



AFRAQ 2024

November 19-22
Hammamet, Tunisia

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“Blue Farming: New Horizons for Economic Growth”

3rd Annual International Conference & Exposition
of the African Chapter of the World Aquaculture Society

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Welcome to AFRAQ24 Tunisia

Dear colleagues and friends,

Welcome to Hammamet, Tunisia, and to Aquaculture Africa 2024! On behalf of the WAS African Chapter Board, I invite you to enjoy AFRAQ24 at the magnificent Medina Mediterranean Resort, hosted by our gracious Tunisian colleagues!

This third Annual International Conference and Exposition of the African Chapter of the World Aquaculture Society follows the highly successful meetings in Alexandria, Egypt (March 2022) and Lusaka, Zambia (November 2023). The AFRAQ24 event marks five years of the Chapter's existence, following its formal establishment in November 2018. It continues to grow from strength to strength as Africa's premier aquaculture forum which brings together the major stakeholders from industry, government, international organisations, and the research community. Through its many continental activities and the annual AFRAQ meeting, the WAS African Chapter has become an internationally respected, non-state actor institution actively promoting the African aquaculture development agenda.

The successful establishment of the WAS African Chapter and AFRAQ events mirrors the rapid growth of the African aquaculture sector and the need for stakeholders to have an annual forum for reviewing progress, networking, generating new ideas, and advancing the development agenda. Africa is the last continent to develop its aquaculture sector, but the growing deficit in overall fish production is spurring a boom in production. African Aquaculture production in 2022 accounted for 18% of total fish production, reflecting a 50% increase over the last decade.

It is appropriate that AFRAQ24 is hosted by the government and people of Tunisia, which is one of Africa's fastest aquaculture producers, with annual production that has quadrupled from 5,437 tonnes in 2010 to 20,924 tonnes in 2022, mostly in marine aquaculture. The WAS community has much to learn from Tunisia's approach to aquaculture value chain development, supported by enabling policies and active institutions that have contributed to building a sector that is meaningfully contributing to improved food and nutrition security, employment, livelihoods, and economic growth. We believe fellow African countries can learn lessons from this great country.

I commend and thank the conference organisers and members of the Steering, Program, and National Organising Committees - who have been working hard to plan, coordinate and bring the technical program, trade show, and associated meetings together. Special gratitude goes to our host, the government of Tunisia through its Ministry of Agriculture, Water Resources and Fisheries, and its associated agencies for welcoming all of us to this great aquaculture and tourist-friendly nation. We hope that all the positive elements of this event will lead to further transformation of the sector - to even greater heights!

Thank you to all participants for joining us to make AFRAQ24 a memorable event. Next year, the WAS African Chapter is excited to be hosting a global WAS meeting: 'World Aquaculture Safari 2025'. This large-scale premium event showcasing the heartbeat of African aquaculture will take place on the shores of Lake Victoria from 24-27 June 2025 in Entebbe, Uganda. Be sure not to miss this global event! I hope to meet many of you there!

Enjoy AFRAQ24 and many other great moments in Hammamet and Tunisia!

Foluke O. Areola
President, World Aquaculture Society – African Chapter

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ABSTRACTS

SELECTIVE BREEDING FOR GENETIC IMPROVEMENT OF NILE TILAPIA (*Oreochromis niloticus* Linnaeus, 1758) IN UGANDA: CURRENT STATUS, CHALLENGES, AND FUTURE PERSPECTIVES

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Nile tilapia (*Oreochromis niloticus*) aquaculture continues to significantly contribute to the growth of the aquaculture sector in Uganda. However, its production is beset by erratic and unreliable seed supply. Also, most hatcheries practice inbreeding of broodstock, resulting in inferior seed characterized by low growth rates. As such, a selective breeding program is necessary to readily avail fast-growing seed that respond to farmers' needs. The present review consolidates available information on developing a Nile tilapia breeding program in Uganda. The article discusses the significance of genetic improvement, drawing lessons from successful Nile tilapia selective breeding programs in other countries. The results indicate that no systematic Nile tilapia selective breeding program was traceable in Uganda. Scanty information on the selective breeding efforts of the species was available, with little evidence of selection for improved performance. Overall, the national capacity for aquaculture research and development, including fish breeding and strain improvement, was weak and poorly funded. The review recommends purposive support for developing a systematic strain improvement breeding program, which will be a source of improved broodstock and seed for hatcheries and farmers, respectively. The program would guide the formulation of standard operating procedures for quality seed production towards ensuring sustainable aquaculture growth in Uganda.

GROWTH PERFORMANCE OF EUROPEAN SEA BASS (*Dicentrarchus labrax* L.) FED *Hermetia illucens* INSECT MEAL UNDER RAS CONDITIONS

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Black soldier fly *Hermetia illucens* larvae meal (HI), one of the seven insect species approved for use in aquafeed, is a widely studied as an alternative for fish diets. This study aimed to evaluate the effects of dietary inclusion of HI on growth performance, plasma biochemistry, nutrient digestibility, intestinal microbiota, and histopathology of European sea bass *Dicentrarchus labrax*. Four isoprotein (43,5% CP) and isolipid (13,5%) experimental diets, with HI inclusion levels of 0%, 15%, 30%, and 45%, corresponding to 0%, 33%, 67%, and 100% replacement of fishmeal on a weight-to-weight basis (HI0, HI33, HI67, and HI100, respectively), were fed to juvenile European sea bass (body-weight 85,11 ± 0,87g, total length 19,03 ± 0,88 cm) for 285 days. The fish were randomly distributed in 12 cylindrical- fiberglass tanks (volume: 800 L), with an initial stocking density of 3,4 kg/m³ (40 fish per tank, in triplicate per diet). They were hand-fed to apparent satiation with one of the four experimental diets twice daily at 8:00 and 15:00, six days a week. The feeding trial was conducted in a RAS system. Temperature and oxygen of the water were measured daily with an average respectively 20,61°C and 5,26 ± 0,23 mg/L. The highest final body weight was recorded in groups fed on HI67 diet. Overall, the average weight gain across the experimental period for fish in all diet groups followed a similar trend, with no significant differences. The effect of HI on specific growth rate (SGR, %/day) was significantly higher (p>0,05) in fish fed HI67 compared to other experimental diets. The feed conversion ratio (FCR) also varied significantly across treatments, with the Duncan test revealing a significant difference between HI67 and the other diets. The best FCR (1,83 ± 0,085), was achieved with the HI67 diet, with no adverse effects on intestinal histomorphology. These findings suggest that *Hermetia illucens* larvae meal can be a valuable alternative protein source in diets of the European sea bass.

Table 1: Growth performance of European sea bass (*Dicentrarchus labrax* L.) fed with four diet for more than 9 months (285 days)

	HI 0	HI 33	HI 67	HI 100
IBW (g)	84,41 ± 0,59 ^a	85,14 ± 0,43 ^a	85,73 ± 1,27 ^a	84,71 ± 1,17 ^a
FBW (g)	338,90 ± 7,18 ^a	345,91 ± 20,4 ^a	373,68 ± 8,61 ^b	338,44 ± 10,68 ^a
SR (%)	95,83 ± 2,88 ^a	94,17 ± 5,2 ^a	95 ± 4,33 ^a	90 ± 5 ^a
WG (g/day)	0,89 ± 0,027 ^a	0,91 ± 0,07 ^a	1,01 ± 0,031 ^b	0,89 ± 0,03 ^a
SGR (%/day)	0,49 ± 0,013 ^{a,b}	0,49 ± 0,020 ^{a,b}	0,52 ± 0,009 ^b	0,49 ± 0,005 ^{a,b}
FCR	1,95 ± 0,09 ^a	1,97 ± 0,07 ^{a,b}	1,83 ± 0,085 ^a	2,14 ± 0,01 ^b

Table 2: Organ somatic indices in European seabass *Dicentrarchus labrax* over a nine-month experimental period

	HI 0	HI 33	HI 67	HI 100
K (%)	1,33 ± 0,02 ^a	1,33 ± 0,04 ^a	1,361 ± 0,01 ^a	1,364 ± 0,02 ^a
HIS (%)	2,92 ± 0,11 ^a	3,02 ± 0,29 ^a	3,03 ± 0,32 ^a	3,25 ± 0,16 ^a
HSI (%)	1,42 ± 0,11	1,17 ± 0,02	1,19 ± 0,07	1,41 ± 0,15
SSI (%)	0,08 ± 0,01 ^a	0,08 ± 0,01 ^a	0,09 ± 0,01 ^a	0,09 ± 0,01 ^a
VSI (%)	8,32 ± 0,37 ^a	8,33 ± 0,73 ^a	8,49 ± 0,27 ^a	8,04 ± 0,42 ^a

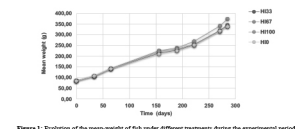


Figure 1: Evolution of the mean-weight of fish under different treatments during the experimental period

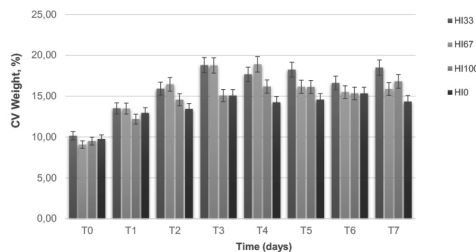


Figure 2: Variation of body weight of European sea bass fed the graded levels of *Hermetia illucens* over time

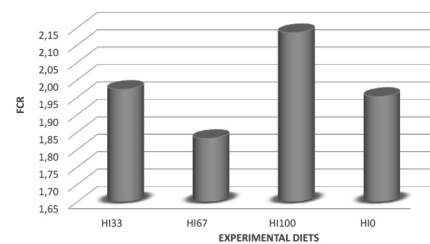


Figure 3: Variation of feed conversion ratio based on the different diets tested (HI0, HI33, HI67, HI100)

WATER QUALITY MONITORING: THE KEY TO A HEALTHY AQUACULTURE SYSTEM

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Aquaculture is an essential component of the world's seafood production. But while technological advancements have improved the odds of operational success, the delicate balance between stock health and operational efficiency can be difficult to achieve.

Accurate and affordable Water Quality monitoring is critical to maintaining that balance. In addition, monitoring water quality involves assessing several key parameters to maintain optimal water quality crucial for the health and growth of aquatic species.

In this presentation, we'll discuss the attributes of dissolved oxygen mainly, pH, Temperature, Nitrate, Ammonia and much more in water for a healthy and efficient Aquaculture system.

We'll also look at an array of Water Quality monitoring solutions featuring RDO Blue, and the Aqua TROLL Multiparameter system that are well-suited for use in a variety of aquaculture applications.

EVALUATION OF STOMACH CONTENT AND FEEDING HABITS OF *Tilapia zillii* IN LOWER OGUN RIVER, AKOMOJE WATER RESERVOIR, NIGERIA

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Introduction

Fish is a high quality food, apart from its protein contents; it is also rich in vitamins and contains variable quantities of fat and minerals for human health (Bard *et al.*, 1976). Fish is often recommended for cardio-vascular disease patients because of its unique fat, which is composed mainly of Omega- 3 polyunsaturated fatty acid.

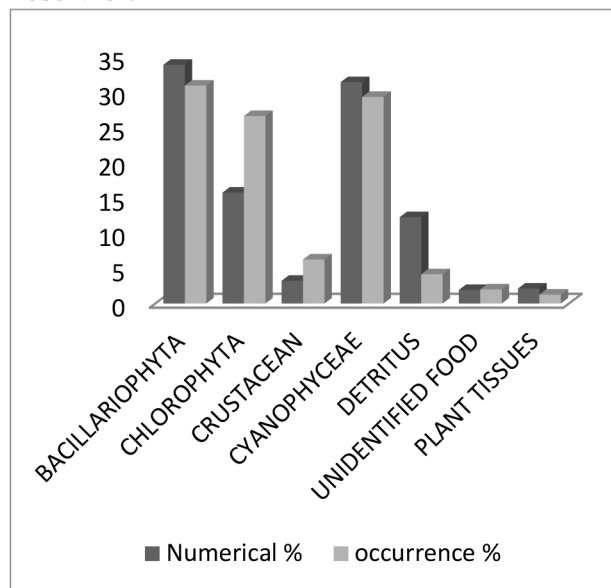
Materials and Methods

The food and feeding habits of *Tilapia zillii* in Akomoje River reservoir, Abeokuta, Ogun State, Nigeria, were examined between the months of August and December 2019. A total number of 125 fish specimens were collected on monthly basis from the commercial landings of fishermen around the water body.

Results

The results of monthly variation in food items show that Bacillariophyta, Chlorophyta, Cyanophyceae, crustacean, detritus, plant tissues, and unidentified food all occurred in varying quantities from August to December 2019. Bacillariophyta (diatoms) was the most important food item in the stomach of *Tilapia zillii* accounting for 14.72% and 78.10% by numerical and frequency of occurrence methods, respectively. Cyanophyceae constituted 11.43% in number and 59.63% in occurrence as the next food item in order of importance. Crustaceans occurred least in order of importance with 2.34% in numbers and 27.12% in frequency of occurrence.

Figure 2: Distribution of food items in the stomach of *Tilapia zillii* from Akomoje water Reservoir.



ASSESSMENT OF HOUSEHOLD FOOD SECURITY, CHALLENGES AND POTENTIAL INTERVENTION ON THE ARTISANAL FISHERIES VALUECHAIN AMONG FISHERFOLKS ALONG OGUN RIVER BASIN, OGUN STATE, NIGERIA

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This study profiled the socioeconomic characteristics of fisherfolks, it also analyzed the food security, profitability and constraints of the value chain actors along Ogun river basin, Ogun state. A two-stage multi sampling procedure was adopted in selecting 151 respondents for three value chain strata: fishers, fish marketers and fish processors. The first stage entailed the purposive sampling of five fishing communities, Oyan, Alamutu, Lafenwa, Oriyanrin, Akomoje, based on activity level in the different fisheries value chain. The second stage involved use of simple random sampling in the selection of 50 percent of the fishers, fish marketers, and processors. The results revealed that highest proportion (34.9%) of the fishers were in the age brackets of 41-50 years, the highest proportion of fish processors (37.9%) were in the 31-40 years of age group. The mean ages of the fishers, fish marketers and fish processors were 44.41±10.17 years, 48.22±13.90 years and 39.55±9.06 years respectively. More than two-thirds (67.4%) of the fishers made use of gillnets, followed by cast net (50.0%), hook and line (41.9%) and gura net (38.4%). A total of 28 fish species from 16 families were found in Ogun River with family Cichlidae accounting for the highest proportion (32.1%) followed by families Mormyridae (10.7%), Alestidae (7.1%), and Anabantidae (7.1%). Of the 28 fish species, only eight (28.6%) were evenly distributed across all locations. The highest proportion (22.1%) of fishers were Yoruba. More than half (55.6%) of fish marketers were Yoruba while all (100.0%) the fish processors were Egun. The most severe constraints faced were, lack of funding for business expansion, lack of modern equipment and inadequate preservation facilities. The mean annual revenue of fishers was ₦5,996,083.72 ($x \pm 5,444,005.00$) while the fish marketers and fish processors earned average revenues of ₦1,015,040.00 ($x \pm 1,226,230.00$) and ₦587,241.38 ($x \pm 215,358.45$) respectively. The difference in total revenues of value chain actors were significant ($F = 28.730$, $p < 0.01$). The mean total revenue between the fishers and marketers was significant (mean difference = ₦5009239.28, $p < 0.01$), the difference in mean revenue of fishers and fish processors was significant (mean difference = ₦5408842.34, $p < 0.01$). There were significant associations between presence of fisheries policies ($\chi^2 = 120.071$, $df = 2$, $p < 0.01$). No significant difference was found in the mean revenue of fish marketers and fish processors (mean difference = ₦399603.07, $p > 0.05$) participation in policy enforcement ($\chi^2 = 70.114$, $p < 0.01$), sufficiency of existing rules and regulations ($\chi^2 = 32.479$, $p < 0.01$), extent of obedience to existing policies ($\chi^2 = 32.243$, $p < 0.01$). Following the outcome of this research, it is important to affirm that all three fisheries value chain actors (fishers, fish processors and fish marketers) individually and collectively play meaningful roles in fisheries value chain development. In line with the findings of this study and the need to improve fisher folks' participation in fisheries policy formulation and implementation, Access to rural credit, storage facilities, subsidized costs of fishing equipment, closed area/season, stocking/recruitment of fish spp. were recommended. Value chain actors were encouraged to organize themselves into cooperative societies to enhance productivity.

(Continued on next page)

Table: Total revenue of fisheries value chain actors (₦)

	Fishers (n = 86)	Fish marketers (n = 36)	Fish processors (n = 29)
Revenue categories (N'000,000)			
<1	3 (3.5)	24 (66.7)	27 (93.1)
1-5	47 (54.7)	12 (33.3)	1 (6.9)
>5	36 (41.9)	0 (0.0)	0 (0.0)
Minimum revenue	572,000.00	78,000.00	338,000.00
Maximum revenue	32,032,000.00	4,056,000.00	1,196,000.00
Mean revenue	5,996,083.72	1,015,040.00	587,241.38
Standard deviation	5,444,005.00	1,226,230.00	215,358.45
Standard error of mean	587,042.16	207,270.70	39,991.06

Figures in parentheses are expressed as percentages of respective sample sizes

EFFECTS OF DIFFERENT ARTIFICIAL FEEDS ON WEANING AGES ON THE SURVIVAL AND GROWTH PERFORMANCE OF AFRICAN BONYTONGUE (*Heterotis niloticus*) FRY

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Poor larval nutrition has been identified as the primary cause of the high larval mortality rates in hatcheries of the African bonytongue (*Heterotis niloticus*). Although, that freshly hatched *Artemia* nauplii increases survival when given as a starter live feed, the high price of *Artemia* has prompted research into sustainable substitutes. This study evaluated the effect of different commercial starter feeds on the growth and survival of the African bonytongue, as well as the optimum weaning age of the fry. Four starter diets: decapsulated *Artemia*, live *Artemia*, fishmeal, egg yolk, and a combination ratio of 50% boiled egg yolk and 50% wheat flour. *Heterotis* fry aged 10, 28, and 46 days after hatching (DAH), respectively were fed *Artemia* nauplii then co-fed with one of the four trial diets for an additional 7 days after which *Artemia* feeding was completely withdrawn. After this, the fry were maintained solely on the experimental diets for 14 days. A control group was kept on *Artemia* nauplii throughout the experiment. The results showed that at 10 DAH fish fed the live *Artemia* had the highest survival rate (97.5%), decapsulated *Artemia* had a survival of (7.5%) while all other treatments had no survival. For fry weaned at 28 DAH, survival rates differed significantly ($p < 0.0001$), with *Artemia* again recording the highest rate (70%), followed by decapsulated *Artemia* (50%) fish meal (35%), egg yolk and flour (12.5%), and egg yolk (7.5%). At 46 DAH, survival rates similarly varied significantly ($p < 0.0005$), with *Artemia* at 75%, followed by decapsulated *Artemia* (60%), egg yolk and flour (27.5%), fish meal (20%), and egg yolk (12.5). The final mean weight, weight gain and survival rate improved significantly ($p < 0.05$) for fry fed *Artemia* nauplii compared to the artificial diets. Survival increased significantly ($p < 0.05$) with weaning age. The lower survival rates (10 - 46DAH) suggest the inability of the fry to digest diet at ages below 46 DAH. Results suggest that live *Artemia* is the most suitable feed for the larviculture of *Heterotis niloticus*.

FIRST REPORT OF A COMPLETE GENOME SEQUENCE OF A REASSORTANT NERVOUS NECROSIS VIRUS IN EUROPEAN SEA BASS (*Dicentrarchus labrax*) FROM TUNISIAN AQUACULTURE

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Betanodavirus, the etiological agent of viral encephalopathy and retinopathy (VER), is a significant pathogen in Mediterranean aquaculture, particularly affecting European sea bass (*Dicentrarchus labrax*). This positive-sense RNA virus belongs to the Nodaviridae family and includes four genotypes: *Redspotted grouper* NNV (RGNNV), *Striped jack* NNV (SJNNV), *Tiger puffer* NNV (TPNNV), and *Barfin flounder* NNV (BFNNV). Reassortment events between RGNNV and SJNNV have resulted in the emergence of novel viral strains, complicating disease management, particularly in the larval stages of gilthead seabream (*Sparus aurata*). Co-infections with these genotypes in wild populations suggest that viral nervous necrosis (VNN) may evolve in other species in the future.

This study reports the isolation and molecular characterization of a reassortant RGNNV/SJNNV strain from European sea bass in Tunisia, following a mortality event in July 2023.

The virus was isolated from brain tissue of affected sea bass using the striped snakehead (SSN-1) cell line, and RT-PCR confirmed the presence of Betanodavirus in the cell culture supernatant. Full-length RNA1 and RNA2 were amplified by reverse transcription polymerase chain reaction (RT-PCR), sequenced bidirectionally, and the resulting sequences were assembled to reconstruct the complete viral genomes.

Phylogenetic analysis revealed that RNA1, encoding the RNA-dependent RNA polymerase, clustered with RGNNV, while RNA2, encoding the capsid protein, aligned with SJNNV, confirming the reassortant nature of the virus.

This is the first complete RGNNV/SJNNV reassortant genome identified in *D. labrax* in Tunisia.

These findings emphasize the need for ongoing surveillance of Betanodavirus evolution and reassortant strains. They also underscore the urgency of developing targeted vaccination strategies to reduce disease prevalence, enhance host resilience, and ensure the long-term viability of aquaculture systems.

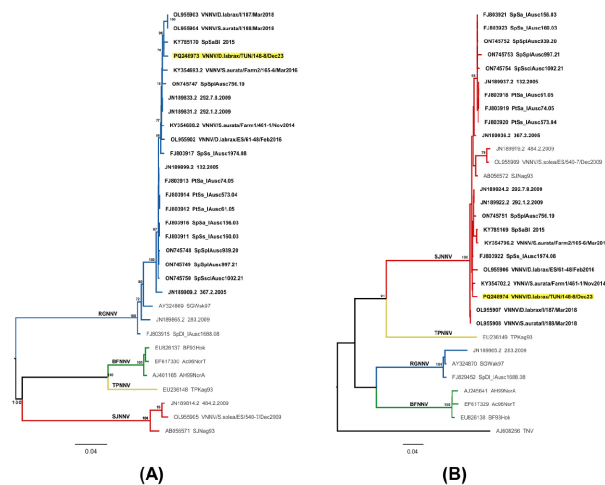


Figure. ML phylogenetic trees based on RNA1 (A) and RNA2 (B) complete sequences. Reassortant betanodaviruses (RGNNV/SJNNV) are highlighted in bold. Betanodavirus genotype subdivision is displayed by labeling the branches with different colors (blue: RGNNV; green: BFNNV; yellow: TPNNV; red: SJNNV). The numbers at the nodes represent bootstrap values (only values >70% are reported), while branch lengths are scaled according to the number of nucleotide substitutions per site. The scale bar is reported.

EFFECT OF SOME SELECTED FOSSIL FUELS ON THE NUTRIENTS COMPOSITION AND ORGANOLEPTIC PARAMETERS ON SMOKED *Tilapia zillii* (REDBELLY TILAPIA)

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Fuel wood is among the most expensive items in fish processing, knowledge on smoking efficiency of various agricultural wastes particularly sugarcane bagasse could be substitute for wood for fish smoking thereby reducing the cost, the problem of deforestation and eventually control of environmental pollution. The research was conducted to determine the efficiency and cost-benefit analysis of ebony wood and sugarcane bagasse as fuel sources for smoking fish. The result of this study showed that the highest crude protein (65.15 ± 0.20) was recorded in *T. zillii* smoked with ebony wood and the least (16.08 ± 0.13) in fresh *T. zillii*. Similarly for ash, crude fat and nitrogen free extracts were observed, and the highest moisture (78.18 ± 0.23) was recorded in fresh *T. zillii* and least (3.38 ± 0.08) from *T. zillii* smoked with ebony wood. The differences in the proximate composition of the smoked *T. zillii* using ebony wood and sugarcane bagasse were significant ($p < 0.05$). The organoleptic assessment of the smoked *T. zillii* using ebony wood and sugarcane bagasse were not significantly different ($p > 0.05$). The cost (₦150) for smoking with sugarcane was less with an equal quality with the cost (₦250) for smoking with ebony wood which is not environmental friendly.

Table 1. Mean proximate composition (mean \pm SD) of fresh and smoked *Tilapia zillii* showing the percentage moisture content, ash content, crude fat, crude protein and nitrogen free extracts

Parameters	Smoked fish (Ebony wood)	Smoked fish (Sugarcane bagasse)
Moisture content %	3.38 ± 0.08^b	4.28 ± 0.03^a
Ash content%	4.53 ± 0.04^b	5.12 ± 0.03^a
Crude Fat%	13.77 ± 0.09^a	12.58 ± 0.08^b
Crude Protein%	65.15 ± 0.20^a	58.22 ± 0.24^b
Nitrogen Free Extracts%	13.20 ± 0.24^b	19.82 ± 0.17^a

The Mean values in the same row with different subscript are significantly different at ($p < 0.05$)

EFFECTS OF TiO₂-BASED PHOTOELECTROCATALYTIC (PEC) WATER PURIFICATION SYSTEM ON GROWTH AND HEALTH IN RAINBOW TROUT FRY *Oncorhynchus mykiss* REARED IN A RECIRCULATING WATER SYSTEM

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The efficiency of a nanotube TiO₂-based photo-electrocatalysis (PEC) on a recirculating aquaculture system (RAS) and its impact on the growth and health of fish reared at different densities and stages of development is the aim of the Fish-PhotoCAT project, (PRIMA2019). Monitoring the histopathology of organs in fish allows to assess the impact of stressors (pollution, toxins, or changes in water quality) on organ systems, providing insights into how environmental changes can affect fish health. This study aimed to evaluate rainbow trout (*Oncorhynchus mykiss*) fry health status when reared in a PEC system at low densities. Rainbow trout fry (7.5 g) was reared at 5 kg/m³ for 21 days in 500 L tanks, in independent RAS. All six tanks were equipped with the standard water filtration setup: in three of the tanks, this constituted the only filtration system (CTR) and in the other three, a PEC system was installed. Water physical and chemical parameters were monitored throughout the trial. At the end of the trial, fish were weighed and measured for total length; the gills and liver were sampled for histological analyses, as the alterations of the structure of these tissues can reflect the water quality. Gene expression analyses of three cytokines (IL-1 α , IL-10, and TNF- α), HSP70, and Claudin-30 were performed on the gills, and the expression of enzymes involved in the oxidative stress response was evaluated in the liver, as it is the primary organ involved in detoxification and metabolism of toxic compounds arising from environmental stress. Authorization code: OPBA_20_2020.

The mean concentration of nitrates was significantly higher in the CTR (122.211 mg/L vs. 108.510 mg/L; $p < 0.001$), probably because of the parallel ammonia oxidation to molecular nitrogen performed by the PEC. On the other hand, no significant differences were found regarding NH₃ and nitrite concentrations between the experimental groups. All groups exhibited similar weight, length, specific growth rates, and conditions factors. Gills morphology was not affected by the PEC system, as demonstrated by the histologic and histometric results (Fig. 1A and B, respectively). The cytokines, HSP70, and Claudin-30 expressions showed no differences between groups, confirming the histological observations. No differences were found in the liver morphology between experimental groups (Fig. 1C). No melano-macrophage centers were present: in rainbow trout, in the liver, these generally begin to appear within the first few weeks of life but only become clearly visible and structurally defined during the juvenile stages, typically within a few months of age. The expression of enzymes involved in the oxidative stress response in the liver showed no differences between groups. No TiO₂ nanotubes were detected in these tissues confirming the safety of this innovative PEC system. These are encouraging results that indicate a beneficial effect of the TiO₂-based PEC reactor in a RAS, even if further investigation is needed.

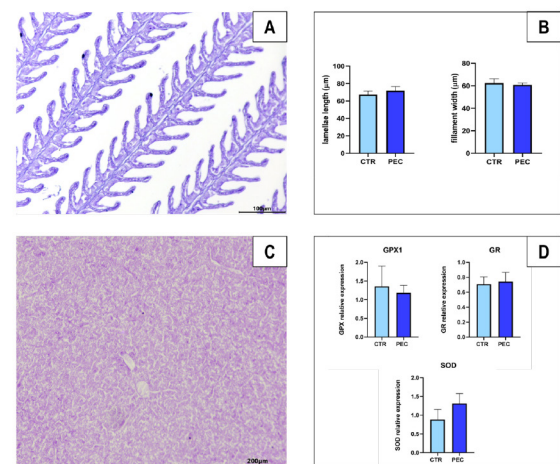


Fig.1. representative images of gills (A, histological section, scale bar 100µm) and liver (C, histological section, scale bar 200µm); gills histometry (B); oxidative stress genes expressions in the liver (D).

EFFECT OF DIFFERENT ORGANIC SUBSTRATES ON MINERAL AND FATTY ACIDS PROFILE OF BLACK SOLDIER FLY (*Hermetia illucens*) LARVAE

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The Black Soldier Fly Larvae (BSFL) is emerging as a sustainable protein source for fish feed production, providing potential for enhanced fish yields and increased profitability. This study investigated the influence of wheat offal, rice bran, and other organic substrates on the fatty acid and mineral profiles of BSFL (*Hermetia illucens*). BSFL was raised under controlled conditions for two weeks, with careful monitoring of egg development. The larvae were analyzed for their fatty acid and mineral content using gas chromatography and laboratory analysis, respectively.

This study reveals that substrates significantly influenced the nutritional content of BSFL, particularly their fatty acid and mineral profiles. Wheat offal-reared larvae exhibited higher levels of both fatty acids and minerals compared to those reared on rice bran. Notably, lauric acid was the most abundant fatty acid, while iron and zinc were predominant minerals across all substrates (Table 1). The mineral analysis revealed that larvae cultured on wheat offal had higher macro-nutrient levels, with calcium and sodium ranging from 0.25±0.01% to 0.55±0.03%, compared to lower values for rice bran substrate. Micro-nutrient levels, particularly Fe and Zn, were consistently high across all substrates, with notable differences in Cu and Fe concentrations between wheat offal and rice bran substrates (Table 2).

These findings highlight the potential of tailoring BSFL nutrient composition through substrate selection. Further research is needed to optimize substrate usage for producing BSFL with specific nutritional profiles for aquaculture applications.

Table 1: Fatty acid profile of black soldier fly larva across different organic substrates

FATTY ACID PROFILE	Treatments			
	Wheat Offal Larva	Corn Bran Larva	Rice Bran Larva	Brewery Waste Larva
Lauric	11.58±0.02 ^d	7.11±0.02 ^c	4.09±0.01 ^a	6.47±0.03 ^b
Stearic	3.27±0.02 ^c	2.36±0.02 ^b	1.88±0.02 ^a	2.28±0.04 ^b
Palmitic	5.81±0.03 ^d	4.87±0.03 ^c	2.81±0.01 ^a	4.64±0.03 ^b
Arachidonic	1.26±0.02 ^d	1.20±0.01 ^c	0.82±0.04 ^a	1.06±0.01 ^b
Oleic	6.39±0.04 ^d	5.88±0.02 ^c	3.17±0.02 ^a	5.22±0.02 ^b
Margaric	0.16±0.16 ^a	0.45±0.11 ^a	2.43±0.04 ^a	0.50±0.09 ^a
Linoleic	6.78±0.00 ^d	5.56±0.03 ^b	3.53±0.04 ^a	6.13±0.03 ^c
Lignoceric	0.21±0.04 ^d	0.15±0.03 ^c	0.06±0.01 ^a	0.09±0.01 ^b
Myristic	1.27±0.03 ^d	1.07±0.01 ^b	0.84±0.04 ^a	1.08±0.04 ^c
Behenic	0.34±0.02 ^d	0.14±0.01 ^b	0.10±0.02 ^a	0.16±0.01 ^c
Palmitoleic	1.34±0.02 ^d	1.20±0.01 ^c	0.78±0.04 ^a	1.10±0.02 ^b
Linolenic	2.72±0.03 ^d	1.23±0.04 ^c	0.91±0.01 ^a	1.13±0.04 ^b

Table 2: Mineral profile of black soldier fly larva across different organic substrates

Minerals	SUBSTRATES			
	Wheat-Offal Larva	Corn Bran Larva	Rice-Bran Larva	Brewery Waste
Na(%)	0.25±0.02 ^a	0.23±0.02 ^a	0.19±0.00 ^a	0.21±0.01 ^a
K(%)	0.55±0.03 ^d	0.38±0.01 ^b	0.32±0.00 ^b	0.37±0.01 ^b
Mg(%)	0.27±0.00 ^b	0.27±0.01 ^b	0.22±0.01 ^a	0.24±0.01 ^c
Ca(%)	0.25±0.01 ^b	0.23±0.01 ^{ab}	0.21±0.00 ^a	0.22±0.01 ^{ab}
P(%)	0.34±0.01 ^c	0.32±0.01 ^{bc}	0.27±0.00 ^a	0.30±0.00 ^b
Zn(mg/kg)	42.65±0.07 ^d	31.82±0.02 ^c	23.89±0.01 ^a	29.48±0.03 ^b
Cu(mg/kg)	15.60±0.14 ^d	12.29±0.02 ^c	7.77±0.09 ^b	11.61±0.01 ^b
Mn(mg/kg)	27.40±0.14 ^d	19.41±0.01 ^c	17.02±0.01 ^a	18.88±0.02 ^b
Fe(mg/kg)	116.83±0.04 ^d	102.48±0.02 ^c	90.39±0.01 ^a	100.29±0.01 ^b
Cr(mg/kg)	23.72±0.0 ^d	18.65±0.07 ^c	15.18±0.02 ^b	17.95±0.21 ^a

GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF *Heterobranchus bidorsalis* FED VARYING LEVELS OF DIFFERENTLY PROCESSED BLACK SOLDIER FLY (*Hermetia illucens*) LARVAE MEAL

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Given the rising cost of fishmeal and its limited supply, and fluctuating qualities, alternative feed sources like insect meals are gaining attention. This study evaluated the growth performance and nutrient utilization of *Heterobranchus bidorsalis* fed diets containing varying levels of differently processed black soldier fly (BSFL) larvae meal. Fish were raised for 84 days, replacing fishmeal with BSFL meal at 0%, 25%, 50%, 75%, and 100% (Diets FM, BSF1, BSF2, BSF3 and BSF4 respectively).

Results indicated that both inclusion levels and processing methods significantly influenced fish growth and nutrient utilization. Treatment BSF1 (25% BSFLM) demonstrated superior body weight gain, feed conversion ratio, and specific growth rate. While replacing 50% fishmeal with BSFLM (Treatment BSF2) was economically beneficial, treatments BSF1 and BSF4 exhibited higher feed conversion ratios. Treatment BSF1 also excelled in nutrient utilization, with higher apparent net protein utilization, protein efficiency ratio, and nitrogen metabolism (Table 2).

These findings underscore the importance of considering both inclusion levels and processing methods of BSFLM in fish diets to optimize growth performance and nutrient utilization in aquaculture. Further research on alternative feed sources and feeding strategies can contribute to more efficient, productive, and sustainable aquaculture practices.

Table 1: Proximate composition of experimental diet

Parameters	Preparations		Treatment (Inclusion levels)				
	Sun-dried	Oven-dried	BSF0	TBSF1	BSF2	BSF3	BSF4
%CP	59.06±0.55 ^a	56.13±0.42 ^b	58.04±0.79 ^{ab}	57.28±0.79 ^{ab}	59.22±0.79 ^a	57.19±0.79 ^{ab}	56.24±0.79 ^a
%ASH	9.23±0.14 ^a	9.28±0.12 ^a	8.95±0.22 ^a	9.01±0.22 ^a	9.16±0.22 ^a	9.65±0.22 ^a	9.50±0.22 ^a
%EE	7.52±0.09 ^b	7.64±0.08 ^a	7.65±0.15 ^a	7.44±0.15 ^a	7.57±0.15 ^a	7.49±0.15 ^a	7.74±0.15 ^a
%CF	0.08±0.00 ^a	0.08±0.00 ^a	0.07±0.10 ^a	0.08±0.10 ^a	0.09±0.10 ^a	0.09±0.10 ^a	0.08±0.10 ^{ab}
%DM	91.54±0.16 ^a	91.22±0.14 ^a	91.39±0.23 ^a	91.06±0.23 ^a	91.50±0.23 ^a	91.40±0.23 ^a	91.56±0.23 ^a

Table 2: Growth performance and nutrient utilization of *H. bidorsalis* fed with Oven-dried and sun-dried black soldier fly larvae meal with different inclusion levels

Parameters	Preparations		Treatment				
	Sun-dried	Oven-dried	CF	BSF1	BSF2	BSF3	BSF4
BWG	29.23±1.01 ^{ab}	29.10±1.06 ^{ab}	29.94±1.61 ^b	32.76±1.61 ^b	28.73±1.61 ^{ab}	27.53±1.61 ^a	26.85±1.61 ^a
FCR	1.81±0.07 ^a	1.81±0.07 ^a	1.76±0.10 ^a	1.72±0.10 ^a	1.72±0.10 ^a	1.87±0.10 ^a	1.92±0.10 ^a
SGR%	1.61±0.04 ^b	1.59±0.04 ^a	1.63±0.05 ^{ab}	1.72±0.05 ^b	1.60±0.05 ^{ab}	1.56±0.05 ^{ab}	1.50±0.05 ^a
ADG	0.43±0.01 ^b	0.35±0.01 ^a	0.42±0.01 ^b	0.46±0.01 ^b	0.40±0.01 ^b	0.34±0.01 ^a	0.32±0.01 ^a
AWG	289.53±10.21 ^a	289.15±10.72 ^a	296.18±16.15 ^{ab}	323.91±16.15 ^b	286.38±16.15 ^{ab}	273.67±16.15 ^{ab}	266.54±16.15 ^a
%Survival	82.67±3.09 ^b	66.67±3.24 ^a	78.67±4.89 ^b	80.00±4.89 ^b	78.33±4.89 ^b	65.00±4.89 ^a	73.33±4.89 ^{ab}
ANPU	12.60±1.11 ^a	13.02±1.16 ^a	13.77±1.76 ^a	7.46±1.76 ^a	11.03±1.76 ^a	15.65±1.76 ^b	16.12±1.76 ^b
PER	1.06±0.09 ^b	0.89±0.09 ^a	1.34±0.14 ^b	1.45±0.14 ^b	0.78±0.14 ^a	0.74±0.14 ^a	0.56±0.14 ^a
FCE	34.25±2.77 ^a	32.66±2.90 ^a	40.45±4.37 ^b	39.45±4.37 ^{ab}	35.37±4.37 ^{ab}	25.45±4.37 ^a	26.54±4.37 ^{ab}
PI	163.08±6.63 ^a	161.99±6.96 ^a	162.51±10.49 ^a	149.72±10.49 ^a	233.85±10.49 ^b	139.11±10.49 ^a	137.49±10.49 ^a
NM	1139.94±45.86	2053.94±48.10	1633.25±72.52 ^a	1720.70±72.52 ^a	1588.41±72.52 ^a	1.555±72.52 ^a	1484±72.52 ^a

EFFECTS OF DIETARY SUPPLEMENTATION OF PHYTASE AND MANNAN-OLIGOSACCHARIDE (MOS) ON NILE TILAPIA FRY FED PLANT-BASED DIET

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This study investigated the effects of a plant-based diet supplemented with phytase and mannan oligosaccharide (MOS) on the growth, feed utilization, fatty acid profile, hematology, and intestinal morphology of Chamo strain Nile tilapia *Oreochromis niloticus* (L.) fry. Plant-based experimental diets were formulated to contain 0% (control), 6 g kg⁻¹ MOS, 1000 phytase (*phytase unit*) FTU kg⁻¹, and a combination of 6 g kg⁻¹ MOS and 1000 phytase (FTU kg⁻¹). Inclusion of Phytase alone or combined with MOS had improved growth performance parameters. MOS alone or combined with phytase had improved lipid quality compared to other groups.

The fish fed with phytase or combined with MOS had higher crude protein and ash content than other groups. The inclusion of a combination of MOS and phytase in the feed increased values of villi length, villi width, and goblet cell numbers of the intestine. Supplementation of additives also improved some hematological parameters. The results suggest that MOS and phytase supplements can enhance the growth performance, health status, and nutritional value of Nile tilapia fed a plant-based diet. However, further studies are needed to optimize the dosage and duration of these supplements and to evaluate their effects on other aspects of fish physiology and behaviour.

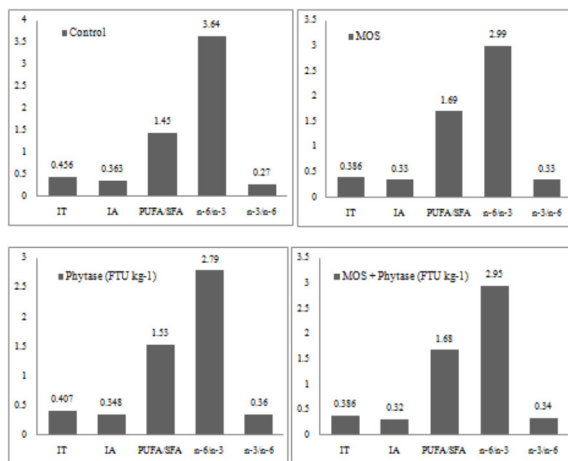


Figure 1. Lipid Quality Indexes (LQI): IT, IA, n-6/n-3, n-3/n-6, and PUFA/SFA

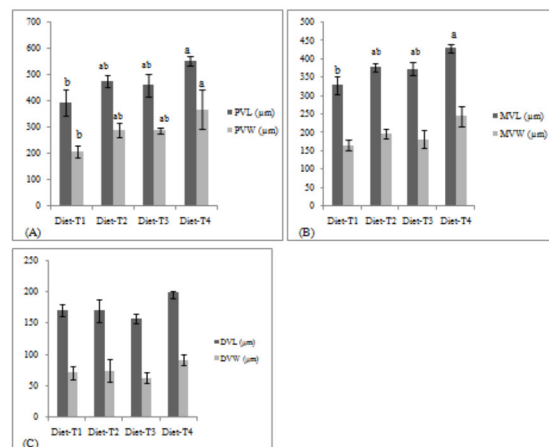


Figure 2. Proximal villi length (PVL) & villi width (PVW) (A), middle villi length (MVL) & villi width (MVW) (B), and distal villi length (DVL) & villi width (DVW) (C) of the intestine of Nile tilapia in µm.

THE MUDDY WATER OF THE UNIVERSITY GENDER POND ‘WHY IS A GENDER MAINSTREAMING APPROACH NECESSARY TO ACHIEVE AFRICA’S AQUACULTURE DEVELOPMENT POTENTIAL?’

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African aquaculture is expected to grow exponentially over the next decade, creating opportunities for sustainable development and achieving gender equity. However, due to the marginalised position of most African women in the fisheries and aquaculture sector, explicit gender mainstreaming strategies are vital for achieving an equitable distribution of resources and opportunity. A major challenge is that gender issues remain poorly understood, and hence most strategies aimed at addressing gender equity within an aquaculture development context are insufficient. The present paper presents insights into complexity and challenges of gender mainstreaming in a natural resource management context, drawing on insights from a gender-focused workshop aimed at fostering deeper learning and critical thinking about gender. The responses of the participants (natural resource management academics and development practitioners) illustrate that gender is a sensitive and complex topic, presenting multiple challenges which need to be recognised and addressed in the formulation of gender mainstreaming strategies. It was found that (i) Diverse perspectives may lead to disagreements and discomfort; (ii) Discussions on gender often evoke strong emotional responses related to self-identity, societal expectations, and personal experiences; (iii) Conversations about inequalities and power imbalances may provoke defensiveness among those benefiting from privileges; (iv) Historical contexts of gender discrimination can be triggering for survivors; (v) Academics may hesitate to engage openly due to fears of causing offense, leading to superficial dialogues; (vi) The evolving conversation around diverse gender identities may cause confusion and discomfort for some; and (vii) Engaging in these discussions can make academic teams feel vulnerable, creating tension in professional settings.

Raising awareness and providing gender education are crucial for fostering a culture of gender responsiveness and sustainability. In this context, higher education stakeholders, alongside governments, private sector actors, civil society, and local communities, have significant roles to play in establishing normative approaches for gender mainstreaming. However, many higher education institutions in Africa appear to be in the early stages of establishing benchmarks and metrics for tracking progress and enhancing gender strategies.

This paper concludes that higher education and development institutions have considerable work to do to effectively integrate gender considerations into the development agenda. Systematic changes across these institutions are required to embed gender considerations into their core operations and formulation of policies, strategies and programs. It is thus essential that academics and development practitioners in the aquaculture and fisheries sector are educated to understand the complexity of gender issues and are equipped with skills to design effective gender inclusion strategies.

OPTIMIZATION OF THE CAGE CULTURE TECHNOLOGY OF STRIPED CATFISH (*Pangasianodon hypophthalmus*) AT HYPOSALINE WATER FOR THE LIVELIHOOD DEVELOPMENT OF MARGINALIZED COUSTRAL COMMUNITY OF BANGLADESH

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Bangladesh is one of the world's leading fish-producing country in the world. Fishes and fishery resources play a vital role in improving the socio-economic condition combating malnutrition, earning foreign currency, and creating employment opportunities in Bangladesh. The country ranked 3rd in inland open-water production and 5th in world aquaculture production. Cage culture has been successfully practiced in the open water body of Bangladesh.

The study was conducted over a period of 75 days from August to November 2023 in the Patuakhali district at kalapara upazila of Bangladesh to assess the impact of stocking density on the growth and production performance of Thai pangas in cages. The experiment was designed with three treatments namely T₁ (25 fish/m³), T₂ (50 fish/m³), and T₃ (75 fish/m³) respectively each having three replications. The floating feed contains 30% protein supplied twice a day at the rate of 10% down to 3% of their body weight. Water quality parameters were recorded every fifteen-day interval throughout the culture period.

The water quality parameters range from temperature 26.2 to 31.6 °C, pH 7.5 to 8.7, dissolved oxygen (DO) 4.3 to 5.4 mg/l, ammonia 0.2 to 0.6 mg/l, nitrite 0 to 0.4 mg/l, alkalinity 140 to 172 mg/l, hardness 154 to 176 mg/l and salinity 1 to 5.6 ppt measured during the experimental period. At the end of the culture period higher weight gain of Thai pangas was recorded in T₁ (595g) followed by T₂ (587g) and T₃ (584g). The survival rates were 97.65 % in T₁, 96.32% in T₂, and 95.89% in T₃ which showed there is no significant difference ($P>0.05$) among treatments. The weight gain, % weight gain, and SGR were found higher in T₁ followed by T₂ and T₃. The FCR was found same at 1.78 among treatments. The BCR was higher in T₃ (1.38) followed by T₂ (1.32) and T₁ (1.16). The result of the study revealed that the culture of Thai pangas in cages is suitable because the growth was appreciable. Besides the stocking density up to 75 fish/m³ is appreciable without any problems in terms of growth and survival and is also economically viable compared to lower stocking density. Salinity did not affect the survivability. So, it is recommended to culture Thai pangas in a cage culture system at hyposaline water.

Yield parameters	T ₁	T ₂	T ₃
Mean initial weight (g)	55 ± 2	55 ± 2	55 ± 2
Initial length (cm)	17 ± 1	17 ± 1	17 ± 1
Mean final weight (g)	650 ^a ± 4.39	642 ^a ± 6.52	639 ^a ± 6.86
Final length (cm)	42 ^a ± 2	41.54 ^a ± 2.3	40.12 ^a ± 2.4
Mean weight gain (g)	595 ^a ± 5.1	587 ^a ± 4.93	584 ^a ± 5
% weight gain	1081.81 ^a	1067.27 ^a	1061.81 ^a
SGR (% day ⁻¹)	3.29 ^a ± 0.04	3.27 ^a ± 0.06	3.27 ^a ± 0.06
Survival Rate (%)	97.65 ^a ± 5.37	96.32 ^a ± 5.48	95.89 ^a ± 5.89
(FCR)	1.78 ^a ± 0.01	1.78 ^a ± 0.01	1.78 ^a ± 0.01
Yield Kg/m ³	15.87 ^a ± 0.52	30.92 ^b ± 0.71	45.95 ^c ± 0.94
BCR	1.16	1.32	1.38

PROSPECTS OF BOOSTING AQUACULTURE PRODUCTION: FISH STOCKING IN A WETLAND IN BUEA, CAMEROON

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Fish production from capture fisheries has not increased in correspondence to the growing world population. Recent global aquaculture production increased in all regions except Africa, probably due to the high cost of fish feeds, given that most African fish farmers are largely resource-poor.

In developing countries, fish stocking with extensive production can be an option in the attempt to compensate the dearth in fish production related to stock depletion in capture fisheries and high feed costs in aquaculture. Hence, the present study investigated the survival of *Clarias gariepinus* fry stocked in a wetland.

Six hundred 21-day old *C. gariepinus* fry of mean total length 1.46 cm and mean weight 0.097 g were stocked in the wetland of the University of Buea, Cameroon, campus and let to scavenge, without supplementary feeding, for 180 days. Protection from predators was not provided.

The results showed 7.17% survival rate with a higher number of adult females than males, while the males recorded higher final weight ($P < 0.05$) (Table 1). Growth was hypoallometric (Figure 1). This first trial showed that stocking *C. gariepinus* fry in a restricted habitat without supplementary feeding nor protection resulted in a relatively substantial recovery rate and growth. This may indicate that there is potential for an even higher survival and growth if the habitat is manipulated to preclude predation and if stocking and harvesting are timed aptly.

Table 1. Survival rate and growth parameters of *C. gariepinus* harvested from wetland 180 days post-stocking.

Parameter	Females	Males	*T-test	Whole batch
Number of fry stocked				600
Number of adults recovered	26	17	$P < 0.05$	43
Survival rate (%)				7.17
Initial mean weight (g)				0.097
Final mean weight (g)	1061.54± 975.43	1752.94± 1146.80	$P < 0.05$	1334.88± 1088.28
Mean weight gain (g)				1,334.79
Condition factor (K)	0.87±0.10	0.73±0.12	$P < 0.05$	0.81±0.12

*There is significant difference at $P < 0.05$.

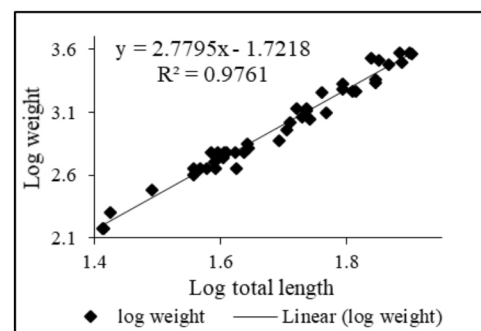


Figure 1. Length-weight relationship of *C. gariepinus* adults harvested from the wetland 180 days post-stocking.

ESTABLISHMENT OF COLD TOLERANCE IN NILE TILAPIA (*Oreochromis niloticus*) NEXT GENERATION

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The optimal growth temperature for most tilapia species ranges between 25 and 28°C, with survival becoming critical at temperatures below 10-12°C. This study focused on developing a cold-tolerant generation of Nile tilapia (G9 strain) from WorldFish, Abbassa. Tilapia fingerlings were reared under winter conditions at two different locations in Egypt. Survivors were then transferred to the Central Laboratory for Aquaculture Research (CLAR) greenhouse, where they were prepared as breeders.

In the first group, 58 males and 42 females were identified from 100 fish in the 1st pond, and 54 males and 46 females from 100 fish in the 2nd pond. In the second group, 45 males and 40 females were found among 85 fish in the 3rd pond, and 45 males and 31 females among 87 fish in the 4th pond. Tissue samples were collected daily from both susceptible and resilient fish for genomic analysis, utilizing DNA isolation and whole-genome sequencing at the University of Maryland, USA.

Molecular characterization of muscle atrophy associated with starvation in tilapia revealed 4,833 differentially expressed genes (DEGs) compared to the control group, including 34 miRNAs and 460 lncRNAs. Gene ontology analysis identified 27 up-regulated and 52 down-regulated biological processes related to muscle structure development and cellular macromolecule metabolism.

