwide consider these ectoparasites harmless, but intensities can reach up to 1000 individuals per fish in tropical regions. In this cross-sectional study, we used the condition factor to estimate the potential effects of low (45 ± 31 ectoparasites per fish) and high (295 ± 191) ectoparasitic burdens across 28 tilapia farms and included the analysis of the effects of 44 management and environmental variables from the farms. A stepwise procedure in a multiple linear regression analysis retained the variables that explained the most variance, which was the ectoparasitic burden (57 %). We found significantly higher values of the condition factor in Nile tilapia with low ectoparasitic burden than in those with high ectoparasitic burden. Additionally, Nile tilapia with a high ectoparasitic burden weighed less than half than those with a low burden (102 ± 105 g versus 230 ± 128 g, respectively). We also found a significant non-linear, negative relationship between the ectoparasitic burden and the relative condition factor values per fish, which was most likely due to an increase in gill mucus caused by the ectoparasitic burden that depleted energy in the Nile tilapia. The economic consequence of the ectoparasitic burden translated roughly into a loss up to 12–15 % in profit margin per ton of fish, based on the price of Nile tilapia in the Mexican market.

Table 1 . Mean length and weight, parameters of the length-weight relationship, range of the body condition factor (*K*) and mean number of ectoparasites (number of *Cichlidogyrus sclerosus* plus all other ectoparasites present in an individual fish) of large and small farmed *Oreochromis niloticus* in the Yucatan, Mexico. The value of α is the intercept, and β is the allometric coefficient parameter. SD = standard deviation, CI = 95% confidence interval.

Model (n=528)	N	Number of ectoparasites (mean ± SD)	Mean standard length (cm ± SD)	Mean total weight (g ± SD)	α (CI-95%)	β (CI-95%)	R^2	Condition Factor (*K*) (*K* ± SD)
Large Nile tilapia	234	30.65 ± 30.44	18.81 ± 3.58	230.08 ± 127.68	0.0058 (0.0040 - 0.0084)	4.00 (3.87 – 4.12)	0.92	0.60 ± 0.14
Small Nile tilapia	294	195.51 ± 144.46	15.00 ± 5.26	101.62 ± 104.70	0.0010 (0.0007 - 0.001)	3.55 (3.42 – 3.67)	0.93	0.12 ± 0.05

Table 2. Generalized additive model of location, shape and scale (GAMLSS) fits for condition factor values (CF; dependent variable) in Nile tilapia (*Oreochromis niloticus* Linnaeus) in Yucatán state. The best model was selected using a stepwise procedure and the lowest values of Akaike information criterion (AIC) and global deviance. The final model was: CF~ *cs*(Cs) + *cs*(Ct) + Tr + Gy where *cs* is a cubic spline smooth function, and those independent variables without smoother had a linear relationship with the dependent variable (CF).

Model	Degrees of freedom (df)	Global deviance	Deviance explained (%)	AIC	*P* (0.05)
(Null model) CF ~ 1	-	132.71	-	130.52	$4.3e^{-6}$*
CF ~ *cs*(Cs)	df =15	104.33	25.11	115.61	0.0003*
CF ~ *cs*(Cs) + *cs*(Ct)	df =16	95.55	31.13	114.65	0.0050*
CF ~ *cs*(Cs) + *cs*(Ct) + Tr	df =18	84.20	38.02	102.39	0.0307*
CF~ *cs*(Cs) + *cs*(Ct) + Tr + Gy	df =17	47.11	65.24	75.55	0.0001*

Acronyms were as follows: Cs=*Cichlidogyrus sclerosus*, Ct= *C. tilapiae*, Tr= Trichodina, Gy= *Gyrodactylus cichlidarum*. *= *P* value < 0.05.

MORPHOLOGICAL DIFFERENCES IN *Oreochromis niloticus* BETWEEN LENTIC AND LOTIC ENVIRONMENTS

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The interaction of living organisms with the disturbed environment as often manifested in distinguishing morphological features. Therefore, analyzing species in these disturbed environments and comparing them to the source populations may serve as a study system to investigate responses to environmental disturbances. In the present work, we analyzed morphological variation of *Oreochromis niloticus* from two reservoirs and compare with a river within the south west Nigeria, with a view to know the effect of environment on fish morphology.

A total of one hundred and nine individual samples of *Oreochromis niloticus* were obtained from the study locations for morphological studies. Morphometric and meristic characteristics of the fish were measured using calibrated measuring board aided with ruler and a pair of divider/caliper. Fifteen morphometrics and six meristics characters were considered for the study. Data were analysed using Paleontological Statistical Test (PAST) software.

The study indicated that there were variations morphologically in the fish from the environments and that, not all the morphological features of *O. niloticus* in the study areas contributed significantly to variations observed. The scatter diagram, indicated that fish samples from Awara and Egbe reservoirs have morphometric features that are more related than to those from Ogbese River. The observed variation with the meristic characters occurred mostly within the entire region. This study indicates that the water reservoir seems to be an important factor influencing morphological variation in *O. niloticus*.

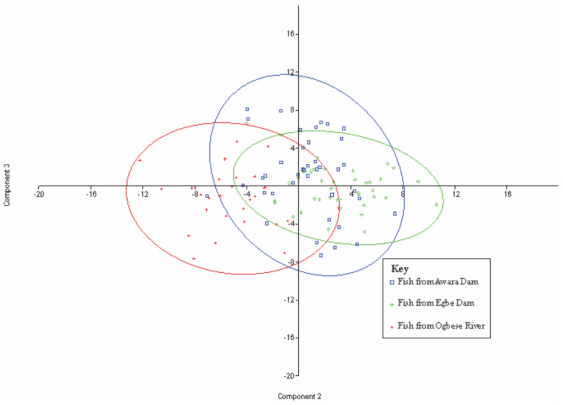

Figure 1. PCA Scatter Diagram showing the variability and linkage of *Oreochromis* sp. across all populations as revealed by their morphometric characters

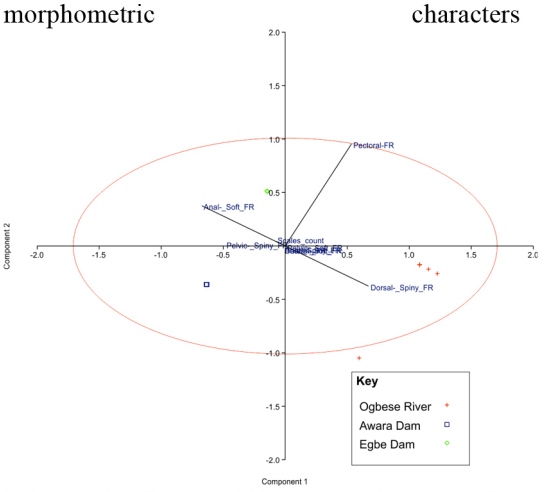

Figure 2. Scatter Diagram showing the variability and linkage of *Oreochromis* sp. from sampled populations as revealed by their meristic characters

THE EFFECTS OF MYCOFIX® ON GROWTH PERFORMANCE, IMMUNE PARAMETERS AND DISEASE RESISTANCE IN TILAPIA (*Oreochromis niloticus*)

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Mycotoxins are toxic secondary metabolites produced by fungi that contaminate a wide variety of grains and finished feed. The prevalence of mycotoxins is different between regions, although global trade and climate change play a role in homogenizing the contamination profile worldwide. Some studies have shown that mycotoxins cost the livestock and aquaculture industry billions in economic losses each year.

Aquatic species can be quite sensitive to mycotoxins and the risk increases with the growing tendency to include plant-derived protein sources which are more economic than fish meal or fish oil in aquatic diets.

Since 2004, Biomin has conducted a survey for the best studied mycotoxins, namely aflatoxins (Afla), zearalenone (ZEN), deoxynivalenol (DON), T-2 toxin (T-2), fumonisins (FUM) and ochratoxin A (OTA). In a survey that encompasses 230 aqua feed samples DON, ZEN and FUM were present in more than half of all of these samples (70%, 62% and 58%, respectively). The incidence of AFLA and OTA in these samples (29%) was also considerably high. The main plant-based ingredients included in aqua feed such as corn & corn by-products, wheat, wheat bran, soybean and soybean meal also showed the presence of mycotoxins but more importantly confirmed that co-contamination is very common.

Mycotoxins can cause different effects in aquatic species including reduced growth and increased susceptibility to diseases due to their immunosuppressive effects. In this study, it could be shown that Mycofix® had a positive effect on growth performance, immune parameters and disease resistance in tilapia that were exposed to a diet containing OTA at levels below the European legislative limits. The results also underline that Mycofix® contributed to improved production and economic potential of the animals.

STOCKING MULLET FINGERLINGS IN THE SEA OF GALILEE AS PART OF AN ECOLOGICAL BALANCE MANAGEMENT

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Stocking fish in ecosystems has many benefits and, among others, can provide a unique tool for maintaining ecological balance in managed water bodies. In the Sea of Galilee, Israel, a lake that has a water residence time of 9 to 10 years, and like many similar closed ecosystems, phosphorus is the limiting factor for the development of algae, that govern water quality. Fish have a nutritional requirement for phosphorus, and as such can play a role in managing the ecological balance, through the consumption of the phosphorous containing algae and debris. Fish contain about 7 kg of phosphorus per ton. Therefore, one of the most effective tools for lowering the amount of phosphorus in a closed ecosystem such as the Sea of Galilee is to manage its fishery regime by removing adult fish from the lake. Presently, the total amount of phosphorus removed annually from the lake through fisheries is about 3.5% of the average annual phosphorus entering the lake (100 tons per year).

Fishery management in the Sea of Galilee is performed by stocking fingerlings of several species. Mullet sp. are a principal group in the stocking program of the Sea of Galilee. For decades, every year about one million mullet fingerlings weighing 0.2 grams are being stocked into the lake. Traditionally, these fingerlings would be captured from the wild, on the shores of the Mediterranean. In recent years Israeli commercial hatcheries continuously supply mullet fingerlings, as an alternative to capturing fry from the wild.

As part of the MERC project on stocking hatchery mullet fingerlings we conducted a long learning process to improve stocking procedures of grey mullet (*Mugil cephalus*) by using Israeli hatchery sourced grey mullet fingerlings. During 2018 & 2019 90,000 mullet fingerlings, produced by Israeli hatcheries, were transferred to the Ginosar research station. Following a rapid acclimation to fresh water, the fish were divided equally into two rearing systems differing in their water temperature regime: 1) A heated and controlled temperature of 26^0C, 2) An ambient temperature of 17^0C.

After four months, as a result of the difference in temperature, fingerlings were classified into two size categories (in two consecutive years): 2018 large (6.25 g') and small (3.02 g') & 2019 large (13.53 g') and small 6.57 g'). Fingerlings were individually tagged using code wire tags (CWT) and were stocked into the lake, representing four stocking treatments representing: fingerlings size (small vs large) and time of the day (morning and night stocking). The stocking of all 4 treatments was conducted at three different occasions, 7 days apart, allowing three replications every year. During the July, 2021, the first tagged adult grey mullets, with an average weight of 1,123 grams, were caught in the fishery in the Sea of Galilee. Further collection of tagged fish and identification of tags of the different treatments is under process. This information provides for the first time accurate growth rate data of the grey mullet in the sea of Galilee on an individual fish basis.

	2018	2019	2021
MB	6.3 g	12.3 g	1,123 g not yet identified
MS	2.9 g	5.8 g	
EB	6.1 g	14.8 g	
ES	3.1 g	7.3 g	

Table of Stocking data: B=big, S=small, M=morning, E=evening

PRODUCTION OF MULLET IN CAGES: EGYPTIAN CASE

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Mullets are important species in Egypt, representing 14% of the total fisheries and aquaculture production and landing 2.1 million tons in 2019. Tot al mullet production in 2019 was 285,000 tons, of which 235,000 tons was produced by aquaculture. More than 26,000 cages are found near the Nile estuary of Roseta, with a total cage water volume of 15.7 million m^3, resulting in an average production of 13 kg/m^3, and total production volume of 201,000 tons. The species produced in these 26,000 cages include Nile and blue tilapia (59%), mullet (27%), silver carp (13%) and European seabass (1%) (GAFRD, 2021). The major advantages for cage culture of mullet in the Nile River over other methods of fish culture include: the anticipated high profitability levels; the use of existing water bodies, thus reducing the pressure on land; the requirements of relatively low capital outlay; the ease of movement and relocation; the flexibility of management (for example, broodstock management of grey mullet, *Mugil cephalus*). The production of mullet (mainly *Lisa ramada*) in Nile cage aquaculture began in 2006 with annual production 19,200 tons, and increasing to 35,400 tons in 2012 and 54,300 tons in 2019 (GAFRD, 2021). This presentation will describe traditional mullet cages (10 x10 x 4 m net depth and 10 x 15 x 5 m net depth) culture management with 1.5 to < 3.0 tons of mullet/cage/18 months with an average weight of 3–5 fish per kg). For the first 15 months, Nile river cage farmers feed mullets a diet of wheat bran, stale bread inconsumable and raw dried pasta and during the last three months, these cage farmers feed a compressed sinking/floating pellets (25% CP). The feed conversion ratio (FCR) during the 1.5 year is estimated for 1:3.5.

Producers usually stock 20,000 to 50,000 mullet fry (0.1 g) in the nursery cages (5 x 5 m and net depth 3 m) for the first year and in the second year, the fish are moved into larger cages (10 x 10 m x net depth 5 m) with a fingerling stocking density of 20-30 gm/m^3. Several researchers have completed experimental trials for the mullet cage culture. Over a 10-month period, Essa et al. (2012) studied the effect of three different stocking density (9, 12 and 14 kg/m^3) on growth performance, feed utilization, production and economic feasibility in an experimental trial where thinlip grey mullet (*L. ramada)* fingerlings (>80 g) were reared in floating net cages (700 m^3) located in the brackish waters of the Rosetta branch of the Nile river. Fish were fed a commercial diet with 23% crude protein, at a rate of 2% of total biomass. The highest growth was observed at a density of 12 fish/m^3, with individual total weight gain of 243 g and average daily gain of 0.83 g fish/day. Azazi et al. (2012) estimated costs and returns for grey mullet (*M. cephalus*) commercial cage production (300 and 600 m^3) in Manzala lake northern Nile delta. Results indicated that cage volume had positive effects on the economic performance of mullet cage culture, with a production 1.5 and 4.9 kg/m^3 in small and large cages, respectively. This investigation concluded that mullet cage culture was successful in brackish water environment and growth is directly related to stocking density and feeding regime. Results demonstrated that under optimum conditions in this experimental trial, mullet production was economically feasible, when compared to traditional fish farm cage production. Thus, it is recommended that the approach described in Azazi et al. (2012) will promote greater and more effective development of fish cage culture in the Nile river, especially the culture of mullet species. In conclusion, the mullet used for cage farming need to be propagated in hatcheries, mullet feed costs need to be reduced by improving the economics of feed formulation, and that continued improvements in minimizing the environment impacts and increasing sustainability of mullet cage farming will advance commercial cage production of mullets.