The results have successfully produced a cold-tolerant tilapia generation that can be utilized in hatcheries to mitigate cold-related mass mortality. This study provides valuable insights into the genetic basis of cold tolerance in Nile tilapia and offers potential for improving aquaculture productivity in regions with cooler climates.

ASSESSMENT OF THE GROWTH AND NUTRIENT UTILIZATION OF *Clarias gariepinus* FINGERLINGS FED DIFFERENT INCORPORATION LEVELS OF PREPARED *Moringa oleifera* SEED MEAL

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Introduction: Exploration of alternative plant protein sources for their prospect as potential replacements for fish meal has been intensified in recent times and *Moringa oleifera* (Lam) has been identified as one of such prospective candidates (Nsofor *et al.*, 2012). However, the elimination of undesirable anti-nutritional substances from plant protein sources is imperative to improve their nutritional quality and maximize their full potential as components in fish feed.

Methodology: The trial took place at the Teaching and Research Fish Farm within the Department of Fisheries and Aquaculture at Usmanu Danfodiyo University in Sokoto located on latitude 13° 07' 47.6"N, longitude 05° 12' 11.3"E and altitude 275m above sea level (Google MAP, 2015). Five experimental diets were formulated, and fishmeal was replaced with the processed (B90min/S72hrs) *Moringa oleifera* seed meal at 0, 20, 40, 60 and 80% inclusion levels and fed to the fingerlings for twelve weeks. Fish growth, feed conversion and nutrient utilization indices were determined.

Results: Highest weight gain (12.77±1.14g) was recorded in the fish with diet T1 which is the control diet but, the difference was not significant from dietary treatment T2 with 20% MSM replacement level. Lowest FCR was recorded with fish fed diet T2 and there was no statistically significant difference in the PERs of all the treatments.

Discussion and Conclusion: Diet with 20% substitution level that contributed 8.33% by gross composition enhanced good growth, and the fingerlings were still healthy at 80% substitution level. The findings of the feeding experiment revealed a similar (p>0.05) survival rate across the treatments. However, the growth response decreased with increased inclusion level of the test ingredient MSM in the diets.

Table 1: Growth parameters of *Clarias gariepinus* fingerlings fed diets incorporating different concentrations of *Moringa oleifera* seed meal.

Parameter	Treatments				
	T1 (0%)	T2 (20%)	T3 (40%)	T4 (60%)	T5 (80%)
No of fish stocked	20	20	20	20	20
Mean initial weight (g)	1.50±0.00	1.50±0.00	1.50±0.00	1.50±0.00	1.50±0.00
Mean initial length (cm)	6.17±0.06 ^a	6.17±0.06 ^a	6.13±0.06 ^a	6.17±0.06 ^a	6.17±0.06 ^a
Survival rate (%)	78.33±2.89 ^a	78.33±2.89 ^a	73.33±5.77 ^a	70.00±13.23 ^a	75.00±0.00 ^a
Mortality rate (%)	21.67±2.89 ^a	21.67±2.89 ^a	26.67±5.77 ^a	30.00±13.23 ^a	25.00±0.00 ^a
Mean final weight (g)	14.29±1.12 ^a	12.35±0.43 ^{ab}	11.08±0.13 ^b	8.48±2.27 ^c	8.21±0.36 ^c
Weight gain (g)	12.77±1.14 ^a	10.87±0.40 ^{ab}	9.57±0.12 ^b	6.97±2.25 ^c	6.70±0.35 ^c
Percentage weight gain (%)	849.13±72.06 ^a	720.39±27.85 ^{ab}	636.71±10.24 ^b	463.72±151.55 ^c	446.03±24.56 ^c
Specific growth rate (%/day)	2.26±0.08 ^a	2.12±0.03 ^{ab}	2.01±0.01 ^b	1.74±0.26 ^c	1.73±0.04 ^c
Mean final length (cm)	10.17±0.45 ^a	10.13±0.55 ^a	10.07±0.42 ^a	9.20±0.56 ^b	9.20±0.17 ^b
Condition factor (K)	1.36±0.11 ^a	1.20±0.15 ^{ab}	1.09±1.14 ^{ab}	1.14±0.49 ^{ab}	1.05±0.01 ^b

Mean values in row having different superscripts are significantly different (p<0.05)

INVESTIGATING THE MECHANISM OF HEAT-SHOCK PROTECTION IN ISKNV INFECTED TILAPIA BRAIN CELL LINE

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Infectious Spleen and Kidney Necrosis Virus (ISKNV) is the causative agent of a fatal disease in many fish species, resulting in mass mortalities and significant economic losses. Since its introduction to Ghana in late 2018, in the absence of effective vaccines, the crude practice of heat-shock treatment (HST) on deliberately exposed cultured tilapia fingerlings was widely adopted by farmers to control the disease in Ghana with some apparent success. This study investigated the interplay between the expression of heat shock protein (HSPs) and viral replication during ISKNV infection.

An *in vitro* experimental challenge study which involved deliberate infection and subsequent exposure of primary *Oreochromis niloticus* (Tilapia) brain (TiB) cell lines at 48 hours post-infection to HST was carried out. The test groups and control groups were screened at various time points for viral proliferation and HSP markers expression using quantitative real-time PCR (qPCR).

Exposure to heat-shock significantly increased HSP 90 and 47 expressions by 4 and 6-folds respectively, with a concomitant 10-fold decrease in viral load as compared to the non-heat shock group. Viral apoptosis gene ORL005L was significantly down regulated following increase in HSPs expression.

This initial finding implies that heat-shock treatment may play an important role in suppressing viral replication through the apoptosis regulatory gene ORF005L. This information will contribute to the understanding of the beneficial effect of heat-shock therapy used in control of the viral pathogen in aquaculture. Further studies in controlled *in-vivo* experiments will give more clarity to the general effect of this treatment on tilapia growth and ISKNV persistence in infected fish populations.

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GROWTH, FEED CONVERSION RATIO, AND PROXIMATE COMPOSITION OF AFRICAN CATFISH *clarias gariepinus* CULTURED IN A BIOFLOC SYSTEM USING FERMENTED AND ACID-HYDROLYZED RICE BRAN AS CARBON SOURCES

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Introduction

Biofloc system uses the presence of microorganisms in the fish culture system to generate flocs from nitrogen waste, thus permitting continued water usage. Factors like carbon source, carbon to nitrogen ratio, and stocking density, affect the quality and density of microorganism and the productivity of the biofloc system (Martínez-Córdova *et al.*, 2007). This study aims to determine the growth, feed conversion ratio (FCR), and proximate composition of catfish reared in a biofloc system using rice bran (RBB), fermented rice bran (FRB), and hydrolyzed rice bran (HRB) as carbon sources.

Methods

Fingerling catfish of an initial mean weight of 10.55 ± 2.60 g were stocked in outdoor 200-liter plastic tanks in a randomized design with the three treatments in two replications. A biomass (g) to volume (l) ratio of 1:2 was maintained throughout the experiment. The carbon-nitrogen contents in the feed and water were used to ensure an overall 15:1 C-N content in the system. Water parameters were monitored and the growth in length and weight of catfish in biofloc system was recorded weekly for 8 weeks. The proximate composition of the fish reared in biofloc was also determined using standard method of AOAC, (1999). The data obtained were subjected to one way ANOVA to test for significant difference in the survival, weight gained, specific growth rate, and proximate composition among the treatment.

Results

The weight parameters at the end of the 8-week rearing trials showed the catfish culture using RBB (81.15 ± 3.1 g), FRB (88.50 ± 5.7 g), and HRB (97.20 ± 2.5 g) were significantly different ($P \leq 0.05$) (Table 1). A similar trend was observed in the feed conversion ratio. The crude protein (65.44%) and protein retention (47.2%) were significantly higher ($P \leq 0.05$) in the FRB and lowest in the RBB, with values of (61.85%) and (58.5%), respectively. This results showed that acid-hydrolysis and solid-phase fermentation of rice bran could boost its performance as a biofloc carbon source.

Table 1. Growth parameters of Catfish reared in biofloc system using rice brown (RBB), fermented rice brown (FRB) and hydrolyzed rice brown (HRB) sources

Parameters	Rice bran (RBB)	Fermented rice bran (FRB)	Hydrolyzed rice bran (HRB)
Initial weight (g)	10.55 ± 2.60^a	10.55 ± 2.60^a	10.55 ± 2.60^a
Final weight (g)	81.15 ± 3.10^a	88.50 ± 5.7^b	97.20 ± 2.5^b
Weight gain (g/fish)	70.60 ± 5.80^a	77.95 ± 6.35^b	86.75 ± 5.90^c
Specific growth rate	1.26	1.39	1.55
Feed conversion ratio	1.50	1.72	1.85

Means (n=2) followed by different letters in each rows are significantly different ($P < 0.05$).

POLLUTION OF SEDIMENTS BY HEAVY METALS IN LAGOS HARBOUR - SOURCES, PATHWAYS AND MANAGEMENT

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The coastal zone is influenced by human activities such as fishing, industries and shipping and can become vulnerable due to these persistence anthropogenic actions. Often enclosed and semi-enclosed marine areas such as harbours can become polluted, and this is detrimental to sediment quality. The basin of Lagos Harbour, Nigeria, is an area with restricted water circulation and typifies this situation. This study aimed to investigate the concentrations of heavy metals in sediments within the Lagos Harbour and Lagoon system. A total of twenty-six sampling stations were established, with more pristine Apese Lagoon serving as the control area. The different stations were selected according to their related anthropogenic activities and hence likely to have varying contaminant sources and types. Surface (1-5 cm) sediment samples were collected using a Van Veen grab on two occasions; during the wet (September 2013) and dry (February 2014) seasons. The sediment underwent two acid digestion (1M HCl or *aqua regia*) procedures according to the Canadian National Water Research Institute guidelines and the United States Environment Protection Agency (Method 3050B). The digests were analysed for the heavy metals: arsenic, chromium, copper, iron, lead and zinc. Some of these were selected due to their persistence, toxicity and potential to bioaccumulate in organisms. The resultant digests were analysed using both inductively coupled plasma mass spectrometry and optical emission spectrophotometry to give the bioavailable and extractable metal fractions. Total metal concentrations were measured using X-ray fluorescence. The concentration of metals was shown to be higher using the *aqua regia* method in the dry season compared with the wet season in all the locations including the control area. High concentrations for three metals (As = 23, Cr = 38, Zn = 144 mg/kg) were found. The concentrations were higher in the Lagos Harbour and urbanised part Lagos Lagoon, where there is high intensity of anthropogenic activities compared with the control zone. These data are useful for the policy makers to use as part of the baseline data for further investigation and in the development of guidelines for the protection of the marine environment in Nigeria.

COST BENEFIT ANALYSIS FOR BARLEY PRODUCTION IN AQUAPONIC AND HYDROPONIC SYSTEMS

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The experiment, conducted in Nablus, Palestine, involved a detailed cost analysis and comparison of barley production in aquaponic and hydroponic systems over a six-month period. Both systems were analyzed for initial investment, operational costs, and production outcomes, including tray net weight, dry matter, and protein content at 7 and 14 days. Chemical analysis was performed to determine crude protein, ash, fiber, and other nutritional parameters. Statistical analysis used a general linear model with significant results determined at $P < 0.05$. Results indicated that aquaponic systems, particularly at 14 days, achieved higher net weights, dry matter, and protein content compared to hydroponic systems. The aquaponic system produced the highest as-fed production, dry matter, and protein yield, highlighting its superior productivity. The cost analysis revealed that while both systems require significant upfront investments, aquaponics may offer dual income streams from fish and plant sales, enhancing economic viability. The study underscores the potential of aquaponic systems for sustainable, efficient, and high-yield barley production, aligning with sustainable agricultural goals by promoting resource conservation and minimizing environmental impact.

HOW TO MEASURE GHG EMISSION FROM AQUACULTURE?

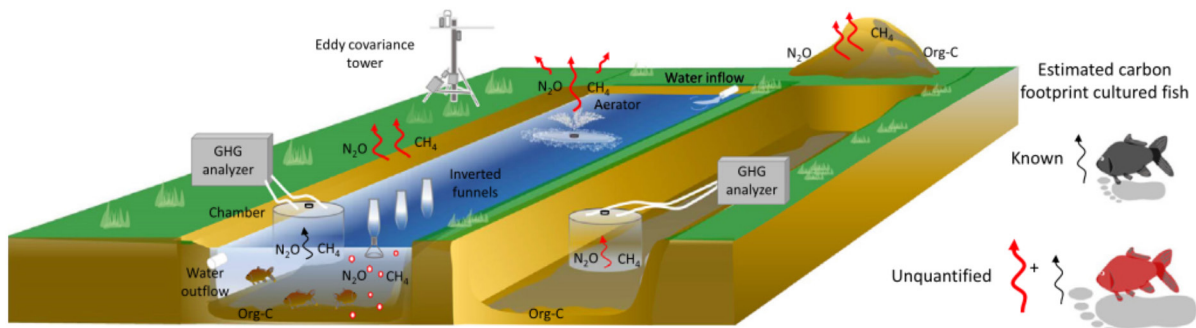
Nathan Barros*; Anderson Melo Júnior; Vitor Duque; Laís Soranço; Arthur Martins; Jonas Costa; Ivo Muzitano; Giovana Cardoso; Ícaro Alves; Giovanni Oliveira

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Aquaculture plays a critical role in global food security, helping to meet the nutritional demands of a growing global population. By 2032, global fish production is projected to reach 202 million tons, with aquaculture expected to account for 55% (or 111 million tons) of this total.

Despite the impressive expansion of aquaculture—growing more than tenfold over the past three decades—concerns are increasing around its environmental sustainability, particularly regarding greenhouse gas (GHG) emissions. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are key GHGs associated with aquaculture, contributing significantly to the sector's overall emissions footprint. Globally, aquaculture is responsible for up to 245 million tons of CO_2 equivalent annually.

In this discussion, we will explore the concepts and methods used to quantify GHG emissions from aquaculture, examining new technologies and models for accurate emissions measurement. We will also address future implications and the need to incorporate these emissions in national GHG inventories.



RECIRCULATION AQUACULTURE CUTS DOWN THE CARBON FOOTPRINT OF NILE TILAPIA FARMING

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Aquaculture plays a crucial role in meeting the escalating global demand for animal protein. However, some aquaculture systems are often linked to high rates of greenhouse gas (GHG) emissions. A promising alternative to minimize emissions is the adoption of recirculating aquaculture system (RAS), an emerging practice in the aquaculture industry that intensifies production while reducing water and land use. Yet the effects of RAS on GHG emissions remain poorly understood. We demonstrate that most emissions from a RAS-based Nile tilapia fish farm with suspended tanks originate from the water treatment system (biofilter), and that the total CO₂eq emission is lower than that of other animal protein sources.

After calculating the daily fluxes of CH₄ and CO₂, we observed that the CH₄ flux increased considerably in the biofilter as the production cycle progressed, while the CO₂ flux decreased due to the primary production by *Lemna minor* and *Pistia stratiotes* L. Additionally, we observed a higher ebullitive emission than diffusive emission from the RAS, and a difference between measurements with the aerator on and off in the tanks. We found a total of 2.97 tons of CO₂eq directly emitted by the RAS-based fish farm and 2.03 kg CO₂eq/kg protein or 0.32 kg CO₂eq/kg live weight. The biofilter accounts for ~98% of the emissions and the total emissions per protein is mostly the result of indirect emissions. Our results highlight the need to seek further improvements in RAS, to reduce emissions particularly from water treatment systems to further decrease emissions per protein production in aquaculture.

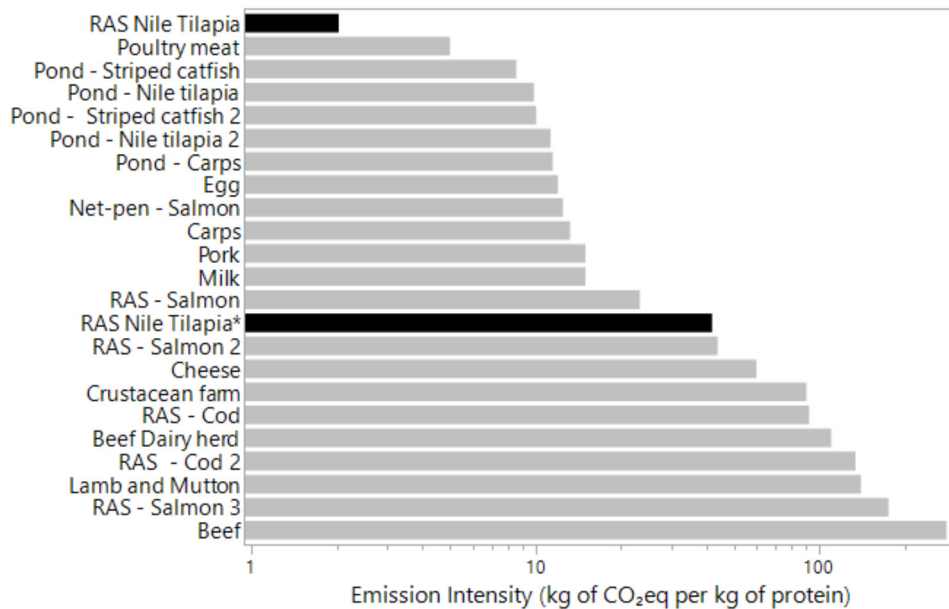


Figure1: Emission intensity of different sources of animal protein. *Inclusion of indirect emissions.

THE IMPACT OF CLIMATE CHANGE ON FISHERIES AND AQUACULTURE IN THE DEVELOPING WORLD AND OPPORTUNITIES FOR ADAPTATION

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This abstract reviews the importance of fisheries and aquaculture, with particular reference to poor people in the developing world, and the likely impact of climate change on these activities and on food security. It highlights some practical measures that can be taken to adapt to the expected effects of climate change. These focus in particular on building the capacity of communities to adapt to climate change in ways that allow them to moderate potential damage, to take advantage of new opportunities and to cope with the consequences of climate change, and on enhancing the resilience of communities and the ecosystems on which they depend. The review paper recommends basing interventions as much as possible on local practices and traditions

CRISPR/Cas9-MEDIATED MYOSTATIN KNOCKDOWN PROMOTES GROWTH IN BLACK SEA TROUT, *Salmo labrax*

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The global demand for fish and fisheries products has increased over the last few decades because of their high protein and highly unsaturated fatty acid contents. To cope with this increase, it has become necessary to use limited resources more efficiently. The myostatin (*mstn*) gene, a member of the transforming growth factor- β superfamily, is a negative regulator of muscle growth by inhibiting the proliferation and differentiation of muscle fibers. In *mstn*-null fish, muscle growth is accelerated, leading to increased muscle mass, a phenomenon known as the double-muscling phenotype. The Black Sea trout (*Salmo labrax*) is an economically important fish species in Türkiye. Therefore, to produce better-growing *S. labrax*, we knocked out the *mstn* gene using the CRISPR/Cas9 genome editing technique.

The *mstn* gene in *Salmo labrax* was cloned and sequenced. Two single guide RNAs (sgRNA) targeting the first exon of the *mstn* were designed using the CRISPOR database. Oligonucleotides were cloned into a pT7-gRNA vector. *In vitro* transcription was performed using the Megascript T7 Kit. Embryos were injected with a mixture of 400 pg Cas9 protein and 200 pg sgRNA. Subsequently, they were incubated in 10 °C water. Genomic DNA was extracted from caudal veins of mutant (*mstn*⁻) and wild type (*mstn*⁺) fish. The target region was amplified by PCR. The products from *mstn*⁻ and *mstn*⁺ fish were cloned into the pCR™4-TOPO® vector using the TOPO TA Cloning Kit and were sequenced. T7 endonuclease assay was performed and digested products were separated by agarose gel electrophoresis.

Hatching rate and larval growth rate of *mstn*⁻ *Salmo labrax* were lower than those of *mstn*⁺ *Salmo labrax*. Mutation rate was 35.4±2.08% (Table). Six-months old *mstn*⁻ fish was approximately %60 heavier than wild type fish (Figure).

We successfully knocked out *mstn* gene in *Salmo labrax* at the first time and this would be helpful to produce faster-growing fish in the future.

*This study was funded by TUBITAK with 222O095 project ID.

Table. Hatching rate, larval growth, mutation rate, and body weight in six-months old *mstn*⁻ and *mstn*⁺ *Salmo labrax*

	Hatching rate (%)	Larval growth rate (%)	Mutation rate (%)	Body weight at 6 mph (g)*
<i>mstn</i> ⁺	93.3±1.7	91.1±1.9	-	4.25±
<i>mstn</i> ⁻	41.7±3.3	64.1±1.1	35.4±2.08	3.54±

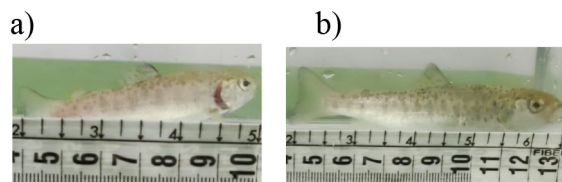


Figure. Six-months old *mstn*⁺ (a) and *mstn*⁻ (b) *Salmo labrax*.

AQUAPONICS APPLICATIONS in TÜRKİYE and DEVELOPMENT PROPOSALS in THIS FIELD

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Aquaponics represents a forward-thinking and eco-friendly method of food production, merging fish farming (aquaculture) with soil-free plant cultivation (hydroponics) in a self-contained water system. This symbiotic relationship between fish and plants efficiently recycles nutrients, conserves water, minimizes waste, and prevents soil pollution. The advantages of aquaponics include resource efficiency, minimal environmental footprint, local food supply, superior product quality, income diversification, and opportunities for job creation, contributing positively to food security, environmental health, and economic sustainability.

Despite its potential, aquaponics faces several challenges, including commercial viability, system optimization, and widespread adoption. Aquaponics systems in Türkiye face significant limitations and challenges, particularly in securing financing. Aquaponics applications in Türkiye and proposals for its development in this sector focus on the innovative method of combining fish farming and soilless plant cultivation. This integrated approach supports sustainable agriculture by recycling nutrients, conserving water, and reducing environmental impact. The article explores current aquaponics practices in Türkiye, along with recommendations for advancing the field. It discusses potential strategies to enhance technology adoption, improve financial support, and address regulatory frameworks. This manuscript outlines the key development suggestions for improving the status of aquaponics in Türkiye. Recommendations include strengthening research and development through local and international collaborations, increasing awareness and training for farmers, establishing effective marketing and trade networks, and providing financial support and incentives. Emphasis is placed on addressing sustainability and environmental impacts, improving technology and automation, and promoting stakeholder involvement to realize aquaponics' potential.

The analysis highlights that aquaponics offers numerous social, economic, and environmental benefits, and its success depends on overcoming technical, financial, and educational barriers. Continued innovation, policy support, and consumer education are essential to advancing aquaponics as a sustainable solution for future food production.

METHODOLOGIES FOR THE STUDY OF ENVIRONMENTAL IMPACTS IN MARINE COASTAL AREAS

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Protein production from aquaculture and fish farming are considered more efficient and sustainable than traditional livestock farming, due to better feed conversion ratio and lower impact on resources such as water and land. However, the quality of the product is sometimes not perceived by final consumers due to poor traceability of the production process and certification. To improve consumer confidence and the profitability of the supply chain, it is essential to implement a clear and detailed tracking of production, processing, distribution and logistics. The article outlines a method for tracking the quality of a small/medium-sized producer's production process. The article focuses on the potential production in the low-anthropogenized waters of the North African coasts in accordance with current regulations. The method is described from a legal, biological and technical/scientific point of view. The theme is declined on various interventions to deepen the various areas of the topic. (MASAF, Avv Silvia Canali - Institute of Marine Biology Piombino, Prof Bedini- University of Rome 3, Prof Leccese- SeTeL srl, Ing De Francesco).

The Institute of Marine Biology and Ecology is in charge of the quality control of waters and bottoms of the areas designated to aquaculture and fish farming.

The environmental control activities of the situation of the marine coastal strip also include the taxonomic determination of the species sampled with various methodologies depending on the sampling areas.

- Scraping of the rocky surfaces.
- Sampling of the sandy bottoms with box-corer (fig.1) which are deposited in plastic basins from which the species photographed under the stereomicroscope and taxonomically determined will be taken (fig. 2, 3, 4).
- Sampling with plankton net (fig. 5) with which the species that live in the *Posidonia oceanica* meadows (Linnaeus) Delile, 1813 are captured (fig. 6, 7).

The presence of all the species captured with the methodologies described indicates the state of the environments where the sampling was carried out (Bilyard G.R. (1987)). The value of benthic fauna in Marine Pollution studies. (Marine Pollution Bulletin. Crema et al. 1983; Bilyard, 1987;

Thomson et al. 2003.) The chemical analysis of the sampled sediments are carried out by I.C.C.O.M., C.N.R. of Pisa.



Fig. 1: Samplings on sandy bottoms



Fig. 2: photos under the stereomicroscope

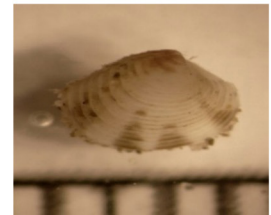


Fig 3, 4: benthos sampled in sandy bottoms



Fig. 5: Sampling on Posidonia meadows



Fig. 6, 7: benthos associated with Posidonia leaves

FROG FARMING, A COMPLICATED DISCIPLINE THAT OFFERS NEW PERSPECTIVES FOR AQUACULTURE

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There is an increasing demand for supplying the culinary markets of frogs. Several farming attempts have been made on the comestible green water frog: *Pelophylax saharicus* to verify its performance and its suitability as an exploitable new resource in Tunisia. The question of adaptation to inert food is the most complex when talking about frog farming in captivity. In fact, adult frogs eat exclusively moving live preys in natural conditions. In this study, we tried several methods to make inert food more attractive. Some frog-farmers mix the diet with live fly larvae, which they reduce progressively until the frogs accept voluntary the inert food. The work reported here examined the effects of this progressive adaptation on performances of the North African green water frog reared in captivity. The results show that after two months of feeding juvenile frogs with fodder granules plus live domestic fly larvae, it is possible to eliminate the larvae completely from the frogs' diet.

THE RHODOPHYTE *Hypnea musciformis*: CULTIVATION, CARRAGEENAN YIELD AND QUALITY PROPERTIES

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Different seaweed farming trials were performed in Tunisia on the agarophyte red alga *Gracilaria* during the last two decades. However, carrageenophyte seaweeds have never been farmed. Moreover, Tunisia is not a carrageenan producing country from its own seaweeds. This study consists of the first trial aiming at providing information on the effect of initial cutting weights on growth of the red carrageenophyte seaweed *Hypnea musciformis* cultivated in the open sea, in the North coast of Tunisia (Salammbô- Tunis). Thus, three initial cutting weights (5 g, 10 g and 15 g) were tested. Seaweeds were put in netting pockets tied to three nylon ropes. Each rope consists of 12 netting pockets and fixed to two metallic stakes. Cultivation was performed at 0-1m depth. On the other hand, carrageenan extraction was carried out to assess yield and quality properties (gel strength, gelling and melting temperatures and viscosity) from farmed seaweeds. Results are presented in Table 1. After 45 days of cultivation, the highest weight gain was obtained in cuttings with an initial weight of 5 g. Daily growth rate (DGR) was also obtained in the same plants, while the lowest one was recorded in cuttings with an initial weight of 15 g. As for carrageenan yield, values ranged from $14.33 \pm 7.30\%$ to $19.93 \pm 3.80\%$ DW, according to the initial cutting weight. Gel strength varied between 70 g.cm^{-2} and 115 g.cm^{-2} . Gelling temperature ranged from 19.5°C to 27°C . Melting temperature ranged from 40°C to 47°C . The highest viscosity of carrageenans was recorded from cuttings with an initial weight of 10 g, while the lowest one was obtained from the plants with an initial weight of 5 g. All these results showed that *Hypnea musciformis* could be a promising seaweed candidate for cultivation and carrageenan extraction in Tunisia. Further investigations are needed to enhance knowledge on farming and carrageenan extraction conditions of *H. musciformis*.

Table 1 : Results of growth, carrageenan yield, and quality properties (means with different letters are significantly different, $p < 0.05$)

Initial cuttings weight (g)	5	10	15
Mean final weight (g)	28.18 ± 13.29 a	27.38 ± 10.96 a	44.14 ± 18.87 a
Weight gain (%)	563 a	273 b	294 c
Daily growth rate (% day ⁻¹)	3.67 ± 0.85 a	2.06 ± 0.70 a	0.96 ± 0.41 b
Carrageenan yield (% DW)	14,33 ± 1,04 a	14,4 ± 7,3 a	19,93 ± 3,8 a
Gel strength (g.cm ⁻²)	83,33± 18,92 a	103,33±7,6 3 a	96,66 ± 16,07 a
Gelling temperature (°C)	25.00 ± 0.50 a	26,16 ±1,04 a	22,16 ±2,7a
Melting temperature (°C)	43,33±3,5 1 a	45,66±1,15 a	41,66±2,8 8 a
Viscosity (mPas)	12898,33 ± 4981,84 a	22702,66± 3907,14 b	21300± 2654,82 b

IMPACT OF LIQUID PHYTASE SUPPLEMENTATION ON GROWTH, FEED UTILIZATION, PHOSPHOROUS RETENTION, ECONOMIC RETURN AND IMMUNE RESPONSE IN NILE TILAPIA REARED UNDER LAB AND FIELD CONDITIONS

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Aquaculture plays a critical role in global food security, and optimizing nutrition is essential for enhancing fish health and growth performance. This study evaluates the effects of liquid phytase (Ronozyme® HiPhos; 20,000 FYT) on growth, feed efficiency, phosphorus retention, economic return, and immune response in Nile tilapia (*Oreochromis niloticus*) through laboratory and field trials.

Methodology: In the laboratory trial, triplicate groups of mixed-sex Nile tilapia (initial weight 18.55 g) were fed for 3 months on either a phosphorus-rich diet (10 kg mt⁻¹) or a phosphorus-free extruded diet supplemented with Ronozyme® HiPhos at varying levels (0, 1000, 1500, 2000, and 3000 FYT kg⁻¹). Performance metrics, as well as flesh and bone phosphorus concentrations, significantly increased with dietary HiPhos levels up to 2000 FYT kg⁻¹. Immune parameters, including lysozyme activity, respiratory burst, ACH50, phagocytic cells, superoxide dismutase, and phenoloxidase, were significantly enhanced, while liver enzyme activity decreased. In the field trial, adult all-male Nile tilapia (70 g) were stocked in 2-m³ hapas and fed for 80 days on a commercial extruded diet supplemented with either 10 kg monocalcium phosphate (MCP) mt⁻¹ (control), 2000 FYT HiPhos kg⁻¹, or 1000 FYT HiPhos kg⁻¹ plus 5 kg MCP mt⁻¹.

Results: Our findings indicated that the 2000 FYT HiPhos diet was more profitable than the control diet.

Conclusion: This research demonstrates that supplementing 2000 FYT HiPhos per tonne of extruded feed can effectively replace 10 kg of MCP without compromising the growth performance, body composition, or physiological functions of farmed Nile tilapia.

Table 1: Composition and Proximate Analysis of Experimental Diets (Lab Trial)

Ingredients	PC	NC0	NC1000	NC1500	NC2000	NC3000
Fish meal (65% CP)	20	20	20	20	20	20
Poultry by-product (57% CP)	76	76	76	76	76	76
Soybean meal (46% CP)	400	400	400	400	400	400
Yellow corn	91.3	101.3	97.9	101.3	101.3	101.3
Wheat bran	160	160	160	160	160	160
Rice bran	230	230	230	230	230	230
SB Oil	5	5	5	5	5	5
Monocalcium phosphate	10	0	0	0	0	0
HiPhos (FYT kg ⁻¹)	0	0	1000	1500	2000	3000
Analyzed HiPhos (FYT kg ⁻¹)	0	0	1060	1250	2060	3450
Calcium carbonate	1	1	1	1	1	1
Salt	1	1	1	1	1	1

EXPLORING MARINE YEAST AS SUSTAINABLE ALTERNATIVES FOR ENHANCING AQUACULTURE: POTENTIAL FOR NUTRITION AND BIOACTIVE COMPOUNDS

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The increasing demand for sustainable aquaculture has driven interest in alternative biological resources to support growth while minimizing environmental impact. Marine yeasts—though underutilized—present promising opportunities for enhancing sustainable aquaculture systems. Unlike traditional terrestrial yeasts, certain marine yeasts, such as species from the genera *Yarrowia*, *Rhodotorula*, and *Candida*, can thrive in saline environments and offer high-quality protein sources due to their favorable amino acid profiles.

This study investigates the potential of marine yeast species as nutritional supplements, probiotics, and sources of bioactive compounds that enhance fish health, growth, and resistance to diseases. Through an analysis of the biochemical profiles and functional properties of specific marine yeast strains, we discovered that *Yarrowia lipolytica* YITun15, *Trichosporon asahii* TaTun15, and *Rhodotorula mucilaginosa* RmTun15 exhibited a lipid content of 40%. Meanwhile, *Debaryomyces hansenii* DhTun15 and *Candida tenuis* CtTun15 revealed protein levels exceeding 40% of their dry weight. The essential amino acids (EAAs) comprised 64.4%, 60.6%, 48.3%, 45.3%, and 38.1% of the total amino acids in YITun15, RmTun15, TaTun15, DhTun15, and CtTun15, respectively. These findings suggest that these yeast species could be valuable additions to animal feed. Overall, our results indicate that marine yeast represents a sustainable and beneficial alternative to traditional fish meal, supporting the conservation of wild fish populations.

These insights underscore the importance of innovative solutions in aquaculture and position marine yeast as a sustainable resource with the potential to advance the industry's environmental and economic goals.

ENSURING THE SAFETY AND QUALITY OF FARMED SHELLFISH THROUGH BIOTOXIN MONITORING IN TUNISIAN AQUACULTURE PRODUCTS

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The safety and quality of farmed shellfish are vital for public health, especially in aquaculture, where filter-feeding shellfish, are prone to accumulating harmful biotoxins. These natural toxins, produced by harmful algal blooms, can concentrate in shellfish, posing serious health risks when consumed. The Food and Agriculture Organization (FAO) categorizes marine biotoxins into four main groups: paralytic shellfish poisoning (PSP), amnesic shellfish poisoning (ASP), diarrhetic shellfish poisoning (DSP), and azaspiracid shellfish poisoning (AZP). Many countries including Tunisia, enforce rigorous monitoring programs to prevent the sale of shellfish products contaminated beyond safe levels.

In response to these needs, we have developed and validated precise methods for detecting and quantifying lipophilic and hydrophilic biotoxins, specifically in mussels (*Mytilus galloprovincialis*) and oysters (*Crassostrea gigas*). Using liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS), this method achieves high sensitivity and specificity for multi-class toxin analysis. To address matrix effects, matrix-specific calibration was applied, yielding linear calibration curves ($R^2 \geq 0.99$) and recovery rates between 96.56% and 103.56%. The method also demonstrates excellent sensitivity, with detection limits (LD) ranging from 0.04–0.58 $\mu\text{mol}\cdot\text{kg}^{-1}$ and quantification limits (LQ) from 0.15–1.82 $\mu\text{mol}\cdot\text{kg}^{-1}$, and high precision with relative standard deviations (RSD) $\leq 2.8\%$. These validated methods were ISO/IEC 17025 accredited, underscoring their robustness and reliability for regulatory monitoring and food safety assurance.

The INSTM laboratory, B3Aqua, functions as Tunisia's National Reference Laboratory for biotoxin monitoring within the national network, under the Ministry of Agriculture. By conducting regular sampling and analysis of shellfish from aquaculture sites in the Bizerte region, B3Aqua ensures these products meet stringent safety standards before consumer distribution. In collaboration with local producers, B3Aqua also implements preventive measures and provides technical guidance on aquaculture best practices. Through these efforts, B3Aqua plays a vital role in safeguarding public health, supporting sustainable aquaculture, and enhancing the quality of Tunisian aquaculture products for both domestic and international markets.

CHALLENGES FOR DEVELOPMENT OF RECOMBINANT VACCINES AGAINST NODAVIRUS: INNOVATIVE STRATEGY IN THE IAEA AQUAVAC-IR PROJECT

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In the framework of the International Atomic Energy Agency (IAEA) Technical Cooperation Project TUN5032 (<http://www.aquavac-ir.tn/>), recombinant VLPs were expressed in prokaryotic systems under the control of different radiation-inducible promoters (AquaVac-ir process-2).

Briefly, the total RNA was used for all-in-one step amplification of the transcript (1040 bp) encoding the Nodavirus P-capsid protein with high fidelity Reverse Transcriptase. Recombinant expression vectors were designed (15 distinct constructions), synthesized and used to transform electrocompetent *Escherichia coli* strains. Each recombinant clone was cultured in a selective medium and recombinant P-capsid expression was induced under optimized UV irradiation conditions. The apparent molecular weight (MW) of the P-capsid protein, estimated at 42 kDa, was observed *in vitro* through SDS-PAGE and subsequently detected *via* immunoblotting. The assay utilized a rabbit anti-Nodavirus polyclonal antibody, followed by an HRP-conjugated anti-rabbit secondary antibody for visualization. Upstream process and downstream processes were optimized for successful carrying out production and purification steps at lab scale.

The primary results demonstrated that P-capsid production driven by a UV-inducible promoter (Construction c-1) reached a yield comparable to that obtained using synthetic IPTG induction (Construction c-2). The recombinant virus-like particles (VLP) were successfully isolated throughout ultracentrifugation, as confirmed by Transmission Electronic Microscopy (TEM). These findings represent a significant advancement in the development of a recombinant vaccine, using radiation-inducible promoters, against Nodavirus-induced encephalopathy, contributing to improved health management in aquaculture.

INNOVATIVE DIETARY APPROACHES FOR PRE-MORTEM QUALITY IMPROVEMENT IN AQUACULTURE: INSIGHTS FROM BIOTECHNOLOGY ON GILTHEAD SEA BREAM (*Sparus aurata*)

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Pre-mortem quality in aquaculture encompasses the condition of fish before harvest, which directly influences the final product's texture, taste, shelf life, and safety. Factors like stress, health, nutrition, and environmental conditions are crucial to achieving optimal pre-mortem quality, especially for species like gilthead sea bream (*Sparus aurata*), a key species in Mediterranean aquaculture.

This study investigated the effects of bioactive feed additives, including extracellular polymeric substances (EPSs) from chlorophyte *Graesiella sp.*, *Aloe vera* and *Zingiber officinale* (ginger) on the pre-mortem quality of gilthead sea bream. The aim was to assess whether these natural additives, sourced from both aquatic and terrestrial origins, could enhance fish health and product quality without compromising physiological well-being under rearing conditions. Key parameters evaluated included muscle composition, antioxidant status, plasma biochemistry, and liver histology.

Results revealed that EPSs from *Graesiella sp.* did not alter biochemical or histological parameters but offered protection against BPA-induced toxicity. Supplementation with *Aloe vera* at 0.5% enhanced hepatic IGFs levels and expression without affecting other parameters while ginger at 2% improved hepatic antioxidant capacity, reduced plasma cholesterol and triglyceride and increased resistance to *Flavobacterium maritimus*. These findings suggest that natural functional additives have the potential to improve the pre-mortem quality of gilthead sea bream.

Further collaborative studies between the Laboratory of Blue Biotechnology and Aquatic Bioproducts and the Aquaculture Laboratory are recommended to optimize additive applications and enhance aquaculture product quality.

ENRICHMENT OF FISH FEED WITH *Portunus segnis* CRAB SHELLS FOR NILE TILAPIA *Oreochromis niloticus* FARMING: A SOLUTION FOR BIOINVASION AND INDUSTRIAL WASTE MANAGEMENT IN TUNISIA

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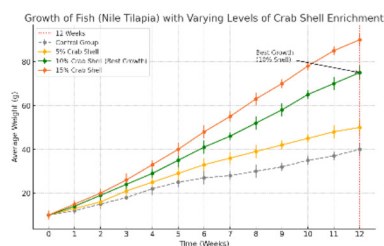
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The bioinvasion of *Portunus segnis*, an invasive crab species in Tunisian waters, presents significant environmental challenges, and the management of industrial crab waste remains unresolved. This study addresses both issues by investigating the enrichment of fish feed for Nile tilapia (*Oreochromis niloticus*) farming using dried *Portunus segnis* crab shell waste, with the main goal of enhancing feed quality and improving aquaculture sustainability in Tunisia.

This study implied the formulation of fish feed using a balanced mix of animal-based fish meal sourced from sardines and plant-based meals, including soybean and maize flour. Dried crab shells from *Portunus segnis* were incorporated into the feed at varying percentages of 5%, 10%, and 15%. The feed formulations were prepared by thoroughly grinding the dried crab shells and mixing them with the fish meal and plant-based ingredients to ensure uniform distribution of nutrients. Afterward, feeding trials were carried out using juvenile Nile tilapia (*Oreochromis niloticus*), and the feed was randomly assigned to four groups: one control group and three experimental groups receiving 5%, 10%, and 15% crab shell-enriched feed, respectively. Fish were reared in controlled aquaculture systems provided with a consistent feed for 12 weeks. In addition, growth performance measures, including weight gain, feed conversion ratio (FCR), and survival, were recorded weekly. Moreover, lipid profiles, particularly the concentrations of polyunsaturated fatty acids (PUFAs), were analyzed using gas chromatography to assess the nutritional benefits of the crab-enriched diet.

As indicated in the figure, adding 10% *Portunus segnis* crab shell waste to fish feed significantly improved the mineral composition, raising calcium content from 2.5% to 6.3%. In addition, the biochemical analysis of the crab shells revealed a composition consisting of 29.7% calcium, 15% chitin, 1.8% magnesium, and 2.2% phosphorus, which contributed to the overall nutritional profile of the feed. Accordingly, adding crab shell waste improved lipid composition, resulting in increased concentrations of polyunsaturated fatty acids (PUFAs), particularly omega-3 and omega-6 fatty acids. Notably, the percentages of eicosapentaenoic acid (C20:5, EPA) and docosahexaenoic acid (C22:6, DHA) were increased significantly in the feed, with EPA levels reaching 1.8% and DHA levels at 1.2%. Moreover, the fish fed with the 10% crab-enriched diet exhibited a 12% higher growth rate and a 9% improvement in the feed conversion efficiency compared to the control group. Furthermore, the enhanced PUFA content in the feed contributed to better overall fish health, increasing their resilience and improving the quality of the final product.

Incorporating *Portunus segnis* crab shells into fish feed offers the dual benefit of controlling the invasive crab population and adding value to the fish feed industry by improving the nutritional quality of the feed. Thus, this sustainable approach can support aquaculture and the local Tunisian crab export market.



DE-RISKING LOANS TO SMALL-SCALE FARMERS THROUGH SOCIAL CAPITAL AND DATA-LED MANAGEMENT - LESSONS FROM NIGERIA

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The Nigerian catfish industry is the second biggest aquaculture sector in Africa with production estimated to be as high as 1 million tons with an estimated 285,000 mainly small-scale farmers. The need for input credit, particularly to fund feed purchases, has been identified as a major constraint to sectoral growth and efficiency. Small-scale aquaculture farmers are largely excluded from access to traditional input loan products which are generally not designed to meet aquaculture farmer business cycle requirements. For example, small-scale farmers lack of collateral to secure loans and can only make repayments when the crop of fish is harvested. Further factors are a widespread inability to demonstrate their credit worthiness as most do not maintain financial records of their business performance and the lack of retail credit providers with the requisite infrastructure and aquaculture knowledge to service thousands of small farmers. Innovative approaches are thus required to develop suitable credit products and service providers for this sector. The Nigerian catfish sector provides some valuable insights. For example, 1) institutions based on traditional social capital such as catfish 'clusters' and farmer cooperatives have been proven to serve as effective vehicles for providing surety on loans and monitoring farmer production performance; 2) initiatives to foster farmer production and financial performance record keeping by innovative small-scale credit providers, feed companies and development NGOs are proving effective in making credit more widely accessible to small scale farmers and 3) private and parastatal credit providers are piloting financial products tailored to farmer business requirements.

BUILDING RESILIENT AFRICAN FISHERIES AND AQUACULTURE VALUE CHAINS TO MITIGATE THE THREATS OF CLIMATE CHANGE

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An accelerated and more systematic approach to climate change adaptation planning is critical in achieving the development goals of the African Union's Policy and Reform Strategy for Fisheries and Aquaculture (PFRS). An 'foresight study' analysis of planning for climate change mitigation and adaptation for the fisheries and aquaculture sectors by African Union (AU) member states was thus undertaken in order to make recommendations for the African Union and its member states (Sauer et al, 2023). A literature survey revealed that the existing and projected climate change impacts on African aquatic ecosystems are profound, with severe social and economic consequences becoming increasingly evident. African Union member states have all submitted United Nations Climate Change Framework Convention (UNCCFC) national level communications and adaptation plans, however, the fisheries and aquaculture sector provisions are generally limited to simple statements of intent, with most lacking implementation strategies. The general absence of national fisheries and aquaculture sector climate change adaptation plans is concerning, as it increases the social and economic vulnerability of member states to climate change. This deficiency highlights a general lack of capacity and resources within national fisheries management institutions, as well as the lack of an integrated value chain and blue economy approach to fisheries and aquaculture development planning. Climate change adaptation and mitigation interventions cannot be decoupled from the basic requirements for sustainable fisheries and aquaculture management, and should thus be approached in an integrated manner at regional and national level. Despite the projected negative impacts of climate change on African fisheries and aquaculture production, there are opportunities to increase continental fisheries production through 1) aquaculture development, 2) reducing the massive African post-harvest losses and 3) improving the sustainability and production of existing fisheries through better management. This will require an integrated institutional planning and implementation approach, with international, continental, and regional organisations such as the Regional Economic Communities (RECs) and Regional Fisheries Management Organisations (RFMOs) working in concert with African Union member states.

Reference:

Sauer WS, Eggers J, and Britz PJ. 2023. Building Resilient African Fisheries and Aquaculture Value Chains to Mitigate the Threats of Climate Change. Foresight study report to the African Union Development Agency – New Partnership for African Development FishGov2 Programme prepared by Rhodes University Centre of Excellence in Fisheries and Aquaculture.

AVALIAÇÃO DA EFICIÊNCIA DO PROCESSO DE REVERSÃO SEXUAL DE TILÁPIAS, UTILIZANDO DIFERENTES DOSES HORMONAIS DE 17 α -METILTESTOSTERONA NA FAZENDA KEVE FISH NA PROVÍNCIA DE CUANZA SUL-ANGOLA

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A piscicultura é o ramo da Aquicultura que envolve a criação de peixes em tanques e viveiros, o cultivo racional da tilápia tem como uma das suas prioridades, a inversão sexual de fêmeas genéticas para machos fenotípicos, os quais possuem crescimento mais rápido, e também evita problemas provenientes da reprodução e desvio de energia que seria para o crescimento.

Contudo, o objetivo do presente trabalho foi de avaliar a eficiência das dosagens (30mg e 60mg) da 17- α -metiltestosterona na reversão sexual de tilápia, na fazenda Kev Fish na provincia de Cuanza Sul-Angola, para estandardização de um protocolo mais económico. Foram utilizadas, para o estudo, um total de 40.000 pós-larvas divididas em dois grupos (E-1) e (E-2) de 20.000 cada um. Cada grupo foi subdividido em 4 subgrupos de 5000 cada, as pós larvas foram alimentadas com ração tratadas hormonalmente (E-1 30mg) e (E-2 60mg) de MT/kg de ração durante 30 dias. Depois deste período continuaram sendo alimentadas com a ração normal durante 120 dias, quando atingiram os 180g. Apartir daqui foram retirados 150 por cada hapa totalizando 1200 exemplares para sexagem e determinação do percentual de masculinização. Os dados obtidos da reversão sexual foram submetidos à estatística descritiva e análise de frequência simples por meio do programa estatístico SPSS 2022.

Concluimos que a taxa de mortalidade no tratamento E-2 (20%) foi maior em relação a mortalidade no tratamento E-1 (15,67%). As doses de 30mg e 60mg da 17- α -metiltestosterona ambas foram eficazes no processo de reversão sexual. Para as condições de cultivos iguais a que foi realizada este experimento (tanques de concreto com recirculação da água) recomenda-se a utilização da dose de 30 mg de 17- α -metiltestosterona para a estandardização de um protocolo mais económico.

Tabela 1- Parâmetros de qualidade de água observados durante o processo de reversão sexual

Variável	Tratamento 30mg E-1 e 60mg E-2
Oxigênio (mg/l)	6
Ph	6,5
Temperatura (°C)	28

Tabela 2- Média da mortalidade em função do tratamento

REPETIÇÕES	TRATAMENTOS	
	E-1	E-2
1	605	1102
2	903	910
3	715	1013
4	911	975
Média	783,5	1 000

Tabela 3- Média de machos sexados por tratamento nas 4 repetições

Machos	N	Mín	Máx	Média	Desvio Padrão	Variância
30mg	4	148	150	149,00	,816	,667
60mg	4	149	150	149,75	,500	,250
N válido (de lista)	4					

CONTINUING EDUCATION MUST DRIVE FOOD SECURITY FOR ALL

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WVEPAH is training and certifying animal production Poultry, Aquaculture and Swine, professionals working closely with producers. These experts work in the private or public sectors, in international institutions or companies acting locally, regionally or globally. WVEPA certification is validated worldwide by World Organization for Animal Health (WOAH) and delivered by Université de Montréal.

We are thriving to provide these experts the latest knowledge and tools to address health and animal production management in a holistic approach, the only approach for the sustainability of animal production.

We believe that our experts are valuable partners to help producers:

1. Attain the best possible outcome for their production systems.
2. Improve animal production and welfare in a sustainable manner, mitigating the impact of production in the environment.
3. Implement health management and biosecurity plans to prevent the occurrence of diseases and reduce the risks of antimicrobial resistance.
4. Adopt good husbandry practices to improve productivity, health and welfare of animals
5. Detect problems at an early stage and act rapidly to mitigate their impact on productivity, health and welfare.
6. Understand that prevention is the best way to manage animals and deliver sustainable results.
7. React quickly to emergency situations.
8. Become more resilient to drastic changes with thorough understanding of optimal health and performance parameters on their farms and within their region.
9. Produce healthier and safer foods.
10. Adopt international standards to make trade smoother and more predictable.

WVEPAH brings a concrete One Health approach to animal production and health. Through training and certification, we empower our experts to serve as the ideal resources for producers, global or local suppliers (Pharmaceutical companies, feed companies, Genetic selection companies...), national or intergovernmental organizations to drive the necessary changes to improve sustainably the global food supply and leave no one behind.

THE CONTROL SYSTEM IN ORGANIC AQUACULTURE IN ITALY. DEVELOPMENT OF PRODUCTION, QUALITY AND INCREASE OF CONSUMER CONFIDENCE. EQUIVALENCE RELATIONS IN TRADE IN ORGANIC PRODUCTS BETWEEN TUNISIA AND THE EU

Silvia Canali

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Protein production from aquaculture and fish farming are considered more efficient and sustainable than traditional livestock farming, due to better feed conversion ratio and lower impact on resources such as water and land.

However, the quality of the product is sometimes not perceived by final consumers due to poor traceability of the production process and certification.

To improve consumer confidence and the profitability of the supply chain, it is essential to implement a clear and detailed tracking of production, processing, distribution and logistics.

The article outlines a method for tracking the quality of a small/medium-sized producer's production process.

The article focuses on the potential production in the low-anthropogenized waters of the North African coasts in accordance with current regulations.

The method is described from a legal, biological and technical/scientific point of view.

The theme is declined on various interventions to deepen the various areas of the topic. (Silvia Canali Lawyer and Legal Consultant Food Law Expert at Italian Ministry of Agriculture, Food Sovereignty and Forestry- Institute of Marine Biology Piombino, Prof Bedini- University of Rome 3, Prof Leccese- SeTeL srl, Ing De Francesco).

In particular, Silvia Canali will illustrate:

- The quality system of organic aquaculture production in Italy, guaranteed by the system of controls throughout the supply chain, which allows national operators to obtain the organic certification of the product and the use of the EU logo.
- The system of equivalence in the commercial relations of organic products between African countries and the EU.
- A critical analysis for reforming the traceability system of organic products or at least to identify best practices in order to increase the consumers confidence of the quality of products.



EVALUATION OF BIOLOGICAL EFFECTS OF WINE INDUSTRY BY-PRODUCTS ON EUROPEAN SEA BASS *Dicentrarchus labrax*

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Introduction

The present study was developed as a part the research project “Potential use of wine and beer bagasse as sources of functional ingredients and nutrients in feeds for aquaculture” (UBAGALAC, P20-00923) jointly funded by the Junta de Andalucia and the EU.

Material & Methods

The objective of this preliminary study was to test different biological effects of grape pomace and a wine by-product concentrated extract (Olpheel® Anti-Ox, OAO, Laboratoires Phodé, France) in feeds for juvenile European sea bass (*Dicentrarchus labrax*), on three different aspects: the oxidative status of fish, functionality of intestinal microbiota, and oxidation of fillets after fish sacrifice and one week storage. A total of 180 juvenile sea bass with average body mass of 46.35 ± 0.12 g were equally divided into 9 under controlled environmental conditions of salinity (37 ‰), temperature (19°C) and photoperiod (10L:14D). Experimental feeds (control diet, a diet supplemented with 80 ppm of OAO) were prepared using a lab-scale extrusion machine. Daily ration was offered till visual satiety distributed in 4 daily meals.

Results

A significant effect of OAO on the microbial profile was evidenced as a reduced biodiversity (a lower number of functional groups) when compared to that of fish fed on the control diet, as well as by a higher functional richness (a higher intensity of the response that could be related to a higher number of specific OTUs (Operational Taxonomic Unit). This effect was not observed in the group fed the grape pomace diet. Significantly higher levels of superoxide dismutase (SOD) were measured in the groups of fish receiving OAO and grape pomace compared to the control. The significantly higher levels of SOD can be the net result of an increased expression of genes coding such enzyme. Regarding oxidation in stored fillet of the fish, a protective effect against oxidation was evidenced in samples of fish fed on diet including grape pomace and OAO when compared to those fed on the control diet

Those results together suggest that incorporating wine by-products like grape pomace or concentrated extract rich in oligoprocyanidins like Olpheel® Anti-Ox to sea bass diets, could improve their antioxidant status and fillet quality. Further studies should then be carried out with higher dosage, and to further understand the effect of such a product on diversity and functionality in microbiota and its consequences.

IMPACT OF A FORMULATED FEED ON THE GROWTH OF TILAPIA (*Oreochromis niloticus*), IN FARMING -CHERCHELL -ALGERIA

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Aquaculture is crucial for Algeria's economy, providing essential protein to support a balanced diet. This study at the ChercHELL School of Fishing and Aquaculture focuses on assessing the effects of two diets on the growth of Nile tilapia (*Oreochromis niloticus*) to address the increasing demand for protein and the limitations of traditional fishing. The research compares a commercial feed (Feed A) with a specially formulated feed (Feed B), examining their impact on tilapia growth through a controlled experiment using four aquariums equipped with thermostats and air pumps to maintain optimal conditions.

During a 40-day internship, forty fish were monitored for growth, with daily tracking of water temperature, weight, and feeding. Feed B was specially prepared from fish waste, Azolla, vegetable oil, multivitamins, and wheat flour.

Results show significant differences in growth rates, with Feed A producing a 10g weight gain (from 24g to 32.5g) over 75 days, while Feed B resulted in an 8.5g increase (from 25.15g to 35.15g). The findings suggest that tailored feed formulations can enhance tilapia growth and support sustainable resource management, contributing to Algeria's food security (Fig. 1 a and b).

According to the results for Average Daily Gain (ADG) presented in Table X, we observe that individuals fed a diet containing 41% Azolla and 35% wheat flour have an ADG of 0.86 g/day. In comparison, the diet containing 41% soybean and 35% corn shows an ADG of 0.75 g/day. (Tabl.1).

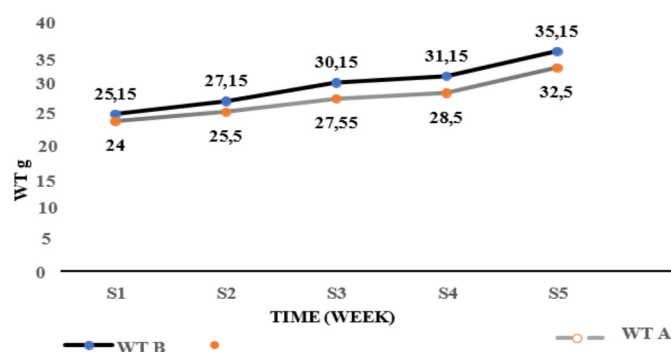


Figure 1. Evolution of average weights over time.

Table 1. Comparative growth of tilapia fed with two types of feed (A and B)

Feed	ADG (g/day)	WG (%)	SGR (%/day)	DGR (g/day)
FEED B	0.13	39.76	0.45	13.33
FEED A	0.11	35.42	0.40	11.33

Legend of abbreviations:

ADG (g/day) = Average Daily Gain; WG (%) = Weight Gain; SGR (%/day) = Specific Growth Rate; DGR (g/day) = Daily Growth Rate according to Diogo et al. (2018)

SHRIMP GUARD, A SOLUTION FOR WHITE SPOT SYNDROME VIRUS, DESIGNED USING SOLAQ PLATFORM, DEMONSTRATES 80% EFFICACY AGAINST VIRAL INFECTION IN THE POND

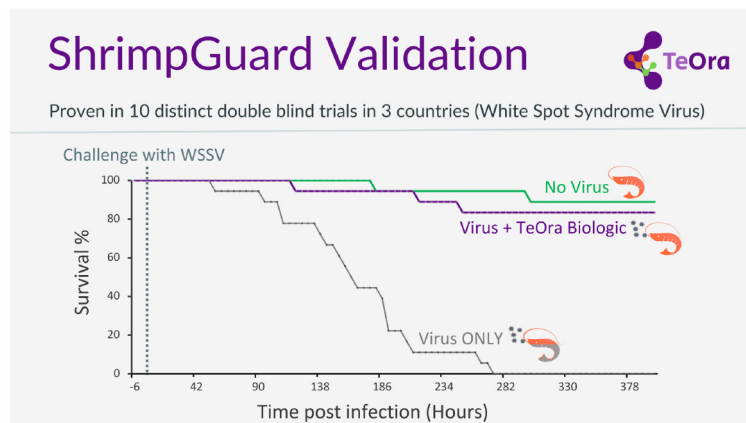
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One in three calories in aquaculture are lost to disease. However, disease management solutions in hatcheries and farms are limited, where limited vaccination, antibiotics, pesticides, and biological control remain unable to prevent losses that can reach up to 90% of the grown fish or shrimp. TeOra aims to revolutionize disease management in aquaculture, using cutting-edge synthetic biology and bioinformatics. Our programmable platform can biomanufacture prophylactic and therapeutic solutions, customized to individual disease for multiple fishes and shrimps. We offer a solution that is easy to store, simple in use, and cost-competitive. SOLAQ platform combines a multidisciplinary approach to disease management. It has 3 pillars, the bioinformatics platform, synthetic biology and material science to deliver safe and effective products orally. The bioinformatics platform has a curated aquaculture database and combines it with machine learning and structural prediction models to next generation disease management and vaccine solutions for aquaculture.

SOLAQ platform has been validated in shrimps, targeting the White Spot Syndrome Virus. We have delivered the prophylactic peptides to shrimps in animal challenge trials and have observed an increase in survival from 0% in untreated shrimps to 83% in treated shrimps. The trials also confirmed the safety of our product in shrimps (no adverse health effects, no weight loss). These are orally delivered by inclusion in the feed as a top coat. We have other solutions in development for shrimp and fish diseases.

We aim our products bring cutting edge biotechnology to managing disease challenges with a wide spectrum of customizable solutions. Our solutions are natural, sustainable and safe, with which, we aim to replace/reduce harmful chemicals.



NEW APPROACHES IN INTEGRATED AQUA-AGRICULTURE (IAA) FOCUSING ON CIRCULAR WATER-ENERGY-NUTRIENT SYSTEMS: THE CONSTRUCTION OF 3 NEW LIVING LABS, UNDER THE EU FUNDED HORIZON PROJECT PrAectiCe

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PrAectiCe is an EU funded Horizon project focusing on food production and farming in Africa. It provides a novel agroecology indicator set for East Africa, aimed at helping smallholder farmers in their agroecological transition. The project goes beyond the existing indicator frameworks with a decision support tool for agroecology advisors supporting the selection of the best suited combination of agroecological farming practices in a local context. One of the objectives of the project was to establish three IAA systems focusing on sustainability and circular economy. Each of these systems were adapted to an East African environment to showcase available technologies and opportunities that can be replicable by local farmers.

Living Lab one (LL1) builds on a previous Horizon 2020 project “VicInAqua”, in the facilities of the Department of Agriculture, Livestock and Fisheries (DALF) in Kisumu, Kenya. It is a Recirculating Aquaculture System (RAS) using municipal wastewater, filtered with a Membrane BioReactor (MBR). The system was upgraded with a new and bigger MBR, and new grow-out ponds holding tilapia (*Oreochromis niloticus*). The wastewater from the raised ponds is used to irrigate local vegetables production. A Black Soldier Fly (BSF) production unit was also constructed to support fish feed formulation and the manure is used to fertilise the crops. New Photo-Voltaic (PV) panels were installed to provide a totally autonomous power system, without the need of the unreliable national grid. Finally, a reliable sensor system was installed, monitoring a range of physicochemical parameters in real time.

Living Lab two (LL2) is an aquaponics system, integrating fish production with a range of crops. It was built in the facilities of National Agricultural Research Organisation (NARO) in Kajjansi, Uganda. The system includes six lines of a combination of media-based beds and Deep-Water Culture (DWC) tanks and one line with Nutrient Film Technique (NFT) systems. Solar panels provide sufficient energy 24 hours a day, being independent from the national grid. The nutrients needed for the crop farming, are produced from the wastes of tilapia fish raised in circular tanks. A sensors system to monitor important parameters for both fish and plants was also installed.

The third living lab (LL3) will utilize a pond culture system integrated with poultry and vegetables. It was built in the Farmer Training Centre of Sustainable Agriculture Tanzania (SAT) in Morogoro, Tanzania. A poultry house and two concrete ponds were constructed. The valuable energy for the needs of the system is provided by both PVs (on the top of the poultry house) and floating panels (on the surface of the ponds), trying not to occupy valuable space, which can be used for crops instead. The poultry waste is used to fertilize newly constructed ponds and the wastewater from the tilapia ponds will support the irrigation of the crops.

Data collected from the monitoring systems are stored and will be used in combination with satellite images to acquire pond-specific production quantities.

The present study is part of the PrAectiCe Project funded by EU, under GA number 101084248.

MAPPING OF THE INTEGRATED AQUA-AGRICULTURE PRACTICES IN EAST AFRICA, AS PART OF THE EU FUNDED HORIZON PROJECT PrAEctiCe

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PrAEctiCe is a Horizon-funded project that focuses on improving food production and farming in Africa. The project supports the development of tools for agro-ecology advisors to aid the selection of the most appropriate Integrated Aqua-Agricultural (IAA) farming practices for local communities.

An extensive survey was conducted to identify the location and types of IAA practices existing in Kenya, Uganda, and Tanzania. The primary goal was to document IAA practices, levels of integration, production, opportunities, and challenges encountered by farmers in the three countries. The study used a KOBO digital questionnaire, which was administered by trained specialists throughout the three countries.

The survey provided useful information on the fish/livestock/crop species farmed, production methods, volumes, and value, circularity of the systems, challenges encountered and possible solutions for their problems developed by the farmers themselves. All these data were categorised and analysed in a report.

The facilities identified were mapped using GIS, and the tooltip content was displayed using coding language, coupled with interactive Geo Maps PRO. Geo Maps PRO is a plug-in integrated into WordPress that creates markers with a more focused level of detail than GIS on a specific map. In this case, PrAEctiCe-specific countries. The plug-in allows for continuous changes to be made and for the addition of more information using different display methods like images, icons or heat maps.

Data protection of the farms involved in the survey was ensured. Only data regarding their activity are displayed; no personal information, such as name or address, is provided in the map.

The output provided location and features of IAA practices that can function as models for local governments and international NGOs, research institutes, funding bodies, private companies and farmers, to facilitate the adoption of sustainable and productive farming systems. The users are able to navigate the map and see the different farm activities. The interactive map can be found on the website of the project, under the “Living Labs” tab (<https://praectice.eu/integrated-agriculture-aquaculture-map/>)

The present study is part of the PrAEctiCe Project funded by EU, under GA number 101084248.

A GUIDE FOSTERING GLOBAL AQUABUSINESS INVESTMENTS

Christopher Ian Brett, Harrison Charo-Karisa, and Ruth Garcia Gomez

Aquaculture the farming of aquatic organisms, has overtaken capture fisheries as the primary source of aquatic blue foods and has been the fastest growing food production sector globally. The fast growth in the face of climate change and resource challenges necessitates the development of sustainable aquaculture. A global operational Guide to promote sustainable aquabusiness development and investments, **The Global Aquabusiness Investment Guide (GAIG)** was recently launched by the World Bank. Developed under the umbrella of the PROBLUE-funded AquaInvest Platform, this guide is a global tool designed to develop and disseminate best practices in aquaculture among public and private sector stakeholders. It can be used by a diversity of aquaculture stakeholders along the entire value chain, including national governments, private and public sector investors, private aquaculture operators seeking investment (primarily SMEs), development partners, NGOs, supporting industries (e.g., seed and feed producers), and research organisations. Importantly, the Guide has been designed as a ‘living document’ to be updated periodically as new learnings emerge.

The GAIG targets all farming systems, scales, value chain segments, and commodities, with special emphasis on small and medium enterprises (SMEs). The GAIG provides a set of comprehensive principles to harness social, economic and environmental opportunities derived from commercial aquaculture, while safeguarding against negative impacts and challenges. The GAIG was developed following extensive engagements with a wide range of industry actors. It describes the necessary requirements and enabling factors for stimulating aquaculture investment and aquabusiness growth that is socially, environmentally, and economically sustainable.

The Guide consists of eight Guiding Principles for Sustainable Aquabusiness, each of which comprises a set of practical recommendations, structured in the form of ‘Questions to ask’ and ‘Finding the answer’. Feedback received during the dissemination and validation stages will be used to inform the revision of the Guide for its next edition.



INTEGRATION AND RESTORATION IN AQUACULTURE: PROMOTION OF ECOSYSTEM SERVICES PROVISION FROM AQUACULTURE TO ATTRACT INVESTMENTS IN AFRICA

Harrison Charo-Karisa and Ruth Garcia Gomez

Aquaculture continues to grow at a remarkable rate over the past decades, accounting for 51% of global aquatic food production, surpassing capture fisheries and 59% when including seaweed. Although the fastest growing food production sector globally, average growth rate of 5.6%, it remains subject to significant environmental impacts and risks and negative consumer perceptions. Improving and fostering knowledge development and analytical data on the positive contribution of the aquaculture sector to the environment and options to reduce its environmental burden is essential for its future sustainability. The World Bank undertook an analytics study on key technical actions aimed at fostering knowledge to advise investments in the aquaculture sector. This study focused on promoting the provision of ecosystem services and environmental co-benefits, with special emphasis on integrated and restorative strategies and tools. Integrated and restorative actions optimize the use of natural resources, minimize waste generation, promote circular economies, maintain ecosystems, and conserve biodiversity while mitigating and adapting to climate change (Figure 1).

In the case of the African continent, numerous investment options for sustainable and environmentally conscious aquaculture systems exist, including integrated, restorative, and multitrophic systems, but data, both technical and economic, are needed to determine their economic viability.

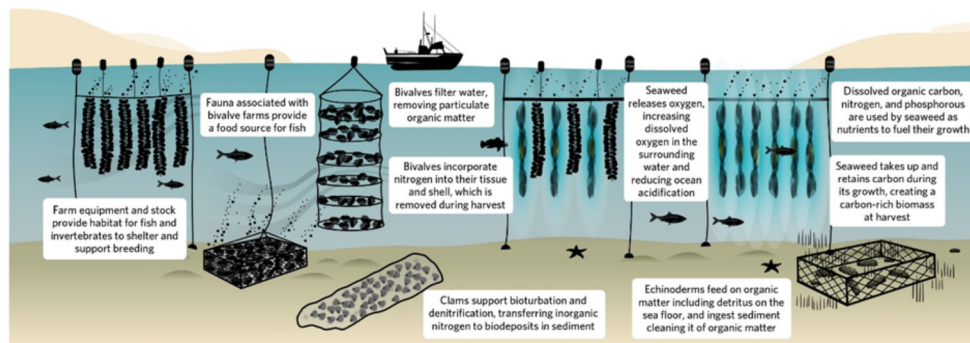


Figure 1. Potential ecosystem services and environmental co-benefits from marine aquaculture (Refer).

LEVERAGING TECHNOLOGY TO ENHANCE AQUACULTURE GOVERNANCE: INNOVATIONS IN REGISTRY, SPATIAL PLANNING, AND CARRYING CAPACITY ASSESSMENT TO SUPPORT SUSTAINABLE SCALING

Rui Gomes Ferreira, J.G Ferreira, Reed Ozretich, Diogo Gomes

Aquaculture holds immense growth potential across diverse regions and species, especially in areas where development remains limited, or aquaculture has yet to realise its full impact. Emerging markets and underutilised aquatic resources present significant opportunities for sustainable expansion, offering pathways to boost food security, create livelihoods, and contribute to economic resilience.

The World Bank AquaInvest Platform, with the overall aim of advising on and improving environmental, social, technical, and economic risks and challenges, has promoted the development of technology applications for public and private aquaculture initiatives in collaboration with Longline Environment.

Provable, technology-driven platforms enhance aquaculture governance by addressing spatial planning, geospatial registries, and carrying capacity assessments. By integrating advanced data analytics and mapping tools, Longline's platforms support precise spatial planning that accommodates local environmental and regulatory requirements, helping to optimise site selection and reduce environmental impact. The geospatial registry system centralises data on aquaculture assets, facilitating transparency, traceability, and regulatory compliance across diverse stakeholder groups. Longline's carrying capacity assessment tools also offer dynamic, data-informed insights into environmental thresholds, ensuring that aquaculture operations remain within sustainable limits. These solutions empower the aquaculture sector to scale responsibly, aligning growth with ecological and regulatory goals.

Case studies in Cabo Verde, the Ivory Coast, Zambia, Pakistan, and Vietnam highlight the application of these approaches across five different jurisdictions and species, exemplifying the approaches' scalability. In Cabo Verde, where aquaculture is in early development, spatial planning and registry systems establish foundational governance. The Ivory Coast uses these tools to meet ambitious production targets through appropriate site selection and carrying capacity optimisation. To enhance compliance and transparency, Zambia seeks to improve governance with geospatial registries and value-chain analytics. The platform highlights spatial and governance improvement in Pakistan, where professionalising the value chain is critical. Vietnam's rapid seaweed scaling aims to benefit from efficient spatial planning and sustainable expansion assessments, underscoring the capacity to support diverse aquaculture needs.

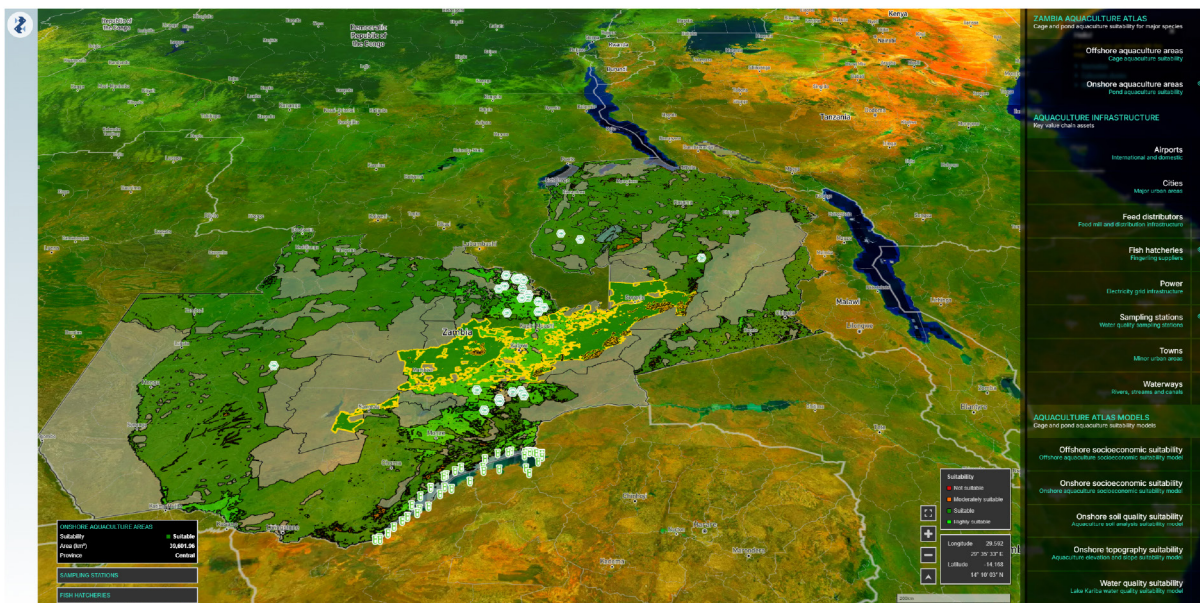


Figure 1 - Zambia Aquaculture spatial planning platform

POTENTIAL FOR SUSTAINABLE MARICULTURE IN EAST AFRICA; CASE STUDY OF KENYAN COASTAL COUNTIES

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Kenya has immense potential for aquaculture growth and development due to recent decline of capture fisheries production from inland fisheries. The coast line and related counties have considerable potential as a source of economic return and, if properly planned would promote aquaculture growth and development for better livelihoods. For example seaweed mariculture farms may change aesthetics & impact on the marketing potential of popular tourist areas.

The work is based on indepth desktop analysis, mariculture farmers' interviews and field visits including field photos and scenarios. The study indicate under production of milk fish/mullet, prawn /shrimp culture, rabbit fish, seaweeds, crab farming, oyster farming, sea cucumber, artemia cysts, pearl culture, coral culture and marine ornamentals.

This poster presentation captures status of mariculture along the Kenyan coast and suggests innovations and sustainable technology for maximizing production and sustainable use.

ASSESSING PROTEIN REQUIREMENTS FOR FINGERLINGS OF TWO *Oreochromis andersonii* STRAINS: GIP AND SUZ

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A 6-week experiment carried to examine the effects of different dietary protein concentrations on the growth of two *Oreochromis andersonii* strains: GIP and Super Upper Zambezi (SUZ). The study tested four protein concentrations: 30%, 35%, 40%, and 45%. Analysis showed significant variations in final body weight and weight gain between strains and concentrations, with a highly significant interaction ($P < 0.05$) between these factors. Fish on a 35% protein diet exhibited notably higher final body weights and weight gain compared to other diets, particularly in the GIP strain, which outperformed the SUZ strain in growth. The optimal feed conversion ratio (FCR) was observed at 35% protein ($p = 0.00028$), while specific growth rate (SGR) was significantly influenced by both strain ($p = 0.027$) and protein levels ($p = 0.001$). The GIP strain had its highest SGR of 2.27 at 35% dietary protein concentration, whereas the SUZ strain achieved its highest SGR of 1.18 at 40% dietary protein concentration. Generally, the GIP strain demonstrated superior performance across various protein levels compared to the SUZ strain. The study found no significant differences in total length gain or survival rate between strains or dietary treatments.

RESPOSTAS FISIOLÓGICAS DA TILÁPIA ANGOLANA *Oreochromis angolensis* EM DIFERENTES GRADIENTES DE SALINIDADE

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Introdução

A aquicultura é uma actividade em alto crescimento em África, desta forma, as pesquisas básicas voltadas a potencialidade das espécies nativas devem ser incentivadas para uma maior rentabilidade da actividade. A maioria das espécies de tilápias estão adaptadas a condições ambientais muito variáveis, químicos e biológicos. Angola possui uma linhagem nativa com pouco estudo de desempenho zootécnico, a *Oreochromis angolensis* originalmente descrita como *Sarotherodon*, abundante no Rio Bengo, Rio Cuanza até às cataratas de Cambambe. Seu comprimento máximo é de 20,4 cm, os machos adultos possuem manchas brancas nas nadadeiras pélvicas e dorsais. O conhecimento da sensibilidade dos peixes ao sal, é um dos princípios básicos para a escolha de uma espécie a ser utilizada em ambientes susceptíveis a mudanças salinas. Este trabalho teve como objectivo avaliar o desempenho da *Oreochromis angolensis* em diferentes gradientes de salinidades.

Metodologia

Os animais foram divididos em quatro tratamentos, com três repetições cada, nas salinidades 5; 10; 15 e 20g/L. A adição de sal foi realizada de forma gradativa, de 8 em 8 horas, deste modo as salinidades desejadas foram atingidas ao final de 32 horas. Foi usado sal de cozinha não iodado. As medições foram feitas utilizando balança de precisão. Os peixes foram estocados em 12 reservatórios feitos de vasilhames de óleo alimentar, cortados ao meio com capacidade útil de 9L, povoados com 9 juvenis cada, peso médio inicial de $1,37 \pm 0,23$ g, durante 30 dias. Os animais foram alimentados 2 vezes ao dia com ração comercial 35% de proteína bruta. A biometria foi realizada no final do experinto.

Resultados

O ganho de peso foi pequeno comparado ao da nilótica, a sobrevivencia foi melhor, maior crescimento em 20g, pode significar que esta seja o gradiente proximo ao ponto isoosmótico da *O. Angolensis*, os tratamentos 20g e 10g, demonstraram melhor aproveitamento alimentar.

Conclusão

Podemos concluir que juvenis da tilápia de linhagem angolana, apresentam grande plasticidade eurialina.

Tabela 1: Desempenho da *Oreochromis angolensis* em diferentes gradientes de salinidade

Tratamentos	5g	10g	15g	20g
Sobrevivencia (%)	100	100	100	90
Ganho de peso (g)	0,34	0,50	0,27	0,67
Conversão alimentar	77,5	21,7	40,18	16,19
Taxa de crescimento específico	0,36	1,00	0,70	1,07

Tabela 2: Desempenho da *Oreochromis nilótica* em diferentes gradientes de salinidade (Candia, 2022)

Tratamentos	5ppt	10ppt	15ppt	20ppt
Sobrevivencia (%)	99	100	100	90
Ganho de peso (g)	19,74	18,21	19,88	19,73
Conversão alimentar	1,25	1,29	1,21	1,15
Taxa de crescimento específico	4,89	4,79	4,91	4,78

FINTECH A PATHWAY TO FINANCIAL INCLUSION: THE CASE OF FISH FARMERS IN MCHINJI DISTRICT, MALAWI

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Introduction: This study explores the role of financial technologies (FinTech) in enhancing agri-business, focusing on fish farmers in Mchinji District, Malawi. The research aims to understand how FinTechs can contribute to economic growth by improving incomes, productivity, and market access for fish farmers. This study aligns with Malawi's agricultural policy and economic development goals.

Methodology: A multi-stage sampling technique selected 94 fish farmers from Mchinji District. Data collection included structured questionnaires and focus group discussions. The study examined factors supporting FinTech adoption, its impact on income and productivity, and strategies to expand FinTech usage among fish farmers.

Results: The findings indicate high technical understanding and willingness to adopt FinTech among rural and urban fish farmers, facilitated by NGO and government extension workers. However, the lack of financial support from traditional banks and micro-financiers has led farmers to rely on personal savings, sales, and NGO assistance. The data reveal that fish farmers are keen to access financial assistance through loans and FinTech platforms.

Discussion: The study highlights the potential of FinTech to provide critical resources such as post-harvest price information, extension services, farm inputs (e.g., fish gear, feed, seed), and financial assistance. Despite the enthusiasm for FinTech, insufficient operating or investment resources remain a significant barrier. Enhancing the capacity of financial institutions to assess aquaculture loan applications and demonstrating the viability of different aquaculture systems are essential steps.

Conclusion: The research underscores the viability of fish farming as a profitable business and the crucial role of FinTech in supporting this sector. The study recommends that financial institutions and policymakers focus on improving access to financial services for fish farmers and enhancing their capacity to utilize these technologies. By doing so, FinTech can significantly contribute to the economic growth and development of the aquaculture industry in Malawi.

Tables:

Payment Method for Inputs	Frequency	Percent
Cash	12	33.3%
Bank Transfer	1	2.8%
Other	23	63.9%

Platform Used for Information	Frequency	Percent
WhatsApp	1	2.7%
SMS	9	24.3%
Call	17	45.9%
Other	10	27.0%

Financial Service/Technology Used	Frequency	Percent
Mobile Money	26	70.3%
Microfinance Loan	2	5.4%
None	9	24.3%

BENEFITS OF DIETARY KRILL MEAL TOWARDS BETTER UTILIZATION OF NUTRIENTS AND RESPONSE TO OXIDATIVE STRESS IN GILTHEAD SEABREAM *Sparus aurata* JUVENILES

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Krill meal (KM) emerges as a promising alternative to fish meal (FM) in aquafeeds, providing a rich source of protein, amino acids, phospholipids, omega-3 fatty acids, and bioactive compounds. This study aimed to investigate the effects of partially replacing FM with increasing levels of KM (3, 5 and 7% of the diet) on growth performance, nutrient utilization, and antioxidant defenses in juvenile gilthead sea bream (*Sparus aurata*) exposed to a crowding stress challenge. The dietary inclusion of 7% KM could effectively replace up to 7% FM in the diet, resulting in a tendency to improve feed conversion ratio (FCR) and nutrient efficiency ratios compared to the control FM diet. Under stress conditions, a significant interaction between diet and time was observed in fish blood omega-3 index (OI3). At 24h after the stress challenge, all dietary treatments except 3% KM presented a significant increase in OI3. At 7d post-stress, fish fed the Control diet led to a significant reduction in OI3 down to the basal levels. On the contrary, those fish fed 5% KM and 7% KM diets kept increased OI3 at the end of the stress challenge (Table). Fish fed 5% KM and 7%KM also showed a lower increase of *cat* and *sod* gene expression 24h after stress, which was inversely correlated with fish blood OI3. Therefore, these results show that KM modulates red blood cells fatty acid profile by increasing fish OI3 after crowding stress as well as potentially function as an antioxidant modulator in fish feeds for mitigating stressful conditions. Thus, KM could be a viable candidate for FM replacement in aquafeeds, aiming to expand the basket of raw materials with functional properties to be used in aquafeed formulation by demonstrating its efficacy in improving nutrient utilization, as well as exhibiting benefits in mitigating oxidative stress in fish.

TABLE: Blood omega-3 index (% total fatty acids) of gilthead sea bream (*Sparus aurata*) fed the experimental diets over the stress challenge.

Diet	Time			Two-Way ANOVA		
	0h	24h	7 days	Diet	Time	Diet x Time
Control	18.76 ± 3.40 ¹	22.56 ± 3.76 ²	19.92 ± 4.59 ^{1a}			
KM3	17.88 ± 2.52 ¹	20.46 ± 4.18 ¹²	22.14 ± 3.93 ^{2ab}	$p < 0.05$	$p < 0.05$	
KM5	19.15 ± 2.97 ¹	22.31 ± 3.85 ²	23.85 ± 2.67 ^{2b}	KM3<KM7	0h<24h, 7d	<i>n.s</i>
KM7	19.52 ± 3.48 ¹	23.72 ± 3.26 ²	23.12 ± 2.56 ^{2ab}			

Different numbers denote significant differences ($p < 0.05$) between experimental sampling points (Two-way ANOVA: Diet x Time x Diet*Time; Tukey post-hoc test); Different letters denote significant differences ($p < 0.05$) between experimental diets (Two-way ANOVA: Diet x Time x Diet*Time; Tukey post-hoc test); KM3- 3% krill meal ; KM5- 5% krill meal; KM7- 7% krill meal. ns: not significant

EFFECT OF KRILL MEAL ON THE REPRODUCTIVE PERFORMANCE OF BROODSTOCK NILE TILAPIA, *Oreochromis niloticus*

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Farmed tilapia is currently the second most farmed finfish in aquaculture representing 5.27% of global aquaculture production. The current study assessed the effects of varying levels of krill meal (KM) incorporation in diets for broodstock of Nile tilapia, *Oreochromis niloticus*. The study sought to elucidate effects on spawning, egg quantity and quality, and the survival of broodstock Nile tilapia larvae produced. Three floating extruded feeds were commercially manufactured as 6.5-mm pellets. Two feeds contained krill meal (QRILL™ Aqua, Aker BioMarine Antarctic AS, Lysaker, Norway) included at 2.00 (2% KM) or 5.00% of the diet, as-is (5% KM). One commercial tilapia broodstock feed with proprietary formulation was used as a control (CTL). Twelve 40-m³ hapas were placed in a 1,500-m³ above ground pond to allow four replicate hapas per dietary treatment. Individual hapas were stocked with 50 females and 16 males, totaling 792 fish resulting in a 3:1 sex ratio. Total fish biomass per hapa reached 98.6 ± 11.6 kg. Four hapas were assigned for each dietary treatment. Fish were fed twice daily for 12 weeks, at 2% of the stocked fish biomass over the rearing period. Egg production exhibited a general decline over time. The control group yielded 16,066 ± 6,124 eggs per hapa, while the 2% KM diet showed a 18% increase (18,976 ± 6,417 eggs), and the 5% KM diet exhibited a 30% increase (20,947 ± 7,029 eggs). The number of spawning females declined over time, with 5% KM showing an overall 29% increase compared to the control. Egg hatching rates remained consistent, but the 5% KM diet hinted at a positive trend with 10% more larvae at day 10 despite the lack of statistical differences. Females fed KM spawned more frequently, and the 5% KM diet influenced higher fat content and elevated levels of omega-3 in Nile tilapia eggs. In addition, the EPA+DHA (8.8% in 5% KM versus 8.3% in control) and total n-3 fatty acid level (13% in 5% KM versus 12% in control) was higher in the 5% KM in comparison to control group. Both the 2% and 5% KM treatments demonstrated higher egg production, increased spawning frequency, and improved larvae survival compared to a control commercial diet. Overall, the study suggests positive effects on reproductive performance and larval survival in Nile tilapia with dietary inclusion of krill meal. The results align with earlier studies on the lipid components of KM, reinforcing its potential to enhance reproductive parameters in aquatic species.

AQUACULTURE EDUCATION: A THREE-PRONGED APPROACH

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Aquaculture is among the fastest growing segments of agriculture worldwide, yet it is still surrounded by misconceptions, myths and lack of understanding. Our job as Extension educators is to find ways to build aquaculture literacy, aid existing and potential practitioners and help train the next generation of aquaculture scientists. Using a multimodal, three-pronged approach allows us to reach teachers and students, producers and researchers, and the public, locally and around the world.

Prong 1 - Using a train the trainer approach with teachers has a multiplying effect. Each teacher has the potential to educate more than 200 students per year. Through our Aquaculture and Aquaponics 101 workshops we have trained more than 700 teachers using hands-on experiences and group learning activities. In addition, Auburn University offers summer camp experiences for 15–18-year-old students. These camps include five days of intense fun and firsthand activities blended into a creative learning experience that provides the broadest possible exposure to natural resource careers with an emphasis on aquaculture, fisheries, and aquatic ecology.

Prong 2 – Webinars provide professional development opportunities for farmers, researchers, students and educators. Thus far, in 2024, the United States Aquaculture Society webinar committee in partnership with WAS, the National Aquaculture Association (NAA) and the Alabama Cooperative Extension System have offered 4 learning opportunities for more than 2,000 people from 62 countries.

Prong 3 – The US Aquaculture Society and the Aquaculture Education and More YouTube channels provide on-demand education for a worldwide audience. These channels have garnered more than 1.25 million views and provided over 65,000 hours of education for people around the globe.

It is our hope that this three-pronged approach can be duplicated by many other entities to help raise aquaculture awareness.

REVIEW OF THE BENEFITS OF FISH PROTEIN HYDROLYSATES FROM PELAGIC SPECIES IN AQUAFEED

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The substitution of marine ingredients in the aquafeed industry by plant sources has led to various negative consequences in terms of zootechnical performances or animal health while the production of standard fish meals (FM) still remains the main industrial process and only source of marine ingredients in most aquafeeds.

Meanwhile, thanks to a more gentle process, Fish Protein Hydrolysates (FPH) feature major physico-chemical properties including high water solubility, emulsifying and foaming properties, water-holding and fat binding capacities. These properties have tremendous interests in the aquafeed by increasing feed palatability in high plant diets and facilitating the nutrient uptake, even at low inclusion. Various studies have confirmed the positive effects on growth and feed efficiency either for farmed fish or shrimps.

Peptides derived from FPH proved to enhance various physiological benefits such as antioxidant, antimicrobial, or immunomodulatory activities. In response to specific infections either viral, bacterial or parasitic, farmed fish fed with FPH have been found to increase innate immunity and disease resistance.

This review updates the benefits of new FPH from pelagic species such as sardines and mackerels in seabass *Dicentrarchus labrax* and seabream *Sparus aurata*.

A NEW AMPHIBIOUS VEHICLE FOR THE AUTOMATION OF MARINE WATER QUALITY MEASUREMENTS

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Protein production from aquaculture and fish farming are considered more efficient and sustainable than traditional livestock farming, due to better feed conversion ratio and lower impact on resources such as water and land. However, the quality of the product is sometimes not perceived by final consumers due to poor traceability of the production process and certification. To improve consumer confidence and the profitability of the supply chain, it is essential to implement a clear and detailed tracking of production, processing, distribution and logistics. The article outlines a method for tracking the quality of a small/medium-sized producer's production process. The article focuses on the potential production in the low-anthropogenized waters of the North African coasts in accordance with current regulations. The method is described from a legal, biological and technical/scientific point of view. The theme is declined on various interventions to deepen the various areas of the topic. (MASAF, Avv Silvia Canali - Institute of Marine Biology Piombino, Prof Bedini- University of Roma Tre, Prof Leccese- SeTeL srl , Ing De Francesco). In particular, SeTel is involved in the Ecomar project with the aim to develop a fast deploy and early warning measurement system of sea or fluvial waters.

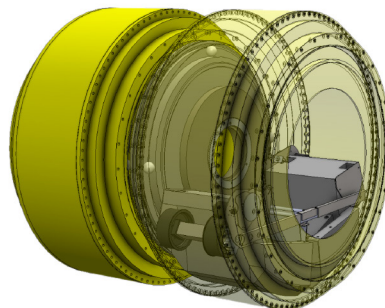


Fig. 1 The MAR systems



Fig. 2 MAR autonomous navigation system

COMPARATIVE ANALYSIS OF TOTAL ANTIOXIDANT CAPACITY, PHENOLICS, AND FLAVONOIDS OF OF KALE GROWN IN AGRICULTURE AND IN AQUAPONIC SYSTEMS

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The aquaponics system is a sustainable way of integrating soilless crop farming and freshwater fish farming in a single system to reduce water consumption and pollution, increase food production per unit area, thereby rendering economic benefits to the farmer.

Leafy greens are the most highly cultured species because of their fast growth and relatively lower operation costs. High yield under suitable conditions and increased profitability are a major factor that makes leafy greens more attractive, compared to fruiting vegetables. Kale (*Brassica oleracea L. var. acephala*) is a green leafy vegetable in Brassicaceae family Initially evidenced in the eastern Mediterranean and Asia Minor regions. Kale has been widely studied for its nutritional highlights, health beneficial properties and value-added products of kale. However, the comparison of nutritional properties of kale produced in aquaponics and conventional systems are scarce.

The present study was carried out to determine the influence of the production system on biochemical composition and the total antioxidant capacity (TAC), total phenolics content (TPC), and total flavonoids content (TPC) of green leafy kale. The results demonstrated that leaves from aquaponic kale contained higher protein content, higher levels of polyphenols and has a higher antioxidant capacity. However, the fiber content and flavonoids were higher in the kale produced in soil agriculture system. This research suggest that kale produced in soilless aquaponics systems can hold high nutritional value compared with kale from traditional agriculture.

As consumers start to value sustainably produced products and become more aware of quality of food items vs quantity, research into nutrient density of sustainable crops can hold promising advantages for the market value and demand of sustainable agriculture.

INCREASED SUSTAINABILITY IN THE AQUACULTURE SECTOR IN SUB-SAHARAN AFRICA THROUGH IMPROVED AQUATIC ANIMAL HEALTH MANAGEMENT

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This project is a unique collaboration between WorldFish, the Norwegian Veterinary Institute, the University of Ghana, and the University of Nairobi. It aims to enhance the sustainability and resilience of the aquaculture sector in sub-Saharan Africa (SSA), by focusing on improved aquatic animal health management and biosecurity governance. Targeting primarily Ghana and Kenya, the project also extends its impact to other SSA countries through extensive training programs and sustainable networking initiatives.

The program had several key objectives: strengthening research capabilities in aquatic animal health management in SSA, enhancing aquaculture education and extension services, and promoting the dissemination of knowledge on aquatic animal health within the One Health and One Food Systems framework across SSA.

A significant project component was the training and supervision of thirteen MSc students from the universities of Ghana and Nairobi, who researched various aspects of aquatic animal health. The project also implemented two comprehensive epidemiological studies in Kenya and Ghana, encompassing 179 and 99 farms. Several peer-reviewed articles were published based on research by MSc students and partner institutions.

Educational outcomes included the development of advanced educational modules on aquaculture and aquatic animal health, making training programs more accessible in SSA. Over 100 participants from eight African countries were trained in person at the WorldFish, Egypt Abbassa Fish for Africa Innovation Hub. Several digital e-learning courses on the Learn.ink platform were developed and made available on low-end mobile devices, benefiting participants from multiple African and Asian countries. Training sessions, both virtual and in-person, were conducted in Egypt, Kenya, Ghana, and Malaysia, covering topics such as general aquaculture, production systems, best management practices, water quality, biosecurity, outbreak investigation, epidemiology, parasitology, molecular-based disease diagnostic techniques, etc. Laboratory support was provided to MSc students, including training in bacterial whole-genome sequencing and antimicrobial susceptibility testing. Additionally, online educational materials on aquatic animal health for SSA were critically reviewed to identify gaps.

The AHA project fostered networking through regular meetings, workshops, seminars, and international conferences, enhancing collaboration and knowledge sharing among partners and students.

Overall, the AHA project has significantly improved aquatic animal health management and biosecurity governance in SSA, enhancing research and education capacities and promoting sustainable aquaculture practices.

PRODUCING GREY MULLET *Mugil cephalus* FRY FROM CAPTIVE BROODSTOCKS AT INSTM HATCHERY; STEPS TO SUCCESSFUL BREEDERS ADAPTATION, HORMONAL INDUCTION OF GONADAL DEVELOPMENT AND SPAWNING

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Sustainability culture of Grey mullet *M. cephalus* in freshwater reservoirs, require regular fingerlings supply from hatchery instead of adopted wild catch. However, under intensive conditions of captivity, obtaining larvae from broodstock remains a challenge due to the high level of barriers in gonadal development and spawning in addition to asynchronous of genders.

A captive broodstock of the grey mullet *Mugil cephalus* has been successfully developed at the aquaculture laboratory facilities of the National Institute of Marine Science and Technology (INSTM - Monastir). A stock of 70 adult specimens consisted by 28 females (BW 1300 ± 218g) and 42 males (BW 655 ± 201g) were acclimated in captivity between 2018 and 2019. A protocol for reducing stress in capturing, selecting fishes, transporting and treatment after stocking in tanks was set up and resulted in significantly enhance survival rate from 40% to 70% in 2019 vs 2018.

Broodstock maintained in captivity was subject of experiments to investigate the effect of hormone-therapy based on GnRHa and dopamine antagonists on vitellogenesis, oocyte maturation and spawning during the spawning season (June - October). During 2021 (year 2), induced to spawn of females did not result in fertilization of eggs due to failed final maturation of males. During 2022 and 2023 (year 3 and 4) oocytes diameter reached maximum size in late September – early October and successful induced breeding trials were conducted using females with average oocyte diameter of 583–630 µm, during the first half of October. Fertilization rates varied from 28 to 93%. Embryonic development and hatching exceed 90%.

Results confirm the possibility of inducing oogenesis from previtellogenesis to the completion of maturation and spawning using combined hormone-therapy based on GnRHa and dopamine antagonists.

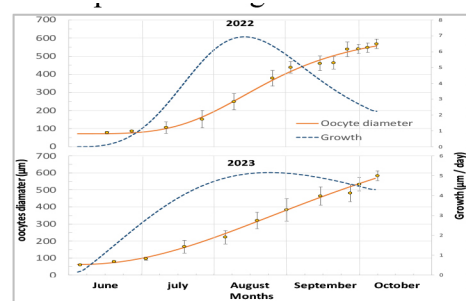


Figure 1. Oocyte growth in the female *M. cephalus*, during the reproduction season.

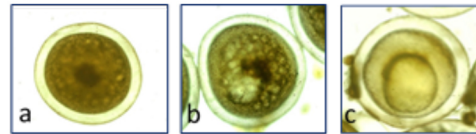


Figure 2. General pattern of final oocyte maturation identified in *M. cephalus*.

Table1. Summary of spawning data obtained from hormone-induced *M. cephalus* in the reproduction season (2021, 2022 and 2023).

year	reproduction cycle no. and date	Body weight of fish (g)		Oocyte diameter (µm) at last inspection	Egg N (10 ⁶)	Fecundity (egg / g BW)	Fertilization	Embryo dev.	Hatching (%)
		M	F						
2021	4 / 12 Oct.	953.3 ± 68	1491.1	630.73 ± 25.1	1.22	818	no		
	3 / 7 Oct.	1103.6 ± 93	1987.1	618.11 ± 18.9	1.5	757.5	27.9	no	no
2022	4 / 18 Oct.	937.6 ± 83	2037.1	583.16 ± 15.5	3.3	1640	91.02	100	98
	2 / 16 Oct.	1032.5 ± 103	1859.6	600.8 ± 25.7	2.77	1485	93.43	96.01	98.36
2023	3 / 17 Oct.	1126.2 ± 98	1901.1	596.7 ± 18.6	2.47	1299	90.46	95.32	95.23

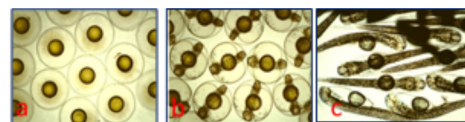


Figure 3. Embryonic development in *M. cephalus*; (a, b and c; 1, 18 and 34 hpf).

RECURRENCE TRIGGER CONDITIONS IN CARP'S ERYTHRODERMATITIS

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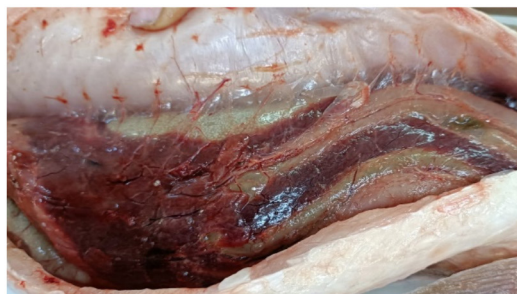
Erythrodermatitis is an infectious-contagious disease that can have a subacute to chronic course and affects various fish species, including carp. The etiological agent of the disease is often represented by the bacterium *Aeromonas hydrophila*. Poor water quality, temperature fluctuations and high stocking densities can stress fish and compromise their immune systems, making them more susceptible to bacterial infections such as erythrodermatitis.

In the current study, carp at the fish farm in Galați County, were treated with florfenicol last year to combat erythrodermatitis. This year, the above-average temperature increase in early April favored the resurgence of erythrodermatitis in carp.

The clinical signs of bacterial infection were evident in terms of lesions: swollen abdomen, integumentary bleeding in the abdomen, hemorrhagic ulcers in the fins, multiple adhesions in the visceral mass/abdominal cavity, perforated and hemorrhagic intestine in the posterior region (the dissection revealed the presence of intestinal contents /food bowl in the abdominal cavity).

The bacteriological examination and the clinical and anatomopathological examinations helped identify the disease-causing agent. Physiological stress, caused by the pathogenic bacteria, was evident in the blood analysis: a decrease in red blood cell count and hemoglobin content, and an increase in the number of neutrophils and monocytes.

Recommendation: It is important to maintain optimal water quality parameters to reduce stress and improve the immune response. Regularly monitor water temperature and take measures to prevent overheating. Keep an eye on fish health for early detection of disease outbreaks. In case of bacterial outbreaks, treat them with specific antibiotics and disinfect equipment to reduce the risk of recurrence.



IMPROVING BLUE ECONOMY TRADE CORRIDORS IN THE SADC REGION: TOWARDS THE ADOPTION OF A REGIONAL STRATEGY FOR ONE-STOP BORDER POSTS (OSBPS) ON FISHERIES PRODUCTS UNDER PROFISHBLUE

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The African Development Fund (ADF) is currently funding the *Programme for improving fisheries governance and blue economy trade corridors in the SADC region* (PROFISHBLUE). Implemented by the Southern Africa Development Community (SADC) and 5 other implementation partners, the objective is to promote the sustainable management of fisheries resources within the blue economy context to improve food and nutritional security, create employment through value chain activities, facilitate intra-regional trade, and build adaptive capacity against climate change and external shocks.

While the SADC region maintains vast water resources and formal fish trade has the potential to significantly create jobs and advance livelihoods, critical inefficiencies remain across SADC borders. Time-consuming border procedures, a lack of harmonized standards, and challenging conformity assessment requirements are some of the main constraints. Although many SADC countries have been making strides towards the use of One-Stop Border Posts (OSBPs), the benefits of such blue trade corridors are yet to be realized in the case of fishery products.

As such, a core component of the UNIDO-implemented assignment under PROFISHBLUE focuses on policy harmonization and trade facilitation through optimizing the OSBP and targets pre-selected bordering SADC countries. Among other objectives, the UNIDO component will lead to the development of a regional strategy on OSBPs for fisheries products piloted under specific border posts. In preparation for the development of this strategy, UNIDO undertook several analyses, including conducting a trade analysis of targeted Southern Africa fish trade, critically reviewing previous OSBP interventions, and mapping quality infrastructure across the target countries.

This publication presents the findings from these analyses, allowing external stakeholders with an interest in SADC blue economy and fisheries trade public access to the data and analysis. UNIDO recognizes that the valuable information collected extends beyond project interventions and can be used by future stakeholders to continue improving regional trade dynamics between Member States.



Improving Blue Economy Trade Corridors in the SADC Region

Towards the adoption of a regional strategy for One-Stop Border Posts (OSBPs) on fisheries products under PROFISHBLUE

BIO-TECHNICAL ASSESSMENTS OF AFRICAN CATFISH *Clarias gariepinus*, (BURCHELL 1822) AND FOUR INDIGENOUS LEAFY VEGETABLES RAISED IN A MULTI-LOOP PYRAMID AQUAPONICS SYSTEM

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This study was carried out to assess the bio-technical performance of African catfish (*Clarias gariepinus*), and four leafy indigenous vegetables namely Spinach (*Basella alba*), Fluted pumpkin (*Telfairia occidentalis*), Amaranthus (*Amaranthus spp*), and Bologi (*Solanecio biafrae*) raised in a Multi-loop pyramid aquaponics system. The experiment was carried out at the Teaching and Research Farm of the Department of Fisheries and Aquaculture Technology where one hundred and fifty African catfish (*Clarias gariepinus*) post juvenile (1274.2g) were stocked in the aquaponics system and fed with commercial fish feed for 56days. Fish biological performance during the experiment was measured based on growth performance and nutrient utilization. The physicochemical parameters of the water used for the experiment was determined. The yield parameters of the leafy vegetable was measured 4 weeks after seed germination and subsequent 2 weeks. Descriptive statistics (frequency, percentage, mean and standard deviation) was used for analysis, while the inferential statistics was done using one way analysis of variance (ANOVA) to compare the growth performance of the four indigenous leafy vegetables at 95% level of confidence and 0.05 level of significance. The study found that the water quality, as well as the fish performance in the system were all within the recommended limits and appreciable performance respectively. The ANOVA result showed a statistically significant difference among the four indigenous leafy vegetables in their number of leaves to vine length ratio ($F(3, 8) = 185.246, p < .05$) as well as a statistically significant difference in their growth performance ($F(3, 8) = 9.195, p < .05$). Furthermore, the Post hoc testing showed the multiple comparisons of the number of leaves to vine length ratio, and growth performance of the four indigenous leafy vegetables indicated that Bologi (*Solanecio biafrae*) has the highest number of leaves to vine length ratio when compared to the three other indigenous leafy vegetables used in the experiment ($P < 0.05$) and Fluted pumpkin (*Telfairia occidentalis*) have the best growth performance when compared to the three other indigenous leafy vegetables used in the experiment ($P < 0.05$). The study concluded that Bologi and Fluted pumpkins has a better production performance and growth performance in aquaponic system thus, integration of indigenous vegetable such as Bologi and Fluted Pumpkin in aquaponics system has the potential of adding more to the benefits of the system not only in the area of pollution control, but also in terms of productivity.

GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF AFRICAN CATFISH (*Clarias gariepinus*) FED COMBINATION OF COMMERCIAL DIET (Blue crown) AND BLACK SOLDIER FLY LARVAE (BSFL)

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Fishmeal is increasingly viewed as insufficient for sustaining the future growth of the aquaculture industry highlighting the need for better alternatives to ensure sustainable aquafeed production. Insect meal, particularly from black soldier fly larvae, emerges as a promising protein source for aquafeeds. This study aimed to determine the growth parameters and nutrient utilization of *Clarias gariepinus* fed combination of commercial diet and black soldier fly larvae meal. A total of one hundred and five (105) *Clarias gariepinus* juveniles of 63.5 ± 0.00 g average weight were used across five dietary treatments which are Treatment 1: 100% Commercial diet (T1), 40% BSFL and 60% commercial diet (T2), 80% BSFL and 20% commercial diet (T3), 100% BSFL (T4), 100% Formulated diet (T5). Bi-weekly weights recorded and feed supplied were taken to compute the growth performance and nutrient utilization parameters.

The result showed that treatment 1 (100% commercial diet) had the highest total weight gain (TWG) values (2157.75 ± 113.22) and Treatment 4 had the lowest (761.37 ± 8.11). Apart from the control (T1), Treatment 2 also had the highest mean body weight (MBW) (224.93 ± 7.62) and average daily gain (ADG) (3.21 ± 0.11). The lowest feed conversion ratio (FCR) was recorded in T1 (0.64 ± 0.01) and the highest (1.04 ± 0.01) was recorded in T4. T1 had the highest value of SGR (2.27 ± 0.06) and the lowest (1.22 ± 0.01) was found in T4. Treatment 3 had the highest protein content (19.49 ± 0.14), and the lowest (16.24 ± 0.12) was found in T5. The survival rate was 100% across all treatments. For protein efficiency ratio (PER), T1 had the highest value (1.18 ± 0.07) and the lowest (0.40 ± 0.00) was recorded in T5. In terms of feed conversion efficiency (FCE), T1 had the highest (157.17 ± 2.83) FCE and the lowest (96.13 ± 0.61) was recorded in T4. For protein intake (PI) and nitrogen metabolism (NM), T1 had the highest values, followed by T2.

The investigation into the growth performance and nutrient utilization of *Clarias gariepinus* fed a combination of commercial feed and black soldier larvae revealed that Treatment 2 showed the best growth performance. Therefore, to enhance feed efficiency, efforts should focus on efficient feed conversion as it is crucial for maximizing fish growth.

Table 1: Growth performance and Nutrient Utilization

PARAMETERS	T1	T2	T3	T4	T5
FEED INTAKE	1372.28±47.56 ^a	1132.86±22.39 ^a	955.45±27.36 ^b	791.98±3.42 ^a	1055.90±28.52 ^c
TWG	2157.75±113.22 ^a	1574.53±53.32 ^a	1158.90±65.16 ^b	761.37±8.11 ^b	1387.38±67.90 ^c
MWG	308.25±16.17 ^a	224.93±7.62 ^a	165.56±9.31 ^b	108.77±1.16 ^a	198.20±9.70 ^c
ADG	4.40±0.23 ^a	3.21±0.11 ^a	2.37±0.13 ^b	1.55±0.02 ^a	2.83±0.14 ^c
FCR	0.64±0.01 ^a	0.72±0.01 ^b	0.83±0.02 ^a	1.04±0.01 ^a	0.76±0.02 ^c
SGR%	2.27±0.06 ^a	1.91±0.04 ^a	1.61±0.05 ^b	1.22±0.01 ^a	1.77±0.05 ^c
Protein diet	18.23±0.11 ^a	17.16±0.06 ^b	19.49±0.14 ^a	19.25±0.07 ^a	16.24±0.12 ^c
%Survival	100±0.00	100±0.00	100±0.00	100±0.00	100±0.00
FCE	157.17±2.83 ^a	138.96±1.97 ^a	121.23±3.29 ^b	96.13±0.61 ^b	131.34±2.86 ^c
PER	1.18±0.07 ^a	0.92±0.03 ^b	0.59±0.03 ^b	0.40±0.00 ^b	0.85±0.04 ^c
PI	250.10±7.76 ^a	194.43±3.48 ^b	186.18±5.28 ^b	152.48±0.72 ^b	171.46±5.63 ^c
NM	62780.21±2175.53 ^a	51829.26±1024.57 ^a	43710.99±1252.08 ^b	36231.16±155.89 ^b	48305.68±1304.79 ^c

INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEMS: BEYOND FOOD PRODUCTION

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8 Fisheries and Marine Institute, Memorial University-Canada

Integrated Multi-Trophic Aquaculture (IMTA) has emerged as a sustainable and adaptable aquaculture model that mimics natural ecosystems by integrating species from different trophic levels. This approach allows wastes produced by higher-trophic-level species (e.g., finfish or shrimp) to be absorbed and utilized by lower-trophic-level species (e.g., urchins, bivalves, urchins, sea cucumber and macroalgae), creating a closed-loop system that enhances overall productivity and environmental sustainability. Ongoing research, under the “Smart Multitrophic Integrated Aquaculture/Aquaponics Systems: beyond food production” project, focuses on improving system design and introducing novel species specifically low trophic species, to optimize the efficiency and sustainability of IMTA and support environmental, economic and social sustainability.

One key area of research investigates how environmental factors, feeding regimes, and nutrient management can optimize the physiological performance of fed aquaculture species in Integrated Multi-trophic Aquaculture Systems. Efforts to genetically improve aquaculture species using the selective breeding aim to increase feed efficiency, growth, and resilience, supporting sustainable production. Research into offshore systems explores integrating seaweed to enhance nutrient recycling and promote future IMTA expansion. Another important focus is using Biofloc technology, alternative protein sources, such as insect larvae and microalgae, eco-friendly functional ingredients and biorefinery approach to reduce the environmental effects, reliance on fishmeal, enhance mucosal health in farmed aquaculture species and make IMTA systems more ecologically viable. Additionally, assessing the impact of climate change and water scarcity on aquaculture and agriculture, along with identifying ways to adapt and maintain productivity in challenging environmental conditions, and ensuring social acceptability and economic diversification, are major focus areas of the project. This oral presentation intends to highlight these research efforts and present preliminary results while also identifying new pathways for research to advance IMTA in Morocco.

PROBIOTICS AS BENEFICIAL MICROBES IN AQUATIC FARMING

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Aquaculture is fast-growing and expanding the highest average compounded rate per year.

However, intensification of aquaculture is threatened by emergence of health disturbances due to abusive use of antibiotics and thus, sustainable treatments and prophylactic measures to overcome emergence of resistant pathogens is still with high interest.

The use of chemical drugs and antiseptic develops drug-resistant microorganisms with antibiotic residues retained in fish and shellfish flesh and destroys benthic aquatic environment. Actual data provided evidence that health and zootechnical performances of in aquaculture can be improved by the prophylactic use of probiotics.

In this respect, use of probiotics is gaining acceptance in aquaculture control for potential pathogens prevention and well-being live food. Else, use of probiotics is a suitable method for keeping the environment, preventing farmed aquatic disease, improving the control of pathogens and increasing feed efficiency, growth and husbandry parameters.

Biography

PhD in Aquatic Microbiology (Molecular Biology and Genetics) and expert on “Aquatic Biotechnology, Microbiology, Biomonitoring and Bioremediation and bio-valorization of aquatic micro-organisms.

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www.instm.org, www.ciesm.org and www.medecc.org



ASSESSMENT OF LAVENDER (*Lavandula angustifolia*) ESSENTIAL OIL AS A NATURAL ANESTHETIC AND SODIUM BICARBONATE AS A SEDATIVE ON PHYSIOLOGICAL AND HISTOPATHOLOGICAL STATUS OF *Tilapia zilli* DURING THE TRANSPORT PRACTICES

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This study presents a new plan to improve the efficiency of transporting live fish using lavender oil (*Lavandula angustifolia*) as a deep anesthetic prior to transportation and sodium bicarbonate (baking soda) as a sedative during transporting on physiological indices, histopathological alterations, and survival rate of *Tilapia zilli* fingerlings. Fish were exposed to conditions simulating those normally used in transporting. This experiment consisted of five treatments using two levels of lavender oil as a pre-deep anesthetic (200 and 400 µl/liter, previously) for 5 minutes thereafter water in all aquaria was totally exchanged then adding different two levels of sodium bicarbonate as a sedative with concentrations (2.5 and 5 g/liter) these treatments were compared with the control group and normal fish that were not exposed to stressful conditions in terms of physiological statues, net ion fluxes, and survival rate after directly or 24 hrs transporting. Results affirmed that the control group and treated group with 400 µl/liter of lavender oil as a pre-deep anesthetic with 2.5 or 5 g/liter of bicarbonate of sodium as a sedative led to an increase in ion loss of fish bodies, deterioration in water quality and physiological statues with increasing mortality rate in comparison with treated groups with 200 µl/liter of lavender and 2.5 or 5 g/liter of sodium bicarbonate in special groups that treated group with 200 µl with 5g of lavender oil and bicarbonate sodium respectively.

TABLE 2. Effect of lavender oil and bicarbonate sodium on blood indices of *Tilapia zilli* during transportation for 4 hours.

Items	Before (Normal)	Control G0	G1	G2	G3	G4
Glucose (mg/dL)	44.00 ^c	89.01 ^b	45.50 ^c	30.01 ^c	99.01 ^{ab}	105.50 ^a
Cortisol (nmol/L)	68.00 ^d	101.72 ^b	89.50 ^{bc}	87.50 ^{bc}	131.02 ^a	137.62 ^a

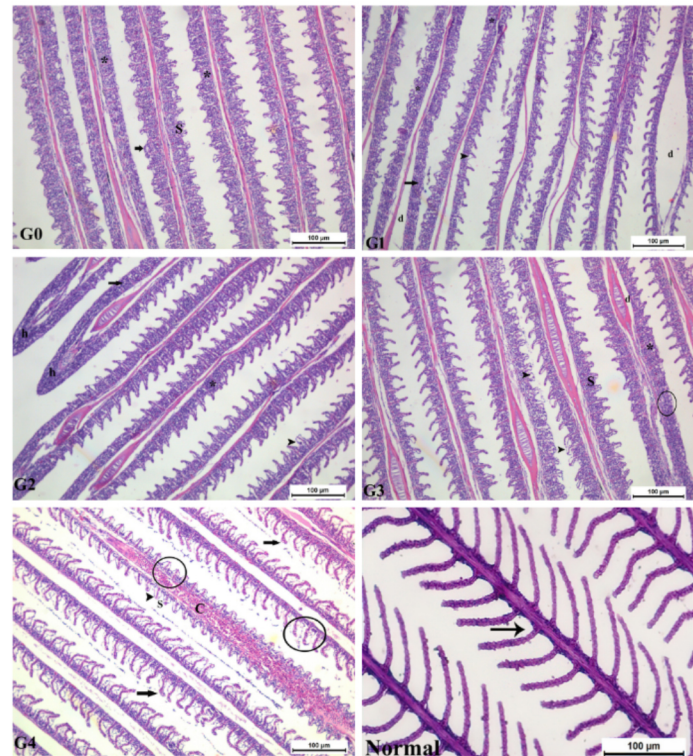


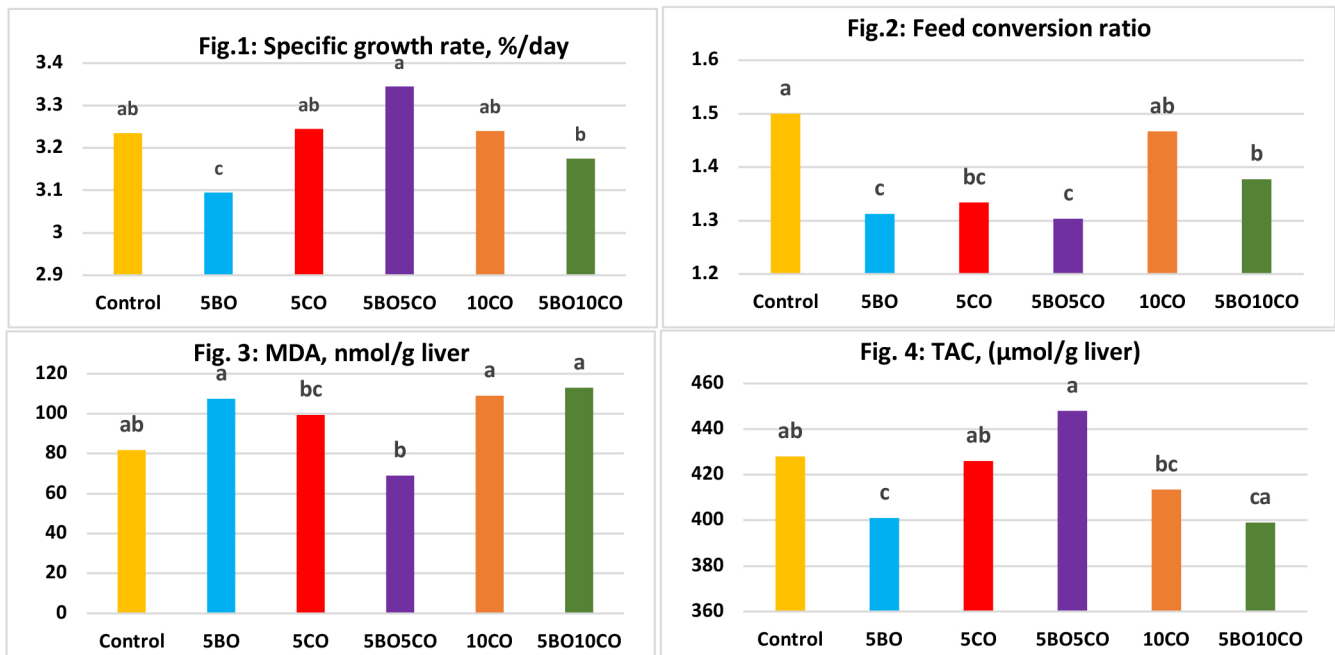
FIG. 1. Histopathological examinations in the gill tissues of *Tilapia zilli* after exposing lavender oil as a pre-deep anesthetic and bicarbonate sodium as a sedative during 4 hr the transporting period.

IMPACT OF DIETARY ESSENTIAL OILS OF CORIANDER (*Corriandrum sativum*) AND BASIL (*Ocimum basilicum*) ON GROWTH, DIGESTIVE ENZYMES, ANTIOXIDANT ACTIVITY AND BODY COMPOSITION OF FINGERLING NILE TILAPIA (*Oreochromis niloticus*)

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Essential oils are known to contain powerful antioxidants such as flavonoids and phenolic compounds. In addition to its content of minerals and vitamins, all of which are important for the function of the immune system and the health of fish in general. As a result, their application as feed additives is crucial in intensive systems and under stressful conditions. A 42-day feeding trial was carried out to evaluate the dietary coriander and basil oils on growth performance, digestibility, and antioxidant activities of Nile tilapia *Oreochromis niloticus* fingerlings. The experimental protocol included 6 experimental groups:- 1-Control: fish fed a basal diet; 2- 5BO: fish fed the basal diet containing 0.5% basil oil; 3- 5CO: fish fed the basal diet containing 0.5% coriander oil; 4- 5BO5CO: fish fed dietary 0.5% basil oil and 0.5% of coriander oil; 5- 10CO: fish fed the basal diet containing 1% Coriander oil and 6- 5BO10CO: fish fed dietary 0.5% basil oil and 1% of coriander oil. 210 fingerling of Nile tilapia with an average Initial weight of 3.35 ± 0.26 were randomly divided into 12 Polyethylene cages (80 L) at a rate of 15 fish/ cage. A basal feed containing 30% crude protein was used and fish was fed at a rate of 5% of biomass twice daily. Water quality was periodically monitored and was within optimal limits for fish health. Results illustrated, that fish that fed dietary 0.5 % of coriander oil was the best in growth indices and the intestinal digestive enzyme levels. Where the growth rate of fish that were fed a diet containing 0.5% basil oil alone was the lowest compared to the other groups. On the other side, Hepatic antioxidant/ oxidant assays showed that fish fed dietary 5BO5CO had the highest total antioxidant capacity (TAC) and the lowest level of malonaldehyde (MDA). While dietary 5BO10CO had recorded the highest level of glutathione peroxidase (GSH), superoxide dismutase (SOD). Generally, dietary coriander oil at the treated doses had a positive effect on the performance and physiological status of fish either blended with basil oil or alone.



Figures 1,2,3, and 4: show some of the growth and antioxidant indicators of Nile tilapia-fed dietary essential oils for 42 days.

TILAPIA FARMING IN EGYPT, “ITS PROGRESSIVE DEVELOPMENT, CURRENT CHALLENGES AND PROSPECTS FOR FUTURE SUSTAINABLE GROWTH”

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While aquaculture has been practiced in Egypt for thousands of years, and art items dating from the beginning of recorded history contain evidence of the importance of tilapia in Egypt, modern aquaculture in Egypt is relatively new, starting during the sixties and early seventies. Consequently, from the early 1980s onwards the growth of the sector has largely been driven by the private sector, led by many of those returning from overseas training.

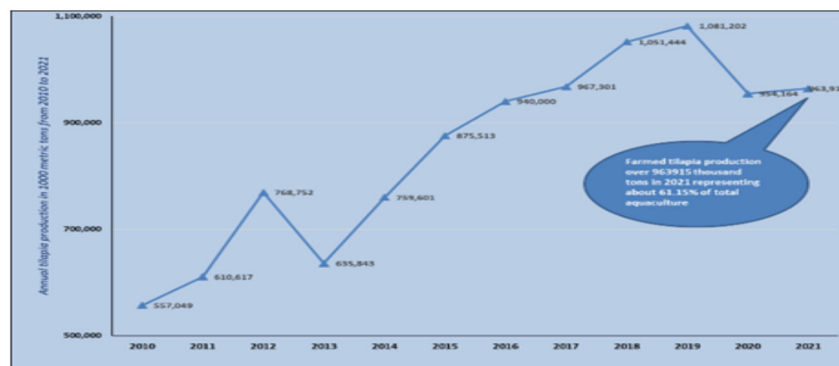
Egyptian aquaculture production coming mostly from fresh or brackish water ponds grew from 61,700 tons in 1995 to 1,576,323 tons in 2021 with an average annual growth rate of 8% and this production (GAFRD 2023).

Tilapia is the main farmed species of Egyptian aquaculture with a total production volume rising from 557,049 tons in 2010 to 1,081,202 tons in 2019 representing 66% of the total aquaculture production contributing 43% of total fish consumption in 2019 (El-Sayed and Fitzsimmons 2023).

Key developments that fostered the growth of the industry were based on strong government support, the entrepreneurial nature of the private sector in the country, the introduction of improved strains, the adoption of recent technology, the growth of the domestic feed industry, and the increasing domestic and regional demand due to the large, and ever growing, population (Macfadyen et al., 2012).

Despite its success, the Egyptian tilapia sector faces some constraints and challenges at local and international levels that threatens the sector sustainability, the sector has been impacted by climate change, conflict and the COVID-19 pandemic suggesting that effective resilience planning is needed. Production of farmed tilapia in Egypt was not severely impacted by COVID-19 pandemic, and initial impacts have been limited. Tilapia production declined by 12% from its record high level of 1,081,202 tons in 2019 to 954,164 tons in 2020. Despite post COVID economic impact, tilapia farming sector started to regain its robustness as a resilient sector and production levels increased slowly to reach 963,915 tons in 2021 (GAFRD, 2023). This quick come back of the tilapia farming sector in Egypt can be noticed from looking at the sector progress over the last decade as illustrated in the figure below, and this is an indicator of the sector’s resilience and ability to absorb shocks and overcome serious hurdles. All of these, suggest that there is a real need to understand the challenges and limitations that can impact (influence) the performance of the sector and its sustainability in order to find means and ways for overcoming these issues and maintaining the sector robustness and ability to absorb these shocks.

Figure 1: Annual tilapia production in 1000 metric tons from 2010 to 2021



FEATURED CLIMATE CHANGE SIGNS IN THE SOUTHERN LEVANTINE BASIN

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Climate change refers to significant and lasting changes in the Earth's climate patterns over extended periods of at least 10 years, and preferred +30 years. These changes can be attributed to natural processes, such as volcanic eruptions and variations in solar radiation, or anthropogenic activities, such as burning fossil fuels and deforestation. Key aspects of change include global warming, extreme weather events, sea level rise (SLR), ocean acidification and ecosystem changes. These changes impact natural and human systems, affecting agriculture, water resources, meteorological parameters, health, biodiversity, fisheries and aquaculture.

The Levantine Sea is a prominent eastern Mediterranean sub-sea. It is surrounded to the north by the Cretan Archipelago and Asia Minor, to the east by the Middle East, and to the south by northern Africa. The Egyptian Mediterranean Coast borders the southern Levantine Basin, spanning from Rafah (east) to Sallum (west) along longitudes 24° to 35°E.

This talk highlights prominent signs of climate change along the southern border of the Levantine Basin. It summarises results from previous studies conducted in the area over different time spans and targeting various parameters.

Over 71 years (1948-2018), a consistent warming trend has been found for the analysed sea surface temperature (SST) data series, with a rate of 0.04°C per a, i.e., 0.4°C per decade. From 1975 to 1991, the mean annual SST was 17.1°C, and this increased to be 19.2°C over the period 2002–2018. Fluctuations in interannual SST and anomalies appear particularly in the southern Levantine SST from June to September.

The analysis of air temperature variations over one decade (2007-2016) revealed an overall positive trend for air temperature values in the Southern Levantine basin with a rate of increase of +0.56°C/decade. This value is in good agreement with the rates calculated for the Northern Hemisphere (+0.44°C/decade) and Europe (+0.50°C/decade) according to NOAA (2017). While the year 2010 had the highest mean annual air temperature at all of the recording stations, 2011 was the coldest year, with the lowest mean annual air temperature values.

The southern border of the Levantine Basin received a total amount of 8193.61 mm of rainfall over the period 2009-2020 (12 years), with a precipitation rate of 2.28 mm/rainy day. The indices of seasonal variations and precipitation concentration showed that rainfall variability along the southern border of the Levantine Basin is highly seasonal.

Over 46 years (1963-2008), the correlation between long-term variations in air temperature and hydrographic parameters (SST and sea surface salinity) and the total catch within the southern Levantine Basin (16 different species) revealed a special impact for the variation in the sea surface salinity on the catch (+0.51). The correlation factor between the total catch and the SST was 0.31, and with the air temperature was +0.29.

AQUACULTURE FEED AND FEEDING MANAGEMENT CHALLENGES IN THE FACE OF CLIMATE CHANGE- ARE WE READY?

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Climate change is “long-term shifts in temperatures and weather patterns”. These shifts may be natural, or a result of human activities, which have been the main driver of climate change, for many decades. These activities produce heat-trapping gases, leading to global warming. Climate change brings cumulative impacts on environmental issues, including aquaculture activities.

The expected major impacts of climate change on aquaculture include direct impacts, indirect impacts, and uncertainty and inaccessibility of food/feed input supplies. Direct impacts affect the behavioral and physiological functions and the nutritional requirements and feed metabolism of framed aquatic animals. Indirect effects on the surrounding environments, include alteration of wind and water circulation, affecting the water’s primary and secondary productivity, changing the structure of the ecosystems, affecting the production and prices of landing crops and input supplies, and posing socio-economic impacts, which can indirectly affect aquaculture practices. Concerning uncertainty and inaccessibility of food/feed input supplies, fish meal (FM) and fish oil (FO) have traditionally been used as major nutritional inputs in aquaculture. However, the supply of FM and FO has been declining in recent years, due to the decline in forage fish landings. Consequently, the competition for FM and FO with human consumption is increasing. As a result, the use of FM and FO in fish feeds has dramatically decreased and will continue to decline, while the dependence on plant proteins and oil sources in aquafeeds has been accelerating. However, land plant crops are also affected by climate change. Climate change, including snow melt, rainfall variability, the availability of irrigation, droughts and floods, soil erosion, and the decline in arable areas will impact land crops.

The following interventions have been suggested to tackle these impacts and ensure aquaculture sustainability: a) searching for novel alternatives; b) production of renewable, nutritional resources; and c) on-farm feeding and feed management. Insect and worm meals (such as black soldier fly (BSF), housefly, blowfly, and mealworm beetle), micro and macro algae, single-cell proteins, and aquatic macrophytes have great potential as alternative aquafeed ingredients. The production of renewable, nutritional resources through recycling renewable biological resources can also be value-added, sustainable aquaculture inputs. The best on-farm feeding and feed management practices (BMP) can also reduce feed consumption and cost, improve feed utilization and fish yield, and reduce environmental impacts. Strategic planning, investment, and concrete-building measures should also be adopted to reduce greenhouse gas (GHG) emissions and aquaculture’s vulnerability to climate change.

DEVELOPING A SMART FISH SMOKING TECHNOLOGY FOR CATFISH AQUACULTURE IN THE NIGER DELTA, NIGERIA

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Directed by Professor Michael F Tlusty

Fish, particularly catfish, plays a vital role in the Nigerian diet, and the aquaculture industry is expanding to meet the increasing demand (FAO, 2017b; Ozigbo, et al., 2014). Smoking fish is a primary preservation method without cold storage facilities, offering extended shelf life, enhanced flavor, reduced waste, and increased protein availability. However, traditional smoking practices pose both sustainability challenges and health hazards. This study aims to develop a new catfish processing smoking technology in the Niger Delta, offering a safer, faster, and more user-friendly alternative. The technology eliminates polycyclic aromatic hydrocarbon (PAH) residues, enhances product safety and quality, increases profitability for processors, improves working conditions (especially for women), reduces environmental damage, and contributes to sustainable development goals. Extensive stakeholder engagement, including interviews with fish farmers, processors, policymakers, and consumers, provided insights into the limitations of traditional methods and expectations for the new hybrid technology. The development of the new technology incorporated solar and biomass components to reduce pollution, health risks, and drying time. Laboratory testing confirmed compliance with EU safety standards for samples 1,2, and 3 produced using the new technology. Product evaluation indicated a clear preference for a specific (45 minutes) smoking duration, highlighting market-leading potential. Despite initial higher costs, the hybrid wood/solar smoker offers long-term cost-effectiveness, sustainability, and market competitiveness. Recommendations include collaboration among stakeholders, training programs, and policy support. Implementing these recommendations can lead to a safer, more sustainable, and culturally significant fish smoking technology in Nigeria.

DIETARY EFFECT OF PLANT BASED ADDITIVE PHYTO AQUANITY™ ON GROWTH PERFORMANCE AND HEALTH PARAMETERS IN FIELD – REARED NILE TILAPIA (*Oreochromis niloticus*)

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This study was performed to assess the effects of natural plant-based additive in juvenile of Nile tilapia (*Oreochromis niloticus*) reared in in-pond hapas under field conditions. The fish (73 g) were stocked in 2-m³ hapas, in triplicates, at a density of 20 fish m⁻³ (40 fish hapa⁻¹). 2 isonitrogenous (30% CP), isoenergetic (17MJ kg⁻¹) extruded commercial tilapia diets were tested at 0 (control) and 0.50 g of the botanical blend (Phyto AquaNity™, PAN) kg⁻¹ diet. The diets were fed to the fish at a daily rate of 2-3% of their body weight (BW), twice a day over 80 days. The growth performance and tissue composition were not significantly affected by dietary treatments. However, feed efficiency was significantly improved in fish fed PAN-based diet. Immune and antioxidant responses were enhanced with supplemental PAN. Furthermore, digestive and hepatic enzyme activities were improved as well. The activities of lysozyme, alternative complement, phagocytic cells, phenoloxidase, superoxide dismutase, glutathione peroxidase, and catalase were all significantly increased (P<0.05), while malondialdehyde decreased, in the supplemental PAN group. The length of the intestinal folds and the number of goblet cell counts also significantly increased in fish fed PAN. Overall, Phyto AquaNity improves feed efficacy, immune and antioxidant parameters. This natural additive is suggested to be included in tilapia feed to support the optimum feed efficiency and health of Nile tilapia.

Table 1. Effect of dietary PAN on growth and feed utilization (mean ± SE; n = 3) in Nile tilapia fed the test diets. Values in the same row with different superscripts are significantly different (P<0.05).

Parameter	PAN0 (C)	PAN0.5
IW (g fish ⁻¹)	74.86±1.27	73.59±1.10
Final weight (g fish ⁻¹)	186.10±2.29	190.72±4.09
Weight gain (g fish ⁻¹)	111.24±3.27	117.13±5.21
PG (%)	148.68±6.17	159.11±3.14
SGR (% day ⁻¹)	1.15± 0.02	1.19± 0.02
FI (g fish ⁻¹)	161.76±3.51 ^a	143.05±2.35 ^b
FCR	1.46± 0.03 ^a	1.24±0.03 ^b
PER	2.25±0.05 ^a	2.69±0.08 ^b

IW : Initial weight; FW : Final weight; WG: Weight Gain; PG : Percentage Gain; FI : Feed Intake; FCR : Feed Conversion ratio; PER : Protein Efficiency ratio.

Table 7. Effect of PAN on immune response and antioxidant capacity (mean ± SE; n = 3) of Nile tilapia fed the test diets. Values in the same row with different superscripts are significantly different (P<0.05).

Parameter	Control	PAN
PA (µM ml ⁻¹)	1.22±0.04 ^a	1.47±0.09 ^b
PO (mU ml ⁻¹)	98.63±2.13 ^a	111.0±2.27 ^b
ACH50 (ng ml ⁻¹)	44.16±2.62 ^a	56.58±2.49 ^b
LSZ (ng ml ⁻¹)	82.57±0.55 ^a	101.3± 2.76 ^b
SOD (mU ml ⁻¹)	29.93±2.06 ^a	39.64±1.41 ^b
MDA (mU ml ⁻¹)	23.41±2.51 ^a	14.14±1.07 ^b
GPx (mU ml ⁻¹)	3.47±0.12 ^a	4.51±0.07 ^b
Catalase	447.57±12.4 ^a	530.90±8.6 ^b

PA, phagocytic activity; PO, phenoloxidase activity; LSZ, Lysozyme; ACH50, alternative complement activity; SOD, superoxide dismutase; MDA, Malondialdehyde; GPx, glutathione peroxidase

INNOVATIVE RENEWABLE ENERGY SOLUTIONS FOR A RESILIENT AQUACULTURE VALUE CHAIN IN EGYPT

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Aquaculture in Egypt is crucial for food security and income generation, but the sector faces significant challenges such as limited resources and adverse climate changes. On the other hand, a growing market demand due to population increase adds pressure on the industry. The use of renewable energy in the aquaculture value chain is an innovative approach to overcoming these challenges and increasing yield in a sustainable manner. The Center of Renewable Energy in Aquaculture project is a groundbreaking collaborative initiative funded by the Royal Norwegian Embassy in Cairo and implemented by WorldFish. It aims to enhance aquaculture practices in Egypt and broader Africa by harnessing cutting-edge renewable energy technologies to support economic growth, address protein needs, and enhance environmental sustainability and climate resilience within the aquaculture value chain.

The primary goal of the project is to refine, test, and scale innovative renewable energy solutions that enable fish producers, processors, and other fish value chain actors in Egypt to increase their productivity and incomes. This, in turn, leads to improved food and nutrition security, reduced food waste and loss, and more energy-efficient and climate-smart aquaculture value chains.

The proposed intervention compromise three main components: studying and surveying to identify key challenges and explore the potential for integrating renewable energy solutions; piloting innovative renewable energy interventions, six cutting-edge technologies selected and matched with proposed beneficiaries across the aquaculture value chain; and scaling; dedicated to scaling up successful pilot interventions across the aquaculture sector.

The findings from the comprehensive baseline study provide critical insights into the energy dynamics of tilapia farming. Of the surveyed farms, only 36% have access to grid electricity, and just 6.5% of farmers have experimented with renewable energy solutions. Fish feed emerged as the largest contributor to greenhouse gas (GHG) emissions in tilapia farming systems, responsible for approximately 65% to 68% of the total environmental impact. Furthermore, on-farm energy use accounted for 19% to 25% of overall GHG emissions. A significant reduction up to 23% in on-farm energy-related GHG emissions could be achieved by totally transitioning from diesel fuel to renewable energy sources.

The project engaged the stakeholders across the aquaculture value chain, including hatcheries, fish farms, post-harvest processing, and wholesale markets. We engaged with stakeholders at every level to ensure a comprehensive and inclusive approach in the adoption of renewable energy technologies.

The CeREA project represents a significant step toward a more sustainable and resilient aquaculture sector in Egypt and Africa. It is expected to unlock the full potential of aquaculture to contribute to economic development, food security, and environmental sustainability.

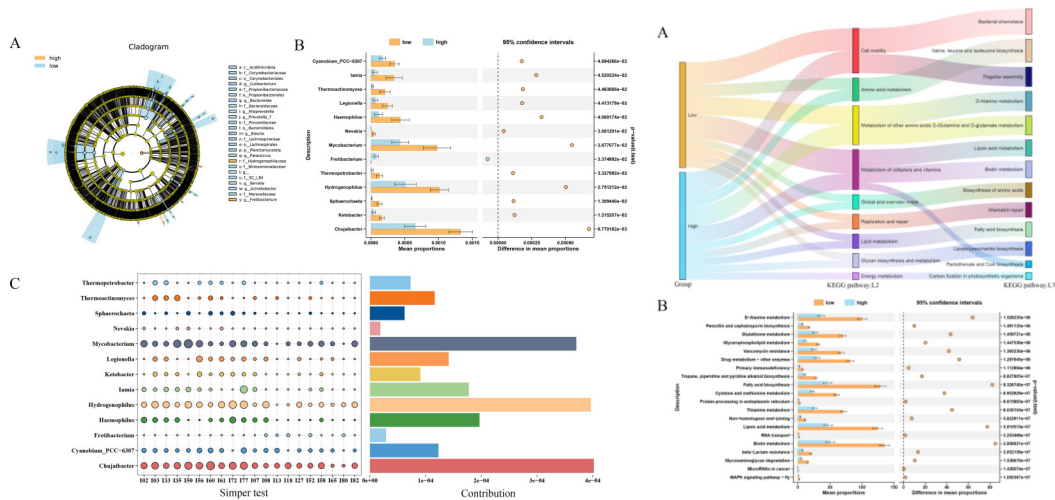
MICROBIOME REVEALS THE LINKAGE BETWEEN GUT MICROBIOTA AND COMMON CARP (*Cyprinus carpio*) GROWTH

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Gut microbiota are increasingly recognized for their crucial role in regulating the health and growth of the host. The mechanism by which the gut microbiome affects the growth rate of common carp, however, remains unclear. In this study, the gut contents of the fast-growing and slow-growing (High and Low) carp were collected for the fish gut microbiome. High throughput 16S rRNA gene sequencing showed that the overall gut microbiota of High group was distinct from that of Low group. For example, the *Cetobacterium* were highly enriched in the guts of High group (39.9%), *vibrio* is highly enriched in the gut microbiota of the Low group (20.0%). LEfSe analysis identified 13 different flora between the two groups, mainly located in 17 KEGG pathways, of which nearly 50% were involved in lipid, vitamin, and amino acid metabolism.

Compared with the Low group, the gut microbiota in the High group significantly enriched the pathways involved in Energy metabolism and Biosynthesis of other secondary metabolites. These metabolic pathways enrich some bioactive substances such as diarylheptane and gingerol, which can have a significant impact on the growth rate of carp. This study can not only elucidate the dynamic changes of gut microbiota of carp with different growth rates, but also help us to screen significant flora that affect growth rate and promote the development of microbiome technologies in aquaculture.



DISTRIBUTION OF HOTSPOT ZONES OF DINOCYST ABUNDANCE IN SURFACE SEDIMENTS OF COASTAL LAGOON IN THE WESTERN MEDITERRANEAN SEA

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Species composition and abundance of dinocysts in relation to environmental factors were studied at 123 stations of surface sediment in the Bizerte Lagoon. Forty eight dinocyst types were identified, mainly dominated by *Brigantidinium simplex*, *Votadinum spinosum*, *Alexandrium pseudogonyaulax*, *Alexandrium pacificum*, and *Lingulodinium machaerophorum* along with many round brown cysts and spiny round brown cysts. Cyst ranged from 1276 to 20126 cysts g⁻¹ dry weight sediment. Significant difference in cyst distribution pattern was recorded among the zones, with the higher cyst abundance occurring in the inner parts of the lagoon near shellfish aquaculture farms. Redundancy analyses showed two distinct associations of dinocysts according to locations and environmental variables. Ballast water discharges are potential introducers of non-indigenous species, especially the harmful ones namely *A. pacificum* and *P. zoharyi*, and currents play a pivotal role in cyst distribution. Findings concerning harmful cyst species indicate potential seedbeds for initiation of future blooms and outbreaks of potentially toxic species in Bizerte Lagoon.

STATUS OF SEAWEED AQUACULTURE VALUE CHAINS IN AFRICA

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Seaweed value chains are increasingly being appreciated as a way of sustaining the seaweed industry worldwide especially since people are becoming more aware of seaweed as food and source of income. Africa's seaweed value chain has been changing over the years starting as early as the 1930's with harvesting and exporting all the harvested seaweed, through the late 1980's when Africa started cultivating seaweed to mid the 2000s when Africa started to add value to its seaweed. Several actors along the value chain are involved including farmers, processors, exporters, users, funding agents and other stakeholders.

In the 1930's Africa harvested mostly eucheumatoids and exported to Europe and other destinations. In late 1980's Africa started to cultivate *Eucheuma* (Spinosum) and *Kappaphycus* (Cottonii) whose market was purely for export. Africa was also farming *Ulva* as food for shellfish (abalone). Africa has increasingly seen the importance of its seaweed value chain and has engaged in processing seaweed. So, while the beginning of the Africa's seaweed value chain was dominated by harvest and export involving harvesters and traders, slowly the value chain changed to existing and emerging value chains incorporating farming/ harvesting, processing, utilisation, and export involving farmers/harvesters, processors (small-scale farmers and large-scale processing factories), exporters and traders of seaweed and seaweed products within Africa as well as outside Africa. In recent years, Africa has seen emerging entrepreneurs including youths. This presentation will show the journey of the African seaweed value chain from early years (1930's) to present (2024).

KNOWLEDGE TRANSFER, TECHNOLOGY AND INNOVATION: A CASE STUDY FROM THE KINGDOM OF LESOTHO

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Lesotho is a small (30 355 km²) landlocked country with a water area of only ± 80 km². Prior to the construction of a series of reservoirs in the country's Highlands region under the Lesotho Highlands Water Project (LHWP), there were no commercial aquaculture activities in the country. Recognising the natural strategic advantage for salmonid farming offered by the new LHWP reservoirs, a successful rainbow trout aquaculture industry was established as a result of private sector driven interventions. This included the development of Highlands Trout, a 2 000 tonne per annum, vertically integrated (hatchery to processing and distribution) commercial rainbow trout (*Oncorhynchus mykiss*) farm at Katse Dam between 2010 and 2016 (Figure 1).

Critical elements of the project included knowledge transfer and innovation in technology. International experts in salmonid farming were involved from the initiation of the project, in scoping and feasibility assessments, business planning and systems design, training of local employees to build a technical skills base for aquaculture business development and operations, and initial operations management. Moreover, the repurposing of existing infrastructure and adaptation of available technologies to the remote Lesotho Highlands were prioritised.

These factors contributed to a successful project. As a result of the high quality of Highlands Trout's production, Lesotho trout was positioned in discerning international markets, including directly into retail outlets in Japan.



FIGURE 1: From left to right: Highlands Trout's hatchery, grow-out cages and processing facility at Katse Dam, Lesotho.

INVESTIGATING NEW AQUACULTURE SPECIES IN BENIN: MORPHOMETRIC CHARACTERIZATION OF THREE STRAINS OF TILAPIA *Sarotherodon galilaeus* ((LINNAEUS, 1758)

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This study was carried out to determine the morphological variation and the condition factor of an aquaculture candidate tilapia species *Sarotherodon galilaeus* strains. from. For that purpose, fish samples of the species were collected from traditional fisheries in Ahozon, Hlan and Togbadji lakes, Southern Benin. Twenty-four morphometric traits were measured and the data was used to perform a Principal Component Analysis (PCA) to determine the relationship between the three populations of *S. galilaeus*.

The results show that the mean values of the total length (TL) of the fish ranged from 9.82cm (Ahozon Lake) to 17.98cm (Togbadji Lake) and the weight was 30.18g, 46.28g and 195.45g respectively in Ahozon, Hlan and Togbadji Lakes.

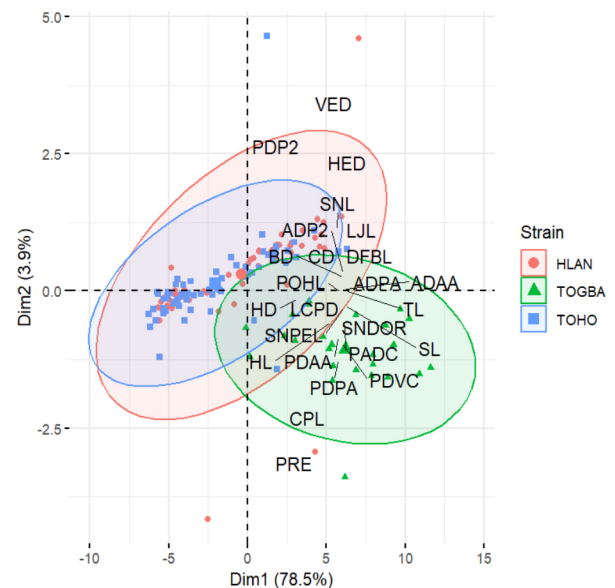
The condition factors varied from 2.34 (Hlan lake) to 2.97 (Togbadji lake), showing that fish from Lake Togbadji have bigger size and better condition. The analysis of variance showed significant differences between the mean values of Total Length (TL), Standard Length (SL), Head Length (HL), Body Depth (BD) and Dorsal Fin Base Length (DFBL) from Lake Togbadji.

Length-weight relationships showed an allometric growth of *S. galilaeus* populations from the three lakes with the allometry coefficient “b” values ranging from 2.92 to 3.55. The PCA revealed an overlap among *S. galilaeus* individuals from Ahozon and Hlan Lakes, discriminating the population from Togbadji Lake.

This suggests that *S. galilaeus* populations from Lake Togbadji are a separate strain with specific characteristics. Further investigations on genetic variability could help to understand the genetic diversity of the three strains in order to establish a breeding program for the for the species in Benin.

Table 1: Total Length (TL) and Weight (W) of *S. galilaeus* from Ahozon, Hlan and Togbadji Lakes

Lake	Total Length (cm)		Weight (g)	
	Mean	St. Dev	Mean	St. Dev
Ahozon	9.82	2.86	30.18	31.65
HLAN	11.70	3.50	46.28	35.01
Togbadji	17.98a	3.20	195.45a	108.22



AN OVERVIEW OF LOCAL ALTERNATIVE INGREDIENTS, AQUAFEED SUPPLY AND FEEDING MANAGEMENT IN SELECTED AFRICAN COUNTRIES

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Aquaculture plays a crucial role in enhancing food security in Africa and holds significant potential for becoming more effective and sustainable. However, the region's fed aquaculture sector faces challenges in accessing or developing the capacity to produce high-quality aquafeeds. According to the FAO Guidelines for Sustainable Aquaculture (GSA), key recommendations on aquafeed include diversifying ingredient sources, developing feed formulations and processing capacities, and improving on-farm feed and feeding management practices for greater efficiency. To better understand the current situation in Africa, the FAO, in collaboration with WorldFish, organized the "Expert Workshop on Local Alternative Ingredients, Aquafeed Supply, and Feeding Management" in Egypt in 2023. This workshop brought together experts from nine African countries - Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria, Uganda, the United Republic of Tanzania, and Zambia - to discuss local alternative ingredients, aquafeed supply, and feeding management in the region. The workshop also included participation from governmental agencies, universities, development organizations, private industry, and farmers from the region.

A pre-workshop questionnaire was used by experts to collect information on feed ingredient suppliers, feed manufacturers and current feeding management practices in order to gain a better understanding of the situation in the respective countries and to identify opportunities for future improvements. The analysis of the nine country reports, along with the discussions held during the workshop identified several key issues: i) limited access to information on alternative feed ingredients, both in terms of availability and accessibility; ii) poor feed preparation, processing, handling, and storage at the farm level; iii) inadequate monitoring of on-farm feeding and farm performances; iv) insufficient investment and operating capital for small-scale feed producers and farmers; v) limited knowledge and skills among farmers and extension workers on improved farm-made feed production, feeding management, and farm performances; vi) poor feed quality and inconsistent availability; and vii) a lack of appropriate legal and policy frameworks necessary for sustainable aquaculture development, including the regulation of quality aquafeed manufacturing. The workshop recommended establishing a regional collaborative program to enhance the technical capacity of small- and medium-scale feed producers and provide farmers with necessary technical support to improve nutrition, feeding management, and overall productive performance, thereby increasing the efficiency of aquaculture production.

INTEGRATING AQUACULTURE INTO NATIONAL CLIMATE STRATEGIES – MITIGATION POLICY OPTIONS

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Aquatic foods are an important part of global food systems being increasingly recognized as a priority for climate action, yet they are often overlooked in climate discussions and underfunded in mitigation and adaptation financing. In 2022, aquaculture production surpassed capture fisheries in aquatic animal production for the first time. As aquaculture expands, strategic planning and investment are essential to reduce aquaculture’s vulnerability to climate change as well as controlling greenhouse gases (GHG) emissions. Addressing climate impacts on aquaculture and leveraging their potential for climate action requires their integration into national climate strategies. Climate decision-makers have an opportunity to use growing momentum and insights into aquaculture to develop concrete policy strategies that can support the sector in the face of climate change. FAO, in collaboration with Stanford Center for Ocean Solutions, WorldFish, Beijer Institute of Ecological Economics, CARE, and Environmental Defense Fund, published “Integrating blue foods into national climate strategies: Enhancing nationally determined contributions and strengthening climate action”. The document outlines policy options organized into five intervention areas, including aquaculture.

Generally, the aquaculture sector has lower GHG emission than other livestock food systems. Among aquaculture systems, there is a considerable variation in GHG emissions considering the different farming practices and geographic regions, as well as farmed species. Sustainable aquaculture management offers significant potential for reducing GHG emissions in existing systems. Integrated multi-trophic aquaculture systems, which cultivate species like sea cucumbers alongside finfish, can enhance resource efficiency and contribute to carbon sequestration. Targeted investments in sustainable and aquaculture with lower carbon footprint can support low-emission development strategies, addressing both poverty and food and nutrition insecurity.

Policymakers, alongside researchers, communities and stakeholders, can prioritize mitigation measures in three key actions. First, improving aquaculture feed and feeding management. Second, transitioning energy inputs to renewable ones and reducing energy use, and third, promoting the expansion of low-input, non-fed aquaculture and integrated systems. Policymakers can adapt these policy options to Nationally Determined Contributions as well as consider their relevance in other areas of climate planning, including water and waste management, nutrition, and economic development.

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INTROGRESSIVE HYBRIDIZATION LEVELS AMONG TILAPIINES DRIVEN BY TRANSLOCATIONS ACROSS AFRICA

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The taxonomical complexities consistently challenge the continued use of the Tilapia as an aquaculture candidate. These complexities have been fueled by fish translocations leading to hybridization and admixture which complicate taxonomy and sound units for management and sustainability. Amidst these challenges, less information is available that is useful to fully understand the African Tilapiines at the continental level. This study characterized 10 tilapiine species collected from different water bodies in Africa, using microsatellites and mitochondrial markers. Three and two lineages of *Oreochromis niloticus* and *Oreochromis esculentus* respectively are defined. Among the 50 populations, comparisons among the East African water bodies showed extremely lower genetic differentiation. For example, Kyoga and Victoria (0.03), and Mulehe and Kayumbu (0.19). Multivariate analysis like principal coordinate analysis (PCoA) showed higher levels of admixtures between the natural and translocated populations. The high level of introgression was recorded between *Oreochromis machrochir* and *Oreochromis mweruensis*. These results provide valuable insights for biodiversity conservation, fisheries management, and the development of genetically sustainable Tilapia breeding programs, ensuring the long-term viability of these species in their natural habitats and aquaculture settings.

LEVERAGING IMAGE SEGMENTATION MODELS: APPLICATION OF THE SEGMENT ANYTHING MODEL (SAM) IN FISH BEHAVIOUR RESEARCH IN RAS

IH. Chen¹, N. Belbachir¹, L. Ebbesson¹, N. Gharbi^{1*}, D. Izquierdo Gomez², L.E. Solberg², J. Kolarevic^{2,3}, S. K. Kumaran², G.N. Helberg² and C. Noble²

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Introduction

Monitoring fish behavior without constant human supervision can lead to improvements on feeding schedules, but also post-analysis of stress events. We therefore present an algorithmic pipeline to leverage the SAM¹ model to cut out fish segmentations without the need for costly fish annotations. We also realized the downstream tasks of calculating orientation angles and identifying fish that do not swim in similar orientations as their close conspecifics.

Materials and methods

A top camera with a video resolution of 1080p @ 30fps was installed above each octagon-like tank (6 tanks, volume of 3.3m³ each). A total of 1000 Atlantic salmon were in each tank with a weight of 40 grams \pm 10 grams. Using segmentation masks from SAM¹ we calculated the orientation of detected fish in video frames. Then we determine if those fish are swimming coherently with its peers by filtering out fish in each k-mean cluster (which used the spatial coordinates of fish) that fell out of the interval with the median absolute distance around the circular median angle of the cluster, respectively. Aggregating the results gave rise to abnormalities scores.

Results and Discussion

We were able to show that both feeding and panic avoidance could be measured with these three metrics. We also showed that panic avoidance has a stronger spike/fall, meaning the intensity of reaction and the increase/decrease in our metrics was proportional. Further work is needed to differentiate between different behavioral patterns that could occlude results. Additionally, the detection count could be increased in the future to reflect the tank behavior more reliably. Overall, the presented methodology tries to push towards easily accessible and interpretable readings for facility personnel.

Acknowledgments

This work was funded by the Norwegian Research Council, Project number 320717 and 32330.

Kirillov et al. Segment Anything. arXiv:2304.02643, 2023.

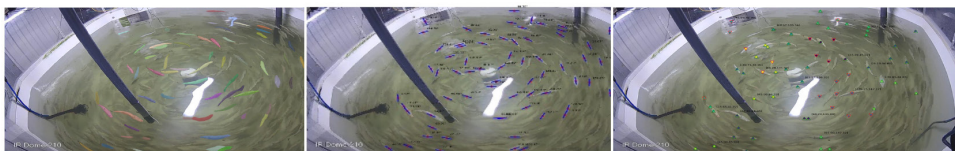


Figure 1 The algorithmic pipeline from left to right: Segmentation masks (left) are used to calculate orientation angles (middle) which then are used for analysis whether fish are swimming in similar orientations as conspecifics that are nearby (fish in the same cluster have the same dot color. A red triangle indicates that the fish individual is swimming with different orientation than its close peers, a green triangle indicates similar swimming orientation).