GROWTH PERFORMANCE IN SEMI-INTENSIVE SHRIMP (*Litopenaeus vannamei)* PONDS FROM DIBA TRIANGLE ZONE, EGYPT USING TWO COMMERCIAL FEEDING TYPES: SHRIMP FEED (38%CP) AND TILAPIA FEED (36%CP)

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An experiment was conducted to determine the effect of two commercial feeding types: Shrimp feed 38%CP (SF38) and Tilapia feed 36%CP (TF36) on the growth performance of white shrimp (*Litopenaeus vannamei)*. Twelve cage nets (2 x 1.5 x 1 m), each 3 m^3 and 10 m^2 were stocked with juvenile shrimp (average weight, 1.65 ±0.85 g) at a density of 20 shrimp/m^2. Shrimp in six cages were fed with SF38 and six others with TF36. Selected water quality parameters were monitored over a 105-days period. Shrimp growth, survival, feed conversion ratio (FCR) and water quality parameters were evaluated at day 105 harvest. No significant differences were found between the SF38 and TF36 treatments in the daily-measured water quality parameters (dissolved oxygen, temperature, pH, Secchi readings, and salinity) and the weekly-measured parameters (total ammonia-N and nitrite-N). Cultured shrimp fed by SF38 showed greater mean weight (18.0 ± 2.6 g) and yield than those fed by TF36 (14.4 ± 3.6g). Feed added at libitum reaching an average per cage 3564 gm in TF36 and 3860 gm in TF36 during the experiment period 105-days. The shrimp survival was not significantly different between the two treatments 71 percent in SF38 and 67 percent in TF36. The FCR of the shrimp in the SF38 treatment (1: 1.4) was significantly lower (P<0.001) than in the TF36 treatment (1: 2.0). The growth rate was defined for 1.1 gm/week in SF38 and 0.85 gm/week in TF36. This work shows that the SF38 diet provided better production results (25.6 gm/m2) 33% higher than the TF36 diet (19.3 gm/m2), yet it did not significantly deteriorate the water quality. The result of the study implied that SF38 more suitable and economically viable than that TF36 treatment for shrimp farming.

NEW PERSPECTIVES OF FISH-PARASITE INTERPLAY BY PROTEOMIC ANALYSES OF *Ichthyophthirius multifiliis* INFECTED COMMON CARP (*Cyprinus carpio*) SKIN MUCUS

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The fish first line of defence against infections through the skin epidermis is the skin mucus. In a previous study, we have investigated the skin mucus proteome of common carp (*Cyprinus carpio*) at 1 day and 9 days post-exposure with *Ichthyophthirius multifiliis*. Using nano-LC ESI MS/MS, we have earlier identified that the abundance of 44 skin mucus proteins has been differentially regulated, including proteins associated with host immune response and wound healing.

Herein, in skin mucus samples, we identified six proteins of *I. multifiliis*, associated with the skin mucus in common carp. Alpha and beta tubulins were detected, in addition to elongation factor alpha, 26S proteasome regulatory subunit, 26S protease regulatory subunit 6B, and the heat shock protein 90. In skin mucus samples, in addition to 44 differentially regulated common carp proteins we identified six proteins of *I. multifiliis*, connected to the skin mucus in common carp.

The recognised proteins are apparently involved in motility, virulence and general stress during parasite growth and development, after parasite attachment and invasion. Alpha and beta tubulins were identified, also elongation factor alpha, 26S proteasome regulatory subunit, 26S protease regulatory subunit 6B, and the heat shock protein 90.

The identification of these six *I. multifiliis* proteins in infected common carp skin mucus suggests their possible role in the parasite invasion strategy of this ciliate and effectively of carp immune defences.

Phagosome and proteasome are two KEGG pathways that were recognised between these parasite proteins, reflecting the proteolytic and phagocytic properties needed throughout growth and development demonstrating effective host invasion strategy of *I. multifiliis*.

The identification of hsp90, which is apparently triggered by eEF through HSF and b-tubulins, which are key for ciliary function, suggests roles in mobility and virulence as well as in homeostasis regulation and cellular stress during host invasion and development.

The identified proteins are involved in heat shock response, which suggests they are crucial for parasite development, virulence and pathogenicity. The identification of hsp90 during infection indicates it may act as a suitable drug and vaccine target and can be tested as vaccine/vaccine adjuvant.

The results obtained from this study can support us to reveal molecular aspects of the interplay between carp and *I. multifiliis*. This may help us understand *I. multifiliis* invasion strategy at the skin mucus barrier. The data may support the development of novel drugs, vaccines, and diagnostics suitable for management and prevention of ichthyophthiriosis in fish.

DECREASING ARTEMIA PERIOD AS A STRATEGY FOR *Argyrosomys regius* LARVAE EARLY WEANING: IMPACTS ON GROWTH AND DIGESTIVE PHYSIOLOGY

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Meagre is one of the Mediterranean region most important aquaculture species due to its impressive growth in captivity compared to other farmed fish species. One of the most challenging bottlenecks to reduce meagre larvae production costs is early weaning protocols. Two feeding protocols were developed for meagre considering the reducing of Artemia period during early weaning. Growth, survival and aspects of digestive physiology were studied during the first 25 days.

Two early weaning strategies were tested, that used microdiets from mouth opening (2 days post hatching – DAH) until 30 DPH . First strategy rotifers were used between 2 and 10 DAH and no Artemia was used (MDROT); Second strategy rotifers, were used between 2 and 10 DAH, and *Artemia* was used between 8 and 17 DAH (MDART). These strategies were compared with the standard feeding protocol (CTRL) used at EPPO, that consist in feeding rotifers from mouth opening until 10 DAH, introduce microdiet at 8 DAH to be used until 30 DAH, whereas *Artemia* is introduced at 8 DAH and used until 22 DAH. Rotifers, grown on w3Yeast 60 (Bernaqua, Belgium), and *Artemia* (Instar II) (SepArtTechnology™ , INVE) were both enriched with Red pepper™ .. WINFAST microdiets from SPAROS, Lda (Olhão, Portugal) were used in the experiment

Fish samples were collected along experimental period for biometry, survival, histology and quantification of digestive enzymes actitivies.

The larvae length growth and dry weight of CTRL were significantly ($p < 0.05$) increased by the time than MDART and MDROT. The 30 DAH larvae survival %. recoded no significant ($p > 0.05$) differnces between all treatments. The 30 DAH larvae recoded highest significant ($p < 0.05$) length growth performance results except 25 DAH was significantly ($p < 0.05$) higher than 30 DAH in specific growth rate.

Fish larvae digestive physiology was negatively affected by the weaning strateagies when compared to control strategy. Fish larvae development status at each sampling was manily responsible for the observed differences.

Acknowldgments: DIVERSIAQUA II project (MAR-02.01.01-FEAMP-0175).

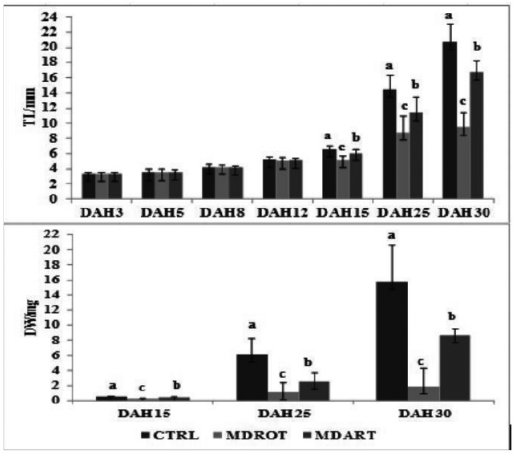

FIGURE 1. The effect of weaning strategy on: A - total length (TL) and B - dry weight (DW) of meagre (*A. reguis*) larvae.
Different letters in the same age are significant ($P < 0.05$) differences.

A STRATEGIC ASSESSMENT OF GEOTHERMAL WATERS FOR AQUACULTURE IN THE WESTERN CAPE, SOUTH AFRICA

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A study conducted by the Water Research Commission in South Africa has indicated that there are 52 thermal springs suitable for aquaculture research and development. Although this potential has been expressed, thermal springs in South Africa have yet to be utilised for aquaculture purposes. The advantage of using a thermal spring is that heated water will be available for warm-water aquaculture all year round. Conventional warm-water aquaculture systems are usually limited to a six-month (per year) production period due to the unfeasibility of artificially heating water during colder winter months. A geothermal spring at Brandvlei Correctional Centre in Worcester in the Western Cape, has been identified as a launch site for a thermal water aquaculture pilot study. The water at the site is safe to use, and also has constant high temperatures (64°C) and fast flow rates (127 L/s) which would support the culture of warm-water fish (i.e. tilapia or catfish), all year around.

This project aims to determine whether the Brandvlei spring can be utilised successfully for warm-water aquaculture; with special focus on the potential cost-savings that are achieved, in comparison to a conventional system where artificial heating is used. The project will run for a period of 12 months, in which required permits and permissions will be obtained, and a small energy-efficient test-system will be set up on-site. Some research and development (i.e. cooling methods) will be necessary with regards to the introduction of the spring water into the test-system, as the spring water emerges from the ground at 64°C and tilapia (*Oreochromis niloticus*) requires a water temperature of 28-30°C for optimal husbandry and performance. This method will be developed with the aim of maximising efficiency, while minimising power consumption and cost. Once the test-system is up and running, and tilapia fingerlings have been introduced, a training workshop will be held to provide training to students and members of the Brandvlei Correctional Centre to promote aquaculture skills development and provide practical experience in the test-system itself.

A co-management plan will then be drafted between Stellenbosch University, Brandvlei Correctional Centre, Department of Public Works and Department of Water and Sanitation to ensure the continued maintenance of the aquaculture system for future successful harvests and exploring commercial opportunities for at other geothermal sites in South Africa. The project has started in April 2021, and authors will share challenges and progress to date.

BIOFLOC TECHNOLOGY ENHANCES SPAWNING PERFORMANCE OF RED TILAPIA BROODSTOCK REARED AT HIGH WATER SALINITY

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The present study was carried out to evaluate the effects of Biofloc technology (BFT) on spawning performance of red tilapia broodstock and hatchability of their eggs under different water salinities. Three levels of salinity (18, 24 and 32‰) with or without BFT were examined. The fish with an average initial weight of 62.61±4.6 g for female and 98.99±3.1 g for male were stocked in triplicates in 3*1*1m^3 concrete tanks at a density of 5 fish/m^3, at a sex ratio of 3♀:1♂. Broodstock were fed on a commercial diet (25% crude protein) at a daily rate of 1-2% of their live body weight, twice a day, for 9 months. At high salinity level (32‰), time to first spawning was significantly longer than at 18 and 24‰, and significantly decreased with the application of BFT. However, time to first spawning of BFT-treated groups did not significantly vary at different water salinities. Inter-spawning intervals (ISI) showed irregular patterns in relation to salinity levels, however, at 18 and 24‰ salinity, the females tended to spawn at shorter intervals in BFT system. Spawning performances, including total number of spawnings per tank, number of spawnings per female, absolute fecundity and average number of eggs per spawn, were all significantly lower ($P<0.05$) in the non-BFT broodstock reared at 32‰ salinity than those reared in BFT system. Egg size was not significantly affected by salinity levels and presence of BFT. At all salinity levels, egg hatchability increased in BFT treatments compared to BFT-free groups. However, eggs produced from broodstock reared in BFT-free system exhibited significantly lower ($P<0.05$) hatchability, longer hatching time, less yolk-sac absorption time, and lower larval length than those reared in BFT system. These results suggest that BFT can significantly improve the spawning performance and larval productivity of red tilapia broodstock reared at high water salinity.

Table 1. Spawning parameters: Time of first spawning (TFS in days); Inter-spawning intervals (ISI); No spawning per tank (NS/Tank); No spawning/female (NS/female); Total No of spawnings / tank; Average spawning/female; Total No of eggs/tank; Average absolute fecundity

Variable	Without biofloc			biofloc		
	18‰	24‰	32‰	18‰	24‰	32‰
TFS (d)	50 ± 0.58^{d}	61 ± 0.58^{b}	83 ± 0.58^{a}	46 ± 0.58^{e}	47.7 ± 0.88^{de}	57.3 ± 0.88^{c}
ISI days	18.7 ± 0.88^{c}	22.7 ± 0.88^{b}	28.7 ± 0.88^{a}	15 ± 0.58^{d}	15 ± 0^{d}	17 ± 0.58^{cd}
NS/female	7 ± 0	5.67 ± 0.33	5 ± 0.58	7 ± 0.58	7.33 ± 0.88	6.33 ± 0.33
TS/tank	84 ± 0^{ab}	57 ± 6.24^{bc}	35 ± 4.04^{c}	107 ± 8.97^{a}	110 ± 13.2^{a}	69.3 ± 1.76^{bc}
AS/female	7 ± 0^{ab}	4.75 ± 0.52^{bc}	2.92 ± 0.34^{c}	8.94 ± 0.75^{a}	9.17 ± 1.1^{a}	5.78 ± 0.15^{bc}
TNE/tank	13500 ± 156^{d}	10500 ± 516^{e}	7600 ± 476^{f}	22800 ± 591^{a}	19900 ± 320^{b}	15900 ± 273^{c}
AAF	1130 ± 13^{d}	872 ± 43^{e}	633 ± 39.6^{f}	1330 ± 22.7^{c}	1900 ± 49.2^{a}	1660 ± 26.7^{b}

values are means ± SEM, n = 3 per treatment group.
*-fMeans in a row without a common superscript letter differ ($P < 0.05$) as analyzed by two-way ANOVA and the TUKEY test.