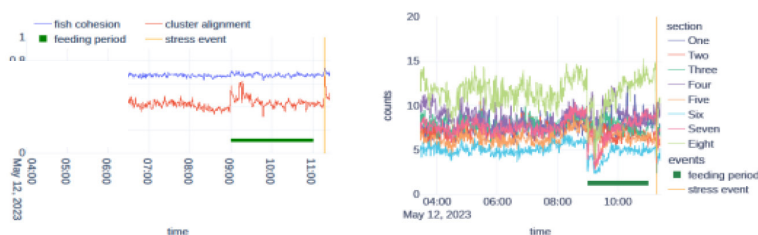


Figure 2. Fish cohesion and cluster alignment as abnormality scores (left) and the detection counts by tank section (right). The green horizontal line indicates the feeding period, and the vertical orange line the stress event at 11:17.

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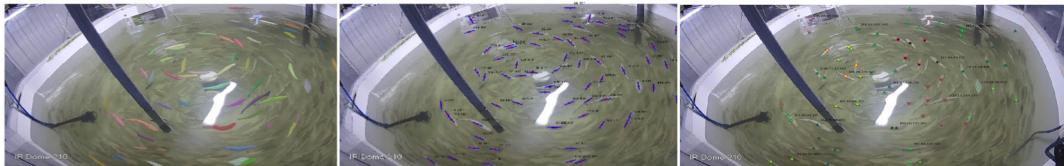


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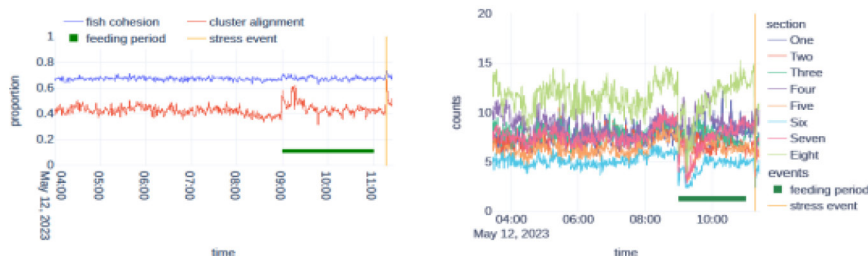


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INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)-AQUAPONICS SYSTEM BASED ON INTERNET OF THINGS (IOT)

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As the global population expands, humanity will need to find ways to produce a large scale of food in a sustainable manner. Integrated Agriculture-Aquaculture Systems (IAAS) have the potential to produce large amounts of food in a smaller area compared to traditional agriculture. The current study introduces a Smart Integrated Multi-Trophic Aquaculture (IMTA) aquaponics system, which includes a low-cost real-time water quality monitoring system, developed through the Internet of Things (IoT). The primary aim of this study is equipping the Mediterranean horticulture community with innovative tools for efficient greenhouse cultivation-year-round. It focuses on enhancing resource efficiency in greenhouses, especially by employing aquaponics methods where water nutrient-rich is transferred from aquaculture to a hydroponics unit. This approach promotes the production of a variety of aquatic animals and plant crops while reducing overall water and nutrient waste and optimizing their utilization. Enhancing fish and plant production while considerably reducing water consumption is critical for Egypt and Mediterranean countries to cope with the anticipated impacts of climate change, as well as land and water scarcity. This work is a part of the PRIMA, Programme supported by the European Union's Horizon 2020 research and innovation programme. Project Title `` Towards circular horticulture: closing the loop on Mediterranean greenhouses``. Grant Agreement Identification Number (1915).

CRYOPRESERVATION OF AFRICAN CATFISH *Clarias gariepinus* SPERM USING A STATIC LIQUID NITROGEN VAPOUR VITRIFICATION METHOD WITH TREHALOSE AND DIMETHYL SULFOXIDE AS CRYOPROTECTIVES

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Captive breeding of *Clarias gariepinus* entails stripping of mature females, while males must be killed - or testes partially excised - to obtain spermatozoa. Sperm cryopreservation could significantly improve the reproductive potential of male catfish. In this study, Ginzburg Fish Ringer (GFR) was the common extender in all protocols with or without 0.3M trehalose. Dimethyl sulfoxide (DMSO) and methanol were tested to determine the preferred equilibration period for the complex before cryofreezing. The cryopreservation method and sperm fertilisation capacity were assessed in terms of hatchability rate. A feasible semen rationing protocol for maximised fertilisation was also evaluated. A customised freezing chamber was constructed to induce vitrification of the sperm with static liquid nitrogen (LN₂) vapour. LN₂ vapour-induced freezing rates ranged from -2.7 to -5°C.min⁻¹, and cryovials/straws were immersed in the LN₂ when -41°C was reached. Straws significantly outperformed cryovials in cryopreservation efficacy. Optimal fertilisation occurred with trehalose and DMSO-treated cryostored sperm, comparable to fresh semen. 0.05mL diluted semen was required to fertilise 35g eggs, compared with a similar volume efficacy for undiluted sperm. The inclusion of trehalose enhanced fertilisation for both fresh and thawed DMSO-treated sperm. All methods produced healthy larvae to 21 days post-hatch. The validated method can yield 60 straws (0.5mL) from 3mL semen, fertilising approximately 2.1kg eggs (~ 162 × 10⁴ eggs). The LN₂ vapour vitrification method was shown to be as effective as - and more cost-efficient - than controlled rate freezing equipment.

Trial no.	Sample Identity	Larvae hatching rate (%) ¹		Sperm motility (%) ²
		Higher semen:egg ratio (0.05 mL:35 g)	Lower semen:egg ratio (0.05 mL:75 g)	
	Fresh sperm mixed with:			
	GFR (control 1)	82.6 ± 1.10	62.6 ± 2.6	> 80
	GFR + trehalose (control 2)	92.8 ± 1.17	73.4 ± 2.2	> 90
	Thawed sperm-cryoprotective complex			
1	GFR + DMSO vial	51.9 ± 2.10	33.4 ± 2.9	~ 50
	GFR + DMSO straw	82.4 ± 1.60	62.2 ± 1.9	> 80
2	GFR + 0.3 M trehalose + DMSO vial	62.4 ± 1.80	41.8 ± 1.9	~ 60
	GFR+ 0.3 M trehalose + DMSO straw	92.6 ± 1.20	72.6 ± 1.4	> 90
3	GFR+ methanol vial	30.3 ± 2.80	10.7 ± 3.4	< 30
	GFR+ methanol straw	61.6 ± 1.30	40.8 ± 2.6	~ 60
4	GFR+ 0.3M trehalose + methanol vial	40.7 ± 3.20	21.2 ± 3.6	~ 40
	GFR+ 0.3M trehalose + methanol straw	72.3 ± 1.70	52.6 ± 2.7	~ 70
¹ Subjective evaluation of post-thawed sperm motility (%)				
² Hatching rate (mean ± SD, n = 4) as a percentage of total eggs in contact with spermatozoa				

Table 1: Hatching rates (mean ± SD, n = 4) as a percentage of total eggs in contact with spermatozoa of trial and control groups

EMERGING FOOD SAFETY RISKS IN AFRICAN AQUACULTURE PRODUCTS

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African aquaculture is undergoing a rapid and significant expansion of production, as high prices are attracting new investment, including feed and fry businesses. African production of farmed fish in 2022 was estimated to be 2.3 million tonnes (accounting for about 2.5% of the global figure), with an estimated annual growth rate of 8% (FAO State of World Fisheries and Aquaculture, 2024). In 2000 Egypt accounted for 85% of continental production, falling to 67% in 2021, illustrating a clear trend to spatial diversification (Table 1).

Within Africa, freshwater species are emerging as the main production targets, particularly the Nile tilapia *Oreochromis tilapia* and African catfish *Clarias gariepinus*, due to their relative tolerance to adverse production conditions and presence as native species well known to the African consumer. Given that aquaculture products are playing an increasingly important role in the future supply of fish (compared to supplies from capture fisheries) the management of associated food safety risks presents new challenges.

The paper explores the most significant food safety risks associated with African aquaculture products, including pathogenic parasites and bacteria, and residues derived from feed. There is increasing concern that African consumption of freshwater aquaculture species can transmit fish-borne zoonotic trematodes (parasitic flukes, including pathogenic *Heterophyidae* spp.) and bacterial food poisoning (including Group B *Streptococcus*). Intensification of production also leads to a need for veterinary interventions (for example with antimicrobial substances, both legal and illegal), residues of which should be monitored and controlled. Feed ingredients such as fishmeal and cereals frequently contain fungal toxins, resulting in harmful residues in the final product. Little attention has been paid so far to understanding these risks, nor to their management by implementing controls during production, based on the HACCP approach. These tasks present significant challenges to aquaculture operators and regulators alike, requiring greater allocation of scientific, legal and human resources to underpin a continued sustainable development of the sector.

Table 1: African Aquaculture Production of Aquatic Animals (thousand tonnes, live weight equivalent)

Country	2000	2005	2010	2015	2020	2021	2022	Regional share 2022 (%)
Egypt	340	540	920	1,175	1,592	1,576	1,552	67.0
Nigeria	26	56	201	317	262	276	259	11.2
Ghana	5	1	10	45	64	89	133	5.7
Uganda	1	11	95	118	124	139	101	4.4
Others	28	38	64	134	225	249	271	11.7
Africa	400	646	1,289	1,788	2,266	2,328	2,317	100

Source: FAO; State of World Fisheries and Aquaculture 2024

THE ROLE OF VITELLOGENIN IN FISH REPRODUCTION - EXPERIMENTAL APPROACH IN EUROPEAN CATFISH (*Silurus glanis* L., 1758)

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Vitellogenin (Vtg) is a well-known phospholipoglycoprotein found in the blood of almost all oviparous species. It is produced in the liver and transported through the circulatory system to target organs, such as the ovaries. In female fish, VTG serves as a precursor to egg yolk proteins, accumulating in oocytes during active vitellogenesis and providing nutrients for embryo development (figure 1.). In male fish, Vtg is typically absent or present in very low levels due to lower oestrogen levels. However, studies have shown that Vtg can be induced in males and juveniles following estrogenic exposure to artificial diets or environmental xenobiotics.

In this paper, we present the pursued experimental steps to gain further insights into this key protein involved in the reproductive physiology of the European catfish, a species of economic significance in Romanian aquaculture. Therefore, *in vivo* study was specifically designed to detect and purify Vtg from juvenile European catfish following controlled administration of 17 β -estradiol (E2). The Vtg was purified by ion exchange chromatography, applying a continuous linear gradient of NaCl ranging from 0 to 300 mM at pH 7.8. The chromatographic fractions were analysed for protein concentrations and samples containing Vtg were verified by SDS-polyacrylamide gel electrophoresis in discontinuous pH regime. After electrophoresis, gels were stained with blue Coomassie, and the bands were compared to high-range molecular mass electrophoresis standards to estimate the Vtg molecular weight and obtain the basic knowledge of the biochemical properties of the *Silurus glanis*'s Vtg. The purified Vtg was utilized to develop an enzyme-linked immunosorbent assay (ELISA) to investigate further the Vtg dynamics in the blood circulation of female European catfish at various reproductive stages.

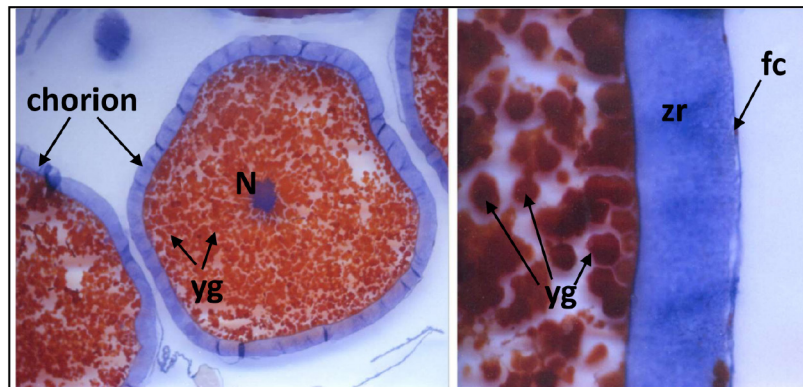


Figure 1. Light micrograph of vitellogenic oocyte in European catfish (*Silurus glanis*) with the central position of the nucleus (N), cytoplasm filled with yolk granules (yg) enclosed in a well-developed inner layer zona radiata (zr) overlain by outer follicle cells layer (fc) (Heidenhain's Azan trichrome stain, original photo).

THE INFLUENCE OF DIET ON GROWTH PERFORMANCE OF COMMON CARP (*Cyprinus carpio* L.) JUVENILES

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Although the nutritional requirements for *Cyprinus carpio* specie are acknowledged and commercial feeds are widely available, many farmers still choose to prepare their own feeds using locally sourced ingredients or purchased from local manufacturers. Properly formulated diet is essential for fish physiology, directly impacting their growth, health, immune function, reproductive success, and welfare. This study presents the results of the effect of three artificial feeds with different nutritional compositions on the growth of common carp juveniles, as part of a broader physiological investigation focused on digestive health and efficiency provided by the tested tailored diets. The research was carried out on 63 one year old juveniles of common carp with the mean size 17.42 ± 1.53 cm and weight 76.44 ± 19.77 g reared in recirculating water condition. Three artificial fish feeds marked as M, N and S with varying nutritional compositions were tested, in triplicate, for 4 weeks, and the biomass gain (BG), feed conversion ratio (FCR), specific growth rate (SGR), body weight gain (GW), average daily gain (ADG), as well as the fish condition were assessed. The fish were randomly distributed into the 9 stocking units (each with a volume of 0.240 m³), ensuring a quasi-equal distribution of fish biomass among the basins. During the trial, the feeding ratio was 2% BW/day, manually administrated in three equal meals (08:00, 12:00 and 16:00). The obtained data were statistically processed and the significance level for all statistical tests was accepted at $p < 0.05$.

At the end of the experiment, no variations between intra-treatment triplicates were recorded, emphasizing the overall somatic response for the tested diets. Partial results regarding growth performances in the experimental variants are presented in table 1.

Also, we applied the length-weight relationship and calculated the condition factor to assess the physical status of the fish across experimental groups, with the assumption that fish with higher weight at a given length are in a better condition following the feeding treatments.

Our results regarding the short-term effect of the tested diets on the growth performances of the one years old common carp, expressed by production parameters SGR, FCR and fish condition, indicated a better fish response to diet S, which had a higher protein level, followed by diets M and N.

Acknowledgements. This work was supported by mobility project within the framework of “Eugen Ionescu” Romanian Research Grants Program supported by University Agency of the Francophonie (AUF). The authors are grateful for the technical support offered by MoRAS through the Grant POSCCE ID 1815, cod SMIS 48745.

Table 1. Fish growth during the experiment

Biotechnological parameters	Aliment M	Aliment N	Aliment S
W_{initial} (g/fish)	74.67 ± 3.54	77.52 ± 1.46	77.14 ± 0.28
W_{final} (g/fish)	88.67 ± 4.29	95.00 ± 3.87	99.81 ± 0.43
GW(g/fish)	14.00 ± 0.76	17.47 ± 2.43	22.67 ± 0.72
GB (g/rearing unit)	98.00 ± 5.29	122.33 ± 17.04	158.67 ± 5.03

POLICY FRAMEWORK AND REFORM STRATEGY FOR FISHERIES AND AQUACULTURE (PFRS), A BLUEPRINT FOR AQUACULTURE DEVELOPMENT IN AFRICA

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The endorsement of the PFRS in 2014 by the African Heads of States and Governments as the blue print for the sustainable development of fisheries and aquaculture in Africa provided abundant opportunities to promote coordination and coherence in the governance of the sector by the AU Member States and Regional institutions. PFRS is aimed at increasing sustainable contribution of aquaculture to food security, livelihoods and wealth creation. Within the framework of the African Union Agenda 2063, the Africa Blue Economy Strategy intends to achieve full wealth-generating potential for aquaculture sector to optimally contribute to the blue growth.

PFRS, developed in broader participatory manner, identified seven key pillars and cross-cutting issues as policy areas for reform in African fisheries and aquaculture sector. Key among the pillars is Sustainable Aquaculture development whose overall objective is to Jumpstart market-led sustainable aquaculture through creating an enabling environment, mainstream aquaculture strategies and plans into national development plans and CAADP, creating an African Centers of Excellence for Aquaculture and Increase research and dissemination of better practices. The PFRS also marks its tenth year in 2024. The PFRS has been domesticated in a number of African Union Member States and Regional Economic communities with a sole purpose of harmonizing aquaculture developments at all levels complemented by the continental aquaculture action plan, the AU recognised centres of excellence in Aquaculture are being utilised to create the critical technical expertise, several regional frameworks such as environmental management, guidelines for the Production, Transboundary Distribution and Trade of Aqua-feeds, Feed Ingredients and Feed Additives; development of viable aquaculture extension service models are some of the achievements made over the years.

EFEITO DA RAÇÃO ARTESANAL À BASE DE RESÍDUOS VEGETAIS E VÍSCERAS DE PEIXES NO CRESCIMENTO DA MASSA CORPORAL DO JUVENIL DA TILÁPIA DO NILO *Oreochromis niloticus*

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Esta apresentação examina o impacto da ração artesanal no crescimento da massa corporal da tilápia do Nilo *Oreochromis niloticus*. O objetivo é avaliar a eficácia das formulações de ração artesanal comparadas às rações comerciais no desempenho do crescimento dos peixes. A pesquisa envolveu a formulação de diferentes tipos de ração caseira com ingredientes locais (mandioca, milho, couve) e vísceras de peixe, em sua aplicação em cultivos de tilápias em condições controladas. Para este efeito foram amostrados 55 peixes, distribuídos e povoados em 3 tanques com um volume de 250L para os tanques T1 e T2 respectivamente e 200L para o tanque T3. Sendo que os juvenis de *O. niloticus* com peso médio inicial de 2100g e 18,03cm de comprimento inicial alimentados uma ração artesanal (T₁); e 2250g e 17,58cm alimentados com uma ração comercial (T₂); e 2750g e 19,01cm alimentados com uma mistura de ração (T₃), durante 22 dias na fazenda do Missombo, província do Cuando Cubango – Angola.

No final do experimento o tratamento T1 atingiu peso médio de (2850g); o tratamento T2 atingiu (3150g) e o tratamento T3 atingiu (4100g). Para os peixes submetidos a dieta experimental (T1) o ganho em peso foi de 30 mg/dia. Para os peixes submetidos a dieta comercial (T2) foi de 36 mg/dia e para os peixes submetidos a dieta mista (T3) foi de 54 mg/dia.

O tratamento T1 teve uma biomassa total produzida de 0,015kg; para o tratamento T2 foi de 0,018 kg e para o tratamento T3 foi de 0,020 kg e um incremento em peso de: 0,75g, 0,9 e 1,35 para o tratamento T1, T2 e T3, respectivamente, com uma taxa de sobrevivência de 75,53% para todos os tratamentos.

Os três tratamentos apresentaram diferença no crescimento e ganho de peso, apesar do tratamento T3 apresentar melhores resultados relativamente ao tratamento T1 e T2.

Concluimos que a formulação adequada de ração artesanal pode otimizar o desempenho de crescimento da tilápia do nilo *O. niloticus*, oferecendo benefícios significativos para a aquicultura local substituindo de forma parcial à ração comercial, diminuindo assim os custos com relação a alimentação dos peixes uma vez que representa 70% dos custos de produção.

Tabela 1 - Resultados dos parâmetros do desempenho e do efeito da ração no crescimento da massa corporal do juvenil da Tilápia *O. niloticus* nos três tratamentos.

	Comprimento médio m)	Incremento em comprimento	Comprimento médio final (cm)
T1: foi usada a ração artesanal	18,03 cm	1,59	19,62
T2: foi a mistura de ração comercial e ração artesanal	19,01	3,02	22,03
T3: foi usado a ração comercial	17,58	2,95	20,53

Tabela 2: Resultados da taxa de sobrevivência, factor de conversão alimentar e da biomassa produzida nos três tratamentos

	Biomassa (kg)	Conversão alimentar (g)	Taxa sobrevivência (%)
T1:	0,015	315,00	60
T2:	0,020	618,75	86,6
T3:	0,018	337,50	80

CONTRIBUTION TO THE STUDY OF THE AGE AND GROWTH OF *Sander lucioperca* (Linnaeus, 1758) IN THE HAMMAM DEBAGH RESERVOIR NORTHEAST ALGERIA

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The present study was conducted in the Hammam Debagh reservoir in northeastern Algeria, from November 2019 to April 2020. In order to study the age and growth of the (*Sander lucioperca*) populating this reservoir, 126 specimens were sampled, including 77 males and 49 females. The ages, total lengths, and total weights of the samples ranged from 0-7 years to 15.7-57.1 cm, and from 92.1 to 1883 gr respectively. The age of the fish is determined by the direct method (scalimetry). The height-weight relationship was described by the equation $TL = 0.003TW^{3.28}$ for total weight and $TL = 0.002EW^{3.43}$ for eviscerated weight. The equation of the linear growth curve according to the Von Bertalanffy model is written (as) $L_t = 61.86(1 - e^{-0.3(t+0.52)})$, and the equation of the weight growth curve is written as $W_t = 2253.96(1 - e^{-0.3(t+0.52)})^{3.28}$. The studied species show a higher rate of masculinity (61.11%) than of femininity (38.89%). The egg-laying period occurs between April and June. Our results also reveal that the liver and muscle contribute significantly in the reproduction of pikeperch.

TOTAL SUBSTITUTION OF FISH MEAL BY BLACK SOLDIER FLY MEAL IN NILE TILAPIA *Oreochromis niloticus* JUVENILE'S DIET: EFFECTS ON GROWTH PERFORMANCES, FEED EFFICIENCY AND FISH BIOCHEMISTRY

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Insect meals (IM) are considered as a sustainable alternative protein source in fish diets in response to over-exploitation of fish meals (FM) and their increasing costs.

In this study, crescent substitution up to total replacement of FM with IM from black soldier fly (BSF) larvae (*Hermetia illucens*, L.) was tested for feeding Nile tilapia (*Oreochromis niloticus*) juveniles, during two months. Four isonitrogenous and isoenergetic diets were formulated for testing a standard control diet containing 180 g FM/kg *versus* three experimental diets in which 33.3, 66.6 and 100% of FM was replaced with BSF meal.

The results showed that the fish fed with the diets containing the BSF meal had better growth performances (final body weight and specific growth rate) than the fish fed the FM diet. In the same way, daily feed intakes (FI) were higher for fish fed the BSF2 and the BSF3 than for those fed with the control diet. The value obtained with BSF1 was intermediary, not differing with the others.

Neither the feed efficiency (Apparent Digestibility Coefficient (ADC) of crude protein, Feed Conversion ratio (FCR) and energy in diets) and nor muscle protein and lipid composition were affected by replacing the FM with the BSF meal.

Moreover, the composition of fatty acids in fish muscles were similar although the experimental diets contained less n-3 fatty acids than the control diet.

Our results clearly indicate that BSF meal is a good source of protein and lipids for Nile tilapia juveniles and that it can totally replace FM in their diets with improved growth performances.

Considering the evolution of production and decreasing price of insect meal as well as the unavailability of fish meal, BSF meal may be an economical and sustainable feedstuff for Nile tilapia.

BIOKOS – A REVOLUTIONARY, NOVEL REMEDY TO COMBAT CILIATE FISH PARASITES

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There is a global lack of efficient environmentally friendly remedies for the containment of parasitic disease in kept or farmed fish. Current treatment relies on old and well proven agents such as formaldehyde, peracetic acid/hydrogen peroxide or similar. Formaldehyde is efficient but also potentially hazardous to plant workers, at times detrimental to the fish, and most often only allowed for use on authorities' exemption.

Certain natural bacteria make so-called cyclic lipopeptides (CLPs), some of which disturb the proper function of the cellular membranes of particular unicellular organisms. One such CLP is Biokos, which was shown to be an efficient countermeasure against all free-living stages of the freshwater parasite *Ichthyophthirius multifiliis* ("freshwater white spot") (Liu *et al.*, 2015; Al-Jubury *et al.*, 2018).

We and others have since demonstrated that Biokos works against most ciliate fish parasites (e.g., *Cryptocaryon*, *Trichodina*, *Philasterides* and *Chilodonella* sp.) as well as some other commercially important protozoan fish pathogens (see, e.g., Watanabe *et al.*, 2023; Sueiro *et al.*, 2022; Maciel *et al.*, 2024). Interestingly, Biokos also kills many of the protozoans causing harmful algal blooms in coastal waters around the globe.

Sundew currently manufactures and sells Biokos in the ornamental fish sector and we are preparing for also entering the food aquaculture sector. Recent collaborative studies done with cultured *Trichodina*-infected *Tilapia* fingerlings in Uganda indicate a bright future for Biokos in that regard (Agoe *et al.*).

Agoe *et al.*, manuscript in preparation.

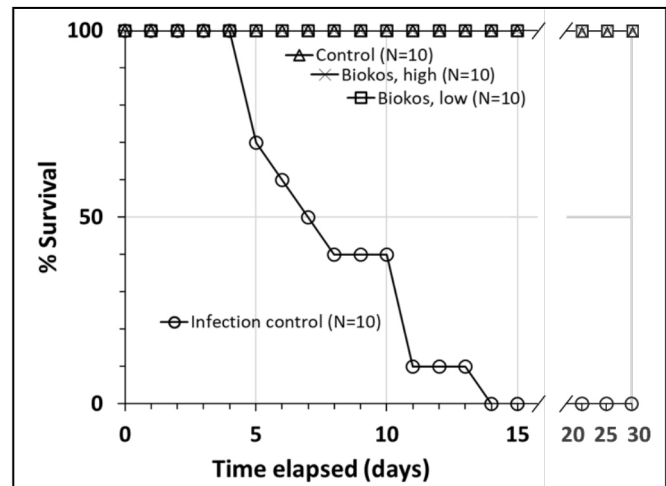
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	IN VITRO KILLING OF PARASITE OR PEST	IN VIVO CURING OF INFECTED FISH
CILIATE FISH PARASITES		<i>Ichthyophthirius multifiliis</i>
		<i>Cryptocaryon irritans</i>
		<i>Trichodina</i> sp.
		<i>Chilodonella uncinata</i>
		<i>Tetrahymena pyriformis</i>
		<i>Tetrahymena thermophila</i>
		<i>Philasterides dicentrarchis</i>
		<i>Uronema</i> sp.
		<i>Epistylis</i> sp.
	<i>Ambiphrya</i> sp.	
NON-CILIATE FISH PARASITES		<i>Ichthyobodo necator</i>
		<i>Piscinoodinium</i> sp.
		<i>Gyrodactylus</i> sp.
		<i>Neoparamoeba perurans</i>
HARMFUL ALGAE BLOOM SPECIES		<i>Heterosigma akashiwo</i>
		<i>Chattonella marina</i>
		<i>Karenia brevis</i>
		<i>Gambierdiscus toxicus</i>
		<i>Alexandrium tamarense</i>
		<i>Prymnesium parvum</i>

GROWTH PERFORMANCE OF MUSSELS *Mytilus galloprovincialis* Lamarck, 1819 IN AN INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM IN OPEN SEA (BAY OF MONASTIR, TUNISIA)

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The rearing of the Mediterranean mussel, *Mytilus galloprovincialis* Lamarck, 1819, has been tested for the first time in an innovative Integrated Multitrophic Aquaculture system (IMTA) in offshore, as part of the EU-funded PATINER project. This farming system could solve several problems including the high mussels mortality observed in Bizerte lagoon especially during summer season and reducing the environmental impact of finfish mariculture cages.

The purpose of this study is to evaluate for the first time the growth performance of the Mediterranean mussel in open sea in an IMTA system in Monastir Bay.

The IMTA system is consisted of several species occupying different trophic levels in the same site of production: fed species (finfish: sea bream and sea bass) combined with filter species such as oysters, mussel and clams; deposit feeders such as sea cucumbers, sea urchin and inorganic extractive species such as algae.

Juvenile mussels aged from 4 to 6 months were used for culture in nylon bags. Every two to three months mussels were randomly sampled and then transferred to the laboratory where the biometric measurement (length, weight), Condition Index (CI) and mortality were assessed. Environmental parameters (temperature, salinity, dissolved oxygen, pH and Chlorophyll-a) were also monitored.

At the end of the rearing period (i.e. 10 months) the preliminary results of this study showed an increased growth of mussel. In fact, growth was increased from $35 \pm 5,34$ mm to $45 \pm 6,02$ mm ($1,08$ mm month⁻¹). Likewise, weight was increased from $4,8 \pm 1,88$ to $8,69 \pm 3,43$ g ($0,4$ gmonth⁻¹) with a specific weight growth rate around 0.17%/day.

HEAVY METAL CONTAMINATION IN TWO AQUACULTURE FISH SPECIES (*Oreochromis macrochir* AND *Coptodon rendalli*) FROM THE KABOMPO RIVER, ZAMBIA: IMPLICATIONS FOR FOOD SAFETY AND AQUACULTURE

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Heavy metal contamination poses a significant risk to aquaculture sustainability and food safety, especially in regions where water bodies serve as major broodstock sources. This study investigated heavy metal contamination in two commonly farmed aquaculture fish species, *Oreochromis macrochir* and *Coptodon rendalli*, sampled from six different sites in the Kabompo River, Zambia. Statistical analysis was conducted using two-way ANOVA, with Tukey's Honest Significant Difference (HSD) test revealing significant differences among the sampling sites and fish species. Nickel (Ni), Zinc (Zn), Copper (Cu), and Manganese (Mn) were detected, while Cadmium (Cd), Cobalt (Co), and Lead (Pb) were below the detection limit. Detected metal concentrations were within permissible limits established by international standards for food safety and potable water, suggesting that heavy metals do not pose significant health risks to fish or consumers. The concentrations of Cu, Zn, and Mn were significantly influenced by both the sampling site and fish species ($p < 0.05$), with Ni concentrations significantly associated with the sampling site ($p < 0.05$). No interaction between site and species was observed for any of the detected metals ($p > 0.05$). Three distinct clusters based on metal concentrations emerged: the Confluence site (Kabompo and Lunga River Confluence), Ntabo, Mubanga, and Mukoka formed one group, while Jivundu and Christella sites formed another. The order of heavy metals across all sites was: Cu > Zn > Mn > Ni. Additionally, physical-chemical parameters of the water, namely dissolved oxygen (DO), pH, temperature, conductivity, salinity, and total dissolved solids (TDS), did not significantly differ across the six sites ($p > 0.05$) and remained within acceptable limits for tilapia growth. The results of this study are crucial for the development of aquaculture in Zambia, providing baseline data on metal contamination in a key river used for tilapia broodstock and aquaculture water supply. Continued monitoring is recommended to ensure the sustainability and safety of practices in the Kabompo River.

Table 1: Concentrations of Nickel, Zinc, Copper, and Manganese (mg/kg) in Fish Species Across Six Sampling sites in the Kabompo River, Zambia

Heavy metals	Fish species	Mubanga	Jivundu	Mukoka	Christella	Ntabo	Confluence
Nickel	<i>O. macrochir</i>	0.01±0.005 ^a	0.034±0.007 ^{ab}	0.029±0.008 ^b	0.022±0.009 ^a	0.011±0.006 ^{ab}	0.257±0.016 ^c
	<i>C. rendalli</i>	0.027±0.009 ^a	0.015±0.007 ^{ab}	0.056±0.015 ^b	0.014±0.008 ^a	0.061±0.019 ^{ab}	0.156±0.024 ^c
Zinc	<i>O. macrochir</i>	11.637±1.513 ^b	3.667±0.605 ^a	15.583±2.438 ^c	5.180±0.076 ^a	10.370±2.207 ^b	12.370±1.456 ^b
	<i>C. rendalli</i>	9.063±1.981 ^b	1.643±0.641 ^a	14.550±1.502 ^c	4.20±0.997 ^a	9.493±2.620 ^b	11.113±1.09 ^b
Copper	<i>O. macrochir</i>	18.377±2.340 ^{ab}	16.133±2.985 ^a	22.770±0.843 ^{cd}	22.243±1.976 ^c	21.633±2.155 ^{bc}	27.253±1.677 ^d
	<i>C. rendalli</i>	15.290±2.304 ^{ab}	13.673±2.060 ^a	20.577±2.387 ^{cd}	19.693±2.779 ^c	16.567±1.476 ^{bc}	23.077±1.99 ^d
Manganese	<i>O. macrochir</i>	0.216±0.116 ^a	0.480±0.135 ^{bc}	0.373±0.131 ^{abc}	0.550±0.213 ^c	0.283±0.075 ^{ab}	0.957±0.150 ^d
	<i>C. rendalli</i>	0.156±0.100 ^a	0.383±0.131 ^{bc}	0.230±0.040 ^{abc}	0.403±0.101 ^c	0.212±0.100 ^{ab}	0.737±0.117 ^d

EFFECT OF TOTAL REPLACEMENT OF FISHMEAL BY INSECT MEAL ON THE GROWTH OF RED TILAPIA FRY *Oreochromis sp.*

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A 60-day feeding trial was conducted at the aquaculture laboratory of Kasdi Merbah University Ouargla to evaluate the effects of substituting fish meal with mealworm meal (MM) (*Tenebrio molitor*) on the growth performance, survival rates, fillet quality, and organoleptic characteristics of red tilapia (*Oreochromis sp.*).

Two test diets were formulated: one with fish meal (FM) and the other with mealworm meal (MM). The growth and feed utilization for *Oreochromis sp.* showed an average of $1.92 \pm 0.05\%$ per day for the MM diet and $1.79 \pm 0.13\%$ per day for the FM diet. The feed conversion ratio (FCR) was recorded as 2.23 and 2.37, respectively. Thus, there is convergence and similarity between the FM and MM diets, with the latter showing slightly better growth performance. Survival rates were similar, ranging from $68.33 \pm 16.07\%$ to $73.33 \pm 7.63\%$. Physicochemical factors were within the standards for aquaculture waters.

Regarding the chemical composition of the fillet, protein and lipid levels were significantly higher in fish fed the MM diet compared to those fed the FM diet. Taste tests conducted by judges did not detect any differences. In conclusion, mealworm meal (*T. molitor*) represents a viable alternative to animal proteins for replacing fish meal in aquaculture feeds.

AQUACULTURE IN AFRICAN – IS IT GROWING FAST ENOUGH?

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The 2022 paper coordinated by the University of Bonn and titled *Prospects for Aquaculture Development in Africa – A Review of Past Performance to Assess Future Potential* (Hinrichsen *et al.*) focused on contextualising the aquaculture output of African countries to allow for an depth of understanding beyond an absolute reported tonnage. The current work builds on this and looks at aquaculture growth imperatives in Africa to sustain the current levels of per capita fish consumption.

Africa's population is fast approaching 1.5 billion (2024), making it the second most populous continent after Asia. The average population growth rate has remained above 2.45 percent from the year 2000, and it is expected that Africa will house 2.5 billion people by 2050. This rapidly increasing population results in a rapidly increasing need for food; especially aquatic foods, and specifically foods produced from within Africa. Additionally, the youthful population of Africa needs skills and jobs, both of which can be addressed by an expanded aquatic food sector.

The 2024 yearbook of the FAO indicates that African capture fisheries yield stands at 10 358 thousand tons (FAO, 2021), with aquaculture at 2 322 thousand tons. This means that the contribution of aquaculture to fisheries supply in Africa is a mere 18,3%; in sharp contrast to the rest of the world where aquaculture supply has surpassed that of fisheries. Moreover, if ignoring the contribution of imports and exports, African per capita fish availability stands at less than 8,5 kg per annum; also in sharp contrast to the global average which is approximately 20 kg per capita per annum. As it is well known that capture fisheries, globally and in Africa, has largely reached capacity, Africa has to look to aquaculture to maintain and increase its per capita aquatic food supply.

In this paper we look critically as to whether aquaculture in Africa is growing fast enough and at the rate at which aquaculture needs to increase to (i) maintain and arrest the current declining levels of per capita fish consumption and (ii) to grow African per capita fish consumption to address the current lag behind global consumptions rates.

FOOD AND FEEDING HABITS OF THE CICHLIDAE IN TAGWAI RESERVOIR, NIGER STATE, NIGERIA

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Four hundred and seventeen (417) samples comprising of one hundred and eighty-six *Sarotherodon galilaeus* and two hundred and thirty-one (231) *Coptodon zillii* were collected on monthly basis for four (4) months (March, 2021 to June, 2021) from the catches of local fishermen operating on Tagwai Reservoir, in Niger State, Nigeria. The fresh samples were transported in ice - chest box to the Biology Department laboratory of Ibrahim Babangida University (IBB), Lapai, Niger State, where analyses were carried out. Eight (8) different types of items that constituted plant and animal materials were found as food in the stomachs of each of *S. galilaeus* and *C. zillii*. This included detritus, sand, algae, plant material, nematode, plankton, seed and unidentified material. Plant material was highest (30.30%) followed by detritus (17.32%) then algae (16.01%) and lowest was nematode and unidentified material each with 2.16%. Feeding intensity of both species of fish was high due to low percentage of empty stomachs recorded during the period of study. 157 stomachs of *S. galilaeus* out of 186 examined had food while 181 stomachs of *C. zillii* out of 231 examined had food. *S. galilaeus* and *C. zillii* are omnivore and herbivore respectively based on their feeding habits. Diet overlap or similarity showed moderate level of association in diet and less competition for food between the two species. There is need to examine other aspects of biology, such as growth, fecundity, age of these fishes in the reservoir. This study can be used as baseline information for carrying out similar study in other water bodies.

COMPARATIVE GROWTH ASSESSMENT OF AFRICAN CATFISH (*Clarias gariepinus*) FED SWEET POTATO (*Ipomea batata*) LEAF MEAL AND RICE BRAN AS ALTERNATIVE FEED MEAL

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The study compared growth performance of *Clarias gariepinus* fingerlings fed sweet potato leaf meal and rice bran as alternative feed meal. Five diets, that contain 0%, 25%, 50%, 75% and 100% inclusion levels were formulated and designated as SPM₁, SPM₂, SPM₃, SPM₄, SPM₅ and RBM₁, RBM₂, RBM₃, RBM₄, RBM₅. Highest initial weight in SPLM₃ (50%) differ significantly ($p>0.05$) from SPLM₁ (0%) while RBM₄ (75%) can be compared to RBM₁ (0%). Final weight and body weight gain follow similar trend with SPLM₂ (50%) recorded highest, which differ significantly ($p>0.05$) with other diets. Decrease of SPLM inclusion level increase fish weight. Highest SGR in SPLM₂ (25%) can be compared favorably with SPLM₁ (0%) and other diets while RBM₂ (25%) differ significantly ($p>0.05$) with RBM₁ (0%). Diet SPLM₃ (100%) can be compared with other diets in SGR with RBM₃ (50%) that differ significantly ($p>0.05$) with only RBM₁ (0%). Highest FE in SPLM₁ (0%) can be compared favorably with SPLM₃ (50%) and SPLM₄ (75%) in feed acceptability. RBM₅ (100%), which is highest differ significantly ($p>0.05$) with RBM₁ (0%). Apart from RBM₄ (75%) other diets were accepted by the fish. It is therefore recommended that 25% inclusion level of SPM should be used in the diet of *C. gariepinus* for better performance than even 75% inclusion of rice bran, study on lower inclusion level of SPM need to be carried out, this type of study need to carried out on other cultured species of fish such as Heterobranchus (catfish) and even Tilapia, study on the use of other processing methods of sweet potato leaf and rice bran for feed formulation should be carried out and this type of study need to be carried out in other culture system.

HAEMATOLOGICAL INDICES OF TILAPIA (*Oreochromis niloticus*) FROM KALGWAI DAM, HADEJIA, JIGAWA STATE, NIGERIA

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The present study investigated the hematological indices of *Oreochromis niloticus* (Nile tilapia) from Kalgwai Dam, Hadejia, Jigawa State, Nigeria, for the period of twenty-four months (24) with a focus on assessing the health status of the fish population in relation to potential environmental stressors and parasitic infections. Moreover, as a result of an array of some devastating activities which include illegal fishing, nomadic farming, washing of clothes, and other households' belongings, using detergents, however, reaches of the dam, serve as refuse dump site, which is increasing pollution influx into the dam. Haematological indices count such as Packed cell volume (PCV), Red blood cell (RBC), Haemoglobin (Hb), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin content (MCHC), White blood cell (WBC), Neutrophils, Lymphocytes, Monocyte, Basophils and Eosinophils were measured using standard laboratory procedures. The mean value recorded for PCV. were 15.00 % to 34.50%, RBC were 1.35 ± 0.21 to 2.70 ± 0.28 , (Hb) were 6.50 g/dL to 11.50 g/dL, mean of MCV, MCH and MCHC ranged from 26.00 ± 14.14 to 61.00 ± 28 , 34.50 ± 16.26 to 52.50 ± 17.68 and 24.50 ± 9.19 to 49.00 ± 7.07 for MCV, MCH and MCHC respectively. WBC were 120.00 ± 28.28 to 230.50 ± 57.28 , Neutrophils ranged from 33.50 ± 14.85 to 56.00 ± 21.21 , Lymphocytes were 34.00 ± 12.73 to 61.50 ± 27.58 . Moreover, 0% was recorded for Monocytes, Basophils and Eosinophils. The observed variations in hematological parameters are indicative of sample fish health conditions, potentially linked to water quality issues or parasite prevalence in the dam. This study underscores the importance of regular monitoring of hematological indices as bioindicators of fish health, which can serve as an early warning system for ecological disturbances and the presence of disease-causing agents in aquatic ecosystems.

AQUACULTURE BUSINESS SCHOOL (ABS)- A TOOL FOR IDENTIFYING BUSINESS RISKS, DEVELOP MITIGATION STRATEGIES AND BUSINESS DECISION MAKING

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The aquaculture sector in India, though promising, faces significant challenges in productivity, income generation, and establishing efficient business linkages. Small-scale aquaculture entrepreneurs often lack the necessary business skills, training, and resources to capitalize on the opportunities within the industry fully. Addressing these challenges is essential for unlocking the sector's potential and promoting sustainable development. The Aquaculture Business School (ABS) is a novel initiative under the Indo-German Development Co-operation project 'Food Security through Integrated Aquaculture (EIAA)' (locally known as Sustainable Aquaculture for Food and Livelihood or SAFAL). On behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implements the SAFAL project in cooperation with the Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD), Government of India. The ABS model is presently carried out by GIZ in Assam in collaboration with the Department of Fisheries (DoF), Assam, India and Assam State Rural Livelihood Mission (ASRLM), Ministry of Rural Development, Govt. of India through a tri-partite MoU. The primary objective of the Aquaculture Business School (ABS) is to professionalize aquaculture entrepreneurs by equipping them with the skills needed to forecast business risks, develop mitigation strategies and business decision making.

ABS in India draws inspiration from the Farmer Business School (FBS) model, developed by GIZ in collaboration with the World Cocoa Foundation, NIRSAL from Central Bank of Nigeria and the European Union (EU) in 2010 for small-holder cocoa farmers in West Africa. The FBS model successfully reached over 1.7 million farmers across 30 countries, empowering them with the skills to manage their farms as businesses. This success led to the creation of the Agribusiness Faculty for Africa (ABF) project, which adapted the FBS approach to other sectors, including aquaculture. The ABS implementation has progressed through several phases, beginning with a pilot training program in Sonitpur, Assam. GIZ in collaboration with DoF, Assam, India and ASRLM organized a 5-day pilot training session for 25 farmers in 2023 led by a master trainer from Africa. This was followed by a 10-day residential program for 20 trainees focused on advanced training techniques in Sonitpur. Training Learning Groups (TLGs) were formed under the supervision of the master trainer to provide hands-on experience on how to impart training to farmers. Additionally, Pair Learning Groups (PLGs) were established to give trainers increased exposure and essential experience. After completing the PLG program, qualified ABS trainers will provide personalized training to 180 farmers over three months. Ultimately, ABS is driving significant progress in empowering aquaculture entrepreneurs by adapting successful models from Africa to create lasting impacts on the fisheries and aquaculture sector of India.

EMPOWERING WOMEN FISH FARMERS AND ENHANCING MARKET OPPORTUNITIES: INSIGHTS FROM THE INDO-GERMAN DEVELOPMENT CO-OPERATION PROJECT

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The Indo-German Development Cooperation Project 'Food Security through Integrated Aquaculture' (EIAA), locally known as Sustainable Aquaculture for Food and Livelihood (SAFAL), aims to increase fish production from sustainable aquaculture sources while promoting gender inclusion approaches. On behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implements the SAFAL project in cooperation with the Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD), Government of India. The methodology included gender sensitization events, training in carp composite fish culture, and capacity-building programs for developing Community Resource Persons (CRPs) as Aquaculture Service Providers. Participants also learned about income generation through value-added fish products, including carp-based fish pickles in Assam and Odisha.

The capacity-building programs had a significant impact, especially on female participants who previously faced barriers due to traditional gender roles (Table-1). A joint training was organised by SAFAL and Indo-German Project Enhancing Rural Resilience Through Appropriate Development Actions (ERADA) to train CRPs in Bihar with Government partners. Awareness programs on value-added fish product preparation highlighted the profitability of selling value-added products alongside aquaculture. A few members from the Srishtri Fish Producer Group, which operates under the women-led fish cooperative, Champabati Fish Co-operative Society in Morigaon, Assam, India, has initiated a new venture called "*Gyanam Food Products*." This enterprise specializes in producing an assortment of pickles, including fish-based varieties and aims to boost the income of its participants. Kopili Fish Producer Group under Champabati Fish Co-operative Society have also started a similar venture of selling fish pickles. These FPOs have received capacity-building training from the SAFAL project. An initiative called the Participatory Guarantee System (PGS) by SAFAL, GIZ and Innovative Change Collaborative Services Private Limited (ICCSPL) has empowered 500 women fish farmers in Morigaon, Assam. It has enabled these farmers to produce higher-quality fish adhering to PGS standards which they now sell in local markets under the brand name "*Morigaon Fish*". In conclusion, the SAFAL project is empowering women by improving household income and strengthening their agency at household and community level.

Table-1 Numbers of female and male participants in various training programs

Training Programs	Total	Female	Male
CRPs trained (3+10-day sessions) Assam, Odisha, Bihar	550	273	277
CRP Trainers developed (Assam, Odisha)	143	81	62
Total Aqua Farmers trained (Assam, Odisha)	7523	3379	4146

THE MERITS FOR REGIONAL COLLABORATION FOR AQUATIC BIOSECURITY AND BIOSAFETY CONTROL IN AFRICA

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Propelling the sustainable development while simultaneously transforming Africa's aquaculture sub-sector into a robust Agri-food system is the question at hand for Africa's aquaculture stakeholders. The continent's Policy Framework and Reform Strategy for Fisheries and Aquaculture (PFRS) and the Africa Blue Economy Strategy (ABES) have opened opportunities that enhance the prospects for diversifying and expanding the profile the continent's aquaculture value chains. Access to emerging regional and global markets through safe and equitable trade, is a key feature of this.

Achieving this aspiration depends on the extent to which the continent can safeguard the integrity of its largely transboundary aquatic ecosystems and resources. Demographic changes, increased levels of environmental degradation and climate-change impacts have become apparent threats affecting the integrity Africa's aquatic ecosystems and resources. The sustainable supply of good quality water, feed ingredients and feedstuffs, fish seed and the health of aquaculture stock and products can only be assured if the aquatic ecosystem is healthy. Recognizing this, Africa as a continent, has opted to strengthen its capacity for aquatic animal health and biosecurity control coherently from a transboundary approach, whereby the designate watersheds and marine ecosystems constitute the primary ecological epidemiological unit. Bearing in mind the multiplicity of factors influencing the sustainable management of water resources for productive uses such as fisheries and aquaculture, regional multisectoral and multi-stakeholder collaboration become key.

STRENGTHENING THE CAPACITY FOR ESTABLISHING EFFECTIVE AND RESILIENT ONE HEALTH AQUATIC ANIMAL HEALTH AND BIOSECURITY CONTROL SYSTEMS IN AFRICA

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There have been mounting concerns from Africa's aquaculture stakeholders on the status and access to aquatic animal health and welfare, biosecurity and biosafety control and environmental management services with consequent negative impacts for sustainable market-led aquaculture development, notably reduced productivity, food-safety, access to markets, public health and aquatic biodiversity. Cognizant of the sectors concerns, the African Union Commission (AUC), in consideration of the continent's Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (PFRS), African Union's (AU) ten year action plans for Sustainable Small-Scale Fisheries and Aquaculture, Animal Health Strategy for Africa, Animal Welfare Strategy for Africa, AU Framework for Antimicrobial Resistance Control, AU Policy Framework on Sanitary and Phytosanitary Standards, the Africa Blue Economy Strategy (ABES) and the African Continental Free Trade Area (AfCTA) in 2023, commissioned the AU Interafrican Bureau of Animal Resources (AU-IBAR) to lead, plan, and coordinate all activities related to aquatic animal health in Africa, and to strengthen continental and regional policy and governance to promote aquatic biosecurity control and improve access to markets for aquatic animal products *in lieu* of its continental mandate. AU-IBAR was thus tasked to undertake the following in collaboration with its sister agency, the AU Pan-African Veterinary Vaccine Center (AU-PANVAC) in accordance with Africa's Fisheries Reform Mechanism (AFRM):

- i. a continental assessment of the status of transboundary aquatic animal diseases and aquatic antimicrobial resistance on the continent to facilitate evidence-based decision making for their control
- ii. review Africa's continental water and aquatic environmental management guidelines with the view to strengthening and promoting sustainable fisheries and aquaculture management, aquatic biodiversity conservation and aquatic ecosystem health
- iii. develop a continental Aquatic Animal Biosecurity Strategy and Aquatic Animal Vaccine Strategy

The AFRM emphasizes an all-inclusive participatory process in the formulation and implementation of all continental fishery and aquaculture development actions. This session at AFRAQ24, marks the first continental public multi-stakeholder consultation to seek the views, share experiences and obtain contributions from the sector's practitioners for the above-mentioned proposed actions.

RELATIVE ESTIMATION OF LYSINE REQUIREMENTS FOR TWO JUVENILE STRAINS OF *Oreochromis andersonii*

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The present study was designed as a 3x2 factorial experimental design to investigate the effects of dietary lysine on growth performance, body indices, feed intake, feed efficiency, whole-body nutrient composition, and amino acid deposition in the SUZ and GIP strains of *Oreochromis andersonii*. Three diets with varying levels of lysine were formulated for a feeding trial involving triplicate groups of fish with an initial weight of 15 g over six weeks in a recirculating aquaculture system. The study also aimed to measure the experimental diets' Apparent Digestibility Coefficients (ADC) of dry matter, crude protein, crude lipids, and total carbohydrates. The study results revealed that although no significant interactions were observed between dietary lysine levels and fish strains for most parameters, exceptions were noted for the condition factor (CF) and ADC of crude protein. Dietary lysine levels significantly influenced final weight, weight gain, thermal unit growth coefficient (TGC), protein efficiency ratio (PER), and ADC of dry matter, regardless of the fish strain. Fish-fed diets with the highest lysine content had superior final weight, weight gain, and TGC. PER was the lowest in fish receiving the lowest lysine level. Moreover, the fish strain significantly influenced the final weight and accumulation of isoleucine, phenylalanine, and alanine, with the GIP strain exhibiting better performance. These findings suggest increased growth and higher lysine requirements in the improved GIP strain compared to the SUZ strain during the juvenile phase, potentially indicating a change in dietary lysine needs due to genetic enhancements.

MANNAN OLIGOSACCHARIDE FROM COCONUT WASTE IMPROVES INTESTINAL HEALTH OF ATLANTIC SALMON (*Salmo salar*) PARR

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The mucosal barriers of fish are an important first line of defense against pathogenic invasion. Functional feed additives such as mannan oligosaccharide (MOS) have the potential to promote improved mucosal physiology and barrier function, which can lead to improved fish robustness, health and welfare. The Atlantic salmon is a valuable production species, with global production exceeding 2.8 million metric tonnes in 2022.

In this study, Atlantic salmon parr (ca. 11.68 ± 0.11 g) were fed with either a control diet or diets comprising the same basal formula but supplemented with one of three levels of MOS (0.25%, 0.35% or 0.5% Pretego™, Greensage Prebiotics Inc) (Table 1). Fish were reared in a freshwater RAS system ($16.22 \pm 0.16^\circ\text{C}$) for a period of 70 days, with three replicated tanks per treatment group. At the end of the trial, there were no significant differences between the treatment groups in terms of growth performance and nutrient utilization (Table 2). However, histological appraisal revealed that dietary MOS increased the length of distal intestinal villi and increased the number of goblet cells in the distal intestine and the dorsal region of the skin.

MFL, mucosal fold length; IGCC, intestinal goblet cell count; SGCC, skin goblet cell count; MVC, microvilli coverage; MVL, microvilli length, IBW, initial body weight; FBW, final body weight; WG, weight gain; SGR, specific growth rate; FCR, feed conversion ratio; SR, survival rate; C.F, condition factor.

In conclusion, feeding Atlantic salmon with MOS derived from coconut by products has the potential to improve mucosal barriers.

This potential will be further explored in on-going analysis which includes intestinal microbiome analysis and intestinal and skin gene expression profiling.

Acknowledgements: this research was funded by Enterprise Solutions and Greensage Prebiotics Inc.

Table 1: Dietary formulations and proximate composition(%).

Ingredients	Control	0.25Pre	0.35Pre	0.50Pre
MOS	-	0.25	0.35	0.50
Wheat	10.83	10.30	10.13	9.83
Wheat gluten	17.93	17.96	17.93	17.93
Fish oil	6.67	6.67	6.67	6.67
Fish meal	30.00	30.00	30.00	30.00
Rapeseed oil	6.39	6.39	6.39	6.39
Faba bean dehulled	7.00	7.00	7.00	7.00
Phosphate	0.56	0.56	0.56	0.56
SPC	20.00	20.00	20.00	20.00
Astaxanthin	0.01	0.01	0.01	0.01
Vitamin premix	0.19	0.19	0.19	0.19
Mineral premix	0.56	0.56	0.56	0.56
Total	100.00	100.00	100.00	100.00
Proximate compositions (g/100g)				
Moisture	8.00	8.1	8	7.9
Crude protein	50.20	50.7	51	51.1
Crude fat	18.70	18.5	18.8	19.1
Ash	5.40	5.6	5.5	5.5

Table 2: Growth performance metrics. Data presented as mean \pm standard deviation of the mean (n = 3).

	Control	0.25Pre	0.35Pre	0.50Pre
IBW (g)	11.64 \pm 0.42	11.60 \pm 0.40	11.87 \pm 0.14	11.60 \pm 0.41
FBW (g)	32.44 \pm 1.32	32.19 \pm 0.44	35.02 \pm 4.05	33.35 \pm 2.02
WG (g)	20.46 \pm 1.16	20.17 \pm 0.75	22.48 \pm 3.78	21.24 \pm 1.90
SGR (%/day)	1.34 \pm 0.09	1.33 \pm 0.05	1.41 \pm 0.15	1.38 \pm 0.09
FCR	1.00 \pm 0.06	1.03 \pm 0.05	0.97 \pm 0.10	0.98 \pm 0.11
SR (%)	98.10 \pm 1.65	100.00 \pm 0.00	100.00 \pm 0.00	99.05 \pm 1.65
C.F	1.20 \pm 0.06	1.24 \pm 0.02	0.95 \pm 0.02	1.22 \pm 0.02

IBW, initial body weight; FBW, final body weight; WG, weight gain; SGR, specific growth rate; FCR, feed conversion ratio; SR, survival rate; C.F, condition factor.

Table 3: Histological analysis. Data presented as mean \pm standard deviation of the mean (n = 9).

	Control	0.25Pre	0.35Pre	0.50Pre
MFL (μm)	329.64 \pm 91.71 ^a	523.05 \pm 184.01 ^b	435.31 \pm 98.50 ^{ab}	447.34 \pm 147.01 ^{ab}
IGCC (n/100 μm)	10.14 \pm 2.25 ^a	13.43 \pm 2.71 ^b	14.20 \pm 1.78 ^b	11.32 \pm 2.88 ^{ab}
SGCC (n/200 μm)	11.11 \pm 1.84 ^a	13.78 \pm 4.0 ^{ab} **	11.53 \pm 2.66 ^a	16.29 \pm 1.67 ^b
MVC (%)	95.11 \pm 0.31	97.03 \pm 0.19	96.68 \pm 0.21	96.07 \pm 0.22
MVL (μm)*	1.25 \pm 0.31	1.44 \pm 0.19	1.21 \pm 0.21	1.21 \pm 0.22

MFL, mucosal fold length; IGCC, intestinal goblet cell count ; SGCC, skin goblet cell count; MVC, microvilli coverage; MVL, microvilli length

DIETS OF ALESTIDAE (TELEOSTEI: CHARACIFORMES) IN TWO RIVERS (BOUMBA AND KADEI) IN EASTERN CAMEROON

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As part of a larger research program on the diversity and role of the forest in maintaining the local ichthyofauna of the Congo Basin, a study focused on the diets of Alestidae, a family of many fishes represented in the Boumba and Kadei rivers in eastern Cameroon. Indeed know the diet of savage specie fish can help to make their conservation by aquaculture processes.

106 specimens of Alestidae were captured using dormant gillnets, cast nets, hooks and creels; they were identified using specific determination keys then were labeled, photographed, measured (total and standard lengths), weighed and dissected in order to remove their stomachs which were preserved in tubes containing alcohol at 70%. These stomachs were then emptied and the contents rinsed in Petri dishes, then filtered through a sieve and the retained fractions were sorted, separated, identified, counted and weighed in order to evaluate the rate of food from the riparian forests.

A total of 106 stomachs were collected from six species of Alestidae (*Alestes macrophthalmus*, *Brycinus longipinnis*, *Brycinus macrolepidotus*, *Brycinus imberi*, *Hydrocynus vittatus* and the *Bryconaethiops spp.* complex made up of several species grouped into one due to the low abundance of each). Of 63 individuals sampled in Boumba, 89.7% had full stomachs compared to 7.7% empty stomachs while out of 43 individuals sampled in Kadei, 76.1% had full stomachs compared to 14.9% empty stomachs. The emptiness coefficients were 8.33 in *A. macrophthalmus* in Boumba and 50 in Kadei.

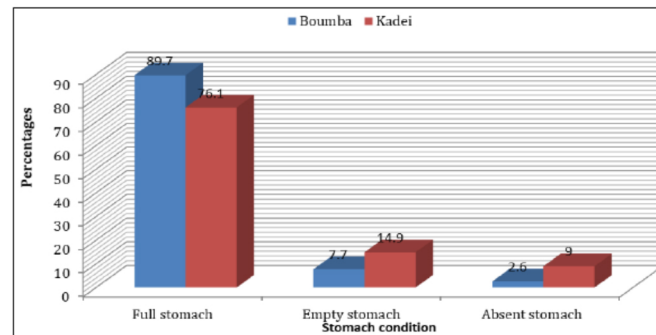


Fig 1: State of the stomachs of fish according to the sampling sites.

Four food categories have been identified in these fish: macroinvertebrates, macrophytes, prey fish and other miscellaneous particles. The frequency of occurrence (Fc) and the preponderance index (Ip), calculated, indicate that Lepidoptera are the very frequent and main prey in the diet of *B. longipinnis* at Boumba, while at Kadei it is rather Orthoptera and prey fish, respectively in *A. macrophthalmus* and *H. vittatus*. Furthermore, it has been observed that the riverside forests provide these prey (leaves, fruits and insects) found in the stomachs of certain species. Thus they mainly contribute to maintaining the balance.

Table 1: Presence-absence of prey identified in the stomach contents of dissected individuals.

Sites	Prey Species	Fish		Macroinvertebrates						Macrophytes				Other									
		Wh/Pat		AI		InsT/InvT		Cr	TP		AP		Mis										
		Sf	Fs	Fd	Co	Tr	Od	Or	Le	Hy	Is	My	De	Lf	Fl	Fr	Se	AP	Ib	Ie	Ff	Un	
Boumba	<i>A. macrophthalmus</i>		+	+																			
	<i>Bryconaethiops sp.</i>		+				+	+															
	<i>B. longipinnis</i>								+														
	<i>B. macrolepidotus</i>									+	+			+	+								
	<i>H. vittatus</i>																						
Kadei	<i>A. macrophthalmus</i>								+														
	<i>B. imberi</i>			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>B. macrolepidotus</i>			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>H. vittatus</i>	-																					

The study of the stomach contents of Alestidae in Boumba and Kadei reveals that this family of fish is made up of herbivores, carnivores and omnivores. It is obvious that the forests of the Congo Basin constitute an essential source of food for the ichthyofauna of the rivers they shelter. Consequently, deforestation would negatively impact certain taxa of fish such as the Alestidae which depend on them and would inevitably lead to their loss. The improving knowledge on the feeding ecology of

ETUDE DE LA BIOLOGIE DU CARASSIN COMMUN *Carassius carassius* DANS LE BARRAGE DU HAMMAM DEBAGH A GUELMA EN ALGERIE

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Le carassin est un poisson d'eau douce vivant dans toutes sortes de plans d'eau. Il est plus fréquent dans les petits lacs et étangs, et vit dans la couche inférieure de la colonne d'eau. *Carassius carassius* est considéré comme une nouvelle espèce en Algérie dont le but principal de son introduction était l'aquaculture et l'enrichissement des niches écologiques vacantes telles que les barrages. En effet nous nous sommes intéressés à l'étude de quelques aspects de la biologie de la population du *C. carassius* peuplant le barrage Hammam Debagh à Guelma (Algérie).

L'étude biométrique de *Carassius carassius* du barrage Hammam Debagh à Guelma montre une allométrie de croissance majorante. La relation taille-poids de la population de *C. carassius*, se caractérise par un type d'allométrie isométrique chez les femelles et les deux sexes combinés. L'analyse temporelle de la répartition numérique des sexes montre que le sex-ratio est en faveur des femelles au cours de tous les mois d'étude. Le sex-ratio globale est en faveur des femelles (0,05 : 1), ainsi qu'une dominance des femelles a été observée dans les catégories de tailles comprises entre 19-22 cm. Cependant, l'étude de la période de ponte montre que le carassin mâle et femelle se reproduit en mars et en mai. L'étude du RHS évolue en sens inverse par rapport à celui du RGS pour les femelles comme pour les mâles. Le suivi des variations temporelles du coefficient de condition K chez les deux sexes a montré des fluctuations au cours de la période d'étude.

Tableau 1 : Equation de régression et coefficient de corrélation (r) et d'allométrie, t_{obs} & type d'allométrie et les valeurs limites des caractères métriques mesurés en fonction de la longueur totale (Lt) chez la population totale (N= 140) de *Carassius carassius* du barrage Hammam Debagh à Guelma

Fonction	R	Equation de régression	Equation d'allométrie	t_{obs} & Type d'allométrie	Valeurs limites (cm)
Lf = f(LT)	0,97	Lf = 0,95 Lt + 0,04 Lf = b Lt + a	Lf = 1,08 $Lf^{0,95}$ Lf = 10 ^a Lf ^b	2,33 (-)	16,4 ≤ LT ≤ 32,7 16,5 ≤ Lf ≤ 30,6
Ls = f(LT)	0,86	Ls = 1,05 LT - 0,153	Ls = 0,70 $Ls^{1,05}$	1,05 (=)	13,6 ≤ Ls ≤ 30,3
Hcp = f(LT)	0,76	Hcp = 1,18 LT + 0,05	Hcp = 1,13 $Ls^{1,18}$	3,08 (+)	3,1 ≤ Hcp ≤ 6,8
Lt = f(LT)	0,84	Lt = 1,08 LT + 0,16	Lt = 1,44 $Lt^{1,08}$	1,60 (=)	3,2 ≤ Lt ≤ 7,9
Hc = f(LT)	0,84	Hc = 1,14 LT + 0,36	Hc = 2,30 $Lt^{1,14}$	2,81 (+)	5,8 ≤ Hc ≤ 13,1
Hpcd = f(LT)	0,82	Hpcd = 1,39 LT - 1,40	Hpcd = 0,04 $Lt^{1,39}$	6,95 (+)	2,1 ≤ Hpcd ≤ 5,9
Do = f(Lt)	0,78	Do = 1,20 Lt - 0,55	Do = 0,28 $Lt^{1,20}$	3,46 (+)	0,5 ≤ Do ≤ 1,8

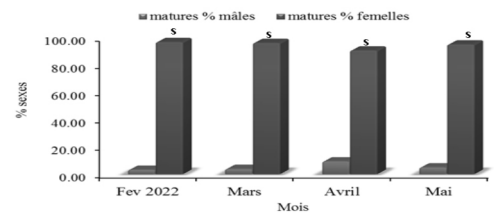


Figure 01. Structure mensuelle de la population de *Carassius carassius* du barrage Hammam Debagh à Guelma (S: sex-ratio en faveur des femelles).

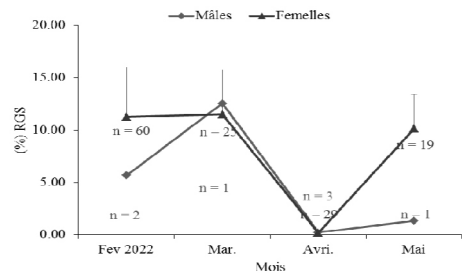


Figure 02. Evolution mensuelle du RHS chez *Carassius carassius* du barrage Hammam Debagh à Guelma.

LOW COST FLOATING FISH CAGES

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Zimbabwe boasts of numerous water bodies ranging from small, medium and large dams. As of 2014 only Lake Kariba was used partially in cage culture systems and there was one Large Scale company on the Lake and using the salmon HDPE circular cages for its robustness against strong winds, perennial on Lake Kariba. The salmon HDPE concept dispelled small scale players to think of going into cage culture systems owing to high start-up costs. The salmon HDPE cages were viewed as requiring large water bodies, hefty overheads costs as well the kind of equipment required for the operations. Water, being the key component in fish farming, the idea to venture into other small and medium dams dotted nationwide was conceived. The proposal will indicate the designs and models of the floating fish cages and a multipurpose Access Rafter boat fit for small and medium dams and according to the background of the water body. Net changing, harvests and security issues were considered in the designs and models. The results of the products were as good as those from large water bodies, yet being produced at a lower cost operational model. Since 2016, a number of small dams are now having these small-scale cage culture models, though the stocking densities are a bit lower than those on large water bodies. Abstract by Sokonia Kaitano (the designer and developer of the system 2014 at Mnandi Dam along Karoi River, Karoi).

HAEMATOLOGICAL RESPONSES, GUT CONTENT, ANTIOXIDANT STATUS AND HISTOPATHOLOGICAL ANALYSIS OF AFRICAN CATFISH (*Clarias gariepinus*) FED WITH COMBINATION OF COMMERCIAL DIET AND BLACK SOLDIER FLY (*Hermetia illucens*) LARVAE

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Aquaculture industry faces challenges in feed availability and quality while striving for sustainability. Traditional fish feeds contribute to overfishing and deforestation, necessitating alternative protein sources. This study investigated the effects of incorporating Black Soldier Fly (BSF) larvae into African catfish (*Clarias gariepinus*) juveniles' diets, examining hematological responses, gut ecology, antioxidant status, and histopathological changes. The experiment used 105 *C. gariepinus* juveniles across five dietary treatments: 100% commercial diet (control), 60% commercial diet with 40% BSF larvae, 80% commercial diet with 20% BSF larvae, 100% BSF larvae, and 100% formulated diet.

Hematological parameters showed no significant differences across treatments. The highest (2043.40±34.27) and lowest (1913.61±3.02) villi height were observed in treatment 1 and 2 respectively. The highest (204.53±1.43) and lowest (191.58±0.07) villi width were observed in treatment 1 and 2 respectively. The highest value for muscle thickness was obtained in treatment 2 (343.71±16.17) while the lowest was in treatment 4 (218.38±1.44). Treatment 5 had the highest value was in total protein, globulin and ALP respectively, treatment 1 had the highest value in Albumin, A:G ratio, AST and creatinine respectively and treatment 3 had the highest value in BUN. Histopathological examination revealed no intestinal lesions, but moderate hepatocyte swelling was observed in some BSF-containing diets in livers and it also showed varying degrees of tubular epithelial changes and inflammation in BSF-containing diets in the kidney.

The study concludes that BSF larvae can be incorporated into African catfish diets without major negative impacts on hematology, serum biochemistry, or intestinal health.

Table 1: Haematological responses

TREATMENT	T1	T2	T3	T4	T5
NTS					
PVC (%)	40.00±3.56*	43.00±2.45*	43.33±9.39*	40.67±6.13*	40.33±5.56*
FB (g/dl)	12.83±1.30*	13.83±0.94*	13.77±3.07*	13.00±2.00*	13.07±1.90*
RBC (×10 ⁹ /L)	3.82±0.32*	3.92±0.27*	3.85±0.52*	3.91±0.45*	3.68±0.44*
WBC (×10 ⁹ /L)	20916.67±100	17666.67±412	15733.33±434	17816.67±141	17433.29*
MCV (fL)	104.57±1.46*	109.79±1.68*	111.38±9.66*	103.58±5.36*	109.39±5.56*
MCHC (Pg)	32.05±0.44*	32.15±0.35*	31.71±0.66*	31.96±0.36*	32.37±0.25*
MCHC (%)	33.51±0.85*	35.29±0.32*	35.35±3.47*	33.12±2.01*	35.41±1.81*
PLATELET (μL)	149333.33±19	172000.00±17	180000.00±18	184000.00±27	183333.33±23
LYMPHOC	482.19*	204.65*	184.24*	820.86*	584.36*
LYMPHOC					
LYTES (%)	70.67±3.30*	72.00±2.94*	72.33±6.24*	72.00±3.74*	69.67±4.11*
HETEROPH					
ILS (%)	23.33±4.71*	20.33±2.87*	21.67±5.79*	20.67±4.11*	23.00±3.27*
MANOPHI					
LS (%)	3.33±0.47*	2.67±0.94*	1.67±1.25*	3.33±0.47*	3.33±0.47*
EOSINOPH					
ILS (%)	2.67±1.89*	4.33±1.25*	4.33±0.94*	3.67±0.47*	3.67±0.94*
BASOPHIL					
S (%)	0.00±0.00*	0.67±0.47*	0.00±0.00*	0.33±0.47*	0.33±0.47*

Table 2: Serum Biochemistry

TREATMENT	T1	T2	T3	T4	T5
TOTAL PROTEIN (g/dl)	4.17±0.12 ^a	3.80±0.29 ^a	4.10±0.33 ^a	3.97±0.52 ^a	4.23±0.24 ^a
ALBUMIN (g/dl)	1.00±0.08 ^a	0.73±0.26 ^a	0.87±0.29 ^a	0.77±0.38 ^a	0.97±0.26 ^a
GLOBULIN (g/dl)	3.17±0.05 ^a	3.07±0.05 ^a	3.23±0.05 ^a	3.20±0.16 ^a	3.27±0.05 ^a
A:G RATIO	0.32±0.02 ^a	0.24±0.08 ^a	0.27±0.09 ^a	0.24±0.10 ^a	0.30±0.08 ^a
AST (μL)	53.67±3.09 ^a	46.00±8.64 ^a	51.67±9.18 ^a	49.67±11.61 ^a	52.00±8.04 ^a
ALT (μL)	42.00±9.90 ^a	41.67±4.50 ^a	44.00±8.49 ^a	37.33±9.67 ^a	42.67±7.13 ^a
ALP (μL)	210.67±10.50 ^a	214.67±15.41 ^a	201.33±1.89 ^a	220.00±2.45 ^a	254.33±62.72 ^a
BUN (mg/dl)	5.40±0.57 ^a	5.33±0.34 ^a	5.67±0.47 ^a	5.33±0.47 ^a	5.50±0.41 ^a
CREAT (mg/dl)	0.57±0.05 ^a	0.53±0.05 ^a	0.53±0.05 ^a	0.53±0.05 ^a	0.53±0.05 ^a

EMPOWERING A SEAWEED SECTOR IN TUNISIA: FROM UNDERRATED RESOURCE TO A SUSTAINABLE INDUSTRY, VISION AND STRATEGY

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Seaweeds are valuable biological and economical resource with different applications leading to a fast-growing sector worldwide. However, macroalgal cultivation and bioprocessing are still scarce in the Mediterranean region and in Tunisia in particular where, despite a rich seaweed biodiversity, algae remain very little exploited. A recent study [1] pointed out that natural seaweed biomass of Tunisian coasts is limited and most of the research is focused on seaweed biotechnology. Nevertheless, to develop the seaweed industry, Tunisia needs to increase efforts by promoting seaweed culture activities for biomass availability. Therefore, one of the major disadvantages of seaweed sector developments is the limited capacity to increase knowledge on seaweed aquaculture. Thus, while the Tunisian aquaculture sector, mainly based on fish production, is in expansion and Tunisian Government is actively pursuing blue economy development initiatives, seaweed farming development is at its ideal timing.

We here present, the potential of the seaweed sector in Tunisia in terms of biodiversity, cultivation, and bioprocessing, and discuss the major challenges, i.e., biology, building capacity, technology, and policy that currently hinder the expansion of a sustainable Tunisian seaweed industry based on swot analysis, questionnaire surveys, training evaluation and workshop exchanges made through the TAHALEB Project.

Acknowledgements:

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REGIONAL AQUACULTURE INTERVENTIONS: A CASE OF PROFISHBLUE IN SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

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The Southern African Development Community (SADC) region is made of Sixteen (16) Member States namely Angola, Botswana, Comoros, Democratic Republic of Congo (DRC), Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic of Tanzania (URT), Zambia and Zimbabwe that are bound through the Declaration and Treaty. The Declaration and Treaty recognises the need for stronger regional integration throughout Southern Africa to further development of the region. Further, it mandates the Member States to conclude such Protocols in areas necessary for cooperation. Therefore, the SADC Protocol on Fisheries provides a regional framework for the development and management of fisheries including aquaculture. Through this initiative the region implements the multinational Program for Improving Fisheries Governance and Blue Economy Trade Corridors in SADC Region (PROFISHBLUE Project) that catalyses the development of the aquaculture value chain. This is after the realisation that the region has a huge resource base both inland and marine (Indian and Atlantic) systems for capture fisheries and aquaculture to support the regional human population estimated at over 380 million and towards offsetting a deficit of fish estimated at 1.8million tons in the region. The project is supporting genetic improvement programmes for the indigenous tilapia cluster to improve the growth rate thereby improving productivity and production of aquaculture in the region. The cold chain initiative to reduce post-harvest losses (PHL) along the aquaculture value chain especially by women and youth engaged in processing and trade of fish and fish products is another intervention in the value chain. Out of the total of 8,987 targeted participants, 94% are women and 53% are youths benefiting from the cold storage network. The project also facilitates intra-regional trade through harmonisation of the fish and fishery product standards and enhance adaptive capacity of fish value chains communities against external shocks. A total of 80 Small to Medium Enterprises (70% women) have been trained in business development, product development and trade facilitation both domestic and international markets.

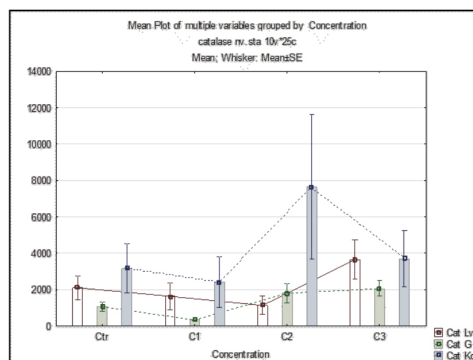
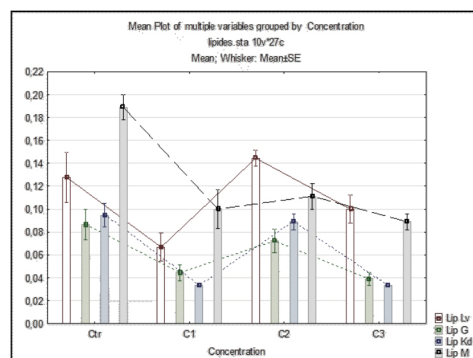
OXIDATIVE STRESS RESPONSE AND BIOCHEMICAL PARAMETERS IN LIVER, KIDNEY AND GILLS OF EUROPEAN EEL, *Anguilla anguilla* EXPOSED TO SIMAZINE

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The European eel, *Anguilla anguilla*, is a common species. It has been known and present for millennia in Tunisia where it has always had a fish farming importance (Sanekli, 1981). Because of its position at the top of the food chain and its benthic way of life, the European eel is a species particularly exposed to organic or inorganic pollutants and therefore conducive to significant bioaccumulation. The pesticide application can lead to the dissipation of these compounds in the aquatic environments and subsequently to a very high risk of contamination of non-target species such fishes. Simazine is a synthetic herbicide of the triazine chemical family that inhibits photosynthesis of plants. This herbicide is capable of inducing physiological disturbances and histological changes in fish. The present study was conducted to determine the toxicity and effects of herbicide simazine commercial formulation on the biochemical parameters and oxidative stress biomarkers in European eel *Anguilla Anguilla*. Eels were exposed to ascending simazine concentrations: C=0 μ g/L [control], C1=0.3 μ g/L, Group 1 (G1), C2=50 μ g/L Group 2 (G2) and C3=100 μ g/L Group 3 (G3)] during 96 hours.

For lipid content, we note, in the different organs studied, a decrease following simazine contamination compared to controls. The lowest protein level was recorded for G1 weakly exposed to simazine. Non enzymatic biomarkers are also influenced by contamination. Overall, there is an increase in the MDA content following contamination compared to controls especially for G1 in the liver, gill and kidney. The liver followed by the kidneys are the organs richest in AOPP whatever the concentration of simazine. Compared to the control, a significant increase ($p < 0.05$) of AOPP is observed in kidney for G1. Decrease of NPSH is recorded in G3 compared to the control. We monitored the activity of catalase as enzymatic biomarkers. We found that the only significant variation was noted in gill with an increase ($p < 0.05$) in catalase activity in G2 and G3 compared to G1. Finally, for acetylcholinesterase activity, we note for gill and in G3 a significant decrease with regard to G2 ($p < 0.05$).



CHARACTERIZATION OF MOLLUSK ASSEMBLAGES ON COASTAL ROCKS IN NORTHERN TUNISIA

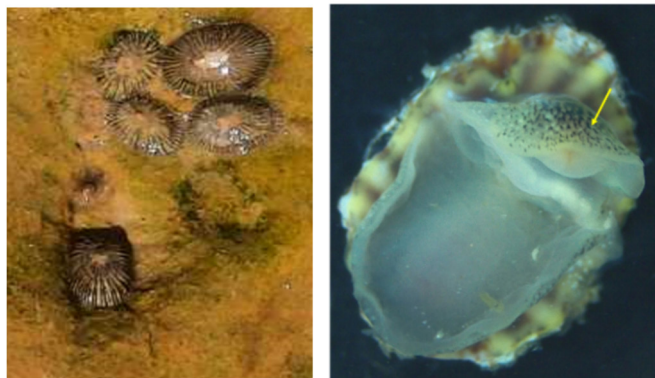
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The present study highlights the essential importance of malacology for understanding and preserving marine ecosystems. Its objective is to identify the molluscs of hard substrates, particularly along the northern coast of Tunisia. Sampling conducted between February and March 2024 at the sites of Bizerte, La Goulette, Sidi Raies, and Tabarka resulted in the collection of a total of 614 live mollusc specimens, representing 15 species, (13 gastropods and 2 bivalves). The composition of the fauna shows that the most dominant species is a pulmonate gastropod of Indo-Pacific origin: the false limpet *Siphonaria pectinata*. Furthermore, we observed that species richness varies according to the sampling site, highlighting the importance of local environmental conditions. The strong presence of *Siphonaria pectinata*, accounting for 75% of the overall sampling, suggests its ability to establish itself in the marine habitats of the northern coast and the Gulf of Tunis as an exotic species.

For the sampling, we used a square frame covering a quadrat of 25x25 cm, which corresponds to an area of 0.0625 m². Five replicates of the quadrat were collected for each station. It was fixed on the rocks at a depth ranging from 0 to 0.5 m (Figure 1). We started by scraping off the molluscs and gathering them in a bag. The bags were pre-numbered and labeled with the site name and date. Our study indicated that *Siphonaria pectinata* is the most abundant species in the overall sampling and provided new information on its distribution to monitor its impact on the marine ecosystem, particularly on the indigenous fauna.

This strong presence reflects the great diversity of micro-habitats available in hard substrates. It suggests that *Siphonaria pectinata*, as an exotic species, has successfully established itself along the northern coast, the Gulf of Tunis, and continues to expand in Tunisia towards the Gulf of Hammamet. The question arises: “Could *Siphonaria pectinata* pose a real threat to native species?” To assess the potential threat of *Siphonaria pectinata*, several aspects must be considered: competition for resources, impact on biodiversity, adaptability of native species, and ecological changes. This exotic species could directly compete with local species for resources and habitats, leading to a decrease in biodiversity and a possible reduction in native species populations.



Dorsal and ventral sides of *Siphonaria pectinata*

THE INVASIVE RED SEA MUSSEL *Brachidontes pharaonispharaonis* AND THE RISK TO THE SHELLFISH ENVIRONMENT IN BIZERTE

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Molluscs are one of the most important taxa that significantly contribute to biodiversity, as they make up about a quarter of benthic species. They are a representative group in the benthos and can be used as indicators of the presence of non-native species in the marine environment. Therefore, to ensure the monitoring of our coastal environment, there is a need for a detailed list of the national malacofauna at any given time in order to detect newcomers. In this work, we have attempted to complete the inventory of molluscs in Bizerte.

Sampling was carried out between February and March 2024 at five stations. It allowed us to collect more than 1042 specimens representing 65 species. During this work, we reported the presence of the Red Sea mussel *Brachidontes pharaonis* in all the harvesting stations of Bizerte, representing a risk for the shellfish farming environment.

The latter is present and abundant in the Bizerte canal, signalling a potential risk for the shellfish farming environment. We were able to show the considerable threat that this species represents on the structure and biodiversity of the La Goulette ecosystem in 2023 and we report that the continued demographic growth of this species and the formation of mytilidae mats accompanied by a strong dominance of a small bivalve *mytilaster minimus* can displace native species and reduce diversity. This can lead to competition for resources, clogging of aquaculture facilities and ecosystem alteration.

It is therefore crucial to issue an alert to encourage rapid detection in the shellfish farm in Bizerte and particularly that of Jouwewda. We strongly recommend the establishment of regular monitoring programs to detect *Brachidontes pharaonis* infestations early and intervene quickly.

HYBRIDIZATION OF HYBRIDS BETWEEN *Oreochromis niloticus* AND *Oreochromis andersonii* CROSSED WITH HYBRIDS OF *Oreochromis niloticus* AND *Oreochromis macrochir* UNDER POND CULTURE

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In freshwater and aquaculture contexts, hybridization between the *Oreochromis* species has recently increased in frequency. The purpose of this study was to assess the development of the gonadal / gametes in crossings between hybrids of *Oreochromis niloticus* and *Oreochromis andersonii* crossed (X) with hybrids of *Oreochromis niloticus* and *Oreochromis macrochir*. Nine males and eighteen female brooders, weighing an average of $180 \pm 0.32g$, were first conditioned by keeping the males and females apart for a month. They were then fed a commercial diet at a body weight of 5%. In a completely randomized setup, the sexes were paired in a 1 x 2 m hapa at a 1:1 sex ratio and the process was repeated three times.

The results indicate that the crosses between the hybrids did not breed after mixing the sexes for a period of six weeks. When subjected to laboratory analysis, three males out of nine had partial gonadal development, whilst six males had no gamete development and a single male developed full gonads. Female brood stock did not develop any gonads. The study demonstrates that the development of gametes in *Oreochromis* hybrids is unpredictable.

The results points to hybrids fecundity rate reduces with generation and sterility sets in, in the subsequent generations.

Therefore, this study advises farmers not to consider choosing brood stock from such batches from the generation of hybridization.

It is imperative to regularly replace broodstock in aquacultural facilities as hybrids are produced to enhance growth rates and for consumption thereby increasing economic productivity.



Figure 1. Specimen 1 is a male hybrid with fully grown gonads and specimen 2 showing a hybrid female with no distinct gonads

GENDER-SPECIFIC ANALYSIS AND MAPPING OF THE AFRICAN CATFISH VALUE CHAIN IN UGANDA: A FOCUS ON WOMEN'S ROLES AND OPPORTUNITIES

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Catfish farming in Uganda presents an opportunity for women to get employment, make a living and obtain nutritious food for their families. There is limited specific information on the women roles and opportunities in literature regarding catfish farming. This study services as an initial investigation on gender specific analysis in the catfish value chain in Uganda to get a better understanding about the involvement of women, their specific roles and opportunities for business and self-employment. The study was conducted in eight districts in the four regions in Uganda with participation of 164 persons in seed and feed producers, catfish farmers, processors, traders and consumers. The data collection method used was face-to-face interviews with the respondents. Results indicated low participation of women in most sectors apart from fish processing. The participation of women as owners or players in seed and feed production was almost negligible. The women involved in processing are very active but with very low economic returns about half of that realized by fish farmers and a third of that obtained by traders and thus economically vulnerable. Many women find barriers to financial resources and most of them utilized more of family savings unlike men who mostly utilized their own personal savings. Their major challenge was high interest rates and a lack of collateral security. More women were involved in groups (45) compared to men (36). Findings call for targeted interventions to enhance women's economic empowerment to effectively contribute to the catfish value chain in Uganda.

READINESS OF SMALL-SCALE FISH FARMERS FOR DIGITAL CLIMATE INFORMATION SERVICES IN SADC REGION: EVIDENCE FROM ZAMBIA

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Climate change poses a significant threat to the fisheries and aquaculture sector, particularly in developing countries like Zambia, where small-scale fish farmers face economic losses due to disrupted value chains, limited access to climate information, and weak adaptation capacities. Introducing digital climate information services (CIS) offers a critical solution by providing localized climate data and tailored advisories to enhance climate-informed decision-making and promote effective climate risk management among vulnerable small-scale fish-farmers. As part of the effort to develop a digital CIS for aquaculture, a survey with a sample of 300 smallholder fish farmers across three districts in Luapula province—Mansa, Kawambwa, and Samfya—located along Lake Bangweulu in Zambia was conducted to gather relevant information for creating a platform to mitigate climate risks in the aquaculture sector. The study aimed to assess the effects of climate change and weather variations on fish production among small-scale fish farmers in Zambia, evaluate the current status of climate change adaptation practices, examine the utilization of CIS, and identify preferences for weather information and communication mediums. Respondents were randomly chosen using registers from local authorities, ensuring representativeness across stakeholder strata.

The findings revealed that 74.8% of the respondents faced challenges due to changing weather patterns, with high temperatures and reduced rainfall being the most common issues. A statistically significant difference ($P < 0.05$) was found between education levels and the challenges experienced from weather changes. There was also a significant relationship between the weather-affected fish production process and access to fisheries training, except for pond preparation, fingerling collection, and harvesting ($P > 0.05$). Only 37.7% of respondents reported using weather information in their farming practices, primarily information related to low temperatures and heavy rainfall. Most of this information was accessed via radio, as financial constraints limited access to digital platforms such as social media or television. In terms of weather information preferences, most respondents desired updates on the onset of rains, critical temperatures, and heavy rainfall, with a preference for weekly updates. SMS messages in local languages were the preferred medium for receiving weather information, especially for pond preparation activities. The research also derived key actions taken by farmers based on specific weather information to minimize the risks posed by weather variations, information critical for the development of a framework according to changes in weather variables. The study recommends large scale capacity-building initiatives to ensure the readiness of small-scale fish farmers in using CIS effectively for managing climate risks in the SADC region.

ANALYSE DES RENTABILITES DE LA PISCICULTURE ARTISANALE ET SEMI-INTENSIF DU *Tilapia nilotica* DANS LA PLAINE DE LA RUZIZI AU SUD-KIVU EN REPUBLIQUE DEMOCRATIQUE DU CONGO

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La production mondiale de l'aquaculture a poursuivi sa croissance en 2020 malgré la pandémie mondiale de covid-19, avec toutefois des différences selon les régions et les pays producteurs au sein de chaque région. Aujourd'hui, l'élevage des organismes aquatiques est devenu une activité Économique majeure à l'échelle mondiale. Plus d'un poisson sur deux est issu de l'élevage [FAOFISH 2012]. Cependant, en République Démocratique du Congo, la contribution globale actuelle de l'aquaculture au volume total de poissons consommés en RDC est marginale, les statistiques de la production halieutique locale sont fortement influencées par les captures des pêches. ». Toutefois, la forte demande de poisson en RDC, soutenue par une forte croissance démographique laissent à penser que les opportunités de développement pour l'aquaculture sont florissantes en RDC. La moyenne nationale de consommation en poisson en RDC est de 5,3 kg loin en dessous de la moyenne recommandée par l'OMS de 21 kg par personne. En 2018 et 2019, la RDC a importé en moyenne 200,000 tonnes des poissons par an. Malgré les volumes d'importation en poisson toujours croissants, les poissons ne sont pas accessibles à toute les couches. La pisciculture familiale présente une alternative pour la production durable à l'accessibilité des poissons pour tous. Mais c'est un secteur qui n'attire pas d'investissements à ces jours. Cette analyse avait pour but de vérifier la rentabilité de la pisciculture en étang avec deux systèmes d'élevage : avec alimentation naturelle basée sur la production primaire de l'étang et avec compléments alimentaires (granule) à partir de 120 jours d'élevage. Les résultats obtenus ont montré les taux de rentabilité de 11% à la première année et de 73% à la deuxième et troisième année avec des rendements de l'ordre de 9,5 t/ha après 7 mois de grossissement pour le système avec alimentation naturelle basée sur la fertilisation tandis qu'en incorporant un complément alimentaire de 1% des poids vifs des poissons à partir de 150 jours, nous avons obtenus des taux de rentabilité de 36% à la première année d'investissement et de 61% à la deuxième et troisième année. L'analyse statistique a montrée une différence significative en faveur du système avec complément alimentaire.

UNDERSTANDING THE AQUACULTURE GOVERNANCE LANDSCAPE IN UGANDA: A PRELIMINARY ASSESSMENT USING THE AQUACULTURE GOVERNANCE INDICATORS

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Uganda is one of the largest aquaculture producers in Africa with a remarkable growth attributed to a private sector led industry. However, current aquaculture production cannot meet the national and regional demand of food fish mainly due to: limited access to affordable quality feed and seed, and limited access to knowledge technologies. Several efforts are set to drive aquaculture into a sustainable and equitable sector through participatory innovations and governance.

Governance is a pivotal transformer for aquaculture's growth but there is limited information on Africa's landscape. Therefore, this study assessed the political, institutional, collaborative arrangements /partnerships, and regulatory dimensions that have contributed to the transformation of Uganda's Aquaculture sector using Aquaculture Governance Indicators (AGIs). Preliminary analysis revealed that Uganda has strong legislative framework covering major industry and sea food watch issue areas including effects of aquaculture effluent on the environment, habitat, chemical use, source of stock disease and escapees. However, it needs to be; i) strengthened at National and local levels ii) efficiently coordinated and enforced, and iii) extension support strengthened to increase compliance for small scale farmers. Voluntary and compulsory national standards relating to aquaculture production, inputs, fish processing and marketing guidelines have been developed by the Uganda National Bureau of Standards (UNBS). However, there is need for more awareness and inclusion of stakeholders. Private standards like ASC are generally perceived to be applicable to large scale commercial farms targeting international export of farmed fish, with only one farm reported to have pursued ASC certification. The key collaborative processes are industry-led (Commercial Fish Farmers Associations) or have interactive governance (donor funded projects implemented by government ministries or research institutions in collaboration with market and civil society actors). Governance and partnership arrangements are deemed very relevant to address the main industry issue areas. However, there is need to: i) enhance the visibility of their deliberative processes, ii) strengthen coordination and learning processes within and between collaborative arrangements. This study provides insights to foster learning, better understanding of the challenges within the sector and a starting point for engagement among different stakeholders around identified gaps to ensure sustainable development.

VALIDATED PCR TESTING FOR AQUACULTURE SUCCESS AND ISO 17025 COMPLIANCE

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With the increasing scale of trade in aquaculture products, ISO 17025 accredited laboratories play an essential role in ensuring product quality, consumer safety, and facilitating international trade. ISO 17025 is an international standard that specifies the general requirements for the competence of testing laboratories to ensure reliable results that are crucial for meeting international market demands. Accreditation under ISO 17025 means that the laboratory has been assessed by an external body to guarantee that the testing carried out by the laboratory is compliant with these global standards.

Amongst others, the ISO 17025 standard requires that the laboratory must demonstrate the capability to achieve accurate, repeatable results using a selected method. Consequently, testing methods need to be appropriate, validated and documented. Furthermore, adequate diagnostic test validation and characterisation of the diagnostic performance of diagnostic tests for infectious diseases, as per World Organisation for Animal Health (WOAH) guidelines, are essential to ensure that the application and interpretation of the results are scientifically robust.

Abalone Herpes Virus 1 (AbHV) is listed as a notifiable disease by WOAH. South Africa is currently classified free from infection with Abalone Herpes Virus at country level, underscoring the importance of reliable diagnostic services and regular testing to maintain this status. In this instance appropriately validated, fit for purpose diagnostic testing capability for targeted surveillance in seemingly healthy animals is essential.

Our study utilised a synthetic plasmid as a positive control and validated a duplex real-time PCR assay for detecting AbHV. This method offers high analytical sensitivity and specificity, targeting a 145 bp segment of an open reading frame on the genome. The validation process included rigorous testing for analytical specificity and sensitivity, repeatability, and reproducibility, ensuring that it meets ISO 17025 accreditation requirements, as well as the additional technical requirements of the South African National Accreditation System (SANAS). This is the first assay to be ISO 17025 validated for the abalone aquaculture sector in South Africa and enhances the credibility and marketability of aquaculture products, facilitating global market access. This validated, soon to be accredited, service supports targeted disease surveillance in outwardly healthy populations, early disease detection and control, fostering sustainability and growth in the industry. This compliance with international standards is vital for successful participation in the global market.

THE BOTTOM-UP APPROACH – GIVING AQUACULTURE STAKEHOLDERS/FARMERS A VOICE IN LEADING THE WAY TO EMPOWERMENT: THE FISH4ACP STORY

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In the aquaculture sector, sustainability is often challenged when projects fail to fully integrate stakeholders—especially farmers—into the design and implementation phases. The FISH4ACP project, through its bottom-up, value chain-driven approach, emphasizes the active engagement of farmers to ensure their voices lead the way to empowerment and long-term sustainability. This intervention, applied across Nigeria’s vast catfish aquaculture value chain, demonstrates that stakeholder-driven solutions not only improve immediate productivity but also foster resilience beyond the lifecycle of donor-led projects.

By focusing on inclusive value chain analysis, the FISH4ACP approach ensures that interventions are tailor-made to address the specific needs and challenges of each actor, from small-scale farmers to processors. The project’s participatory methodology equips farmers to actively contribute to decisions and policies, securing their buy-in and ownership of outcomes. This leads to greater adoption of best practices, better management of resources, and the creation of sustainable business models that continue to thrive post-project.

This paper will present key findings and lessons learned from Nigeria’s catfish value chain under the FISH4ACP project, highlighting how farmer-led innovations and engagement is transforming the industry. It will explore how this inclusive model can be replicated across other aquaculture systems, promoting a more sustainable and resilient future for the sector across Africa.

QUALITY OF FISH MEAL USED IN AQUAFEED MANUFACTURING PLANTS IN SUB-SAHARAN FACTORIES

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African Aquaculture production is on the rise. This development is fuelled by an extension of the production surface and by the intensification of farming methods. The use of feed at different farming stage is more and more common in fish farms. Such feeds can be imported or locally manufactured.

This presentation will be about the quality of different fish meal (FM) found in feed mills operating in different feed mills producing aquaculture dedicated feeds in Sub-Saharan Africa. Developments toward the possible use of these meals in feed formulations for tilapia and catfish will be proposed in the conclusion.

Methods

Sampling and observations were made during audit and technical visit in 5 countries (Guinea, Ivory Coast, Congo, Rwanda, Madagascar) and a total of 12 plants. Samples were then analysed both visually and chemically. Compositions are then compared with international standards. Results of close examinations are also discussed in a feed manufacture and formulation perspective.

Results

FM are almost always sold without any data sheet and the traceability of bags and batch is practically impossible. There is no information about fish species used.

Close and attentive examination of samples collected show that locally manufactured FM are obtained through a huge variety of process. Physical presentation of the products bought by feeds millers differ a lot. Some are made of raw dried fish when other are finely grinded. The presence of foreign bodies likely to cause technological and nutritional problems is frequent.

Fish meal manufactured and used in Sub-Saharan Africa are characterized by a low to very low level of protein and high to very high ash content. Fat content is generally low. In most cases, their amino acid profile does not differ too much from standards.

Observations and conclusion

FM found in factories operating in Sub-Saharan Africa are characterized by their medium to poor quality. They differ significantly from the standard used in the industry. Discrepancies are particularly important for protein and ash. Such characteristics are limiting the interest for their inclusion into the formulas. However due to the scarcity of protein rich raw material in most of these context they still constitutes an interesting ingredient for the formulators.

MEASUREMENT ASPECTS FOR THE AUTOMATION OF MARINE WATER QUALITY MEASUREMENTS

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Protein production from aquaculture and fish farming are considered more efficient and sustainable than traditional livestock farming, due to better feed conversion ratio and lower impact on resources such as water and land. However, the quality of the product is sometimes not perceived by final consumers due to poor traceability of the production process and certification. To improve consumer confidence and the profitability of the supply chain, it is essential to implement a clear and detailed tracking of production, processing, distribution and logistics. The article outlines a method for tracking the quality of a small/medium-sized producer's production process. The article focuses on the potential production in the low-anthropogenized waters of the North African coasts in accordance with current regulations. The method is described from a legal, biological and technical/scientific point of view. The theme is declined on various interventions to deepen the various areas of the topic. (MASAF, Avv Silvia Canali - Institute of Marine Biology Piombino, Prof Bedini- University of Roma Tre, Prof Leccese- SeTeL srl , Ing De Francesco). In particular, Roma Tre is involved in all the measurement aspects joined with the automation of water quality measurements and this paper would to analyze the state of the art of this topic and its future trends.

Usually many events can affect the quality of marine water. Such phenomena, in general, occur in narrow time windows making it impossible to intervene promptly through “classic” monitoring campaigns. Therefore, it is essential to design innovative methodologies and systems for controlling water quality (Water Quality Monitoring – WQM). Obviously, research must be directed towards proposing economically sustainable systems and procedures; only in this way is it possible to hypothesize an extensive use of water quality control and management systems. Fig. 1 illustrates, in a schematic way, the various methodologies that can be used in WQM. The work aims to show the state of the art in this topic and the future trends, even explaining the last novelties developed at University Roma Tre.

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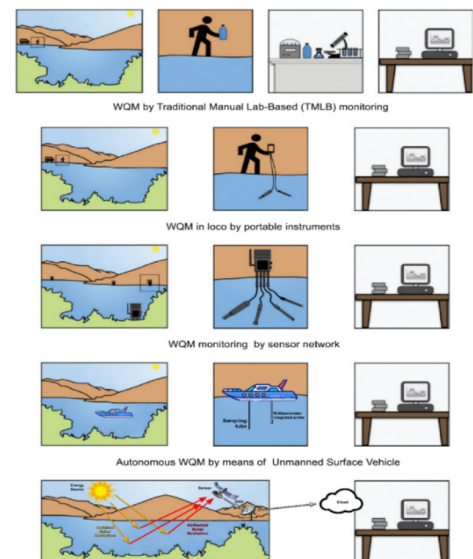


Fig. 1 Schematic representation of the various methodologies that can be used for WQM.

PROMOTING SUSTAINABLE AQUACULTURE AND BLUE ECONOMY LITERACY THROUGH INNOVATIVE TRAINING PROGRAMS

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Over the last few decades, there has been an urgent need to increase knowledge in the blue economy to promote sustainability and enhance the literacy of employees working in marine areas. Education and training are key drivers for developing and maintaining the skilled workforce required to meet the global challenge of achieving a more sustainable aquaculture industry. Therefore, investing in capacity building in aquaculture, marine sciences, and the blue economy is essential for fostering social inclusion and strengthening the competitiveness of the aquaculture sector.

S2AQUAcoLAB is a private, non-profit institution dedicated to research and experimental development in aquaculture. Its mission is to respond to the needs of the industry, focusing on promoting a smarter, more sustainable aquaculture grounded in scientific knowledge, innovation, and technological development. One of S2AQUAcoLAB's core goals is to provide training tailored to the specific needs of the aquaculture industry.

In collaboration with partners and stakeholders, S2AQUAcoLAB has designed training programs that are customized to address critical industry gaps, focusing on both soft and technical skills essential to the aquaculture sector. S2AQUAcoLAB's training initiatives are divided into three main categories: Essential, Tailored, and Innovation programs, all aiming at empowering individuals, catalyzing the growth of the aquaculture sector and driving innovation. These training programs are available at S2AQUAcoLAB's Moodle online platform, allowing the replicability of the training content across different organisations, regions and countries.

These online training programs have significant potential to expand learning opportunities for workers in the aquaculture sector in African countries, where training in marine sciences, aquaculture and the blue economy is limited. Additionally, the historical, linguistic and geographical ties between Portugal and the Community of Portuguese Language Countries (CPLP) provide a strong foundation for extending these training courses to Portuguese-speaking African countries.

Leveraging S2AQUAcoLAB's multidisciplinary team extensive experience in aquaculture, offering these programs represents a strategic approach to strengthening the aquaculture sector in Africa. By doing so, S2AQUAcoLAB aims to support sustainable economic growth, enhance the aquaculture industry, and contribute to food security in this emerging and vital sector across the region.

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S2AQUACOLAB: DRIVING INNOVATION AND SUSTAINABILITY IN AQUACULTURE THROUGH RESEARCH AND INDUSTRY COLLABORATION

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The S2AQUAcoLAB (S2AQUA) is a private, non-profit institution, established in 2021, which plays an important interface role between academia, research and the aquaculture industry. Our mission is to drive innovation and research aimed at advancing aquaculture through sustainable and intelligent practices.

S2AQUA brings together 17 member organizations, including 1 state laboratory, 2 higher education institutions, 3 R&D centres, 1 municipality, 1 producer's association and 10 private companies. Supported by a core team of 31 highly qualified human resources and 49 additional researchers from partner institutions, our expertise covers a broad spectrum of aquaculture-related fields, strengthened by a robust track record of scientific contributions.

Our research priorities include:

- Specialized human resource training for aquaculture students and professionals.
- Optimization of marine organism production for increased efficiency and sustainability.
- Development of analytical tools for assessing health and welfare bioindicators, alongside *in vitro* systems.
- Environmental monitoring and adaptation strategies to address climate change impacts.
- Technological development and new products for the aquaculture market.

In addition to research, S2AQUA offers services in:

- Zootechnics and aquaculture production.
- Specialized technical training.
- Aquatic organism health, welfare, and biosecurity.
- Species identification (biochemical and molecular).
- Environmental interaction studies.
- Reproduction optimization.
- Nutrition.
- Macroalgae cultivation.
- *In vitro* cellular systems.
- Modelling and emerging technologies.
- Event planning, scientific outreach.
- Comprehensive management of scientific projects.

With state-of-the-art infrastructure, equipment, and strong partnerships, S2AQUA is uniquely positioned to bridge the gap between scientific research and industry applications. We are committed to fostering the growth of the aquaculture sector by promoting food security, facilitating knowledge transfer to industry stakeholders, and supporting product diversification.

Join us at S2AQUAcoLAB - your strategic partner in sustainable aquaculture innovation.