ANALYSIS OF MORPHOLOGICAL INDEXES AND BIOCHEMICAL IN BROODSTOCK OF *Lutjanus colorado* AND *L. argentiventris* FOR MATURITY IN CAPTIVITY

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The objective of this work was to evaluate the morphological variability of the yellow snapper *Lutjanus argentiventris* and the red snapper, *Lutjanus colorado*, in its natural environment in the Gulf of California México. Blood biochemistry and morphological analysis were determined during the spring and autumn of 2016, in the San Ignacio-Navachiste-Macapule lagoon system, Sinaloa and each of them, 1.5 ml of blood was extracted to obtain the following biochemical parameters: proteins, cholesterol, triglycerides and glucose. Likewise, morphological tales such as hepatosomatic index, condition factor, gastric replenishment index and gonadsomatic index will be analyzed. In the evaluation of the blood chemistry reference values, no specific differences are observed between the species with respect to morphological indices, total proteins, triglycerides, cholesterol, but there are specific differences ($P < 0.05$) in glucose in both species.

Variables	*Lutjanus colorado*	*Lutjanus argentiventris*
Hepatosomatic	1.29 ± 0.07	1.4±0.08
Condition factor	1.20 ± 0.04	1.4±0.30
Gastric Repletion Index	2.72 ± 0.14	2.6±0.26
Gonadosomatic Index	0.07 ± 0.009	0.11 ± 0.008
Total Protein (g dL-1)	7.54 ± 0.44	7.9±0.41
Triglycerides (mg dL-1)	137.11 ± 11.97	130.0±13.60
Cholesterol (mg dL-1)	87.72 ± 2.21	80.7±2.70
Glucose (mg dL-1)	46.56 ± 2.23	70.7±3.91a

EVALUATION OF THE PRESENCE OF MICROPLASTICS IN COMMERCIALLY IMPORTANT FISH FROM TWO LAGOON SYSTEMS IN NORTHWESTERN MEXICO: AN ALTERNATIVE FOR THE SUSTAINABLE MANAGEMENT OF FISHERIES

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The present study was carried out in the lagoon and island systems of Navachiste and Ohuira Sinaloa México. Four samplings were conducted during an annual cycle, at eight sampling sites, during an annual cycle from November 2018 to October 2019., 573 organisms from 6 commercially important fish species were captured and analyzed. The stomachs of each organism captured were analyzed under the stereomicroscopic technique. The results show that four of the six species analyzed presented contamination by microplastics, finding 5 types with sizes that varied from 0.33 to 4.72 mm. nylon was the microplastic with the highest number of occurrences, found in four of the six species observed (*Pomadasys macracanthus*, *Diapterus peruvianus*, *Cynoscion othonopterus* and Lutjanus sp.), with a total of 99 particles. In *D. peruvianus* in a single organism polyurethane was found with 42 counted fragments, followed by fragments of plastic bags (polyethylene) in *P. macracanthus*, 14 plastic elements, polyethylene terephthalate (PET) and fragments of polyester fibers were observed on the silver carp. It is suggested that organisms with omnivorous eating habits present a higher degree of susceptibility to the ingestion of microplastics and that predatory organisms acquire plastic pollutants through bioaccumulation processes. The microplastics found are related to fishing activities, so it is suggested to work with the communities of the fishing places, to strengthen the knowledge bases around this environmental problems.

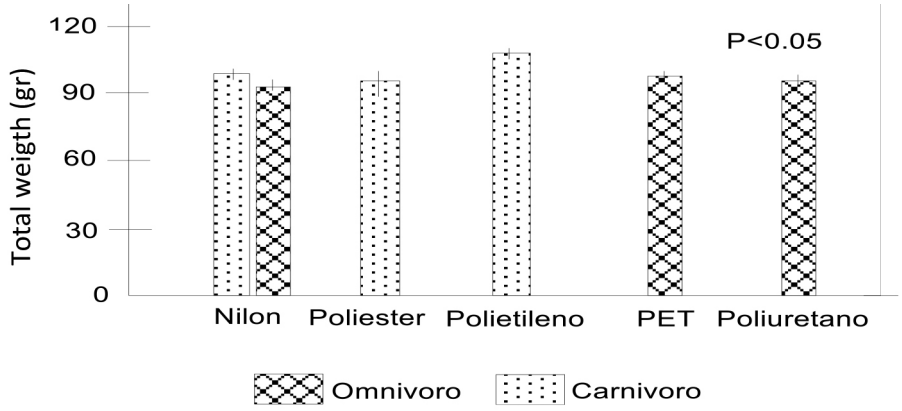

Figure 1.- Total, weight in grams of microplastic fragments found by type of eating habits found in the digestive tract of commercially important fish in North Sinaloa.

SEX RATIO, GROWTH AND SURVIVAL OF *Oreochromis Tanganicae* (GÜNTHER, 1894) FED ON A DIET WITH VARYING LEVELS OF 17α-METHYLTESTOSTERONE

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Aquaculture is a promising and developing industry world over. One of the first step in increasing productivity is by culturing of monosex fingerlings, all-male fry by the use of hormones particularly in tilapia species.To this effect, a study was carried out to determine the optimal level of hormone diet with four inclusion levels of 17α-Methyltestosterone (17α-MT), that is 0mg MT/kg^{-1}, 40mg MT/kg^{-1}, 60mg MT/kg^{-1} and 90mg MT/kg^{-1}. The four treatments were replicated thrice and laid out in a Completely Randomized Design (CRD). Fry of average weight 0.307±0.002g were stocked in 12 concrete tanks each measuring (1m x 1m x 1.5m) at the rate of 500 fry/m^2. The fry were fed with the treated diet for 28 days starting from their first feeding stage. They were then shifted into hapas (1m x 1m x 1.5m) set up in a semi concrete pond and fed on a hormone diet. After three months of growth, microscopic evaluation of gonads was conducted to determine the sex of fish by gonad squashing and aceto-carmine staining method. The proportions of males were 54 %, 90 %, 94 % and 70 % for treatments 0 MT/kg^{-1} (T-1), 40mg MT/kg^{-1}(T-2), 60mg MT/kg^{-1} (T-3) and 90mg MT/kg^{-1}(T-4), respectively (Table 1). The maximum mean body weight gain after 90 days was observed in fry fed 60mg/kg^{-1} 17 α-MT (T-3), which was 15.31±0.14g. However, this was not significantly different from 40mg MT/kg^{-1}(T-2) (P>0.05). Furthermore, the highest dose 90mg MT/kg^{-1}(T-4), produced a significantly lower (P<0.05) male proportion (70%) compared to treatments; (T-2 and T-3). The anabolic effect of 17α-MT diminished over time. Survival rates of 98%, 97%, 97% and 96 % for treatments 0mgMT/kg^{-1}, 40mg MT/kg^{-1}, 60mgMT/kg^{-1} and 90mgMT/kg^{-1}, respectively, were recorded. The study revealed a 60mgMT/kg^{-1} of hormone inclusion level that yielded the highest treatment efficacy at 94% and a mean weight gain of 15.31±0.14g after 90 days. However, 51.10mgMT/kg^{-1} was determined to be optimal with an efficacy of 93.71 (%) after exposing the data to quadratic contrasts.

The study recommends for production of mono sex *O. tanganicae*, 51.10mgMT/kg^{-1} should be used.

Table 1: Proportions of males and females per dose of MT microscopic gonadal

Treatment	Male (n, %)	Female (n, %)	Chi square (X^2)	Sex ratio	p value	Efficacy (%)
Control	27(54)	23(46)	0.040	1:1.2	0.841	54±7.41
40mgMT/kg^{-1}	45(90)	5(10)	17.190	1:0.1	<0.001	90±0.75
60mgMT/kg^{-1}	47(94)	3(6)	22.868	1:0.1	<0.001	94±0.75
90mgMT/kg^{-1}	35(70)	15(30)	3.375	1:0.4	0.066	70±3.01

BIOCONTROL OF DISEASE-CAUSING SNAILS USING MONO-SEX PRAWNS

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An unresolved problem in aquaculture ponds is the susceptibility of freshwater fish to parasitic diseases, caused by *trematodes*, which are transmitted by freshwater snails. Unfortunately, these snails are very common in aquaculture ponds evident by more than 150 scientific articles since 2020 that were published on fish infections by *Centrocestus* alone, around the globe.

At least four species of such snails are common in freshwater aquaculture ponds in Israel: the local and over-abundant *Melanoides tuberculata,* and the invasive *Thiara scabra, Tarebia granifera* and *Pseudosuccinea columella,* All being hosts of various disease-causing parasitic trematodes. Since 2017 an ongoing field study in fish ponds, accompanied by laboratory experiments, present a promising future for this biocontrol technology

The giant freshwater prawn, *Macrobrachium rosenbergii*, a proven voracious predator of freshwater snails - when stocked in polyculture with fish, reduced snail abundances (Fig. 1) and the accompanied parasitic load among fish. Consequently, the demand for *M. rosenbergii* PLs among fish farmers in the region has been rising (Fig. 2).

Prawns in contrast to fish, occupy a benthic niche in the aquaculture pond and may thus be expected to prey on disease-carrying snails, which burrow into the pond bottoms. Prawns also bring the added advantage of constituting a high-value side-product to the pond-produced biomass without the need for additional feed. Following recent biotechnological advances in monosex prawn production, non-reproducing monosex prawn populations are now commercially available as non-invasive, ecologically safe biocontrol agents in aquaculture.

The effectiveness of this biocontrol agents for *Tilapia* aquaculture in terms of reduction in both snail abundance and rates of fish infection with the snail-borne parasites.

We suggest a novel sustainable biocontrol concept that presents a win-win-win situation rewarding both Farmers-Fish & the Environment.

Figure 1 Resperentative pond bottons after harvest

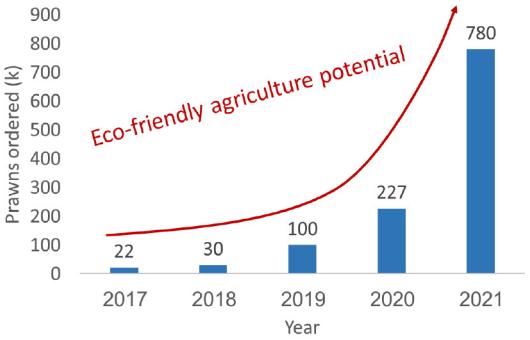

Figure 2. Demand for bio-control agents (M. rosenbergii PLs) in the trematode infected region

MARINE AQUACULTURE RESEARCH & DEVELOPMENT IN SUB-SAHARAN AFRICA: EXAMPLES FROM WEST, EAST, AND SOUTHERN AFRICA

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World per capita fish consumption is expected to increase by 2030 with the exception of Africa, due to population growth outpacing supply. This raises food and nutrition security issues owing to the high prevalence of malnutrition in the region and the contribution of fish to total animal intake in many African countries. The annual growth rate of Africa's aquaculture production has been the highest worldwide during the last 20 years; however, it represents less than 3% of the world's total annual production. Brackish and freshwater aquaculture production have greatly increased in Africa over the last two decades, while marine aquaculture production has remained low. The latter only represents 5% of the total 2019 production (in tonnes), of which 92% are seaweeds. Marine aquaculture production is very unevenly developed in the different African coastal countries, and Mauritius, South Africa, and Tanzania are by far the main producers of finfish, molluscs, and seaweeds, respectively.

The objective of this work is to provide an overview of the current situation of marine aquaculture in several sub-Saharan African countries with different socio-economic and environmental contexts, in which this food production system is at different points of development. The farmed species and/or species of interest that are the subject of research, the new initiatives that are being implemented, as well as the challenges and opportunities to develop marine aquaculture sustainably in Senegal, Ivory Coast, Namibia, South Africa, Mauritius, Tanzania, and Kenya will be presented.

EXOGENOUS PHYTASE APPLICATION IN NILE TILAPIA *(Oreochromis niloticus)* FEED REDUCES THE REQUIREMENT FOR INORGANIC PHOSPHORUS AND ENHANCES GROWTH PERFORMANCE

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Excessive use of phosphate in the aquatic environment is well documented to cause serious eutrophication in water courses. Plant ingredients contain a significant quantity of Phytate Phosphorus (PP) ~65-70% that is poorly utilised in fish species and is a known anti-nutritional factor. As tilapia feed formulations are typically derived from 90-95% plant material there is a significant opportunity to utilise this PP. In terrestrial monogastric nutrition phytase enzyme unlocks considerable (PP) and significantly enhances animal performance. A 93 day feeding trial was conducted to test the performance of a phytase enzyme applied post pellet to an extruded tilapia feed (1500FTU/kg). A 50% reduction in inorganic P supplementation which is a finite and expensive material, was tested to assess the impact of growth performance indices when using phytase to unlock the (PP) that is currently poorly utilised within fish.

Three experimental diets were produced:

- Control feed (MCP 1.9%)
- Negative Control (MCP 0.8%) (NC)
- NC (MCP 0.8%) + Phytase 1500 FTU

Each diet was randomly assigned to quintuplicate groups, (30 fish tank, N=150 in 350l round tanks) Fish were raised in a recirculating system and maintained at a water temperature of 27.7 ± 0.04°C. After 93 days of feeding it was demonstrated that it is possible to successfully replace at least 50% Mono Calcium Phosphate (MCP) with a phytase enzyme and have significantly positive effects on fish performance as detailed in table 2 below.

Table 1. Formulation of the experimental diets.

Ingredients, %	NC	NC+1500FTU	MCP
Soyabean meal	25	25	25
Wheat bran	25	25	25
Maize gluten 60	15.87	15.87	16.05
Maize	13.74	13.74	12.43
Rapeseed meal	10	10	10
Fishmeal	5	5	5
Monocalcium phosphate	0.805	0.805	1.901
DL Methionine	0.006	0.006	0.007
Soya oil	1.8	1.8	1.8
Salmon oil	1.8	1.8	1.8
Vitamin & Mineral premix	1	1	1
OptiPhos Plus 5000L	0.00	0.03	0.00
Calculated analysis, %			
Moisture*	11.5	11.5	11.3
Protein	33	33	33
Fat	7	7	7
Fibre	5.4	5.4	5.4
Ash	5.6	5.6	6.5
Ca	0.55	.55	0.74
P	0.98	0.98	1.22
Av P	0.40	0.40	0.60
GE (MJ/kg)	18.1	18.1	18.1

Table 2. Growth performance after **93 days** of feeding (end of the trial).

	NC	NC+1500FTU/kg	MCP	P value
Survival, %	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	-
IBW, g	13.3 ± 0.1	13.3 ± 0.1	13.4 ± 0.1	0.459
FBW, g	74.6 ± 1.5 ^{a}	101.2 ± 2.5 ^{c}	96.6 ± 1.9 ^{b}	**<0.001**
SGR, %/d	1.85 ± 0.03 ^{a}	2.18 ± 0.02 ^{c}	2.13 ± 0.02 ^{b}	**<0.001**
FCR	1.10 ± 0.04 ^{b}	0.95 ± 0.03 ^{a}	0.99 ± 0.03 ^{a}	**<0.001**
FI, % ABW/d	1.65 ± 0.05	1.56 ± 0.05	1.62 ± 0.05	0.074
PER	2.74 ± 0.11 ^{a}	3.17 ± 0.09 ^{c}	3.03 ± 0.10 ^{b}	**<0.001**

Values are means ± standard deviation (n=5).
Different superscripts within a row denote a statistical difference (P<0.05).