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REGIONAL CHALLENGES AND OPPORTUNITIES FOR THE DEVELOPMENT OF SUSTAINABLE SEED SUPPLY CHAINS

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The availability of and access to quality seed is broadly recognized as one of the key constraints to the growth of the sustainable aquaculture, especially in least developed countries.

The FAO Blue Transformation Roadmap 2022-2030, which represents the vision of the Organization for its work on aquatic food systems, identifies improvement in the supply of quality seed as a necessary action in leveraging the sustainable aquaculture sector worldwide.

“*Sustainable seed supply*” is listed as a major component of the recently adopted FAO *Guidelines for Sustainable Aquaculture* (GSA). The GSA recommends conditions and actions required for the well-functioning of seed supply systems reflecting commonly cited needs, including the main needs of many African countries. The proposed strategy of quality seed supply chain includes: effective national policies and strategies; the establishment of breeding nuclei and the decentralization of seed multiplication; genetic improvement program; effective broodstock management; good practices in hatchery, nursery, efficient packaging and transport; the regulatory mechanism of private sector for the long-term sustainability of genetic improvement programmes.

An Expert Workshop on the “Improvement of seed supply for small-scale inland aquaculture” was recently held to identify good practices and science-based solutions to unlock aquaculture’s potential for species key to small scale aquaculture and food security in developing regions. Following the experts’ recommendations, FAO is developing technical manuals for the design and operation of small modular hatcheries for key species (such as carps, catfish and tilapias), guidelines for policymakers to promote the development of breeding programmes for lower-value species in developing countries, and a policy brief to support the development of capacity to design and implement breeding programmes. The Expert Workshop also reviewed the draft *Assessment Framework for Seed Supply Systems in Aquaculture*, a tool to assess needs, gaps, challenges and strengths of seed supply systems and designed around five interdependent components: seed availability and distribution; seed production and quality; information flow and networking; policy and regulatory frameworks; R&D, education and training.

AquaGRIS: THE FAO GLOBAL INFORMATION SYSTEM FOR AQUATIC GENETIC RESOURCES IN AQUACULTURE

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Launched in September, 2024, the new FAO Aquatic Genetic Resources Information System (AquaGRIS), the first of its kind, is a publicly accessible tool collecting a variety of information on aquatic genetic resources (AqGR) used in aquaculture, specifically farmed types (e.g., strains, varieties, hybrids etc.) and wild stocks of farmed species. The information in AquaGRIS is entered by country representatives through an online questionnaire, whose access is restricted to them, and includes: species origin, impact on local biodiversity, climate change impact, habitat status, production purpose and trends, lists of farmed types available for species and their characteristics (genetic, phenotypic and performance), breeding programmes, conservation efforts, list of genetic stocks and their use for seed and broodstock collection etc. A set of indicators, developed in consultation with countries, are integrated within the tool and will allow the monitoring of status and trends in the management of these resources in key areas like characterization, conservation and genetic improvement.

AquaGRIS was developed in response to a request by FAO Members recognizing that the aquaculture sector generally lacks information on farmed stocks of cultured species and on the wild stock on which aquaculture depends.

AquaGRIS has a range of applications benefiting a variety of aquaculture stakeholders (e.g. policy makers, researchers, producers and intergovernmental and non-governmental organizations). From its public user interface (UI), users can: filter data by geographic area, taxonomic group (finfish, crustaceans, molluscs, aquatic plants, algae, etc.), species, farmed type and genetic stock; and generate fact sheets at country, species, farmed type and genetic stock level.

The availability of this tool providing access to robust data on aquatic genetic resources will help ensure the implementation of the Global Plan Action on aquatic genetic resource, and contribute to the future developments and monitoring of the status of global biodiversity within the context of the Sustainable Development Goals and the Kunming-Montreal Global Biodiversity Framework.

USING ICT IN CAGE FISH FARMING EQUIPS FISH FARMERS WITH KNOWLEDGE - THE NARO CAGE AQUACULTURE APP

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Micronutrient deficiencies, especially among vulnerable groups in Africa, underscore the significance of sectors like fisheries and aquaculture in addressing nutrition challenges. Recognized as a nutrition-boosting sector, aquaculture, particularly cage fish culture, offers innovative solutions to scale up production on the continent. This is crucial given the decline in wild capture fishing due to various factors such as overfishing and climate change.

Sustainable development of cage fish culture necessitates addressing social, economic, environmental, and technological aspects. The app integrates face-to-face training with modern ICT and GSM technologies, ensuring equitable outcomes. Its objectives include providing easy access to information on establishing and managing profitable and environmentally sustainable cage fish farming ventures. Moreover, it seeks to enhance the usability and adaptability of Best Management Practices (BMPs) for cage culture, enabling farmers and investors to maximize productivity and efficiency while ensuring a return on investment.

Despite its potential, the full realization of cage fish farming's benefits in Africa remains unrealized. The NARO Cage Aquaculture App aims to bridge this gap by equipping farmers with the knowledge to enhance productivity from cages while preserving aquatic resources.

COMBINING AQUACULTURE BIOFILTERS TO IMPROVE SUSTAINABILITY AND RECOVER EXCESS NUTRIENTS IN MARINE INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEMS

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Expanding environmentally friendly and sustainable aquaculture systems is needed to reduce fishing pressure on declining wild fish populations and meet the ever-increasing demand for safe and sustainable seafood. Conventional aquaculture is challenged by high water demand, pollutant discharge, biosecurity, and disease. Marine or salt-water recirculating aquaculture systems (RAS) have the potential to address many of these challenges; however, these RAS systems face obstacles that need to be addressed, such as high energy demand, discharge of saline water and organic salty solids, and the lack of a standardized RAS filtration system. Improving the economic viability and sustainability of zero-discharge marine RAS led Mote Aquaculture Research Park (Mote) scientists to develop a marine aquaponics or Integrated Multi-Trophic Aquaculture (IMTA) system. This IMTA system was engineered to efficiently use nutrients, water and conserve energy to produce marine fish and edible sea vegetables. Mote, in partnership with the National Mariculture Center (NMC) in Israel, the University of South Florida's College of Engineering (USF) and Auburn University are now exploring opportunities to combine aquaculture biofilters in IMTA systems to recover excess nutrients, produce additional end-products and increase revenue. Incorporation of periphyton biofilters into Mote's IMTA not only improved water quality by reducing excess nitrogen and carbon dioxide, but produced dissolved oxygen and repurposed nutrients that can be harvested and used as a potential ingredient for fish feeds. In addition, some nutrients removed from the water can be reclaimed and harvested monthly. Analysis of the microbiome in the periphyton community revealed the presence of denitrifiers, ammonia-oxidizing microbes, nitrite-oxidizing microbes, and valuable algae such as *Chlorella*. Results from trials evaluating different aquaculture biofilter combinations with halophytes, periphyton and moving bed biofilm reactors will be presented. The goal of this research is to develop a pragmatic system that can be managed by family or farmer-owned cooperatives, to supply communities with locally produced fresh seafood and provide expanded job opportunities in rural and urban communities.

POTENTIAL INERT DIETS TO SUPPLEMENT ARTEMIA IN LARVICULTURE OF THE GIANT AFRICA RIVER PRAWN *Macrobrachium vollehovenii*

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The protocol of culture of *Macrobrachium vollehovenii* the main indigenous candidate for freshwater prawn culture in Africa is still under study. Though just few information exists, the transition of larvae from stage V to stage VI has been reported as the critical rearing period in larviculture. This study was to evaluate the efficiency of two locally diets to supplement Artemia in the feeding scheme from stage V to post larvae in the larviculture of this species.

The two experimental diets were differentiated by the main source of protein: fish silage (Diet 1) and shrimp meat (Diet 2). One batch of larvae was cultured till stage V. The experiment itself was conducted in triplicate with three treatments: feeding *Artemia* exclusively (T0, control); fed partial replacement of *Artemia* with inert diet 1 (T1) or fed partial replacement of *Artemia* with diet 2 (T2).

Larval development in T2 was significantly faster than TA and T1 (Table 1). Survival rate from stage VI to Post larvae (stage XII) was significantly higher in T2 (12.64±1.2%) than T0 (6.57±0.29%) and T1 (6.77±0.17%) (Figure 1). The total length of larvae in T2 was significantly higher than T0 and T1. Though the highest survival at post larvae obtained in this study is still low, it's however higher than those reported in other studies with this species. Also, the importance of finding alternatives to *Artemia* and cheaper diets remains very important.

Table 1. Larval stage index of *Macrobrachium vollehovenii* larvae in the three treatments

	Artemia (T0)	Diet 1 (T1)	Diet 2 (T2)
LSI Day 10	4.87±0.05a	4.87±0.05a	4.87±0.05a
LSI Day 20	5.53±0.06a	5.2±0.35a	5.8±0.01a
LSI Day 30	6.9±0.10b	6.47±0.16b	7.57±0.06a
LSI Day 40	8.26±0.06c	7.47±0.92b	8.93±0.06a

Figure 1. Survival rate from stage VI onwards in the different treatments.

Different letters between treatments in each developmental stage denote significant differences (P<0.05)

THE AUTOMATED FINGERLING CARRIER

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The transportation of fish seed (fingerlings) from hatcheries to farms or other aquatic environment is a critical aspect of aquaculture operations. Ensuring the health and safety of fingerlings during transportation is essential for the success of aquaculture enterprises. The automated fingerling carrier presents the design of a novel fingerling transportation system utilizing a portable and durable transparent bucket equipped with a 12 volts water pump, carbon dioxide sensor and batteries for power source to both the sensor and the Arduino board. The system aims to maintain optimal environmental conditions within the carrier, thereby enhancing the survival rate and overall fish health of transported fingerlings. The carrier involves, water circulation mechanisms for the purpose of dissolving oxygen in the water, to create an efficient and reliable transportation system for fingerlings.

The changing global environment is increasingly threatening life forms because countries are focused on development without caring about the environmental damage caused by pollution and degradation of agricultural lands. More factories are being built, using harmful chemicals, and people are using plastic bags, which harm the environment (Jalil et al., 2011). Fingerlings transportation plays a crucial role in the aquaculture industry, as it facilitates the transfer of juvenile fish from hatcheries to grow-out facilities or natural environments. During transportation, fingerlings are susceptible to stress, oxygen depletion, and accumulation of metabolic wastes, which can adversely affect their survival and growth. To address these challenges, innovative transportation systems equipped with monitoring and control mechanisms are being developed. This research focuses on the design and implementation of a fingerlings transportation system that utilizes advanced technology to maintain optimal environmental conditions within the transport container.

MITIGATING AFLATOXIN B₁ (AFB₁) TOXICITY IN NILE TILAPIA *Oreochromis niloticus* FEED USING NATURAL CLAY CHISUMBANJE VERTISOL

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Contamination of feed and food with aflatoxin B₁ (AFB₁) is a prevalent issue in the tropical and subtropical regions. This contamination is exacerbated by environmental conditions that favour fungal proliferation and mycotoxin production, particularly affecting aquaculture because of the industry's vast use of plant-based feedstuffs. AFB₁ contamination in tilapia feed leads to diminished fish health, reduced productivity, economic losses, and potential health risks to human consumers. While mitigation strategies exist, more effective, safe, and affordable solutions are needed. This study investigated the efficacy of Chisumbanje Vertisol, natural clay found in Zimbabwe, as an AFB₁ adsorbent in Nile tilapia feed. Laboratory tests assessed the effects of clay inclusions (0%, 2.5%, and 5%) on pellet physical quality. For growth response, a seven-week feeding trial was conducted on Nile tilapia juveniles (20 ± 1g) using six treatment diets: Basal diet + no additive (Diet 1), Basal diet + 200ppb AFB₁ (Diet 2), Basal diet + 2.5% Clay (Diet 3), Basal diet + 5% Clay (Diet 4), Basal diet + 2.5% Clay+200ppb AFB₁ (Diet 5), Basal diet + 5% Clay+200ppb AFB₁ (Diet 6). The results showed significant ($P<0.05$) improvements in pellet physical quality with the inclusion of clay. Specifically, the 5% clay treatment exhibited the highest bulk density (0.39±0.01 g/mL), percentage floatability (73.10±0.41 after 35min), and durability (96.12±0.65%). Growth performance metrics (FBW, NWG, ADG, and SGR) were significantly higher ($P<0.05$) in fish fed 5% clay diets (Table 1). Moreover, the combination of 5% clay and 200ppb AFB₁ showed significantly ($P<0.05$) better growth parameters than diets without clay inclusion, indicating the protective role of clay against aflatoxicity. FCR and survival rate were unaffected ($P>0.05$) across treatments (Table 1). Overall, Chisumbanje Vertisol at 5% inclusion improves pellet physical quality and promotes better growth performance in Nile tilapia, offering a natural solution for the mitigation of AFB₁ toxicity in aquaculture.

Table 1: Final body weight (FBW), net weight gain (NWG), average daily gain (ADG), specific growth rate (SGR), feed conversion efficiency (FCR), and survival (%) of Nile tilapia juveniles fed on six practical diets over a period of 7 weeks. Means sharing similar letters in a row were statistically non-significant ($P>0.05$).

	Diets					
	1	2	3	4	5	6
FBW (g)	58.3±1.5 ^b	48.7±3 ^b	58.3±1.2 ^b	64±1 ^a	51.7±1.5 ^b	59.3±0.6 ^a
NWG (g/fish)	38.3±2.5 ^b	28±4 ^b	38±0 ^b	42.7±0.6 ^a	31±1 ^b	38.3±0.6 ^a
ADG (g/fish/day)	00.78±0.05 ^b	0.57±0.08 ^b	0.78±0 ^b	0.9±0.01 ^a	0.63±0.02 ^b	0.78±0.01 ^a
SGR (%/day)	20.19±0.15 ^b	1.75±0.22 ^b	2.15±0.08 ^b	2.24±0.03 ^a	1.87±0.02 ^b	2.12±0.08 ^a
FCR	10.54±0.10 ^a	2.56±0.71 ^a	1.76±0.19 ^a	1.84±0.21 ^a	1.91±0.34 ^a	1.69±0.22 ^a
Survival (%)	93.3±5.77 ^a	83.3±5.77 ^a	86.7±5.77 ^a	86.7±5.77 ^a	90±10 ^a	86.67±5.77 ^a

THE RELATIONSHIP BETWEEN BIOTIC AND ABIOTIC FACTORS AND THE GROWTH OF CULTURED TILAPIA IN EARTH POND AND INDOOR SYSTEMS

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Tilapia studies in Iran were begun since 2008. Now, various rearing systems are used for semi-intensive and intensive tilapia culture. In the present study, limnologic factors of indoor and outdoor tilapia culture ponds, also growth performance of the cultured tilapia were investigated. Both systems have advantages and disadvantages.

Growth performance and limnologic factors of indoor and outdoor tilapia culture ponds were investigated. In the earth ponds, the ranges of minimum and maximum of water temperature were 16.6-27.5°C and 20.5-31°C, dissolved oxygen was 2.11-10.19mg/l in the morning and 7.06-14.64mg/l in the afternoon. PH was recorded 8.97-10.9 in the morning and 9.04-11.00 in the afternoon. The depth of the water transparency was 40-105 cm. Water salinity was 7.94-8.82 ppt. The concentration of NH₄⁺ was less than 0.05 to 0.4 mg/l. The frequency of phytoplankton and zooplankton was 2050-2848 and 269-101 per liter, respectively, macrobenthos was 3467-558/m². The dominant phytoplankton, zooplankton and macrobenthos were chlorophytes and diatoms, rotifers and chironomids, respectively. Pearson 2-tailed correlation between the amounts of temperature, salinity, dissolved oxygen, pH, NH₄⁺, length and weight of farmed fish in earth ponds showed a direct significant correlation between pH value against ammonium concentration, and total length against body weight of the fish, also between pH against water temperature and total length of the fish.

In indoor tanks, the range of water temperature was 29-24°C, dissolved oxygen 1.65-8.38mg/l, pH 9.37-7.25, water salinity 7.12-7.7ppt, and ammonium 0.16-0.5 mg/l.

Pearson 2-tailed correlation between the amounts of temperature, salinity, dissolved oxygen, pH and ammonium with length and weight of fish showed a direct significant correlation between the length and weight of the fish body with each other, the amount of salinity against pH, salinity against total length and body weight. Also, there was a reversed significant correlation between the amount of dissolved oxygen against water temperature, pH and the total length of fish.

Both in earthen pools and indoor ponds, there has been a significant increase in the average size of the length and weight of the reared fish in the last months of the breeding period, that is expected.

Raising tilapia in earthen ponds is a common method of raising this fish because the cost of infrastructure is relatively low. Also, it is possible to provide the nutrients based on fertilization, leading to reducing the cost of fish production. However, it should be noted that high temperature and wind cause water evaporation, which is not recommended, especially in dry areas.

In indoor ponds, as well as other closed systems such as greenhouses and aquaponics, it is possible to breed tilapia twice a year, in addition to conserving water and higher densities fish production, while they are more compatible with environmental considerations

BLACK SOLDIER FLY (*Hermetia illucens*) LARVAE MEAL IMPROVES GROWTH, FEED UTILIZATION, AND INTESTINAL HEALTH IN MIRROR CARP (*Cyprinus carpio*) JUVENILES

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Aquaculture is crucial for global food and nutrition security but it relies on raw materials that are often acutely finite or unsustainably produced such as fishmeal and soybean meal. Global fishmeal production is stagnant, while soybean meal faces food-feed competition and its use must be limited in the diets of carnivorous fishes. Insect meals, especially from black soldier fly (BSF), hold promise as an alternative due to their high protein content and minimal environmental needs, providing potential for sustainable production. This study investigated the effects of BSF meal on growth, feed utilization, and intestinal health of mirror carp (*Cyprinus carpio*) juveniles.

An 8-week feeding trial was conducted with *C. carpio* (initial weight: 6.44 ± 0.05 g) in tanks (13 L, each) in a RAS. Three experimental diets were prepared based on the known nutritional requirement of carp to contain 0 % (Control: BSF0), 20 % (BSF20), and 40 % (BSF40) defatted BSF larvae meal (Table 1). The fish were divided into 3 groups of 20 juvenile fish in triplicate tanks and were fed the diets at 4 % biomass. After the trial, compared to the control group, the final body weight, weight gain (WG), specific growth rate, protein efficiency ratio and feed conversion ratio (FCR) were improved with increasing BSF meal inclusion levels in the diet (Fig. 1). Histological analysis revealed significantly elevated intestinal mucosal fold length in BSF-fed fish compared to control fed fish (Fig. 2). However, the lamina propria width, muscularis thickness, goblet cell density, and intraepithelial lymphocytes were not affected by the diets. Therefore, BSF meal can serve as a suitable protein source in the diets of *C. carpio*, promoting growth performance and feed utilization. However, scaling up insect meal production is essential for reducing costs and enhancing its viability as a raw material.

Ingredient (g/Kg diet)	Experimental diets		
	Control (BSF0)	BSF20	BSF40
Soybean meal	400.00	264.00	46.00
Sunflower meal	320.00	375.00	394.00
Black soldier fly meal	0.00	200.00	400.00
Wheat gluten meal	15.00	5.00	5.00
Wheat meal	0.00	0.00	50.00
Fishmeal	20.00	20.00	20.00
Soy protein concentrate	150.00	50.00	10.00
Sunflower oil	68.00	56.00	43.00
Fish oil	10.00	10.00	10.00
Lysine HCL	3.00	5.00	9.00
Carboxymethyl cellulose	5.00	5.00	5.00
Fish premix (0.3%)	5.00	5.00	5.00
DL Methionine	3.00	3.00	3.00
Proximate composition (% DM basis)			
Dry matter	90.89 ± 0.07	91.52 ± 0.25	91.46 ± 0.11
Crude protein	42.66 ± 0.24	43.10 ± 0.11	42.69 ± 0.31
Crude fat	7.54 ± 0.44	7.56 ± 0.18	7.67 ± 0.24
Ash content	5.54 ± 0.26	5.92 ± 0.35	6.11 ± 0.29

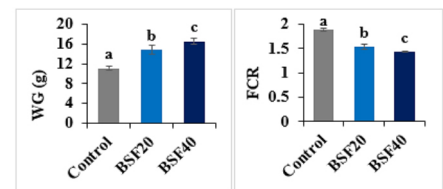


Figure 1: Growth and feed utilization (Mean±SEM) of *C. carpio* juveniles fed experimental diets.

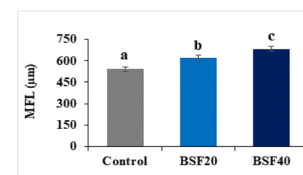


Figure 2: Mucosal fold length (MFL; Mean±SEM) of *C. carpio* juveniles fed experimental diets.

PERCEIVED EFFECTS OF CLIMATE CHANGE ON AQUACULTURE PRODUCTION IN ZAMBIA: STATUS, VULNERABILITY FACTORS, AND ADAPTATION STRATEGIES

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Aquaculture plays a critical role in Zambia’s food and nutrition security. However, aquaculture is highly vulnerable to the effects of a changing climate which can lead to economic losses, and food and nutrition insecurity.

This study investigated the perceived effects of climate change on aquaculture production in Zambia, vulnerability factors, and adaptation strategies. Semi-structured and structured questionnaires were used to collect data from aquaculture producers in all provinces across the country. Results revealed high (over 80%) awareness of climate change, primarily attributed to literacy levels and access to media. Producers perceived occurrence of climate-related changes such as rising temperature, altered rainfall patterns, cyclones frequency, and disease outbreaks, impacting production costs (Table 1). Generally, the results indicate a high to medium perception of rising temperature and increased frequency of flooding and droughts across the country. Although rising temperature did not appear to affect aquaculture production cost, the frequency of droughts, floods, cyclones, and disease outbreaks showed a significant association with production costs. Identified vulnerability factors include reliance on a limited range of fish species, absence of insurance coverage, and low adoption of adaptation practices. Vulnerability levels vary across regions, with provinces in agroecological zone I (Eastern, Lusaka, Southern, and Western) showing higher vulnerability. Despite this, many producers aren’t implementing adaptation measures due to financial limitations, species diversity constraints, and insufficient knowledge of alternative economic pursuits (Fig. 1). Main adaptation strategies involve livelihood diversification and adjustments in fish cultivation periods and infrastructure. To foster aquaculture sustainability amid climate change, critical interventions such as farm insurance, research diversification in aquaculture species, and enhancing producer resilience are necessary.

Table 1: Effects of perceived climate change on aquaculture production in Zambia.

Perceived climate changes against cost of production	Level of agreement to observed change (%)				Pearson’s chi-square (X ²)	P-value
	Neutral	Low	Medium	High		
Rising temperature						
No observed change	7	8	67	103	6.188	0.402
Cost has decreased	2	6	41	67		
Cost has increased	47	27	247	404		
Drought frequency						
No observed change	34	26	79	46	29.721	0.000
Cost has decreased	4	15	45	52		
Cost has increased	94	149	278	204		
Flooding frequency						
No observed change	44	46	50	45	27.003	0.000
Cost has decreased	6	23	37	50		
Cost has increased	128	168	234	195		
Cyclones						
No observed change	80	73	23	9	37.899	0.000
Cost has decreased	38	24	36	18		
Cost has increased	300	252	104	69		
Disease outbreak						
No observed change	86	73	18	8	14.305	0.026
Cost has decreased	38	51	23	4		
Cost has increased	321	266	88	50		

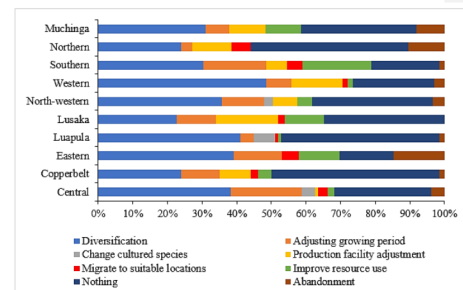


Figure 1: Climate adaptation strategies adopted by aquaculture producers in Zambia.

LARVAL AND POST-LARVAL GROWTH, SPAT PRODUCTION AND OFF-BOTTOM CULTIVATION OF THE GROOVED CARPET SHELL *Ruditapes decussatus* IN THE GULF OF GABES (SFAX, OUED MALTINE)

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The grooved carpet shell *Ruditapes decussatus* is one of the most abundant species in the coastal ecosystems of the gulf of Gabès (South-East Mediterranean Sea, Tunisia); however, natural population are overexploited or depleted, so production by culture is recommended and aquaculture represents an alternative for preserving this resource.

The aim of this work is to define methods to support successful larval, postlarval and spat culture of *R. decussatus* and provide a basis for large-scale propagation of this species.

Adult *R. decussatus* obtained from natural banks were used as broodstock. Conditioning, induction of spawning, cultivation of larvae, then settlement of pediveliger larvae and nursing of postlarvae were performed under laboratory conditions in the shellfish experimental hatchery (INSTM Monastir).

The larval development was completed in 18 days at 18°C and postlarvae reached $617.47 \pm 130.28 \mu\text{m}$ at day 50 and growth rate was 0.36 mm month⁻¹. Larvae, postlarvae and spat showed exponential growth.

Pediveligers (length 250 μm) entered metamorphosis at days 18-24 after fertilization, and reached spat size (>5 mm) after 126 days of culture.

Spats were seeded in their natural habitat (Oued Maltine, Sfax S4) to complete their culture over a period of 27 months. Samples of clams and tissues were collected each season to measure shell growth and weight increase and a Condition Index.

The survival rate during fattening phase of the first two groups seeded showed a decrease until the end of the experiment and was 36% after 12 months of growth (length 24.45 ± 2.95 mm) and 11% after 27 months of growth (length 52.65 ± 4.07 mm) with growth rate 1.93 mm month⁻¹.

Our results show that spat of *R. decussatus* can be produced in the hatchery and were able to grow in the intertidal zone of South of Sfax until reaching the first sexual maturation and the commercial size.

ALGAE-BACTERIA SYNERGY LEADS TO IMPROVED GROWTH AND IMMUNE DEFENSE IN RED TILAPIA (*Oreochromis sp.*)

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This study explored the impact of combining biofloc technology with microalgae on the growth and immune gene expression of red tilapia (*Oreochromis sp.*). Four experimental treatments were set up: C (Biofloc only), T1 (Chlorella vulgaris and Nannochloropsis sp. in a 1:1 ratio), T2 (Biofloc plus Chlorella vulgaris and Nannochloropsis sp., 1:1), and T3 (Biofloc plus Chlorella vulgaris and Nannochloropsis sp., 2:1), all in 500L fiberglass-reinforced plastic (FRP) tanks over 60 days, with each treatment in triplicate. The incorporation of microalgae significantly enhanced water quality, particularly in T2 and T3, which showed the lowest ammonia and nitrite levels. The control treatment (C) had the highest volumes of floc and sludge. T3 recorded the highest chlorophyll a and b concentrations, while T2 had the highest carotenoid content. Bacterial counts were highest in T3, and algal counts were highest in T1.

Microalgae also contributed to better fish growth. T2 showed the best results, with the highest weight gain ($142 \pm 0.7\text{g}$), specific growth rate (SGR: 1.61 ± 0.02), and the lowest feed conversion ratio (FCR: 1.79 ± 0.009). In terms of immune gene expression, T2 had the highest upregulation of cathepsin L (CTSL, 7.8-fold), toll-like receptor 7 (TLR7, 3-fold), interleukin-1 β (IL-1 β , 6.7-fold), tumor necrosis factor- α (TNF- α , 4.7-fold), and metallothionein (MT, 2.8-fold) in the intestine. In the head kidney, MT expression was most elevated in T3 (7.2-fold), while TNF- α and TLR7 were most upregulated in T2 (5.9-fold and 5-fold, respectively). The liver gene expressions were highest in T3, with 6.4-fold upregulation of MT, 5-fold for CTSL, 2.7-fold for TLR7, 3-fold for IL-1 β , and 5.4-fold for TNF- α .

The findings demonstrate a synergistic effect between algae and bacteria, leading to enhanced immune and antioxidative responses in red tilapia. Incorporating microalgae into biofloc systems proves to be a beneficial approach to improving fish health and performance, presenting a viable strategy for sustainable aquaculture using biofloc technology.

BASELINE ANALYSIS OF LOCAL FEED INGREDIENTS FOR ENHANCING SCALABLE AQUAFEEDS IN KENYA'S RESILIENT AQUATIC FOOD SYSTEMS

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Aquaculture plays a pivotal role in addressing the growing global demand for fish, with its long-term sustainability hinging on the availability of high-quality feed sources. This study explores the potential of insect-based feed as an alternative in Kenyan aquaculture, motivated by concerns surrounding environmental sustainability, resource efficiency, and food security. Primary data were collected from 933 fish farmers across nine counties in Kenya, assessing their current feeding practices, attitudes towards insect-based feed, and willingness to pay for this innovative feed source.

The results revealed that most farmers exhibited positive attitudes towards the adoption of insect-based feed, with a strong willingness to pay for this alternative, highlighting a promising market potential in Kenya's aquaculture sector. Social factors, such as veterinary approval, recommendations from extension officers, peer influence, and media promotion, were identified as key drivers in shaping these positive attitudes and perceptions.

The findings indicate a conducive environment for promoting insect-based feed as a sustainable and resource-efficient option in aquafeed formulations. However, the successful integration of insect-based feed will require overcoming several challenges, including knowledge gaps, concerns about feed costs, and the issues faced by feed millers, such as limited ingredient supply, high prices, and quality control problems, notably aflatoxin contamination. Addressing these challenges will be critical to ensuring widespread adoption and enhancing the sustainability of Kenya's aquaculture sector.

BLACK SOLDIER FLY LARVAE IN AQUAFEEDS: DRIVING ECONOMIC GROWTH AND SUSTAINABLE WASTE MANAGEMENT IN KENYA'S SMALL SCALE AQUACULTURE

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The application of Black Soldier Fly (BSF) larvae as an alternative protein source in aquaculture is emerging as a game-changer for sustainable fish farming and circular economy models. In Kenya, small-scale aquaculture farmers, who produce approximately 24,000 metric tons of fish annually, face significant challenges in accessing affordable, high-quality feed, with fishmeal accounting for over 60% of production costs. BSF larvae, containing 40-50% protein and 25-35% fat, provide a nutrient-dense, cost-effective feed solution that can reduce feed expenses by up to 30% compared to traditional fishmeal.

This study evaluates the integration of BSF larvae into aquaculture systems and its potential to improve the livelihoods of Kenya's small-scale farmers. By utilizing organic waste, such as food scraps and agricultural by-products, to rear BSF, farmers can convert up to 50 kilograms of waste into 15 kilograms of larvae within a few days. This not only provides a sustainable feed source but also addresses waste management issues, as it reduces organic waste by up to 60%. Moreover, studies have shown that fish fed on BSF-based diets achieve growth rates comparable to those on conventional feeds, leading to healthier yields and increased profits.

The adoption of BSF in aquafeeds promotes a circular economy by closing the loop between waste and resource utilization. This approach can improve household incomes by 20-25%, contributing to food security, economic growth, and environmental sustainability. The BSF solution offers a pathway for small-scale farmers to reduce costs, manage waste effectively, and achieve long-term sustainability in Kenya's aquaculture sector.

FAO GUIDELINES FOR SUSTAINABLE AQUACULTURE (GSA)

Ana Menezes

The Guidelines for Sustainable Aquaculture (GSA) were prepared at the request of Members in an inclusive, transparent and participatory manner under the guidance of the Sub-Committee on Aquaculture of the FAO Committee on Fisheries. Members urged FAO to lead the crafting of the GSA in response to the rapid expansion of aquaculture, the fastest-growing food production sector in the world, driven by scientific progress, technological innovations and investment, amid a consistently increasing global demand for aquatic foods. However, as with all food production sectors, this rapid growth has exposed challenges to the sustainability of aquaculture and raised concerns about potential negative impacts. The GSA provide a comprehensive framework for addressing these challenges.

The GSA consist of three sections: A) vision, objectives, scope and guiding principles, B) guidelines for promoting sustainable aquaculture; and C) implementation and monitoring. In line with the FAO Blue Transformation roadmap, which has a major pillar dedicated to the sustainable intensification and expansion of aquaculture, the GSA envision an aquaculture sector that contributes significantly to food security and to the equitable improvement of the living standards of all actors in its value chain, including the most vulnerable. To achieve these goals, collaboration among States and stakeholders is crucial, and States are encouraged to facilitate the use of national-level platforms to implement the GSA.

POLICIES AND STRATEGIC PLANS IN SUPPORT OF AQUACULTURE DEVELOPMENT IN SUB-SAHARAN AFRICA – A TOOL FOR PLANNING AND RESOURCE MOBILIZATION

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The policy research initiative aims to enhance the FAO capacity to support African Member Countries' design and implementation of aquaculture policies and strategic plans aligned with the 2030 Agenda for Sustainable Development and the FAO Blue Transformation vision. This study examined existing aquaculture policies at the national, regional and continental levels. Examination of the aquaculture objectives of Blue Transformation, the African Union Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (PFRS), and the Regional Economic Community aquaculture priorities showed broad similarities in the policy narrative and overarching dimensions. Specifically, the PFRS aims to jump-start market-led aquaculture; the East African Community's (EAC) goal is to promote investment in sustainable commercial aquaculture and effective biosecurity measures; the Southern African Development Community (SADC) aims to increase the contribution of aquaculture to local, national and regional economic growth and trade; the Economic Community of West African States (ECOWAS) aims "to increase the profitability of environmentally and socially sound aquaculture to achieve continued sector growth"; and the Intergovernmental Authority on Development (IGAD) aims to enhance aquatic organism supplies, generate income and employment, and diversify livelihoods.

Despite common policy priorities, differences were also observed in the prioritization of policies. For this reason, a tool for planning, implementation and monitoring was developed. The national aquaculture development strategy and country plans are incorporated in the consolidated action plan.

The action plan outlines objectives, strategic, actions to be taken, expected targets, anticipated output, and the region and country responsible for implementing activities. Performance indicators are given with periods for accomplishment. The consolidated action plan has three major objectives: (i) assisting Member States in developing aquaculture strategies and programmes to expand and transform the sector; (ii) enhancing regional cooperation to equalize African aquaculture and harmonize policy development; and (iii) facilitating advocacy for increased investment in the aquaculture sector within the framework of national development policies and for research in semi-arid lands

Ultimately, the outcome of this exercise is expected to enhance the ability of FAO and member countries in the project cycle (planning, implementation and evaluation phases) and guarantee that aquaculture programmes in sub-Saharan Africa will be better coordinated and achieve more coherent and consistent aquaculture sector growth in the region.

SEAWEED CULTIVATION IN TUNISIA: STATE OF THE ART

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In our presentation, we aim to address the following questions: 1) Why do we continue to promote the seaweed industry in Tunisia? 2) What are the challenges that this industry has faced and the responses provided by various research actions? In Tunisia, a research program for the development of seaweed farming started in 1996 but did not lead to the actual initiation of this activity. Seaweed cultivation in Tunisia faces three main challenges: 1) the limited number of suitable species for starting a cultivation activity; 2) the appropriate cultivation technique; 3) understanding the variability of yields and chemical composition. 4) The commercial value of agar is relatively low. The results obtained from research conducted since 1996 at INSTM in the lagoon environment and in the open sea are important for the development of this sector. The cultivation of *Gracilaria* on the substrate in the Bizerte lagoon, a practice widely used in Asian countries, could be one of the many possible options for the development of this sector by studying the interaction of the cultivated algae and its associated fauna. This technique is only applicable in depths less than 2 m, representing an area of 10% of the entire lagoon. The culture model we have developed is in suspended mode, allowing the cultivation of this species at depths beyond 4 m. However, a significant area between 2 and 4 m remains unusable. Therefore, the idea of developing another technique to cultivate algae in water columns arose. The cultivation of *Gracilaria* in Bizerte Bay using the suspended mod was a first attempt to initiate the cultivation of this species in the open sea, both in Tunisia and in the Mediterranean basin. In conclusion, the acceptable growth rates and the richness of algae in proteins, phycobiliproteins, and agar in specific culture situations can certainly justify the cultivation of this species of macroalgae. The limited possibilities of the lagoon environment and the high production costs, both in this lagoon environment and in the open sea compared to other countries, encourage us to exploit all the molecules of interest through the development of innovative biotechnology processes such as biorefinery to make its cultivation profitable in the future.

CLOSED-LOOP AQUAPONIC SYSTEM WITH COMMON CARP (*Cyprinus carpio*) WHICH WAS FED A MIXTURE OF INSECT MEAL, INSECT FRASS AND HYDROPONIC BY-PRODUCTS CO-CULTURED WITH LETTUCE (*Lactuca sativa*): AWARE PROJECT

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Aquaponics is recognized as an innovative and environmentally friendly production system. The aim of this study is to examine the effect of feeding insect meal (*H. illucens*), insect frass and hydroponic by-products (vegetative parts of tomato and cucumber plants, as well as low quality, non-marketable cucumbers and tomato fruits) as a replacement of fishmeal on the protein metabolism performance of common carp (*Cyprinus carpio*) reared in a laboratory closed-loop aquaponic system (CLA). A total of 297 *C. carpio* individuals were obtained from a local fish hatchery and were distributed in 9 CLA systems. In the hydroponic part of the system, 108 *L. sativa* individuals were placed in the hydroponic baskets. Three diets (3 replicates/dietary treatment) were formulated, the Control diet (C) containing 15% of fishmeal, the *H. illucens* diet (B), where the fishmeal protein of the control diet was replaced at 50% by *H. illucens* meal and the plant residues (F) diet where the fishmeal protein of the control diet was replaced at 50% by a mix of *H. illucens* meal, *H. illucens* frass and hydroponic by-products at a 2:1:1 ratio. Growth performance indicators of common carp showed no statistically significant differences across the three dietary treatments ($p > 0.05$) during the 45 days of the experimental period. All 9 CLA systems effectively cultivated lettuce with optimal root-to-shoot ratios. Immunoblotting analysis was employed to evaluate the expression of proteins involved in cellular signaling, such as p38 MAPK, Bad and Bcl-2, and Na⁺K⁺ATPase, in the kidney of *C. carpio* under the three dietary regimes. According to the results, both the activation of p38 MAPK (Figure 1) and the Na⁺K⁺ATPase levels were significantly suppressed in response to the diets B and F. Previous studies have indicated that MAPKs are considered among the downstream members that are activated through the Na⁺K⁺ATPase. Moreover, both B and F diets led to reduction of the Bad/Bcl-2 ratio, a crucial indicator in the death or survival of the cells. These results indicate that the experimental diets may exert beneficial effects regarding the cellular response of *C. carpio*.

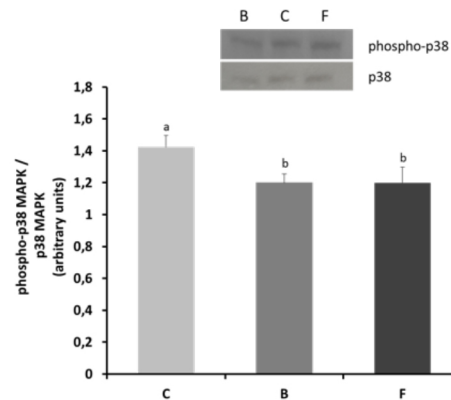


Fig. 1: Activation of p38 MAPK in the kidney of common carp under the C, B and F dietary treatments. Representative protein bands are shown on the top of the panel. Western blots are representative of at least three independent experiments with overlapping results and data represent mean \pm SD for at least three independent experiments; $n = 8$ preparations from different animals. Different letters $p < 0.05$ compared to C diet.

BIOACCUMULATION OF HEAVY METALS IN THREE FISH SPECIES *Barbus barbus*, *Sander lucioperca* AND *Abramis brama* IN THE HAMMAM DEBAGH DAM (NORTHEAST ALGERIA)

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The dam of Hammam Debagh considered to be an artificial lake, is considered as the most important resource for drinking water, irrigation and fishing in the wilaya of Guelma. Being subjected to a strong agricultural anthropization and domestic, this site was the subject of a study of four months as of January 2017, with two companions per month, where we were interested in the bioaccumulation of the trace metals (Zn, Cu, Fe, Cd and Cr) in different organs (heart, muscle, liver, gonads, and kidneys) in three species of fish (common barbel, common bream and pikeperch).

The sampling was carried out in eight sites: two of which are chosen downstream, in the vicinity of the dike. two others, upstream, located near the entrance to the wadi Bouhamdane, main artery of the dam, while on both banks, the left bank and the right bank, two points are distributed on each of them. It's here. The fish specimens are dissected and the organs are removed, dried, mineralized and assayed by Perkin Elmer Analyst 400 flame atomic absorption spectrometry (SAA). The results obtained revealed contaminations in fish examined at different levels. The strongest are Zinc, copper, and iron, while the lowest concentrations are cadmium and chromium.

Thus, the statistical processing by Excel statistica ANOVA two-factor software (species and organs) did not record any significant difference between the three species and also no other significant difference in their organs ($P > 0.05$) by iron, copper, cadmium and zinc. The only significant difference between the three species was recorded by the chromium metal ($P < 0.05$) and no significant difference in their organs ($P > 0.05$). Levels of concentrations of the trace metals reflect a certain contamination of them of the dam. However, the results of the study seem reassuring with regard to the consumption of these three species of fish, the most captured in the dam.

INVESTIGATING THE BENEFITS OF *Bacillus rugosus* AS A NOVEL PROBIOTIC STRAIN FOR NILE TILAPIA: A COMPREHENSIVE EVALUATION

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The aim of this study is to assess the effect of the *Bacillus rugosus* strain as a probiotic on growth performance, hemato-biochemical profile, intestinal morphometry, immune response, digestive enzymes and antioxidant activity of Nile tilapia. Three different doses 0 g/kg, 0.1g/kg, 0.2g/kg of *B. rugosus* potential probiotic powder have been supplemented to fish (5.13 ± 0.09 g, N=240) and representing the triplicate control (C), T1 and T2 groups and kept for 90 days.

The probiotic-supplemented groups demonstrated improved performance and health status. The treatment groups (T₁, T₂, and T₃) outperformed the control group in terms of fish growth. Specifically, the T₂ group showed the highest results. The blood analysis showed significant differences between *B. rugosus* supplemented groups and the control group, especially in T₂, which has the highest levels for hemoglobin, red blood cells and white blood cells. Biochemical assessments revealed significant improvements in liver enzyme activities in probiotic related group with the lowest ALT and AST recorded in T₂ groups. The total protein and albumin levels were the highest in T₃. Oxidative stress markers indicated a significant difference in probiotic related groups that the highest levels of SOD and CAT were recorded in T₃ group. T₃ also showed the lowest MDA levels. Lysozyme activity showed the highest level in T₂ group, and levels of immunoglobulin G (IgG) were also increased in probiotic related groups. Digestive enzymes amylase and lipase also have a significant difference in probiotic related groups when compared to the control group. In addition, *B. rugosus* potential probiotic also reveals an improvement in the intestinal histological and morphometric parameters as compared to control group. The muscularis thickness, villi height, villi width and number of lymphocytes analysis results showed significant effects. The liver histological analysis showed that the probiotic related groups have no harmful effect in fish, as there was absence for signs of hepatotoxicity. After 90-days experimental trial the histological examination of liver tissues did not show any inflammation changing, necrosis or pathological lesion.

Based on these findings, *B. rugosus* potential probiotic shown promising results in enhancing the health and performance of Nile tilapia and could serve as a novel probiotic for aquaculture.

USING OPERATIONAL WELFARE INDICATORS FOR BETTER TILAPIA WELFARE IN AQUACULTURE

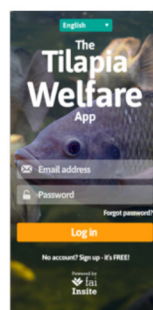
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In contrast with livestock, animal welfare in aquaculture remains a highly neglected topic. Where the few welfare standards for aquaculture exist, the implementation model is usually top down, meaning that certification bodies are the ones stepping in to address rising consumer awareness about poor farming conditions. However, this model has its limitations as it relies on a niche of educated and sympathetic consumers. Farmers are the most important actors driving improvements in aquaculture production chains and their willingness to produce food in better ways can be supported through practical farm assessments that align both business and animal welfare objectives. Food Animal Initiative (FAI) has developed a new bottom-up approach for the assessment of farm animal welfare. The assessments help farmers understand what good animal welfare looks like and show them how it can naturally lead to the better fulfilment of the animals' nutritional, health, environmental and behavioural needs. Welfare assessments can kickstart a positive spiral of improvements, tapping into farmers' innate need to be better and do better. If a problem is identified, actions are likely to be taken to fix or improve it, resulting in better animal welfare. The assessment protocol and tool developed by FAI can be used by farmers and/or other stakeholders. The tool users are guided through a series of simple questions that will help them to monitor and drive progress regarding welfare and best practices.

- Protocols that use scientific and operational indicators for tilapia;
- Support for other scientists and practitioners who want to use our rigorous methodology to develop welfare indicators for other species;
- A free application for farmers to perform self-assessment and help them monitor and improve welfare and production outcomes. The app monitors progress, identifies improvement gaps, and provides immediate feedback to the user; and
- Free online training series aiming to guide those involved in the sector.

With the proven successful application of the framework and tools in Brazil, Thailand and China, Egypt is the next logical region in which to introduce this, given it is one of the major tilapias producing countries in the world.



MITOCHONDRIA DNA CYTOCHROME C OXIDASE SUBUNIT I GENE ANALYSIS

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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 the genetic variability, hence the need for variability insight for species conservation and aquaculture expansion. We tested the level of Genetic diversity, population differentiation and phylogenetic relationship 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 gene sequence. Nucleotide sequences of 650 bp gene fragment of the species were compared. Four and five haplotypes were distinguished in the populations of *H. bidorsalis* & *H. longifilis* with accession numbers (MG334168 - MG334171 & MG334172 to MG334176) respectively. Haplotypes diversity revealed a range (0.59 ± 0.08 to 0.57 ± 0.09) in *H. bidorsalis* and 0.000 to 0.001051 ± 0.000945 in *H. longifilis* population. Analysis of molecular variance (AMOVA) revealed no significant variation among *H. bidorsalis* population of 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 separation between *H. bidorsalis* and *H. longifilis*. mtDNA COI genes fixation index (FST) statistics revealed high gene flow between populations with no distinct genetic differentiation. However, a proportion of population-specific haplotypes was observed with degree of genetic distinctiveness for each population. These results generated will help to protect the valuable wild resource and contribute to their recovery and selective breeding in Nigeria.

PURIFIED BREWERS' YEAST (*Saccharomyces cerevisiae*) ADDITIVES MODULATE THE MUCOSAL HEALTH OF ATLANTIC SALMON PARR

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Cell wall components of *Saccharomyces cerevisiae* (rich in β -1,3 and -1,6-glucans and mannan oligosaccharides) in isolated or whole forms have been shown to confer immunomodulatory effects in fish. These benefits are at least partially induced by improvements of intestinal health. Despite the reported benefits, many knowledge gaps exist with regards to the optimal form and dosage.

An experiment was conducted to investigate the efficacy of highly purified β -glucans (P β G) and whole yeast cell walls (WYCW) to enhance the mucosal health of Atlantic Salmon (*Salmo salar*) parr. A total of 120 parr (ca. 21g) were randomly assigned into six experimental units (20 per tank) and fed either 1] Control (no yeast additives), 2] P β G (0.02% Leiber[®] Beta-S) or 3] WYCW (0.2% Biolex[®] MB40) treatments for 4 weeks. All treatments were fed to the same % of biomass (between 1.5% and 2% per day). At the end of the experiment, there were no significant differences in zootechnical performance (weight gain, SGR and FCR) between fish fed the different diets.

Histological appraisal revealed that fish fed the WYCW treatment had a 39% increase ($P = 0.0422$) in goblet cell abundance in the distal intestine and that the P β G treatment-fed fish had a 49% increase ($P = 0.0459$) in goblet cell abundance in the skin when compared to the control group.

In addition, transmission electron microscopy (TEM) analysis of the distal intestine revealed significantly different microvilli morphometrics. Fish fed the P β G treatment had significantly longer ($P < 0.0001$) and more densely packed ($P = 0.0001$) microvilli than the other treatment groups. Fish fed the WYCW treatment had significantly denser microvilli arrangement ($P = 0.0056$) than the control group.

Ongoing analysis includes gene expression profiling of immunomodulatory and barrier function genes.

In conclusion, both dietary products demonstrated the potential to enhance the epithelial barriers studied.

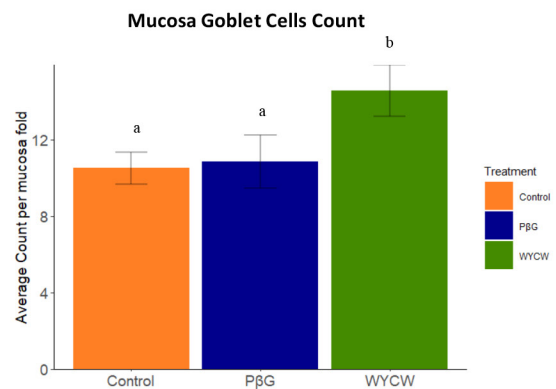


Figure 1: Goblet cells levels of the distal mucosal folds of Atlantic salmon parr after 4 weeks feeding on experimental diets. Treatments with different letters are significantly different ($P < 0.05$).

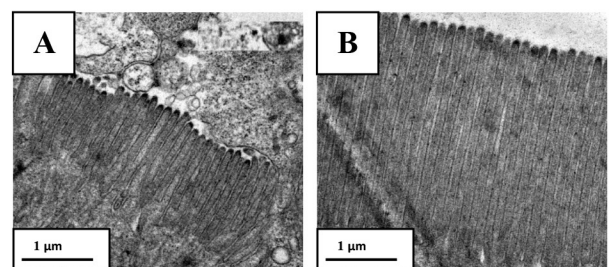


Figure 2: TEM electron micrographs of the microvilli from the distal intestine of Atlantic salmon parr subjected to (A) Control (B) P β G treatments. Scale bars = 1 μ m.

NERVOUS NECROSIS VIRUS VACCINATION IN EUROPEAN SEA BASS: A MULTI-OMICS ASSESSMENT APPROACH

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Nervous Necrosis Virus (NNV) is a formidable threat to both wild and domestic fish, particularly impacting aquaculture and fish biodiversity in the Mediterranean Sea. Its genomic versatility enables antigenic drifts, complicating vaccine development and immunisation strategies.

In our study, we utilised multi-omics machine learning to create an immune knowledge graph following the vaccination of European sea bass. We divided 300 fish into control and experimental groups, with the latter receiving a formalin-inactivated NNV vaccine. Over 15 months, we regularly sampled brain, head kidney, and blood to evaluate the immune responses the focus has been put on the key immune biomarkers including IgM, IL-4, MDA5, IFN I, IL-12, CD4, CD8, Granzymes, and IL-7R (Fig.1)

Our results demonstrated a late and short immune response by significantly increasing all biomarkers levels especially anti Nodavirus IgM. Immunohistochemistry assessment further validated these findings. The knowledge graph revealed intricate interactions among biomarkers, highlighting IFN I as a promising therapeutic target for enhancing protection against NNV. Our research leads the way towards precision immunology, combining prior knowledge of immunology with the efficacy of artificial intelligence.

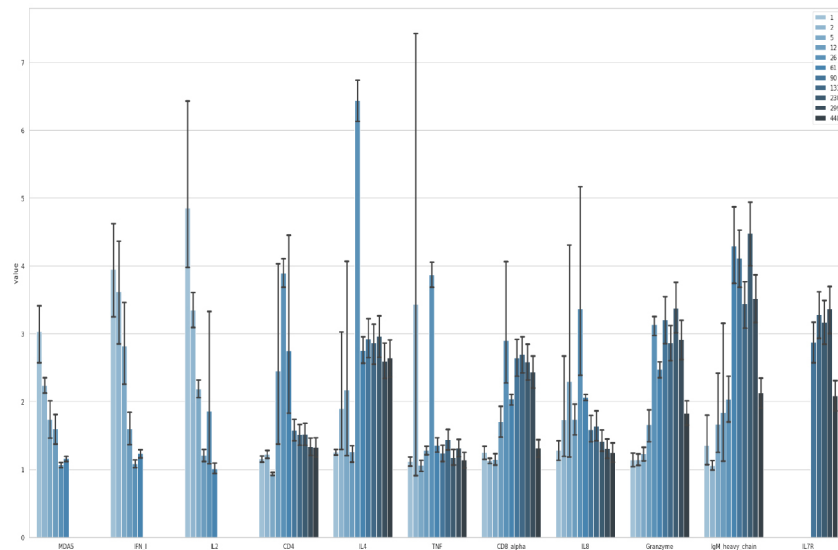


Fig 1: Relative expression levels of immune genes

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA): CAN IT BE A FUTURE FOR SUSTAINABLE MARINE AQUACULTURE IN TANZANIA?