SANACORE® GM SUPPLEMENTED FEED BOOST THE HAEMATO-IMMUNOLOICAL PATTERNS, ANTI-OXIDATIVE RESPONSES, AND *Aeromonas Vernoii* RESISTENCE IN NILE TILAPIA (*Oreochromis niloticus*)

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A 30 days feeding trial was performed to investigate the effect of Sanacore® GM on the final growth, hematological indices, biochemical parameters, antioxidant response, immune status, and disease resistance of Nile tilapia. The fish were randomly distributed in two groups in triplicate and fed with Sanacore® GM at a dose of 5 gm/kg diet for a period of 30 days. At the end of the feeding trial, fish were challenged by *Aeromonas veronii* (*A. veronii*) and mortality rate was recorded for 15 days. The results showed that fish fed Sanacore® GM had significantly ($P< 0.05$) higher final weight than those fed control diet. Red blood cell, white blood cells, hemoglobin concentration, lymphocytes, and neutrophils were significantly increased in treated group. Serum total protein and albumin levels exhibited significant increase in treated group compared with control. In addition, the activity of antioxidant enzymes (superoxide dismutase and glutathione peroxidase) revealed significant increase ($P< 0.05$) in Nile tilapia fed Sanacore® GM supplemented diet. Meanwhile, Catalase activity recorded non-significant change ($P> 0.05$) among treated and control groups. Sanacore® GM supplemented group showed significant increase in immunological parameters (phagocytic activity, serum bactericidal activity, lysozyme activity, IgM and nitric oxide levels). After *A. veronii* challenge, the survival rate was higher in treated group than the control ($P< 0.05$). The results of this study indicated that sanacore® GM could significantly enhance growth, hemato-immunological parameters, antioxidant capability of Nile tilapia, as well as disease resistance against pathogenic strains of *A. veronii*.

EFFECTS OF HETEROTROPHIC BACTERIA ON METAL CONCENTRATIONS IN THE CULTURE OF *Litopenaeus vannamei*

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Nowadays, Fisheries is considered one of the most important resources. By increasing the population over the world, aquaculture is one of the very important ways to provide food for humans. Aquaculture includes *Litopenaeus vannamei* farming by biofloc technology in presence of organic carbon sources with consideration the heavy metals and other wastes pollution. In this experiment, *L. vannamei* is cultured using sugarcane bagasse (T1) and rice bran (T2) as carbon sources with following up of the growth of heterotrophic bacteria (THB) and Vibrio bacteria (TVC) as an indicator for pathogenic bacteria and their impacts on metals level in water resulting from aquaculture process.

Over 120 days, the number of total heterotrophic bacteria and Vibrio bacteria in the control was lower than the other treatments (T1 & T2). As for the effect of carbon sources, the number of bacteria in the sugarcane bagasse (T1) was greater than rice bran (T2). The highest number of total heterotrophic bacteria was at the end of the experiment (Figure 1).

Looking at the metal results, it was found that the mean values of control samples in the first of study were (0.8503, 5293, 0.4035, 0.2313, 0.1071, 0.0279 and 0.0765 µg L^{-1}) while at the end of the study these values were (0.8632, 0.4675, 0.3764, 0.2242, 0.0930, 0.0237 and 0.0795 µg L^{-1}) for Cu, Zn, Pb, Cd, Ni, Co and Mn, respectively. In the same order of metals it was found that the percentage of metal removal were {(85, 76); (71, 66.5); (93, 89); (83, 75); (84.1, 76.1); (78.4, 59.5) and (81.8, 69.5){for sugarcane bagasse and rice ban, respectively (Figure 2).

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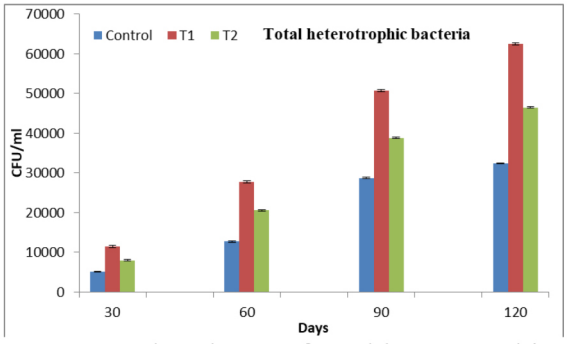

Figure 1: Abundance of total heterotrophic bacteria via *L. vannamei* aquaculture

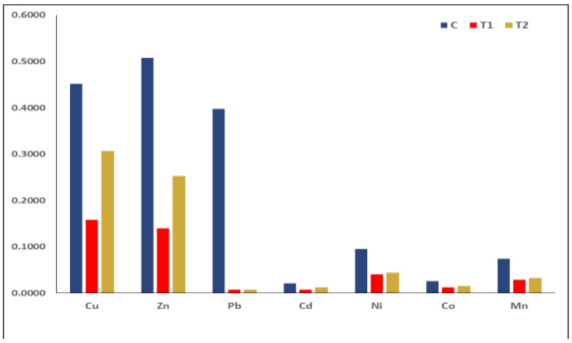

Figure 2: Heavy metals concentration (µg/L) in *L. vannamei* culture water during the experiment.

IMPACT OF ORGANIC CARBON SOURCES ON NUTRIENT DIGESTABILITY EFFICIENCY OF *Litopenaeus vannamei* IN THE BIOFLOC SYSTEM

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In the biofloc system, the potential of carbon sources may include simple ones such as molasses, glycerol and glucose, and complex ones such as flours and starches. Different carbon sources result in different nutritional values of the biofloc. In addition, they have varying effects on the composition of the microbial community in the biofloc, the production, and the immunity of the cultured shrimp. The addition of different carbon sources effectively increases the growth of microorganisms (bacteria, protozoa, algae and zooplankton), which could be attributed to the higher densities of bacteria in the biofloc system. So, the biofloc system could serve as an important food source without the need to add feed or external diets, and thus increase the growth of shrimp.

A 90-day out-door growth trial was conducted to evaluate the influence of using different carbon sources on nutrient utilization efficiency in biofloc system on the digestive enzymes in both stomach and intestine of *Litopenaeus vannamei* post-larvae (0.02±0.01g). Both sugarcane bagasse (SCB) and rice straw (RS) were used as an organic carbon sources that were added into the tanks to promote the development of biofloc as a natural feed during the experiment. During the entire experiment, good water quality and biofloc development were achieved under the addition of different carbon sources. Overall, the specific activities of protease, amylase, lipase and cellulase in both stomach and intestine of *L. vannamei* shrimp in biofloc treated group were significantly improved (Figures 1 & 2) when compared with control one ($P < 0.05$).

Acknowledgements: The research was performed within the "EGY-DRAFT" project (Development and Research Application of bioFloc Technology for increasing shrimp production in Egypt), funded by the Science, Technology & Innovation Funding Authority (STDF), Egypt. Agreement No.: 25305/Reintegration Grants (STDF-RG)/ STDF-Youth. The authors are grateful for all the support

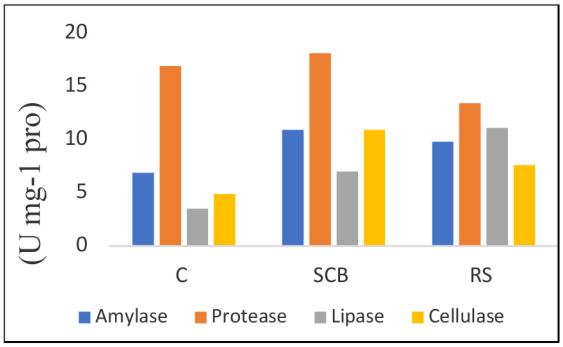

FIGURE 1. Effect of carbon sources on the digestive enzymes activity in the stomach of *L. vannamei* shrimp.

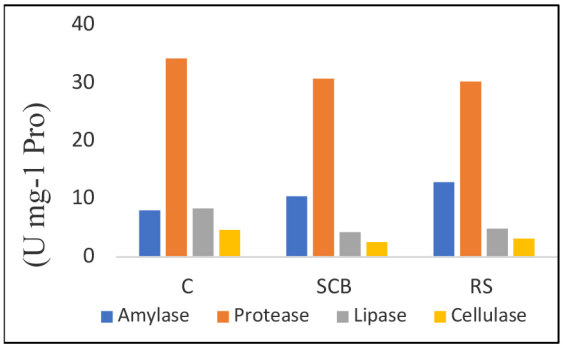

FIGURE 2. Effect of carbon sources on the digestive enzymes activity in the intestine of *L. vannamei* shrimp.

BEST MANAGEMENT PRACTICES IN RAISING NILE TILAPIA *Oreochromis niloticus* FOR FOOD SECURITY AND ECONOMIC EMPOWERMENT IN KENYA

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Fish farming is an emerging blue economy in Africa where if fish farmers are well trained can be a source of food security, economic growth and decent livelihoods (Ababouch et al, 2015) Fish farming is undoubtedly profitable, especially when cheap but nutritious ingredients are used along side best management practices (Sunwit, 2021)

Objective

To train fish farmers on best management practices in Raising Nile Tilapia fish in Kenya
To raise Nile Tilapia 0.4 g fry to 350g in 6 months on high quality feed from Company X

Materials and Methods

Experimental design was adopted for the study where a group of 27 fish farmers were selected and provided with 1000 all male Nile tilapia fingerlings of 0.4g.

The fish farmers were trained on physical, chemical and biological water quality parameters where, the commonly monitored parameters were; temperature, dissolved oxygen, pH, alkalinity, hardness, ammonia, and nitrites. Water temperature and turbidity were taken 3 times daily before feeding. First two months the fry were fed four (4) times a day at interval of 2 hours on grumble of 44% crude protein. Third month fingerlings were transferred to fertilized pond and fed four (4) times a day on 2mm feed of 38% crude protein, Fourth to sixth month the fish was fed three (3) times a day on 35% crude protein feed. Sampling was done twice a month where weight in gramms and length in cm were determined to establish weight gain. The first two months the fry were raised in hapa nets to minimize predation. In the third month they were transferred in 300m^2 covered with a predator net.

Table 1: Fish sampling

Time (Days)	Sample Size	Total Weight(g)	Average Weight(g)	Est. Weight Gain (g)	Water Temp(^{0}C)
0	1000	400	0.4	-	27
26	40	80	2	1.6	26
49	40	3700	93	10	26
70	40	6000	150	3	27
132	40	6333	240	90	23
180	40	14200	355	115	27

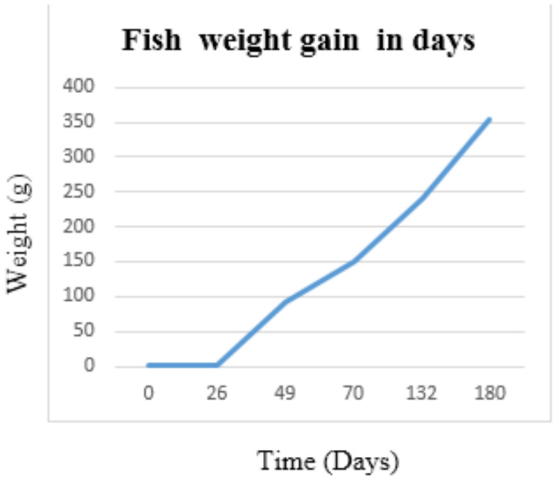

Fig 1: Fish Weight gain in days

Results

From a total of 1000 fingerlings stocked a maximum of 910 fish were harvested while 90 pieces were uncounted for, representing 9% loss. Another 10% weighed between 300 – 350 g which was still considered better results as they were the most prefered by the farm gate market.

Conclusion

Feeding protocols, water quality, on farm best practice and feed quality influence fish growth.

Tiliapia farming is profitable if cheap but nutritious but feed is used.

AN EPIDEMIOLOGICAL STUDY OF EPIZOOTIC ULCERATIVE SYNDROME (EUS) IN FIN-FISH ON LAKE KARIBA AND INLAND WATER BODIES IN ZIMBABWE

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An epidemiological study of epizootic ulcerative syndrome (EUS) was conducted in Zimbabwe within Kavango Zambezi (KAZA) and Great Limpopo (GL) Transfrontier Conservation Areas (TFCAs), during the period between May 2016 and September 2018. The study aimed at understanding factors associated with EUS spread, biosecurity risk factors, pathological features, fish species affected and establishment of disease prevalence. During the three-year study period, and within the prescribed study area, twenty-seven randomly selected study sites from wild (artisanal) capture fisheries on Lake Kariba and impoundments on inland rivers were surveyed. These emanated from four respective provinces in Zimbabwe, namely Mashonaland West, Midlands and Matabeleland North & South provinces, eleven (11) fish farms were also sampled.

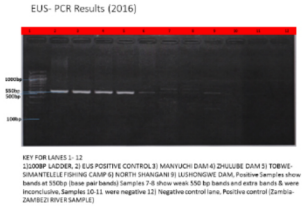
Out of the 2569 fish sampled in wild fisheries 246 were found with typical gross pathological skin lesions of EUS disease, derived from 15 positive locations indicating a prevalence rate of 9.58%. The most important observations of highest infection rates and most severe skin lesions were found on inland water bodies as opposed to Lake Kariba, signifying the state of water quality. Clinical observations highlighted C*larias species* as the most severely affected, followed by *Barbus* and *Oreochromis species* respectively, similar findings were made during a retrospective study by Sibanda et al., 2018. The Epidemiological and a Socio-economic studies involving detailed interviews with key stakeholders and fishermen established an initial rise and steady decline, in disease outbreaks from 2008, when EUS was first suspected and later confirmed on Darwendale impoundment in 2012 (Gomo *et al*., 2016). No outbreaks were recorded during the peak winter EUS disease season of 2018.

The disease spread from endemic Zambezi River Basin (ZRB) in KAZA TFCA to the Great Limpopo TFCA drainage system was attributed to flood events experienced subsequently following the establishment of the disease in several Southern African countries sharing the ZRB, including Zimbabwe. No EUS disease outbreaks were confirmed on 11 randomly selected aquaculture farms surveyed during the study. The Epidemiological study was envisaged to contribute towards formulation of policy frameworks and strategy guidance in aquatic animal health which currently are inadequate in view of the recently fast-growing production of particularly the aquaculture sub- sector of Zimbabwe.

Table 3: Mean [± standard errors (se)] of water parameters according to sites observed to have fish with EUS lesions and those without

Water parameters	Sites	
	Fish with EUS lesions	Fish without EUS lesions
Temperature °C	$22.6^{a} \pm 2.8$	$23.4^{a} \pm 2.0$
pH	$7.2^{b} \pm 0.8$	$7.8^{a} \pm 1.0$
Dissolve Oxygen (%)	$18.2^{a} \pm 3.7$	$15.1^{b} \pm 5.0$
Dissolved Oxygen (mgL)	$7.5^{a} \pm 1.4$	$7.4^{a} \pm 1.3$
Conductivity (µS)	$0.16^{a} \pm 0.1$	$0.21^{a} \pm 0.2$
Conductivity (ppm)	$106.5^{a} \pm 64.3$	$129.5^{a} \pm 71.8$
Submerged vegetation (%)	$88.9^{a} \pm 36$	$66.7^{b} \pm 45$

*Figures with a different superscript in the same row under each parameter are significantly different at $P < 0.05$



FIT FOR GROWTH: FEED FOR INTENSIVE FARMING OF AFRICAN CATFISH *(Clarias gariepinus)*

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Particularly when raised in intensive aquaculture, African catfish is an enormously fast growing species. It has been reported, that 40 to 60 days are needed to grow fry to 20 g. After that, the grow-out stage begins, where the fish requires 90 to 120 days to reach 1 kg (Figure 1). Clearly, the desired harvest weight can be reached earlier when farming inputs promote the growth potential of African catfish. Among other factors, feed quality plays a key role here.

Feed raw material quality

Raw material selection and quality are important factors for producing highly palatable and digestible feed. Imbalances in nutrient composition affect the water quality of the fish housing unit. For example, feeds leading to high feed conversion ratios will result in high amount of feces. The feces of African catfish are unstable and difficult to filter from the water. Given relatively low water exchange rates and high fish biomass per cubic meter, feces disintegrate into many small particles and pollute the water body. Although African catfish can gulp air from the surface, a filled digestive tract and high biomass together with inappropriate environmental conditions can cause high and sudden mortalities on the farm.

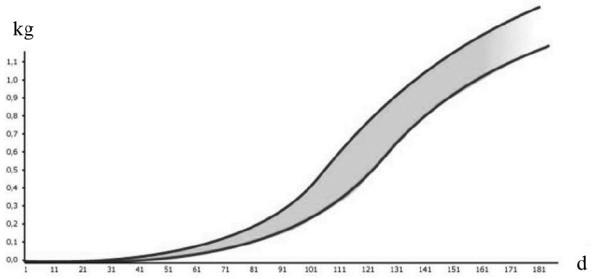
Physical feed quality

Physical quality of feed for African catfish refers to feed floatability, level of dust and fines, even pellet size and hardness as well as other parameters. These physical parameters can contribute to optimal feed intake and feed conversion efficiency. Especially feed wastes through uneaten feed, dust and fines negatively impact water quality and will eventually lower the farming success.

Summary

Due to the fast growth of African catfish, it can be quickly demonstrated, that high-performance feed of stable nutritional and physical quality enables faster fish growth and gives fish ready for the market in about 130 to 180 days. Popular feeds in African markets are fit for intensive fish farming and thus enable the farmers to utilize the growth potential of African catfish in the most economical way.

Figure 1: Growth of African catfish in intensive aquaculture.



FEED CONSUMPTION AND FEED CONVERSION OF *Clarias gariepinus* RAISED IN SMALL PLASTIC TANKS AFFECTED BY METHOD OF WATER EXCHANGE

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We tested the mode of water exchange in tanks containing *Clarias gariepinus* to determine if different methods yielded differing results for feed consumption or feed conversion. The purpose of the research was to better design future trials comparing feeds and different rates of water exchange. Twelve plastic tanks with capacity $1m^3$ were each stocked with 25 subadult catfish, *Clarias gariepinus*, averaging 151±2g. Water exchange was designed to use the same total amount of water (500 litres per day), but on three different schedules: treatment 1 was a one-time 500L water exchange per day, treatment 2 was a one-time 1000L single exchange every two days and treatment 3 was a continuous (flow through) slow rate of exchange at a rate of 500L of water per day. The water source was a borehole located on the farm. All tanks drained their water from the bottom. Fish were fed every afternoon to satiation for 87 days on feed of 42% crude protein, followed by 33% crude protein feed for a total of 115 days. Treatments 1 and 3 resulted in significantly higher fish growth and better feed conversion than treatment 2. Even though the same amount of water exchange was applied in all treatments, a steady rate or smaller, more frequent exchanges worked better for intensive Clarias production.

Table 1: Growth indices and food utilization parameters of *Clarias gariepinus* produced under different frequencies of water renewal. Means±S.E on the same row with different subscript differ significantly ($p<0.05$).

Parameters	Treatment 1	Treatment 2	Treatment 3
Initial Weight (g)	$149.50\pm1.72_b$	$146.70\pm1.63_b$	$158.20\pm3.81_a$
Final Weight (g)	$541.87\pm33.49_a$	$394.63\pm22.37_b$	$601.52\pm13.50_a$
Survival (%)	93.00±3.42	99.00±1.00	95.00±2.52
Feed Conversion Ratio	$1.55\pm0.05_b$	$1.82\pm0.07_a$	$1.40\pm0.03_b$
Specific Growth Rate	$1.11\pm0.05_a$	$0.86\pm0.04_b$	$1.16\pm0.02_a$
Feed cost per kg gain (FCR*feed price in Naira)	$662.05\pm23.45_b$	$776.20\pm31.74_a$	$596.68\pm13.99_b$
Volume of water use per weight gain (L/Kg)	$5710\pm609.9_b$	$8406\pm693.5_a$	$4822\pm229.0_b$

Table 2: Dissolved oxygen and temperature parameters of *Clarias gariepinus* produced under different frequencies of water renewal.

Parameters/Treatments	Treatment 1	Treatment 2	Treatment 3
Dissolved Oxygen (mg/l)	$14.37\pm0.28_a$	$12.03\pm0.12_b$	$12.19\pm0.19_b$
Temperature (^OC)	30.37±0.12	30.21±0.14	30.07±0.07

INVESTING IN SUSTAINABLE AQUACULTURE IN AFRICA

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Introduction
Aqua-Spark is nearing the close of a USD 50 million Africa Fund that will focus on aquaculture investments in Africa.

Vision
To significantly contribute to building a thriving and sustainable aquaculture industry in sub-Saharan Africa to create jobs, contribute to food security, and relieve pressure on natural resources.

Interventions
1. Investing in aquaculture and associated enterprises;
2. Focusing on production and identifying gaps in the supply chain;
3. Diversifying across geographies and value chains;
4. Providing necessary technical assistance; and
5. Bringing expertise of the Aqua-Spark community and portfolio companies.

Investment Criteria
1. Greenfield to growth stage;
2. Equity investments aiming for 20-49% range; and
3. Long-term, active strategic investor.

DISEASE MITIGATION STRATEGIES IN TILAPIA: A POSITIVE AND NEGATIVE APPROACH

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Disease remains a major bottleneck for the expansion of aquaculture. This is particularly true as aquaculture intensifies and production stressors negatively impact the animal, increasing disease susceptibility and denting the profits of producers. This has created the need for prophylactic disease management, through the use of functional feed. There is often a misconception that additives can solve all problems, and these unrealistic expectations have resulted in skepticism about feed additives.

This is particularly true when combatting bacterial disease. There are two types of bacteria, which differ in membrane structure. Gram-negative bacteria have an outermost layer of lipopolysaccharides (LPS) whilst the external layer in Gram-positives is comprised of peptidoglycans. Both types contain pathogens and not surprisingly, different management approaches are needed to combat them. In tilapia this is particularly relevant, as the fish are exposed to many bacterial pathogens, including *Aeromonas hydrophila*, *Edwardsiella tarda*, *Francisella noatunensis* etc. (G-ve) and *Streptococcus* spp. (G+ve).

Organic acids and their salts have been used extensively in aquaculture, and are a 'go-to' additive to combat fish disease. It is often thought organic acids act to reduce the pH in the gut, but this is not always true unless a very high dosage is used. More important is to explore antimicrobial properties where lower doses might work, but are highly formulation specific. For example, an enhanced acidifier (Biotronic® PX Top3) was found to be more effective than similar products, despite having a 4x lower inclusion rate (0.5 kg/t vs 2.0 kg/t). After an eight-week feeding period, tilapia (initial weight = 10.96 ± 0.02g) were exposed to an *Aeromonas hydrophila* challenge via IP injection (7.5×10^5 CFU/ fish). After monitoring for 20 days, highest survival was seen in the Biotronic® treatment (85.7%), followed by the competitor products (50-64.58%) and lowest in the control (43.75%). These data demonstrate the value that organic acids can bring in the fight against G-ve pathogens, but also highlights the importance of product formulation.

On the other hand, phytogenics have not been used so widely, but their benefits are particularly interesting against Gram-positive pathogens. To demonstrate this, tilapia fingerlings (initial weight = 10.63 ± 0.01g) were randomly split into two treatments and stocked into 12 tanks (n = 6). Fish were fed either a control diet, or one supplemented with a phytogenic feed additive (PFA, Digestarom® P.E.P. MGE) at 0.2 kg/ t. After a 57-day growth trial, where the PFA significantly improved biomass, weight gain and FCR ($p < 0.05$) fish were exposed to an *S. agalactiae* challenge via immersion (5×10^6 CFU ml^{-1} for 1 hr). Following a 15-day monitoring period, a survival of 52.5% was seen in the control treatment. This compared to 70.0% survival in the PFA treatment, a real term increase of 33.3%. This demonstrates that phytogenics can be a useful tool in the continual fight against *Streptococcus* spp.

These studies demonstrate that in order to see the value of feed additives, the additive type and active components should be carefully selected for the specific field challenge. In addition, they are not 'silver bullets', and their use should be complemented with other management considerations, including biosecurity, vaccinations, water quality etc.

AQUAPONICS RESEARCH AND EDUCATION DEVELOPMENTS AT STELLENBOSCH UNIVERSITY IN SOUTH AFRICA

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Aquaponics is the combination of aquaculture and hydroponic technology to grow both fish and plants together in a closed-loop system. While aquaponics can play a role in increasing food security, it may also be a potential educational tool because of its interdisciplinary nature and required technological skill set. With aquaponics, students could conduct hands-on activities involving chemistry, physics and biology to solidify their understanding of a range of theories. Beyond standard science, technology, engineering and mathematic principles, aquaponics may be related to projects on sustainability, environmental science, agriculture, the food system, health, economics, business and marketing. The interdisciplinary nature of aquaponics may make it an appealing tool for education, yet that same aspect may also make an aquaponics system challenging to implement and manage. Educators require appropriate training materials and training courses for their particular educational settings. Stellenbosch University and its industry partners aim to develop digital and interactive aquaponics study programmes for South Africa and across the SADC region by way of a hybrid teaching approach comprising of pre-academic online courses, scientific graduate studies, live practical training workshops and accompanying formats such as virtual workshops.

It is the firm belief of the partners that aquaponics will play an essential role in supplying the planet, particular semi-arid and arid areas, with healthy and safe fresh produce and that aquaponics as a farming technology is less harmful to the environment compared to conventional agriculture. The partners are convinced that; people make companies and with the cooperation inspired and committed to helping all stakeholders of the evolving aquaponics industry to develop their highest potentials. With the right knowledge of modern aquaponics growing techniques and business practices, local aquaponics farmers will act as catalyst in the exponentially growing local food economy. The purpose of the cooperation is to educate and empower them to make that happen.

The Education Programme aims to substantially contribute to the development of a future-oriented, ecological, sustainable and economically thriving farming era allowing for the circular plant and aquatic food production in harmony with nature.

EMERGING VIRAL DISEASES THAT THREATEN GLOBAL TILAPIA AQUACULTURE

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Infectious diseases are a serious threat to global tilapia aquaculture. Recently, outbreaks of new viral diseases in cultured tilapia, including Tilapia Lake Virus (TiLV), Infectious Spleen and Kidney Necrosis Virus (ISKNV), Tilapia Parvovirus (TiPV) have been associated with massive death and severe economic impact in many countries. For example, TiLV has been reported in 15 countries since its first report in 2014. The affected fish showed signs of abnormal swimming, skin congestion, hemorrhage, abdominal swelling, skin erosion, and eye protrusion (Figure 1) associated with 80-100% mortality, causing high economic loss to fish farmers. The outbreaks usually occur after fish are transferred into ponds or cages in rivers or water reservoirs. Histopathological alterations include syncytial cell hepatitis, lymphocyte infiltration with foamy cytoplasm, depletion of red blood cells in the spleen and kidney (Figure 1). These emerging viruses can be transmitted via horizontal and vertical of infected broodstock. Despite this growing interest in these viruses, there is little knowledge that could lead to the sustainable management of the disease. Currently, there is no vaccine or antiviral therapy to prevent emerging virus diseases in tilapia, causing the diseases to regular spread and causing severe economic impacts to the industry. Interestingly, recent research indicated that tilapia produce an antibody response that provides protective immunity against subsequent emerging viral infection, suggesting that a promising vaccine candidate would prevent TiLV disease. Vaccines are also an important tool to lessen the use of antibiotics and reduce the spread of the virus in the environment.

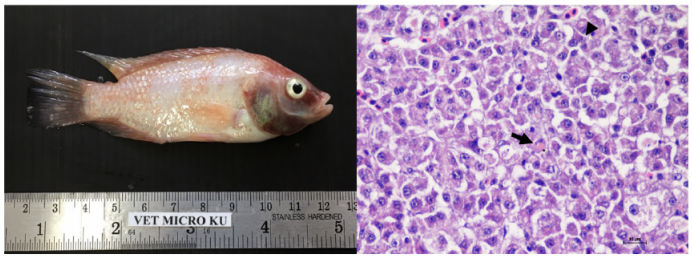

Figure 1 (A) gross appearance of red hybrid tilapia (*Oreochromis* spp.) experimentally infected with TiLV. (B) Histopathological changes of liver in TiLV-infected fish with syncytial cells (arrow head) and eosinophilic intracytoplasmic inclusion body in hepatocytes (arrow).

RISK ASSESSMENT OF VIRAL ENCEPHALOPATHY AND RETINOPATHY INTRODUCTION AND SPREAD IN MEDITERRANEAN SEABASS FARMS

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The objective of this study was to use risk assessment to determine the biosecurity risk associated with Viral encephalopathy and retinopathy (VNN) introduction and spread in Mediterranean seabass production, and to identify the control measures to manage the risks.

Biosecurity plans for prevention of introduction and further spread of disease pathogens involve knowledge on risk assessment of disease hazards in the region, likelihood of introducing the infectious agent into the production system, epidemiology and transmission routes, critical points for introduction and control. VNN was identified as the most important disease of seabass in the western, central, eastern and southern Mediterranean areas in terms of production and economic impact due to factors such as the high mortality and morbidity by literature, survey, and expert opinion.

A group of 10 experts consisting of fish health specialists, veterinarians, biologists, and epidemiologists were asked to provide their opinion regarding disease hazards, likelihoods of disease introduction and spread in the Mediterranean seabass. Expert knowledge elicitation (EKA) approach was used to elicit expert opinion and perform the risk assessment. Risk matrix was used to present the overall risk estimates by integrating the numerical scores for the likelihood of disease introduction and the economic consequences. The experts to identify the points at which VNN introduction and spread could occur and be prevented. At each action point, experts gave a weight for potential biosecurity measures concerning its feasibility and effectiveness for controlling VNN

The main risk pathways differ by type of production for which the likelihoods of introduction are similar for hatchery and pre-growing, but different from the likelihoods for on-growing. Intake of water, live fish and eggs, vehicle transporting live fish, human, equipment, and high-risk purchasing were identified by the experts as the risk pathway for all types of production. This illustrates a clear recommendation to encourage focusing on introductory risk.

The economic consequences of VNN depend on the type of production of the facility. The consequences of VNN introduction were regarded most devastating in economic terms for hatcheries and pre-growing units and the risk estimate was in general high or very high for these productions. For on-growing the risk estimates were regarded medium to high. Measures to comply with introduction entail requirements of reliable health certificates and quarantining newly acquired fish upon arrival. The measures for disease management entail removing dead fish daily, preventing direct contact between quarantined fish and the other fish on the facility, separate water flow between quarantined fish and the other fish on the facility, and follow-up investigation of disease outbreaks.

A SYSTEMATIC APPROACH FOR QUANTIFYING BIOSECURITY MEASURES IN AQUACULTURE

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Diseases are the major constraints in aquaculture, and biosecurity is critical for sustainable development of aquaculture. This work emphasizes how biosecurity measures and their relative importance can be quantified and documented in an objective way. The system approaches internal and external biosecurity in a general manner, focusing on transmission routes shared by numerous different types of infectious agents. Norwegian veterinary institute worked with research institutes and farmers from Croatia, Egypt, France, Greece, Italy, Spain, Tunisia, Turkey to estimate biosecurity risk associated with disease introduction and spread into seabass and seabream farms in 8 different countries surrounding the Mediterranean basin (Tavornpanich, S. et al. 2020). The same approach has been tested for Atlantic salmon farms in Norway. This quantitative system helps to identify gaps and weaknesses in the biosecurity plan, assists farmers to allocate resources and tailor the biosecurity programme to fit the risk profile of their farms. If the system is applied in region it also helps to compare a specific farm with an average of the biosecurity scores obtained by neighbouring farms, so that the owners can benchmark their biosecurity and evaluate the risk profile of the region. This benchmarking may give owners impelling reason to improve their farm biosecurity. The system can be modified to fit various farm production characteristics (e.g. RAS), different exposures (e.g. antibiotics), and for different disease agents. This system is developed to be a farmer self-assessment tool with a user friendly automate dashboard containing the functionalities so that the farmers interested in an objective evaluation of farm or regional biosecurity can have a secure access of their own information.

Tavornpanich, S., Leandro, M., Le Breton, A., Chérif, N., Basurco, B., Furones, D., Muniesa, A., Toffan, A., Dalla Pozza, M., Franzago, E., Zrnčić, S., Varvarigos, P., Saleh, H., Cagirgan, H., Dverdal Jansen, M., and Brun, E. (2020). Biosecurity and risk of disease introduction and spread in Mediterranean seabass and seabream farms. Deliverable 4.1 of the Horizon 2020 project MedAID (http://www.medaid-h2020.eu/index.php/deliverables/)

IMPROVING FISH HEALTH CAPABILITIES IN EMERGING AQUACULTURE INDUSTRIES IN WESTERN SUB-SAHARN AFRICA

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The American Soybean Association's World Initiative for Soy in Human Health (ASA/WISHH) is leading efforts to strengthen agriculture value chains in emerging markets, creating trade and long-term demand for soy in sub-Saharan Africa. Through the support of the United States Department of Agriculture (USDA) and U.S. soybean farmers the program has expanded to include aquaculture value chain programs in Western Africa, with Nigeria, Ghana, and Senegal as the focus countries. One of the primary economic losses and inefficiencies in the value-chain is due to the losses associated with non-infectious and infectious diseases. Because of the complex interactions of the host-environment-pathogen relationship, ASA/WISHH's partnership with producers, universities, and government agencies is providing training and field demonstration trials in underlying problems with production methods, water quality, diagnostics, diagnostic report interpretation and facilitating changes to farm management approaches to improve overall fish health and decrease mortalities. Example cases, problem approaches, and training will discussed.

Table1: Impact and influence tool focus

Opportunity Vhembe	Impact (1-10)	Influence (1-10)
1. Equipment (aeration, water quality monitoring, filters)	9	9
2. Fingerling (access, quality)	9	7
3. Topography (land sloping)	8	8
4. Water quality (polluted rivers, ammonia)	9	6
5. Training (skills, knowledge, production)	9	10
6. Marketing (fish price, capacity, clear market)	10	8
7. Finance (access)	7	5
8. Feed (high costs, quality, feeding)	8	6
9. Access to water (dry rivers/ dams; not enough water)	10	4
10. Overstocking/ overcrowding (fish, stocking)	9	10
11. Production system and design (ponds, rivers)	10	8
12. Poaching/ predation and security	9	5
13. Compliance	6	4

Table 2: Score Best Option: 1-3 for 8-Criteria Tool for Vhembe District

	Training	Equipment	System design	Marketing	Fingerlings
1. Benefit	3	3	3	1	3
2. Cost of not implementing	3	3	3	1	3
3. Ease	3	3	3	1	3
4. Motivation	3	3	3	2	3
Total	**12**	**12**	**12**	**5**	**12**
5. Financial cost	2	3	3	3	3
6. Risks	1	3	3	3	2
7. Time	3	1	3	3	3
8. Term	3	1	3	3	3
Total	**9**	**8**	**12**	**11**	**11**

INTRODUCING THE AQUACULTURE GOVERNANCE INDICATORS (AGIs)

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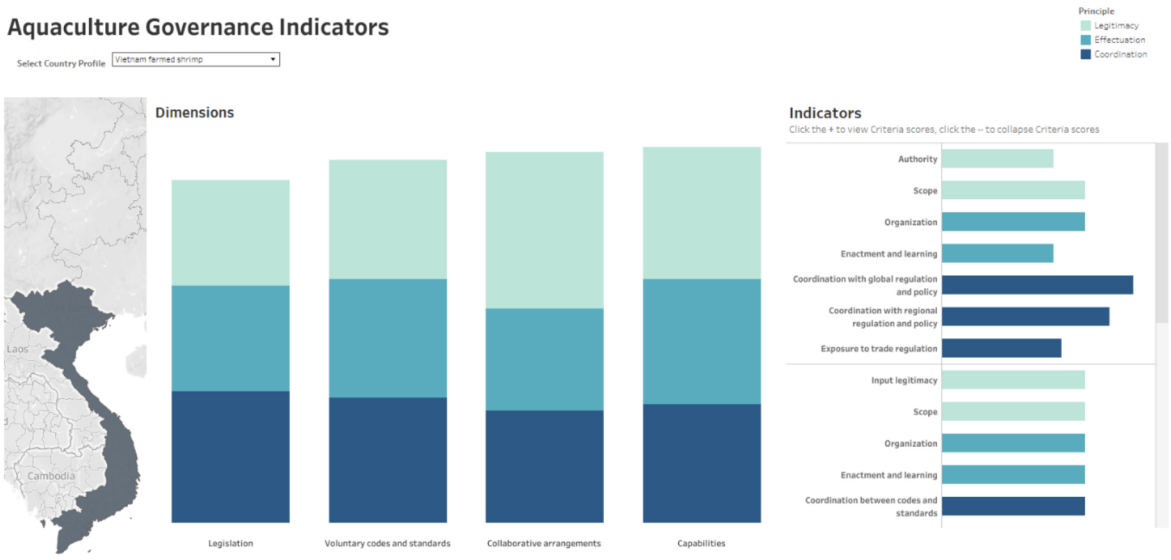
In response to aquaculture's rapid expansion, the environmental and social performance of the industry has been put under scrutiny. However, most tools focus on setting technical improvement on the farm level, and/or assessing legislative coverage and compliance. While important, there remains a gap within current understanding of governance in aquaculture. We have developed the Aquaculture Governance Indicators (AGIs) to assess an existing governance system in any given country, and the means by which improvements of the environmental performance of the industry can occur. The AGIs generate a comprehensive overview, by including an analysis of legislation and voluntary codes and standards, as well assessing the ways in which state, industry and civil society organizations collaborate, and the extent to which they are able to identify and resolve sustainability challenges. The AGIs allow for identifying potential gaps, and provide actionable insights for aquaculture improvement. In our presentation, we introduce the AGIs, and showcase the application of the assessment framework by sharing results from assessments across salmon and shrimp aquaculture-producing countries.

See also the AGI Dashboard on our website: www.aquaculturegovernance.org.

Figure 1. The Aquaculture Governance Indicators (AGIs) framework featuring the four governance dimensions, indicators and three governance principles.

Governance principle	1. Legislation	2. Voluntary codes and standards	3. Collaborative arrangements	4. Capabilities
LEGITIMACY	Authority Scope	Input legitimacy Scope	Input legitimacy Scope	Reflexivity
EFFECTUATION	Organization Enactment and Learning	Organization Enactment and Learning	Informational processes Enactment and learning	Agility Innovation drive
COORDINATION	Coordination with global regulation and policy Coordination with regional regulation and policy Exposure to trade regulation	Coordination between multiple codes & standards Coordination with state policy & regulation Coordination with global frameworks	Coordination between collaborative arrangements Coordination with state policy and regulation Attribution to change in codes and standards	Rescaling Responsiveness

Figure 2. Screenshot of the AGIs dashboard. Interactive version at https://www.aquaculturegovernance.org/agi-dashboard



REMOTE SENSING OF CHLOROPHYLL-A AND TSM AS A MEASURE OF PRODUCTIVITY USING SENTINEL-2A IN POWAI LAKE FOR AQUACULTURE

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Powai is a freshwater lake in Mumbai, known for supporting dense algae bloom in which lead to the eutrophication in recent years. An algorithm for the remote sensing of chlorophyll-a and total suspended matter (TSM) as an indicator of productivity biomass has been adopted using time series of Sentinel-2A and *in-situ* measurement. Water samples were collected for Pre-monsoon, Monsoon, and Post-monsoon monthly. The results show that a total of 18 acquisitions were available by Sentinel-2A; about half (44%, that is 8 images) were cloud-free while up to 56% (10 images) were cloud cover images by focusing on a shorter period (November 2016 to October 2017). The finding reveals the productivity of the lake in terms of plankton and nutrients varies with the season of the year. This research indicates the potential relationship between remote sensing and conventional methods of data obtained for aquaculture. The model has several significant uses such as provide information to policymakers for a more harmonized development for aquaculture in the Powai lake in future, it includes data for aquaculture investment analysis to decrease the hazards caused by pollution, and it provides a model capable of application to wide-field scenarios and suitable for both fresh and marine water.

OPPORTUNITY STUDY ON CIRCULAR PROTEINS FOR AQUAFEED IN EGYPT

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Fish is an important food source in Egypt, accounting for 25.3% of the average household's protein intake and a fish consumption of 23.5 kg/person/year. The aquaculture sector in Egypt is contributing approximately 80% of the over 2 mln tons of total fish consumption. Capture fisheries and limited imports contribute the other roughly 400 ktons. The aquafeed production in Egypt amounts in 2020 between 1.5 and 2 mln tons but the required feed ingredients for this production are generally imported. Local crops are largely destined for human consumption rather than animal feed. There are several promising options to generate high(er) quality nutritional aquafeed ingredients to a big extent derived from presently not or not appropriately utilized waste streams.

Considering the size of the poultry industry (over 1.7 bln broiler birds), the associated potential to render by-products (over 250 ktons sellable poultry by-products with a market value of over well 100 mln US$) and Egypt being the no. 8 global aquaculture producing country and globally 3rd tilapia producer obviously opportunities will arise in the rendering industry for feed ingredient supply. Poultry-by-products meal (PBM) produced in Egypt today are generally of substandard quality due to lack of hygiene, inappropriate collection practices and processing methods which all can be improved. Poultry-by-product meals (also including poultry blood and feather meal) of good quality could contribute approximately 16% of the tilapia feed ingredient requirement in volume and 34% of the required protein for the annual 1.5 mln tons tilapia feed that is consumed in Egypt today. This would greatly reduce the import of raw materials and reduce feed cost. In order to achieve this volume and the desired quality it will be necessary to abandon wet poultry markets as they are today, centralize slaughterhouses and rendering and develop cold chains to distribute poultry meat (legs, breast, etc.) throughout Egypt.

Insect protein production is presently not officially authorized in Egypt neither is insect protein (or oil) a registered feed ingredient. Thus, from the regulatory point of view some steps need to be taken before considering producing insects at industrial scale in Egypt. Proteinea is a startup insect company in that is eyeing a first scale-up to produce 1 ton of live insect larvae per day to produce approximately 2 ktons insect protein meal and 0.8 ktons oil from agriculture waste streams. The economics look promising, but a proof of concept is lacking till now. Phase 2 and 3 of the Proteinea project could deliver 0.06% and 0.3% respectively of the protein needed for the Tilapia feed requirement in Egypt.

Brewery-by-products such as spent yeast and grain (dried distillers grains) are already applied in aquafeed in other parts of the world but not in Egypt yet. Al Ahram Breweries (part of Heineken Group) has 2 waste stream that may be upgraded by drying them to supply the aquafeed industry. Surplus yeast processing could render approximately 500 tons brewer's yeast and drying of spent brewery grains would give 3-4 ktons dried distiller's grains. The volumes of dried yeast and spent grain are relatively small (≈0.04% and ≈0.33% of the tilapia feed protein requirement) but as such would contribute to the circularity of the Egyptian aquaculture industry.

GROWTH EFFICIENCY, APPARENT NUTRIENT DIGESTIBILITY, AND NATURAL FOOD INTAKE IN NILE TILAPIA *Oreochromis niloticus* FED DIETS WITH DIFFERENT LEVELS OF BIO-AVAILABLE PHOSPHORUS

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This study formulated experimental diets with three different phosphorus levels (6.3, 10.1 and 13.8 g kg^{-1}diet) that were fed to tanks in a Recirculating Aquaculture System (RAS) and to Ponds. The diets contained respectively 1.6, 5.0 and 8.5 g bio-available phosphorous kg^{-1} dry matter and are referred to as sufficient phosphorus "SP" (control), moderate phosphorus "MP" and deficient phosphorus "DP" diets. Genetically Improved Abbassa Nile Tilapia (GIANT) were stocked in the experimental units (RAS with 125-L tanks, each stocked with 15 fish, and 200 m^2 ponds each stocked with 1000 fish). The hypothesis was Nile tilapia grown in clear water tanks in RAS would perform best on the SP diet and worst on the DP diet, while in ponds Nile tilapia would reduce the dietary phosphorous deficiency by consuming natural food. In ponds, fish will perform better and show smaller differences in performance between the diets than in RAS. There were 5 replicates per treatment. Fish were fed restrictedly a daily ration of 18 and 20g/Kg $^{0.8}$ in ponds and aquaria, respectively.

The apparent digestibility was not different between fish fed the SP, MP and DP diets ($P > 0.05$; Table 1). In RAS, fish fed the SP diet reached a final weight of 110 g, compared to 105 and 90 g for fish fed the MP an DP diet, respectively ($P < 0.05$). In ponds, fish fed the SP, MP and DP diet reached similar weights after 8 weeks of culture of 120, 112 and 111 g, respectively ($P > 0.05$) (data not shown). The diversity and count of phytoplankton was higher than for zooplankton in the ponds, but the phytoplankton and zooplankton abundance in the ponds was similar between diets. Nevertheless, the phytoplankton gut content in Nile tilapia was higher ($P < 0.05$) in ponds fed the DP diet ($77*10^6$ organisms L^{-1}) than in ponds fed the MP ($41*10^6$ L^{-1}) and SP ($37*10^6$ L^{-1}) diet (Table 2; $P > 0.05$).

In conclusion, in absence of natural food, deficiency in dietary bio-available P reduces feed intake and performance in Nile tilapia, while in ponds, access to natural food supplements dietary deficiency in bioavailable P. A follow-up study covering a full culture cycle is advised, to check if the ponds would not become deficient in P towards the end of the production cycle.

Table 1: Apparent digestibility coefficients (ADC, %) of nutrients in Nile tilapia (*O. niloticus*), fed diets with sufficient P (SP), moderate P (MP) and deficient P (DP) bio-available phosphorous.

			RAS		
ADC (%)	**SP**	**MP**	**DP**	**SEM**	**P-value**
Protein %	89.66	86.38	86.34	0.89	0.237
Lipid %	82.25	77.89	77.21	1.40	0.319
Carbohydrate %	77.38	74.42	77.42	1.87	0.804
Ash %	16.69	11.93	14.02	2.25	0.745
Crude fibre%	74.42	72.64	67.17	2.17	0.420
Phosphorus	94.87	93.60	93.24	0.42	0.294
Calcium	91.06	88.40	88.27	0.70	0.203

Data represented as means ± SEM (n=5) corresponding means are significantly different at $P < 0.05$. SEM: standard error of the mean.

Table 2 : plankton counts in gut content of Nile tilapia, *O. niloticus,* fed diets with sufficient P (SP), moderate P (MP) and deficient P (DP) bio-available phosphorous.

		PONDS				
Organisms		**SP**	**MP**	**DP**	**SEM**	**P-value**
Phytoplankton $*10^6$	Euglenophyta	1.50	2.00	9.00	1.92	0.808
	Bacillariophyta	17.40^b	21.20^b	39.80^a	3.52	0.008
	Cyanobacteria	7.00	6.80	9.60	1.51	0.723
	Chlorophyta	12.80	13.25	18.20	1.35	0.190
	Dinophyta	1.00	2.50	1.00	0.60	0.178
	Total	36.60^b	40.80^b	77.00^a	6.37	0.005
Zooplankton $*10^3$	Copepoda	0.40	1.00	0.60	0.21	0.531
	Rotifera	0	6.00	7.60	1.83	0.212
	Cladocera	0.60	1.20	2.60	0.42	0.140
	Protozoa	0.60	1.00	2.00	0.44	0.456
	Total	1.60^b	9.20^{ab}	12.60^a	2.13	0.088

Data represented as means ± SEM (n=5) corresponding means are significantly different at $P < 0.05$. SEM: standard error of the mean

THE NUTRITIOUS POND CONCEPT

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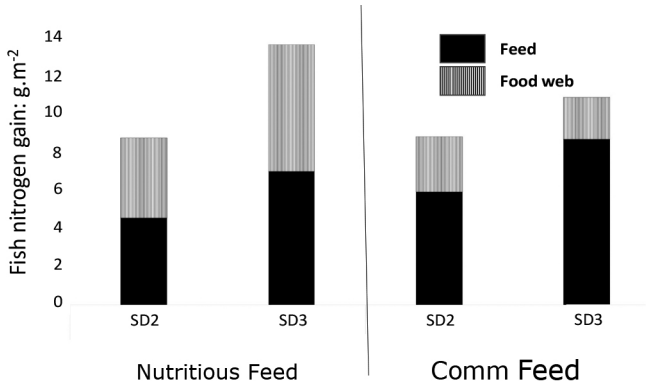
Ponds are by far the main aquaculture production system for finfish and crustaceans, responsible for 80% of the global production volume of these commodities. During the last decades, the contribution from pond aquaculture to the global production of finfish and crustaceans still slightly increased, in spite of the fact that less than 1.8 of peer reviewed literature on aquaculture looked at pond culture. Important advantages of ponds are its self-purifying capacity and the provision of natural food, supplementing formulated feed. Disadvantages are high water use and low productivity. Nevertheless, the fact that pond produced fish is relatively cheap, and does not require high investment in areas with sufficient water availability, explains its importance in putting affordable omnivorous species (e.g. carps, tilapia, pangasius) into the market, contributing to reduction of malnutrition and raising incomes in rural areas in the tropics and sub-tropics.

New developments in water purification and sanitation of nutrient wastes are driving intensification, including intensification of pond aquaculture. On average, intensification reduces the discharge of nutrient from aquaculture per unit production. One complementary solution is to develop local circular food systems, which reduce the overall resource use and hence diminish the degree of intensification needed. In a circular economy, aiming to produce within ecosystem boundaries, more attention should be given to optimizing the self-purifying and natural food production capacities of pond production systems.

Nutritious pond feeds nourish both the farmed species and other pond organisms, like bacteria, plankton and protozoa, to stimulate the pond's inherent capacity to break down fish wastes and produce natural foods for fish. Nutritious pond feeds have more carbohydrates, which fish only partially digest. Once excreted, the carbohydrates provide energy for bacteria to break down fish wastes and any uneaten feed and release nutrients into the pond. Other organisms metabolize these nutrients to grow and multiply, becoming nutritious food sources for the farmed species and reducing nutrient accumulation in the pond. The high levels of carbohydrates in nutritious pond feeds can be sourced from inexpensive and often locally available ingredients, which reduce feed costs while maintaining or increasing fish production, thereby raising profits. On-farm research in Bangladesh shows that nutritious pond feeds increase tilapia production by stimulating natural food production. In combination with the lower cost of nutritious pond feeds, farm income increased 22 percent as compared to a conventional tilapia feed. Intermediate results from ongoing farm trials in other locations, comparing conventional and nutritious pond feeds revealed similar outcomes, with great promise for small-scale fish farmers across Africa, Latin America and Asia.



CIRCULARITY IN AQUACULTURE AND ITS PERSPECTIVES FOR AFRICA

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The global human population faces big societal challenges: its growth demands for huge increases in food supply, which should be nutritious, healthy and accessible for all. Thanks to its strong innovative capacity and intensification, food production has kept pace with this growing demand. At the same time, global effects of climate change, loss of biodiversity, land and soil erosion, ocean acidification etc. demonstrate that the borders of our planetary resources are at reach. Therefore, our food production needs a paradigm shift, from production efficiency towards a focus on resource use efficiency.

The importance of aquatic foods for global food and nutrition security has received much attention in recent years (e.g., the CFS 2014; UN Nutrition Discussion paper on the role of Aquatic Foods 2021; The UN Food System Summit, the World Food Prize, Golden et al. 2021). As the extraction of natural populations from the oceans and inland waters has reached its limits, aquaculture is considered as the main source for future supplies of these aquatic foods. Just as for any other form of food production, the required paradigm shift counts also for the production of aquatic food through aquaculture. Circular approaches are considered as a possible solution to produce food within the context of the planetary borders, environmentally healthy and sustainable.

Circular systems are characterized by inputs which are derived from waste products from another resource, which can be terrestrial, aquatic or even abiotic. They are therefore ideal to connect the aquatic food system with the much larger green/terrestrial one. Examples are the traditional Asian fish-cum-animal integrated pond system or the modern fish-cum-hydroponic system (so-called aquaponics) and its marine equivalent IMTA (integrated multi-trophic aquaculture). The level of integration, or circularity, depends on the spatial scale of governance. The above examples are typical for the level of farm units, but at a regional or even national scale, other opportunities for developing circular systems can be found, by combining the operations of different farms, or organizing the collection, processing and distribution of waste products for their use in other commodities. A prominent role in this seems to be allocated to the feed industry, thereby relying on necessary inputs from fish nutritionists. Left-over stream products from the agro-food industry may be valorized as an ingredient for aquafeeds, provided that they are nutritionally safe and valuable. Intermediate steps might be required such as the use of insect meal derived from insects growing on these waste products.

In the presentation, the concept of circularity will be discussed at the different scales of governance, and examples presented with a particular reflection on their feasibility for Africa.

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ON-FARM TRIALS IN CENTRAL/EASTERN KENYA TO EVALUATE OPTIONS WHEN EXTRUDED FISH FEEDS ARE EXPENSIVE

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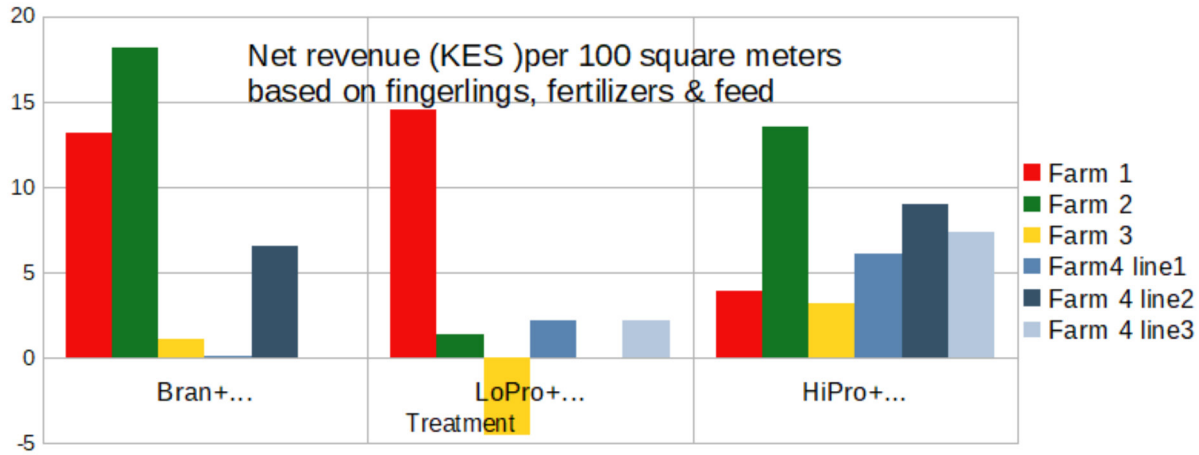
Growth of small scale aquaculture in East Africa has been limited by cost of feeds and management strategies related to lack of appropriate technologies. The objective of this on-farm trial was to propose the most profitable and practical pond management options and to test them on farms to evaluate their profitability and repeatability. The trials began in December 2020, and were conducted at four farms in Central and Eastern province. All ponds, including lined ponds were treated with agricultural lime prior to stocking. Ponds were then stocked with sex reversed male Nile tilapia, *Oreochromis niloticus* (2.5- 4.5 g) at 3 fish/m^{-2} followed by an addition of clarias at 0.3 m^{-2} three months later. All treatments used fertilizer (DAP and urea) to produce natural food for the tilapia and the fish were offered different qualities of supplemental feed to complement the natural food derived from the fertilizer. Three supplemental feeding protocols were tested: TRT1, wheat bran (about 16%CP, cost \$0.25 kg^{-1}); TRT 2, low protein feed (25%CP, cost \$0.85 $kg)^{-1}$; and TRT 3, high protein feed (30-32%CP, costing over \$1 kg^{-1}) fed at half rate. Weekly water quality monitoring included temperature, dissolved oxygen, secchi disk visibility, pH and occasionally, total alkalinity and total hardness. Fish were fed twice daily, according to a feed table and fertilizers applied weekly, until May, then suspended. No aeration was used and ponds were static except for topping off from evaporation or seepage.

The higher protein feed given at half ration resulted in the most reliable net revenues per are (100 m^2). However, because management was highly variable, some farmers found the bran plus fertilizer treatment to be highly profitable. Farm management differences included low survival due to bird depredation (farm 4); overfeeding beyond the set protocol (farm 1, HiPro), and low fish recovery due to incomplete pond draining (farm3, all treatments). Previous surveys that showed very low to negative profits from pond fish farming were likely based on farmers who purchased the less expensive floating feeds and fed at high rates, with no fertilization. Farmers need to be taught to only use feed tables as a guide and to be conservative on feed use. The individualized farm advising provided during the trials helped participating farm managers increase their understanding of pond management, feeding and water quality management.



THE EFFECT OF DIETARY CARBOHYDRATE-TO-PROTEIN RATIO IN GROWTH PERFORMANCE, HEPATIC HEALTH AND DYNAMIC OF GUT MICROBIOTA IN ATLANTIC SALMON (*Salmo salar*)

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Atlantic salmon (*Salmo salar*) fed on a carbohydrate-rich diets exhibit suboptimal growth performance along with other metabolic disturbances. It is well known that gut microbes play a pivotal role in influencing metabolism of the host as well as they can be modified by diet. The main goal of the study was to determine the effect of feeding grading levels of digestible carbohydrates to Atlantic salmon on distal intestine digesta microbiota at 3 sampling time (i.e., week 4, week 8 and week 12), during a 12-week trial.

A low carbohydrate-to-high protein diet (LC/HP, 0% wheat starch), a medium carbohydrate-to-medium protein diet (MC/MP, 15% wheat starch) or a high carbohydrate-to-low protein diet (HC/LP, 30% wheat starch) was fed to triplicate fish tanks (27-28 fish per tank). We performed an in-depth characterization of the distal intestine digesta microbiota. Further, growth parameters, liver histology and the expression of genes involved in hepatic neolipogenesis in fish were measured.

Major results are fish fed on a HC/LP diet showed greater hepatosomatic and viscerosomatic indexes ($P = 0.026$ and $P = 0.018$, respectively), lower final weight ($P = 0.005$), weight gain ($P = 0.003$), feed efficiency ($P = 0.033$) and growth rate ($P = 0.003$) compared with fish fed the LC/HP diet. Further, feeding salmon on a high digestible carbohydrate diet caused greater lipid vacuolization, steatosis index ($P = 0.007$) and expression of fatty acid synthase (*fas*) and delta-6 fatty acyl desaturase (*d6fad*) ($P = 0.001$ and $P = 0.001$, respectively) in the liver compared with fish fed the LC/HP diet. Although, the major impact of feeding a carbohydrate-rich diet to Atlantic salmon in beta diversity of distal intestine digesta microbiota was observed at week 4 (HC/LP vs MC/MP and HC/LP vs LC/HP; $P = 0.007$ and $P = 0.008$, respectively) and week 8 (HC/LP vs MC/MP; $P = 0.04$), no differences between experimental groups were detected after 12 weeks of feeding. Finally, at the end of the trial, there was a significant negative correlation between lactic acid bacteria members, including *Leuconostoc and Lactobacillus,* with hepatic steatosis, expression of *fas* and *d6fad* and the hepatosomatic and viscerosomatic indexes, and between *Weissella* and hepatic steatosis and the hepatosomatic index. Further research to explore the potential use of LAB as probiotics to improve liver health in carnivorous fish fed fatty liver-induced diet is warranted.

NEEDS ASSESSMENT STUDY FOR GIANT FRESH WATER PRAWN FARMING IN KILIFI COUNTY KENYA

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Giant Freshwater prawn (GFP) is a species with production potential and that can be integrated with other farmed species to boost aquaculture production at the coast and nation at large. This necessitated an assessment study to understand the needs for GFP farming in Kilifi County. The study was undertaken in Kilifi County where data was obtained from fish farmers and fishermen.

75% of the fish farms are privately owned and 80% of the farmers confirmed they have had less than 5 years of experience in fish farming. Of this, majorities (58.3%) of the fish farmers were male and all farmers (100%) were willing to farm GFP. Table 1 shows competency need to enable uptake of GFP and also strengthen general production in the county.

GFP landings have distinct seasonality patterns for; May, June and July are peaks for postlarvae, hence aquaculture may be the perfect alternative in provision of farmed prawn for existing demand. The main fishing ground in the county is near a river mouth. 100% of the GFP fishermen recorded that GFP is landed in mixed sizes (adults, postlarvae, beeried females) despite the fish mongers prefering large size due to customer preference.

Fishermen strongly agreed (100%,) that unpredictable weather patterns occasioned by drought was a major factor undermining development of GFP fishery trading, 50% of the fishermen agreed that flooding episonds caused by unpredictable weather condtions are affecting seed recruitment. Since the animal is an excellent alternative of the commercially important marine prawn, aquaclutre may come to brigdge the gap in supply and uplift the fishery nationalwide.

Table1. Fish farmers' level of competency need for uptake of GFP Not competent (M=1.0-1.49), moderately competent (M=1.50 -1.99.) and competent (M= 2.0-2.49)

	Competency need	Mean	StdDev±
	Pond preparation		
i.	Systems of water depth and pond dyke measurement	1.73	0.91
ii.	Techniques in pond construction	1.36	0.51
iii.	Lime and disinfection of ponds	1.36	0.67
iv.	Fertilizers & manure use	1.46	0.52
	Selection of quality seed, species and their stocking density		
v.	Selection of species for polyculture	1.27	0.47
vi.	Knowledge on integrated farming methods		
vii.	Stocking density of fish species	1.27	0.47
	Water quality management		
viii.	Knowledge in increased nutrient level in ponds	1.46	0.69
ix.	Knowledge in water quality management	1.27	0.65
	Feed management		
x.	Fish nutrition & formulation	1.46	0.82
xi.	Way of feed application	1.55	0.82
xii.	Proper time of feeding	1.73	0.79
xiii.	Feeding dosage	1.27	0.47
xiv.	Feed storage	1.46	0.69
xv.	Knowledge of polyculture	1.55	0.69
xvi.	Knowledge of integrated aquaculture	1.20	0.42
xvii.	Seed handling and transportation	1.09	0.30
xviii.	Fish grading	1.18	0.41
xix.	Health care and disinfection of culture facilities	1.27	0.47
xx.	Fish stress reduction	1.73	0.91
xxi.	**Fish health management**		
xxii.	Identification of diseased fish	1.18	0.41
xxiii.	Preventive measures of some diseases	1.27	0.65
xxiv.	Ways of predator & pest control	1.27	0.65
	Staff welfare		
xxv.	Knowledge on workers safety	1.18	0.60
	Financial management		
xxvi.	Knowledge on how keep accurate records of all expenditure, revenue and practices	1.36	0.81
xxvii.	Knowledge on calculation of profitability & breakeven	1.36	0.67

ENHANCING FOOD SECURITY, JOB AND WEALTH CREATION IN AFRICA THROUGH AQUACULTURE: CASE STUDIES OF SUCCESSFUL COUNTRIES AND INNOVATIONS

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African aquaculture is rapidly growing with support from Governments, development partners and private sector. This study identifies investment and policy priorities that can advance the aquaculture sector in Africa sustainably with the aims of income and employment generation, rural development, and food security. Five successful countries were assessed to identify promising innovations or drivers that can transform the aquaculture sector in Africa. Furthermore, lessons learned will inform policy and investment priorities at the national, regional and continental levels to sustainably expand aquaculture production in Africa so that it promotes food security, employment/income generation and women empowerment. Scaling of aquaculture innovations through gender-responsive science and technology will contribute to the development of African agricultural sector.

UTILISATION OF PLANT EXTRACTS AS GROWTH PROMOTER IN NILE TILAPIA (*Oreochromis niloticus*) IN UGANDA

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Aquaculture production has intensified over the recent years in Uganda. However, the industry is threatened by emergence and re-emergence of disease incidences leading to massive mortalities particularly in fish hatcheries and cages. Farmers use antibiotics and chemicals in disease prevention and management, but these chemicals have negative impact to the environment, aquatic life and human health through development and transfer of drug resistant strains. Therefore, this study was conducted to investigate the effect of plant extracts as growth promoters for farmed Nile tilapia (*O. niloticus*). Results showed increase in weight of fish and good health. High mean weight gain was observed at 0% treatment, however, survival was highest at inclusion of 0.5%. Use of plant extracts have a potential to improve growth of farmed fish while saving the environment and safety of consumers.

ASSESSING THE POTENTIAL FOR AQUACULTURE DEVELOPMENT IN AFRICA IN RELATION TO LAND USE PROJECTIONS

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Tools for long-term planning are required to support aquaculture development, especially in developing regions like Africa. Many African countries lack reliable data and coherent policies for the aquaculture sector, in addition to existing weak natural resource regulation. Hence, this study aimed to develop an approach for estimating aquaculture growth potential in data poor situations.

Using Nigeria as a case study, a scenario planning exercise was conducted to generate four alternative but plausible pathways (scenarios) for aquaculture development up to 2035. These qualitative scenarios were titled; 'familiar route', 'nipped in the bud', 'vicious cycle' and 'autopilot', depicting a baseline, favourable, somewhat favourable, and unfavourable aquaculture developments respectively (Table 1). Then land use change in Nigeria was modelled and projected in a manner consistent with the assumptions of each scenario. Accordingly, pond-based aquaculture production was simulated relative to growth in Urban area (the main land use associated with aquaculture expansion in the study area) and compared to government's estimate of aquaculture potential.

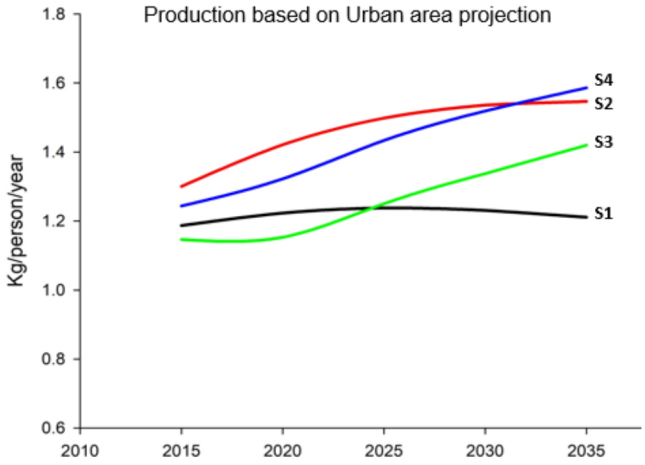

FIGURE 1: Pond-based aquaculture production (per capita) in the different scenarios based on Urban area projection

TABLE 1: Scenarios and the outcomes used to define their driving forces

Scenario	Input availability/cost	Government policy	Land use change	Climate change
			Regulation:	Impact/adaptation:
S1: A familiar route	medium/high	Politically motivated	Ineffective	Poorly understood
S3: Nipped in the bud	high/low	Evidence-based	Effective	Fairly understood
S2: Vicious cycle	medium/medium	Politically motivated	Ineffective	Fairly understood
S4: Autopilot	low/high	Largely absent	None	Poorly understood

REPLACING FISHMEAL WITH THE SINGLE CELL PROTEIN, DY-PRO, IN NILE TILAPIA *Oreochromis niloticus* DIETS

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A study was conducted to investigate the effect of either partially or totally replacing fishmeal (up to 15% of the diet) by the inactivated dry yeast product DY-Pro in Nile tilapia *Oreochromis niloticus* diets. The DY-Pro replaced 0% (DY-PRO0), 2% (DY-PRO2), 5% (DY-PRO5), 25% (DY-PRO25), 50% (DY-PRO50), 75% (DY-PRO75) or 100% (DY-PRO100) of the protein provided by fishmeal in seven isonitrogenous and isocaloric experimental diets, which were fed to the experimental fish (initial average body weight 11.33±1.65 g) for 12 weeks. At the end of the experiment, the graded replacement of 2% to 100% of fishmeal protein by the DY-Pro did not significantly ($P < 0.05$) affect fish weight gain or gut length and weight, but linearly improved feed and nutrient utilization. Moreover, the DY-Pro did not have any negative impacts on the gastrointestinal tract as shown by histopathology. There were no pathogens or signs of significant metabolic or toxicant-related disease in the epithelium. Results showed that tilapia given diets containing DY-Pro consumed less feed to achieve the same weight gain as tilapia given fishmeal-based diets, indicating that DY-Pro is an efficient feed ingredient, which could totally replace fishmeal in Nile tilapia diets and possibly lead to reduced feed costs.

Nannochloropsis oculata ENHANCES IMMUNE RESPONSE, TRANSCRIPTION OF STRESS, AND CYTOKINE GENES IN NILE TILAPIA SUBJECTED TO AIR EXPOSURE STRESS

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The beneficial role of dietary Nannochloropsis oculata (*N. oculata*) on health parameters of Nile tilapia (*Oreochromis niloticus*) under air exposure stress were investigated. Fish were fed for 4 weeks in three groups: the control group, N5 (5% of *N. oculata*), and N10 (10% of *N. oculata*). The fish in the supplemented groups were then exposed to the air stress experiment for 1 hour (h) and designed as N5+AE and N10+AE, respectively. The results revealed that serum cortisol and glucose were elevated only in the N10+AE group, whereas C-reactive protein (CRP) and Immunoglobulin-M (IgM) decreased and increased; respectively, in the supplemented-only groups compared to the control (Fig.1).

Intricate changes in stress and cytokine gene expression patterns were evident. In the N10 group, the highest transcription levels of hepatic and intestinal heat shock protein 70/ HSP70 were noted, whereas lower and higher transcription levels of hepatic and intestinal HSP70 were evident in N10+AE and N5+AE groups, respectively.

The hepatic glutathione peroxidase/ GPx, intestinal glutathione S-transferase/ GST, and GPx were induced in the N5 group but declined significantly upon air exposure in the same group. The intestinal transforming growth factor β1/ TGFβ1 and the IL-10 expression level were significantly induced in the N10 group compared to the N5 group. Interestingly, the N5+AE group exhibited a significant upregulation of TGF-β1, and IL-10 expression levels compared to N5 and N10+AE groups. Dietary supplementation of *N. oculata* maintained the liver and intestinal histomorphology and mitigated the air-exposure impacts on the induced tissue histopathological changes. Overall, both levels of *N. oculata* dietary supplementation showed advantages in different scenarios regarding mitigation of air-exposure stress; nonetheless, these findings support the vital role of *N. oculata* as feed additives on fish health and in mitigating physical stressors, like air exposure stress.

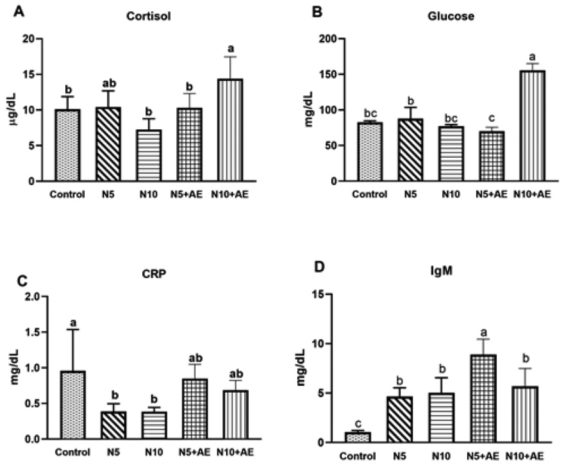

Fig. 1. The effects of *N. oculata* supplemented diets and air exposure on A) Cortisol, B) Glucose, C) CRP, and D) IgM.