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Tanzania has embraced the potential of mariculture as an important source of livelihood and enhanced economic development for both coastal communities and the country. The main mariculture sector is seaweed with a production of ca. 170,000 tons (FW) employing about 30,000 farmers and small-scale processors. Other mariculture sectors are finfish, sea cucumbers, and some crab fattening activities. However, the future of this sector is severely hampered by climate change that results in occurrence of diseases and pests that cause declines in production and quality of the mariculture organisms.

One of the interventions proposed is Integrated Multi-Trophic Aquaculture (IMTA), which involves farming of two or more organisms from different trophic levels in the same production system to improve efficiency, reduce waste, and provide ecosystem services. IMTA is an idea that has been experimented upon in Tanzania since the 1990s. Such IMTA experiments include culturing finfish, shellfish and seaweed in earthen ponds, tank cultures of seaweed with shellfish, sea cucumbers and halophytes, and culturing seaweed and sea cucumbers. While most interventions were conducted in small-scale settings, a recent intervention involves culturing of seaweed and sea cucumber at a commercial scale in a community-based set up.

With these kinds of efforts, can IMTA be indeed the future sustainability endeavour for the Tanzanian mariculture sector? In this presentation, the different approaches will be explained with results of their feasibility as future IMTA interventions. Considerations of the technologies used and production volumes, as well as value of the produced organisms as food and source of revenue for the coastal communities will be presented.

GENETIC BACKGROUND OF GROWTH AND SEX DETERMINATION IN INDIGENOUS FARMED POPULATIONS OF NILE TILAPIA (*Oreochromis niloticus*) IN UGANDA

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Nile tilapia (*Oreochromis niloticus*) is the most important aquaculture species in Uganda and Africa at large, providing high-quality animal protein for human nutritional security, and a major source of income that sustains the livelihoods of many people involved in the value chain. Although the species is native to Africa, the genetic background of key traits in the indigenous farmed populations on the continent is largely unknown which constrains genetic improvement of these populations for increased production efficiency.

Our study evaluated ~600 juvenile tilapia produced from a commercial hatchery broodstock population (originally sourced from Lakes Albert, Kyoga, and Victoria in Uganda) were evaluated for growth. Fish were tagged at ~3 months of age, and body weight and morphometric traits were measured biweekly. Fin clip tissues were collected from 500 fish, and subsequently used for genotyping the fish for 27 M variants (SNP and INDELs) via low-coverage sequencing and imputation. Genotype data was cleaned of variants with low minor allele frequency ($maf < 0.05$) and those that significantly deviated from Hardy-Weinberg Equilibrium (HWE, $P < E^{-7}$), resulting in 497 fish that had good-quality genotype data (5.4M SNP and INDELs). This data was then used for principal component analysis (PCA) and genome-wide association study (GWAS) analyses for average daily gain (ADG), and sex.

Fish from the three stocks did not significantly ($P > 0.05$) differ in growth, but L. Albert stock grew slightly faster (0.58g/day) than the stocks from L. Victoria (0.57g/day) and L. Kyoga (0.54g/day). In all three sub-populations, male fish grew significantly ($P < 0.05$) faster than the females. Despite the minimal physical separation of the three sub-populations at the hatchery, PCA results showed substantial genetic differentiation between the three sub-populations kept by the hatchery (Figure 1A). The GWAS identified a polygenic architecture for growth rate (Figure 1B). We identified three major quantitative loci (QTLs, 2 on Chromosome 23 and 1 on Chromosome 6) underlying sex determination in the studied Nile tilapia populations (Figure 1C). Our results contribute genomic resources towards sustainably improving tilapia aquaculture production.

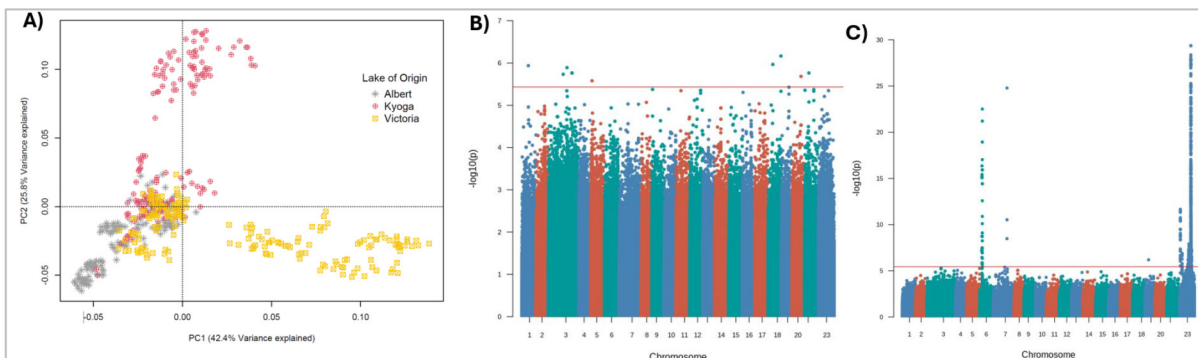


Figure 1: A) PCA plot showing the genetic structure of the studied population; B) and C) Manhattan plots of the GWAS for ADG and sex determination respectively.

REGIONAL CHALLENGES AND OPPORTUNITIES FOR THE DEVELOPMENT OF SUSTAINABLE SEED SUPPLY CHAINS

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The availability of and access to quality seed is broadly recognized as one of the key constraints to the growth of the sustainable aquaculture, especially in least developed countries.

The FAO Blue Transformation Roadmap 2022-2030, which represents the vision of the Organization for its work on aquatic food systems, identifies improvement in the supply of quality seed as a necessary action in leveraging the sustainable aquaculture sector worldwide.

“*Sustainable seed supply*” is listed as a major component of the recently adopted FAO *Guidelines for Sustainable Aquaculture* (GSA). The GSA recommends conditions and actions required for the well-functioning of seed supply systems reflecting commonly cited needs, including the main needs of many African countries. The proposed strategy of quality seed supply chain includes: effective national policies and strategies; the establishment of breeding nuclei and the decentralization of seed multiplication; genetic improvement program; effective broodstock management; good practices in hatchery, nursery, efficient packaging and transport; the regulatory mechanism of private sector for the long-term sustainability of genetic improvement programmes.

An Expert Workshop on the “Improvement of seed supply for small-scale inland aquaculture” was recently held to identify good practices and science-based solutions to unlock aquaculture’s potential for species key to small scale aquaculture and food security in developing regions. Following the experts’ recommendations, FAO is developing technical manuals for the design and operation of small modular hatcheries for key species (such as carps, catfish and tilapias), guidelines for policymakers to promote the development of breeding programmes for lower-value species in developing countries, and a policy brief to support the development of capacity to design and implement breeding programmes. The Expert Workshop also reviewed the draft *Assessment Framework for Seed Supply Systems in Aquaculture*, a tool to assess needs, gaps, challenges and strengths of seed supply systems and designed around five interdependent components: seed availability and distribution; seed production and quality; information flow and networking; policy and regulatory frameworks; R&D, education and training.

GUIDE FOR ENHANCING PRIVATE INVESTMENT IN AQUACULTURE: OVERVIEW AND SCOPE

Murekezi

The presentation outlines the background, objectives, and structure of the “Guide for Enhancing Private Investment in Aquaculture,” which was developed as part of FAO’s Guidelines for Sustainable Aquaculture (GSA) initiative. The Guide responds to the request of the FAO Sub-Committee on Aquaculture (COFI) to promote responsible aquaculture growth aligned with the Sustainable Development Goals (SDGs). It provides strategic guidance to governments, investors, and financial institutions to foster increased investment flows and ensure the sustainable development of the aquaculture sector.

Key sections of the presentation cover:

Historical Context: Tracing the roots of the Guide back to 2017 with the 9th COFI session and the subsequent global consultation to develop the GSA, approved in 2023.

Objectives of the Guide: Focus on enhancing private sector engagement and investment in aquaculture to drive sustainable operations at all levels.

Structure: The Guide is divided into three key parts targeting governments, entrepreneurs/investors, and financial institutions.

Scope: Global in nature, the Guide applies to various aquaculture systems and aims to facilitate investment while improving risk assessment for business success.

Future Directions: The Guide is part of FAO’s broader programmatic efforts to promote responsible aquaculture practices, raise awareness, and support members through technical assistance and partnerships.

This presentation serves as an introduction to the Guide’s importance for stakeholders in aquaculture, aiming to foster informed decision-making and investment for sustainable sector growth.

DECREASE STRESS: PRODUCE QUALITY PRODUCTS

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The world's population is rising and the subsequent demand for high protein sources of food is rising with it. A push for healthier sources of protein is also an increasing demand. Hence, aquaculture is rising in prevalence and importance in today's society with the increase in fish consumption and the limitations imposed by normal fishing methods. Aquaculture offers a solution to these issues by providing high protein foods that require less space to farm, a lesser time to harvest, and a lower cost to produce, and it is lesser detrimental to the environment. However, current aquaculture techniques involve the use of chemicals to reduce disease and mortality within the crops, caused by stress. In order to provide solutions to the problems of farming and the needs of the people without the use of potentially harmful substances many researchers are looking in to the decrease of stress responses and to the increase of immune responses to increase growth and produce quality products – both from fish and shellfish. In this presentation, I will highlight all these issues and suggest solutions.

APPLICATION OF THE GEOMETRIC MORPHOMETRICS APPROACH IN THE DISCRIMINATION OF SHAPE CHANGES BETWEEN *O. andersonii* GENERATIONS UNDERGOING GENETIC IMPROVEMENT IN ZAMBIA

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The population of Zambia is growing, and with it, so is the need for fish, but the nation's fish output hasn't kept up the required growth rate to keep up with the rising demand. Recently, improved indigenous germplasm has been developed in the nation thanks to a collaborative effort on the genetic improvement of *Oreochromis andersonii*. The Zambian government, WorldFish and its partners collaborated to develop this GIP, which aims to provide improved germplasm and ultimately increase aquaculture outputs. Understanding that employing exotic material poses risks to biodiversity, the Zambian tilapia genetic improvement program has concentrated on the development of the native species, *O. andersonii*. To determine the genetic diversity of *O. andersonii* that are undergoing the GIP, it is crucial to continuously characterize the generations tilapia species fish in a GIP. In the past, fish morphology was the primary source of knowledge for taxonomy and evolutionary studies. Because of their cost and accessibility of use, scientists have continued to rely heavily on the morphology of taxonomic features, even in the face of the availability of DNA markers for these sorts of research. This is especially true when paired with statistical analysis. In larger biological studies, this has proven to be of higher value for identification and classification. In order to investigate shape variations across generations of *O. andersonii* that are undergoing genetic improvement in Zambia, this study used the geometric morphometric technique. Discriminant function analysis and canonical variate analysis were used to examine and characterize shape variation. The observed form differences might be attributed to the genetic diversity resulting from the genetic improvement effort or the phenotypic plasticity of *O. andersonii*. Further investigation is necessary to elucidate the source of this shape variation.

AQUACULTURE GENETIC IMPROVEMENT PROGRAMME IN ZAMBIA: THE CURRENT STATUS, OPPORTUNITIES, CHALLENGES AND ADAPTABLE LESSONS LEARNT FROM ITS IMPLEMENTATION

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With an estimated 15 million hectares of water, or 4.5% of all inland water in Africa, Zambia is a landlocked nation in the southern part of Africa. Zambia's fisheries play a significant role in rural development by creating jobs, generating revenue, and reducing poverty. The country is the largest producer of farmed fish in the Southern African Development Community (SADC) and among the top producers of aquaculture in sub-Saharan Africa. According to projections, Zambia's population will increase from its current estimated 19 million to 24 million by 2030. To meet the projected demand for aquatic products, an additional 71,591 tonnes of fish will be needed, reflecting the ongoing demand for fish. Fish output in Zambia has not kept up with the required rate of growth to fulfil the increasing demand; the country's per capita domestic supply is presently just about 8 kg, significantly less than the global average of 20 kg.

Aquaculture is considered by the Zambian government and a number of organisations as a viable and promising way to address the country's fish deficit. In order to increase productivity and production, three regional endemic fish species were approved for improvement at the 2017 Southern Africa Development Community (SADC) Council of Ministers of Agriculture and Aquaculture meeting in Eswatini, and this spurred the development of the *Oreochromis andersonii* Genetic Improvement Program (GIP) in Zambia. Zambia launched the GIP through the implementation of the Zambia Aquaculture Enterprise Development Project (ZAEDP), a government initiative with a major focus on the *O. andersonii* genetic improvement program. The SADC Secretariat initiated the regional PROFISHBLUE Project in 2022, which builds on the GIP effort started by ZAEDP and includes a genetic improvement component. As the GIP's technical consultant, WorldFish has been able to create a base population and subsequently selected generations that will serve as the foundation for the breeding program's future expansion, thereby taking a significant step towards the actual formation of a national GIP.

Reviewing Zambia's GIP's present status, prospects, and challenges while deriving some lessons from the program's execution was the study's main aim. The review details the GIP's accomplishments as well as the opportunities that exist to promote further development of the GIP, which might lead to a major expansion of Zambia's aquaculture sector. Nevertheless, there have been difficulties with the program's implementation. Nevertheless, great potential still exists to further develop the GIP and potentially meet the ever-growing demand for improved germplasm.

FISH REPRODUCTION IN MEDITERRANEAN AQUACULTURE AND ITS CONTROL

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Development of aquaculture for any species requires absolute control of reproductive function and the production of large numbers of fertilized eggs of good quality for larval rearing. Reproduction of almost all fish species in aquaculture exhibit some form of dysfunction, ranging from (a) lack or incomplete gametogenesis (vitellogenesis and spermatogenesis), (b) failure of oocyte maturation and ovulation at the end of vitellogenesis, (c) reduced sperm volume and/or quality and (d) failure of spawning after ovulation and spermiation.

In Mediterranean aquaculture, the major species of interest include the gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), meagre (*Argyrosomus regius*), sharp-snout seabream (*Diplodus puntazzo*), Senegalese sole (*Solea senegalensis*), Japanese red seabream (*Pagrus major*), recently renamed as “short-finned porgy” for the European market, and recently greater amberjack (*Seriola dumerili*). All species have asynchronous development of the ovary and spawn multiple times during their annual reproductive season, and produce pelagic eggs (~1mm in diameter). Of these species, only gilthead seabream -and to a lesser extent short-finned porgy- reproduce consistently without any biological or production issues and are considered fully domesticated.

Hormonal therapies based on GnRH α injections or implants have been tested in all Mediterranean aquaculture species, including some past and present candidates such as the shi drum (*Umbrina cirrosa*), dusky grouper (*Epinephelus marginatus*), wreck fish (*Polyprion americanus*) and Atlantic bluefin tuna (*Thunnus thynnus*). These treatments induce the pituitary release and further synthesis of the gonadotropin hormone responsible for maturation (Luteinizing hormone, LH). Released in the circulation, LH reaches the gonads and stimulates steroidogenic changes in the synthesis of sex steroid hormones, which are the final effectors of oocyte maturation, ovulation and spermiation. If environmental conditions are appropriate (*e.g.* tank size and depth, water temperature and salinity, other factors that may not be known yet, etc.), then spontaneous spawning takes place, otherwise *in vitro* fertilization is necessary (*e.g.* in wreckfish and Senegalese sole).

A major issue in the reproduction of fish in aquaculture is the limited parental contribution of males during a particular day's spawning. This results in only a limited number of families being produced and a gradual reduction in the genetic variability of the stock of each hatchery, as not all of the males contribute equally to the produced offspring. The small number of families produced is very important and is limiting the implementation of breeding selection programmes based on mass spawning protocols, and communal rearing of the eggs and larvae. The use of GnRH α -based hormonal therapies may be used to increase parentage contribution of a given stock by (a) synchronizing the maturation, ovulation and spawning of a larger number of females at a given time and (b) increasing the number of males that contribute to the fertilization of larger numbers of eggs.

Future research will enable control of reproduction without the use of hormones, to allow production of organic fingerlings for grow out.

SUSTAINABLE AQUACULTURE PLANNING THROUGH MSP: A FOCUS ON POSIDONIA MEADOWS IN MONASTIR BAY, TUNISIA

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Marine aquaculture, particularly in nearshore and offshore environments, is gaining traction as a sustainable solution to meet global seafood demand. However, this expansion often leads to conflicts with other marine activities, especially in sensitive ecosystems. Marine Spatial Planning (MSP) provides a valuable framework for optimizing marine aquaculture site selection and expansion, minimizing environmental impacts, and promoting sustainable practices. This study focused on the application of MSP in Monastir Bay, Tunisia, one of the country's key aquaculture zones, with a specific emphasis on *Posidonia oceanica* meadows, which support biodiversity and provide essential ecosystem services. We gathered data from 1,500 GPS observation points, using scuba diving surveys and artisanal fishermen's reports, and cross-referenced them with bibliographic sources. GIS tools were used to map both the current distribution and potential areas where *Posidonia* once existed, emphasizing their regeneration potential. These areas were then integrated into seabed map layers to conduct a comprehensive assessment of benthic habitats and ecosystem services. The assessment revealed that nearly half of the benthic habitat types in the study area are highly vulnerable to aquaculture activities, underscoring the region's ecological sensitivity. This vulnerability highlights the need for targeted management strategies to mitigate potential impacts on these critical habitats. By integrating ecosystem service assessments into aquaculture planning, this study offers crucial insights for decision-makers to ensure that development balances economic growth with environmental conservation. These findings contribute to the enhancement of sustainable aquaculture practices and align with the Ecosystem Approach to Aquaculture (EAA), providing a model for future aquaculture development that respects marine ecosystems.

REMOTE RURAL ENTERPRISE PROMOTION IN AQUACULTURE VALUE CHAIN

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The fisheries sector in India has shown a sustained annual average growth rate of 8.61% for the last 8-year period. Hence the aquaculture value chain has significant potential to become a lucrative area for young aspiring entrepreneurs. However, it is a challenge for development agencies, governments to facilitate promotion of rural entrepreneurship in freshwater aquaculture. The major challenges are how to identify potential entrepreneurs in remote rural areas and how to build an ecosystem that supports nurturing and attracting identified entrepreneurs. Globally enterprise promotion suffers from a high failure rate. There is no definitive way to address the challenges, however there is high possibility of reducing failure rate by adopting a comprehensive and integrated approach, which includes steps such as awareness campaign, screening and selection etc. where social, behavioral, economical as well as psychological parameters are pillars of the process and framework. The intervention was initiated in Odisha and Assam state of India with the funding support from German Federal Ministry for Economic Co-operation and Development (BMZ) facilitated by Indo German development cooperation project 'Sustainable Aquaculture for Food and Livelihood' (SAFAL) of German Development Co-operation (GIZ) in partnership with the Ministry of Fisheries, Animal Husbandries and Dairying. The initial roadmap was conceptualized through workshops by inviting relevant stakeholders including established entrepreneurs and others from the states. Based on the output of the discussions and recommendations the process was co-created and implemented in selected areas of the states with the support of implementing partners.

The approach includes 5 steps such as, sensitization, identification and selection, nurturing, pitching, mentoring and incubation) The screening was done for 1080 number of selected aspiring aqua entrepreneurs in the two Indian states of Odisha, Assam. Out of which only 2% have gone to the final step of the framework, who are further facilitated with incubation support.

Figure 1 : Timeline and process versus participation



PATHOGENIC BACTERIA CAUSING INFECTIOUS DISEASES IN CAGE-FARMED FISH IN THE LAKE VICTORIA

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Sub Theme: Sustainable Fisheries and Aquaculture (SFA)

Despite Tanzanian government initiatives promoting cage fish farming to offset income losses from declining capture fisheries, disease-related mortalities have emerged as a significant challenge, resulting in substantial economic setbacks for farmers. Since the pathogens responsible for these mortalities have not been adequately screened, farmers have resorted to guesswork, employing treatments that are often incorrect or insufficient. Therefore, this study aimed to identify and characterize the etiological agents responsible for infectious diseases in cage-farmed fish in Lake Victoria. A total of eighty-one swab samples were collected from morbid fish at twenty-six cage fish farms on the Tanzanian side of Lake Victoria, across six districts: Nyamagana, Sengerema, Musoma Rural, Musoma Urban, Rorya, and Busega. Microbiological and biochemical analyses revealed three bacterial genera: *Aeromonas* spp. (43.75%), *Streptococcus* spp. (31.25%), and *Pseudomonas* spp. (25%). A pathogenicity challenge trial was conducted at the Blue Economy Research Center, Sokoine University of Agriculture, involving 180 healthy Nile tilapia weighing 50-200 g. These fish were inoculated intraperitoneally with 0.5 ml of overnight cultures of the virulent bacterial isolates at a concentration of 3×10^7 cfu ml⁻¹. The mortality rates observed were 86.7% for *Pseudomonas* spp. within six days, followed by 66.7% for *Aeromonas* spp. and 40% for *Streptococcus* spp. for ten days. Fish exposed to *Pseudomonas* spp. exhibited ragged fins, gill erosion, skin hemorrhage, white patches, detached scales, and scattered hemorrhagic spots. *Streptococcus* spp. caused fin rot, scale loss, eye hemorrhage, bulged eyes, eye opaque and finally eyes loss. *Aeromonas* spp. led to fin rot, skin hemorrhage, skin ulcers, and finally open sore. The findings provide crucial insights into the specific pathogens responsible for fish diseases, establishing a baseline for developing more effective disease management strategies in cage fish farms across the country.

AQUACULTURE, A PROMISING SOLUTION FOR FOOD INSECURITY POVERTY AND MALNUTRITION IN KENYA

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Food insecurity remains one of the most visible dimensions of poverty. The increasing population amid competition for land and water resources means that the global demand for food will continue to increase. In Kenya, the food insecurity trend is worrying as the population is expected to hit 55 million by 2020 against an annually declining arable land per capita and consequent increase in food prices. The Kenyan agricultural sector has failed to either eliminate or reduce malnourishment for poor populations as the annual national production for both staple food and livestock products fall short of national consumption levels. With increasing food production challenges like dwindling capture fisheries and impacts of climate change becoming more eminent, solutions to food insecurity and malnutrition in Kenya must bring quick results in food availability by stimulating more own-food production. Aquaculture has so far been recognized as an important opportunity to enhance household food security in developing countries. Aquaculture, the controlled land-based or open-ocean farming of aquatic organisms such as tilapia, catfish, finfish, shellfish and plants, is the fastest growing food sector globally alongside terrestrial crop and livestock production. Fish provides protective effects on a wide range on health including obesity, stroke, high blood pressure, and coronary heart disease. Fish has a nutrient profile superior to all terrestrial meats, an excellent source of high quality animal protein, omega-3 polyunsaturated fatty acids (PUFAs) and vitamins. Unfortunately, in Kenya, fish has been only marginally included in the national debate on reduction of micronutrient deficiency, precisely where it could potentially have the largest impact.

INTRODUCING FISH VACCINES TO NEW MARKETS: OPPORTUNITIES AND CHALLENGES

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Fish farming is widely regarded as an efficient and sustainable way to produce high-quality protein, and global aquaculture is becoming increasingly important in feeding the world's growing population. However, as with terrestrial animals, the risk and impact of disease outbreaks increase with intensification, posing significant threats to the sustainability and commercial viability of aquaculture operations.

Antibiotics are often used as a first line of defense to control disease outbreaks. Estimates suggest that more than 10,000 tons of antibiotics are administered globally each year in aquaculture, with a significant portion used preventatively, particularly in Asia. This widespread use has led to the emergence of antimicrobial resistance (AMR), which poses a serious threat not only to aquaculture but also to animal and human health.

The solutions required for fish health are as diverse as the industry itself. Preventive and evidence-based fish health management is essential for facilitating healthy and sustainable growth. This approach includes a combination of tools such as genetic and nutritional improvements, targeted diagnostics, efficacious vaccines, biosecurity measures, and regulation. Vaccination has been routine in the salmon industry for decades, with fish vaccinated against up to ten different pathogens simultaneously using fully automated vaccination devices. Vaccination programs have also been used successfully for sea bass for more than two decades, and more recently, vaccination has been successfully introduced to other industrialized species such as tilapia, and pangasius. Despite this progress, the percentage of farmed fish vaccinated globally remains low.

In this presentation, we will review PHARMAQ's experiences in developing, licensing, and introducing vaccines to new species and markets. We will focus on the opportunities, obstacles, and success factors relevant to African aquaculture.

CITRUS PEELS FERMENTED WITH *Penicillium notatum* REPLACED UP TO 75% OF MAIZE IN THE DIETS OF AFRICAN CATFISH *Clarias gariepinus*

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Introduction: World production of citrus fruits exceeds 124.3 million tons annually. Citrus peels make up about 60–65 % of the citrus fruit body weight, which means that 74.6-80.8 MT of peels may be available annually as animal feeds. Citrus peels are rich sources of functional bioactive compounds, especially phenolic (flavonoids and phenolic acids) and essential phytochemicals that possess health benefits. Therefore, this study investigated the effect of replacement of maize with citrus peels from sweet oranges fermented with *Penicillium notatum* on the growth, carcass quality and biochemical profile of African catfish.

Materials and methods: Orange fruits were harvested, washed in clean waters and the peels removed, dried at room temperature and blended into fine particles. The particles were fermented for 7 days using *Penicillium notatum*. The fermented citrus peel was used to replace 0, 25, 50, 75, and 100% of maize in the diets of *Clarias gariepinus* juveniles (12.50±14g) and the fish were fed in triplicate groups to apparent satiation twice daily for 56 days.

Results: Table 1 shows that fermentation improved the nutritional quality of the citrus peels, which helped to improve fish performance and nutrient utilization. The fermented peels have protein of 26.2% which is more than double the protein of 10% contained in maize.

Growth performance, Table 2, shows that the fermented peels could replace up to 75% of maize in the diets of the fish. Wt. gain and SGR were statistically the same in the fish fed diets with up to 75% of citrus peels. Peels also increased ($P<0.05$) carcass ash and protein.

Biochemical profile indicates that total cholesterol, triglycerides, LDL, urea and MDA decreased marginally while HDL increased marginally with increasing levels of peels in the diets.

Conclusion: Replacing maize with fermented citrus peels positively influenced growth, carcass minerals and fish quality.

Table 1. Nutritional composition of citrus peels

Parameters	unfermented	Fermented with <i>P. notatum</i>
Protein	7.55	26.2
Ash	4.47	10.0
Lipid	2.13	9.33
Na	30.4	70.4
K	59.4	90.2
Fe	1.86	4.10
Tannin	30.0	28.9
Phytate	0.13	0.10

Table 2. Growth performance of fish fed fermented citrus peels

	citrus peels				
	Diet 1 100% maize	Diet 2 25% peels	Diet 3 50% peels	Diet 4 75% peels	Diet 5 100% peels
In.Wt.(g)	13.4±.04	13.4±.07	13.4±.02	13.5±.04	13.5±.06
F.Wt (g)	57±3.62 ^b	56.3±1.69 ^b	58.9±5.2 ^b	47.5±3.0 ^{ab}	27.7±1.5 ^a
Gain (g)	43.6±3.6 ^b	42.9±1.7 ^b	42.1±5.2 ^b	34±2.9 ^{ab}	14.2±1.5 ^a
SGR	2.57±.89 ^b	2.56±.53 ^b	2.53±.17 ^b	2.25±.10 ^{ab}	1.28±.09 ^a
FCR	2.6±.06 ^a	2.61±.19 ^a	2.76±.44 ^a	3.03±.13 ^a	3.46±.17 ^a

Means on the same row with similar superscripts are the same ($P>0.05$)

EU-EAC TRUE FISH FARMING STORY IN THE LAKE VICTORIA BASIN (TRUEFISH)

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The Lake Victoria Fisheries Organization (LVFO), of the East African Community (EAC), in partnership with Landell Mills, Food and Agriculture Organization (FAO) of the United Nations and WorldFish is implementing the EU EAC True Fish Farming Story in the Lake Victoria Basin (TRUEFISH) Project. The TRUEFISH project is a significant initiative funded by the European Commission with €10.15 million under the 11th EDF. It benefits the East African community in Kenya, Uganda, and Tanzania over five years, with additional benefits for Burundi and Rwanda in the area of Aquatic Animal Health. The project's goal is to foster competitive, gender-equitable, and sustainable commercial aquaculture in the Lake Victoria basin. It aims to overcome key challenges faced by investors, such as a lack of technically skilled operators, insufficient investment finance, and incomplete networks, while addressing potential threats to sustainable aquaculture development.

Currently, the project is in the implementation phase. It has facilitated farmers from Burundi, Kenya, Rwanda, Uganda, and Tanzania to conduct study tours to Egypt, Malaysia and China where they were exposed to new ideas, technologies, and best practices in aquaculture. The project has organized conferences both online and physical in Bondo, Kenya, and in Mwanza, Tanzania, and developed a standardized business plan for Tilapia and Catfish to help fish farmers present credible, bankable business plans and interact more effectively with financial institutions. The project has also worked towards unifying the aquaculture sector by creating a regional aquaculture association. Furthermore, short and long courses have been developed to train aquaculture farmers, students and training of trainers. The Lake Victoria Regional Aquatic Animal Health Strategy has been developed, and spatial planning is underway for the Lake Victoria Zoning for Cage Aquaculture. A study was conducted to assess the genetic diversity of tilapia populations across the Lake Victoria Basin, identifying risks to biodiversity potentially posed by aquaculture and resulted in formulation of key scientific recommendations/policy brief for sustainable management of biodiversity in the region. The project has facilitated capacity building to a broader EAC community in various disciplines e.g., fish farming technics, spatial planning for sustainable aquaculture, aquatic health and biosecurity, molecular genetics and bioinformatics. The project is also supporting the development of national aquatic animal health strategies and organizing the World Aquaculture Conference in Uganda in June 2025.

As the project is in the implementation phase, it is expected that at the end of the project access to commercial networks for aquaculture-related businesses will have improved, the availability and quality of skilled local workers will have increased, and the sustainability and biosecurity of regional aquaculture production systems will have been enhanced.



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TRUEFISH
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WorldFish



ENHANCING THE SURVIVAL OF THE AFRICAN BONY-TONGUE *Heterotis niloticus* FRY THROUGH TRANSPORT AND HUSBANDRY TECHNIQUES

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Aquaculture continues to be an important sector in the African economic development agenda. To further strengthen and diversify the industry, in response to the requests by farmers, there is an essential need to increase the number of cultured species in Africa. The African bony tongue (*Heterotis niloticus*) has a huge potential for culture. However, the major challenge hindering its commercial culture is the availability of high-quality juveniles due to high larval and fry mortality, which have been linked to inadequate nutrition and handling stress. The aim of this work is to share the experiences acquired in handling fry and juvenile *H. niloticus* over the last four years and to contribute to the knowledge base for managing hatcheries of *Heterotis*. It summarizes the best practices for managing water quality, collecting larvae and fry, feeding preferences, transporting fry, and the beneficial effects of using the green water technique in *H. niloticus* larviculture. To understand the conditions under which the species thrives, the breeding behaviour and water quality in larval nest and surroundings were monitored during the breeding season. Additionally, a feeding trial was conducted with *H. niloticus* fry from 6 to 27 DAH using six feeds: *Artemia* nauplii; rotifers; 50% *Artemia* nauplii and 50% rotifers (w/w); egg custard, egg yolk and compared to fry that were not fed. Moreover, a simulated transportation trial was conducted for four different periods 24, 48, 72 and 96 hours with mortality and water quality (temperature, DO, pH and ammonia) monitored before and after transportation of fish inside the bags. Finally, fry were reared in two rearing media: “clear water” and “green water” with *H. niloticus* fry at 8DAH for 6 weeks. The results indicate that *Artemia nauplii* is best live feed organism for *H. niloticus* larviculture after yolk sac absorption. Additionally, there was deterioration in the water quality and a gradual increase in mortality with increase in transportation periods. Fish reared in “green water” systems, had higher survival and showed better growth. These studies on *H. niloticus* larviculture have given insights into some best practices in terms of husbandry techniques, transportation strategies and feed preferences at each growth stage. Additionally, the green-water rearing approach used has demonstrated high practical efficacy in the growth and survival of *Heterotis niloticus* fry; farmers can easily adopt this and we continue to work on ways to improve hatchery practices for the species.

UNCERTAINTY IN FEED SUPPLY AFFECTS THE GROWTH, HEMATOLOGICAL, AND GLUCOSE RESPONSE OF *Clarias gariepinus* (Burchell, 1822)

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The uncertainty of feed supply is an understudied welfare issue in the Aquaculture sector. In most scenarios, it is an unforeseen circumstance that could occur due to malfunctioning of fish feeders or delay in maintenance activities before feeding among others. Here, we examined the growth, hematological, and glucose response of *Clarias gariepinus* exposed to unpredictability feeding stress for 12 weeks. 90 *C. gariepinus* (10.65±0.11g) were exposed to a predictable feeding time or the control (PFT, T1), early unpredictable feeding time (EUFT, T2), and the late unpredictable feeding time (LUFT, T3) treatments. in triplicates. Growth indices (weight gain (WG), specific growth rate (SGR), and Feed Conversion Ratio (FCR) were observed weekly. Hematological indices from blood samples and glucose response were examined at the end of the study period. Statistical analyses were performed using the generalized linear models in the R statistical package.

The unpredictability in feed supply affected ($p \leq 0.05$) the African catfish with similar ($p \geq 0.05$) MWG in EUFT and LUFT. FCR was significantly ($p \leq 0.05$) different between treatments and the treatment affected ($p < 0.05$) the SGR of the fish. African catfish exposed to PFT had the best condition factor with the least ($p \leq 0.05$) mortality rate in T1 (Table 1).

Moreover, WBC, MCH, and MCHC of the fish species were affected ($p < 0.05$) by the treatments (Table 2) and the glucose response increased ($p \leq 0.05$) with an increase in the intensity of the unpredictability in feed supply (Fig 1).

In conclusion, our study provides insight into the hematological and growth responses of *C. gariepinus* when reared at unpredictable feed supply and this could compromise the welfare of *C. gariepinus* and indirectly affect sustainable fish production.

Table 1: Growth parameters of *C. gariepinus* exposed to handling-related stress

Parameters	PFT	EUFT	LUFT
MWG(g)	58.5±2.76 ^a	49.9±2.02 ^{bc}	53.3±2.14 ^b
FCR	1.13±0.09 ^a	0.99±0.01 ^c	1.01±0.03 ^b
SGR(g/day)	2.35±1.12 ^a	2.06±0.77 ^c	2.11±0.85 ^b
k-value	1.01±0.06 ^a	0.91±0.04 ^{bc}	0.83±0.02 ^c
Survival rate (%)	96.7±5.35 ^a	93.3±8.11 ^b	90.0±7.56 ^c

MWG = Mean Weight Gain, FCR = Feed Conversion Ratio, SGR = Specific Growth rate, k-value = Condition factor

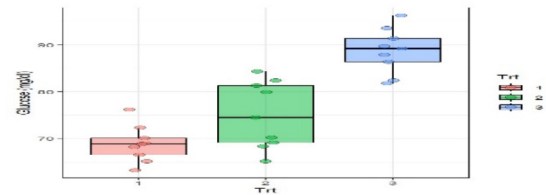


Figure 1: The glucose response in mg/dl of *Clarias gariepinus* (n=90) exposed to predictable (T1), early unpredictable (T2), and late unpredictable (T3)

Parameters	PFT	EUFT	LUFT
PCV	33.6±2.5 ^a	33.2±2.5 ^a	31.6±2.1 ^b
HGB	101.4±9.7 ^a	100.9±9.2 ^{ab}	99.6±8.1 ^b
RBC	3.02±0.73 ^a	2.8±0.51 ^b	2.2±0.46 ^{bc}
WBC	183.5±12.46 ^c	201.8±15.7 ^a	197.4±13.7 ^{ab}
HCT	41.5±5.32 ^a	34.0±3.18 ^{bc}	36.2±3.97 ^b
MCV	109.82±8.45 ^b	117.9±9.11 ^a	101.87±8.88 ^c
MCH	57.25±1.98 ^a	49.10±1.55 ^b	37.69±0.76 ^c
MCHC	203.4±11.5 ^a	194.8±10.6 ^b	198.16±11.0 ^c

PFT (Control) = Predictable Feeding time, EUFT = Early Unpredictable feeding time, and LUFT = Late Unpredictable Feeding time. Means (Mean±S.E) with different superscripts indicate significant differences ($p < 0.05$) among the treatments.

DIETARY INCLUSION OF *Citrullus lanatus* SEED IN FISH FEED: PROXIMATE ANALYSIS, GROWTH PERFORMANCE AND FEED UTILIZATION IN *Clarias gariepinus* FINGERLINGS IN CENTRAL NIGERIA

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One of the factors militating against fish farming in Nigeria have been lack of adequate feed that are formulated to meet the nutrient requirement of culturable fish species. To this end, the study on dietary inclusion of *Citrullus lanatus* (watermelon) seed in fish feed: the proximate analysis, determination of growth performance and feed utilization in *Clarias gariepinus* fingerlings in Central Nigeria was carried out between August and October 2019. The proximate analysis and economic viability were determined according to standard methods. The experimental diet was set up across varying proportions: 0% as the control, 15%, 20%, 25% and 36% inclusion levels, respectively. The result of the proximate analysis for the experimental diets showed that diet 3 (20.00% inclusion) had the highest crude protein content; lipid level was highest in diet 4 (25% inclusion); while diet 1 (control) had the highest dry matter, ash and nitrogen free extract contents. The result of the experiment showed that 36% watermelon seed inclusion yielded the highest growth performance and feed utilization in *Clarias gariepinus* fingerlings. However, there was no significant difference ($P > 0.05$) in relation to inclusion percentages of watermelon seed on growth performance in *Clarias gariepinus* fingerlings. In conclusion, relatively high proportion of watermelon seed inclusion in fish feed formulation is hereby recommended in order to improve growth performance and feed utilization in *Clarias gariepinus* fingerlings.

Table 1: Proximate Composition of Experimental Diets in Relation to *Citrullus lanatus* Seed Inclusion

Parameters (%)	DT1 (Control)	DT2 (15% seed inclusion)	DT3 (20% seed inclusion)	DT4 (25% seed inclusion)	DT5 (36% seed inclusion)
Dry matter	95.43±0.03 ^a	93.65±0.03 ^d	93.46±0.03 ^e	93.74±0.03 ^c	93.77±0.03 ^b
Crude Protein	29.44±0.52 ^e	31.79±0.52 ^c	32.38±0.52 ^a	31.70±0.52 ^b	31.42±0.52 ^b
Lipid	2.36±2.20 ^e	3.20±2.20 ^d	3.32±2.20 ^b	3.36±2.20 ^a	3.30±2.20 ^c
Ash	2.67±0.02 ^e	4.73±0.02 ^d	4.81±0.02 ^a	4.81±0.02 ^a	4.82±0.02 ^c
Moisture	5.12±0.14 ^a	4.12±0.14 ^b	3.80±0.14 ^e	4.08±0.14 ^c	4.04±0.14 ^d
NFE	75.48±0.26 ^a	74.35±0.25 ^d	73.76±0.25 ^e	75.21±0.25 ^c	75.38±0.25 ^b
Fibre	56.64±0.01 ^a	54.21±0.01 ^b	38.54±0.01 ^e	46.51±0.01 ^c	46.48±0.01 ^d

Same superscript letter indicates no significant difference between the diets means for each parameter

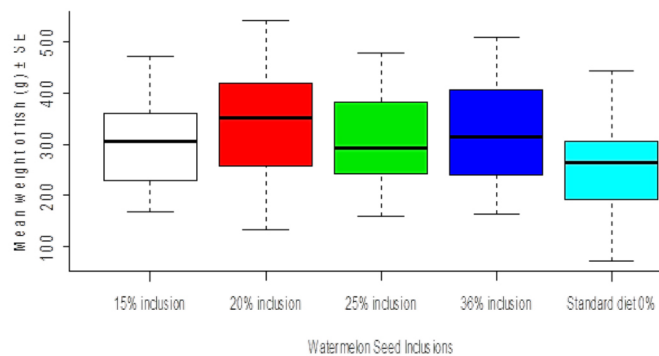


Figure 1: Mean Weight Gain of *Clarias gariepinus* Fingerlings Fed with Varying Percentages of Watermelon Seed Inclusion in Fish Meal

HAEMATO-IMMUNOLOGICAL RESPONSES AND HISTOMORPHOLOGY OF *Heterobranchus bidorsalis* FED DIFFERENTLY PROCESSED BLACK SOLDIER FLY LARVAE MEAL

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Black soldier fly larvae (BSFL) meal is increasingly recognized as a sustainable and eco-friendly protein source in aquaculture, yet there is limited information on its use in feed production for *Heterobranchus bidorsalis*. This study aimed to evaluate the haemato-immunological responses and histomorphological changes in *H. bidorsalis* fed with differently processed BSFL meal. BSFL were harvested a greenhouse set up in the University of Ibadan Fish farm. The larvae were processed by sun drying and oven drying, and then used to formulate diets with inclusion levels of 0%, 25%, 50%, 75%, and 100%. A total of 300 *H. bidorsalis* (average weight: 10.5g) were divided into five treatments, with three replicates for both processing methods.

The highest white blood cell (WBC) count (18.93±1.52) was observed in the BSFL 75 group, while the lowest (15.95±1.52) was in BSFL 100. The highest platelet count (263±26.03) was recorded in the BSFL 50 group, and the lowest (204±26.03) in the control group (BSFL 0). Lymphocyte and Heterophil counts were highest in the control. Values for Aspartate aminotransferase (AST), Alkaline phosphatase (ALP) and Alanine aminotransferase (ALT) were significantly low in the control group (Table 1). The highest total protein (TP) levels (16.13±0.53) were found in BSFL 100, while the lowest (12.38±0.53) were in BSFL 25. Glutathione peroxidase (GPx) was highest (12.58±0.85) in the control group and lowest (9.26±0.85) in BSFL 75. There were no alterations observed in the kidneys of fish fed either sun-dried or oven-dried BSFL meal. However, varying fat deposit levels and congested sinusoids were noted in the kidneys of fish fed the 100% sun-dried BSFL diet, likely due to the high-fat content of the BSFL meal (Table 2).

Overall, this study demonstrates that both processing methods of BSFL meal improve the haematological parameters of *H. bidorsalis* without negatively affecting the histopathology of the kidney and liver.

Table 1: Haematological and serum biochemistry parameters analysis

HAEMATOLOGICAL PARAMETERS	SUNDRY	OVENDRY	BSFL 0	BSFL 25	BSFL 50	BSFL 75	BSFL 100
PCV(g/dL)	34.06±0.69	32.07±0.69	35.00±1.09 ^a	33.83±1.09 ^{ab}	34.33±1.09 ^{ab}	30.67±1.09 ^a	31.50±1.09 ^{ab}
Hb (g/dL)	10.93±0.25	10.15±0.25	11.13±0.39 ^a	10.83±0.39 ^{ab}	10.87±0.39 ^{ab}	9.75±0.39 ^a	10.12±0.39 ^{ab}
RBC (×10 ⁶ /μ L)	3.34±0.68	3.13±0.68	3.51±0.11 ^a	3.29±0.11 ^{ab}	3.29±0.11 ^{ab}	3.05±0.11 ^a	3.04±0.11 ^a
WBC (×10 ⁶ /μ L)	18.87±0.96	16.43±0.96	18.78±1.52 ^a	17.75±1.52 ^a	16.85±1.52 ^a	18.93±1.52 ^a	15.95±1.52 ^a
PLATELET(×10 ⁶ /μ L)	205±16.46	272±16.46	204±26.03 ^a	245±26.03 ^a	263±26.03 ^a	261±26.03 ^a	220±26.03 ^a
LYMP(%)	60.27±1.64	60.07±1.64	63.67±2.59 ^a	53.50±2.59 ^a	63.50±2.59 ^a	58.83±2.59 ^{ab}	61.33±2.59 ^{ab}
HET(%)	35.20±1.59	37.07±1.59	32.67±2.52 ^a	43.33±2.52 ^b	32.50±2.52 ^a	36.50±2.52 ^{ab}	35.67±2.52 ^{ab}
MON(%)	2.20±0.22	2.07±0.22	1.67±0.35 ^a	1.67±0.35 ^a	2.33±0.35 ^{ab}	2.83±0.35 ^b	2.17±0.35 ^a
EO(%)	2.33±0.33	1.67±0.33	2.00±0.53 ^{ab}	1.50±0.53 ^a	3.17±0.53 ^b	2.17±0.53 ^{ab}	1.17±0.53 ^a
BG(%)	0.00±0.47	0.67±0.47	0.00±0.75 ^a	0.00±0.75 ^a	0.17±0.75 ^a	0.00±0.75 ^a	0.00±0.75 ^a
MCH(FI)	102.11±1.62	102.61±1.62	99.78±2.56 ^a	102.70±2.56 ^a	104.36±2.56 ^a	101.07±2.56 ^a	103.90±2.56 ^a
MCHC(%)	32.08±0.21	31.62±0.21	31.81±0.33 ^a	31.96±0.33 ^a	31.63±0.33 ^a	31.79±0.33 ^a	32.08±0.33 ^a
MCH(pg)	32.77±0.63	32.46±0.63	31.76±0.99 ^a	32.83±0.99 ^a	33.03±0.99 ^a	32.13±0.99 ^a	33.34±0.99 ^a
AST (μl)	55.27±1.53	51.93±1.53	51.00±2.42 ^a	54.50±2.42 ^a	53.33±2.42 ^a	55.33±2.42 ^a	53.83±2.42 ^a
ALT (μl)	27.40±1.50	26.20±1.50	25.00±2.38 ^a	27.67±2.38 ^a	28.00±2.38 ^a	26.67±2.38 ^a	26.67±2.38 ^a
ALP (μl)	231±11.74	220±11.74	208±18.56 ^a	234±18.56 ^a	231±18.56 ^a	229±18.56 ^a	226±18.56 ^a
TP(μg/dL)	14.53±0.33 ^a	13.87±0.33 ^a	13.02±0.53 ^{ab}	12.38±0.53 ^a	14.49±0.53 ^{bc}	14.98±0.53 ^{cd}	16.13±0.53 ^d

Table 4: Oxidative stress parameters

PARAMETERS	PROCESSING METHOD		MEAL INCLUSION				
	SUNDRY	OVENDRY	BSFL0	BSFL 1	BSFL 2	BSFL3	BSFL4
TP (μg/dL)	14.53±0.33 ^a	13.87±0.33 ^a	13.02±0.53 ^{ab}	12.38±0.53 ^a	14.49±0.53 ^{bc}	14.98±0.53 ^{cd}	16.13±0.53 ^d
GPx (units/mg protein)	11.10±0.54 ^a	11.59±0.54 ^a	12.58±0.85 ^b	12.36±0.85 ^b	10.45±0.85 ^{ab}	9.26±0.85 ^a	12.08±0.85 ^b
GSH (μg/mL)	513±59.27 ^a	509±59.27 ^a	575±93.72 ^a	446±93.72 ^a	509±93.72 ^a	462±93.72 ^a	516±93.72 ^a
GST (unit/mg protein)	43.92±5.53 ^a	40.83±5.53 ^a	43.39±8.75 ^a	37.06±8.75 ^a	46.94±8.75 ^a	49.49±8.75 ^a	35.02±8.75 ^a
H ₂ O ₂ (μmol/mg protein)	7.37±0.69 ^a	6.98±0.69 ^a	6.48±1.09 ^a	6.32±1.09 ^a	7.02±1.09 ^a	8.39±1.09 ^a	7.67±1.09 ^a
MDA (μmol/mg protein)	2.21±0.26 ^a	1.79±0.26 ^a	1.76±0.40 ^a	3.02±0.40 ^b	1.84±0.40 ^a	1.78±0.40 ^a	1.61±0.40 ^a
SOD (units/mg protein)	4.05±0.69 ^a	3.82±0.69 ^a	3.72±1.10 ^a	3.07±1.10 ^a	3.65±1.10 ^a	4.82±1.10 ^a	4.43±1.10 ^a
CAT	2.33±0.24 ^a	2.29±0.24 ^a	2.27±0.38 ^a	1.94±0.38 ^a	2.13±0.38 ^a	2.19±0.38 ^a	3.01±0.38 ^b
MPO	2.67±0.44 ^a	3.45±0.44 ^a	2.19±0.69 ^a	5.68±0.69 ^b	2.47±0.69 ^a	2.02±0.69 ^a	2.94±0.69 ^{ab}
RBA	133±8.99 ^a	162±8.99 ^b	122±14.22 ^a	136±14.22 ^a	174±14.22 ^{bc}	155±14.22 ^{bc}	165±14.22 ^{bc}
LYSOZYME	5.26±0.44 ^a	6.64±0.44 ^a	3.74±0.69 ^a	4.26±0.69 ^a	5.06±0.69 ^a	5.26±0.69 ^a	11.42±0.69 ^b

IMPACT OF AERATION ON NURSERY PRODUCTION OF HYBRID CATFISH (*Heteroclarias*) UNDER LIMITED WATER EXCHANGE CONDITIONS

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Aeration has long been utilized in commercial shrimp, tilapia, and ictalurid catfish production in ponds. However, there is limited evidence of its value in producing air-breathing fish species. This study aimed to evaluate the impact of aeration on the nursery production of hybrid catfish (*Heteroclarias*: *Clarias gariepinus* × *Heterobranchus longifilis*) under limited water exchange conditions. The trial was conducted at CHI Farms in Aiyeye, Sagamu, Ogun State, Nigeria, over 31 days. A total of 32,000 juvenile hybrid catfish, with an initial mean weight of 6.8g, were stocked into eight indoor circular plastic tanks (4,000 L capacity), divided into two treatment groups: (1) routine water exchange (control), and (2) aeration combined with limited water exchange (aerated). Growth performance and survival data were analyzed using an independent T-test.

The results indicated no significant differences between treatments in growth rate, specific growth rate (SGR), or feed conversion ratio (FCR). However, survival rates were significantly higher in the aerated group (96.87%) compared to the control group (90.43%) ($p < 0.05$). Water quality, particularly dissolved oxygen (DO) and pH, remained more stable in the aerated treatment, with DO levels averaging 4.04 mg/L in the morning and 2.69 mg/L in the evening in the aerated tanks, compared to 0.31 mg/L in non-aerated tanks. Despite higher unionized ammonia levels in the aerated tanks, no adverse effects on fish health were observed.

A cost analysis revealed that while aeration incurred additional energy costs, savings were achieved through reduced water exchange, leading to no significant difference in total production costs per unit between the aerated group ($\square 161.36 \pm 4.03$) and the control group ($\square 163.23 \pm 7.42$). In conclusion, aeration improved survival and stabilized water quality but did not significantly enhance growth performance or FCR. Further research is recommended to optimize nitrogen cycling in aerated systems and explore alternative energy sources to reduce the cost of aeration.

COMPARATIVE ASSESSMENT OF THREE KEY PHYSICOCHEMICAL PARAMETERS AND ICHTHYOFAUNA ACROSS FOUR RIVERS IN IKWUANO LOCAL GOVERNMENT AREA, ABIA STATE, NIGERIA

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This research conducts a comparative assessment of three key physicochemical parameters (pH, total alkalinity, and total hardness) and the ichthyofauna of four rivers (Akor, Okuugo, Ehie, and Anya) located in Ikwuano Local Government Area, Abia State, Nigeria. The study spans four clans: Ibere, Oloko, Ariam, and Oboro. To ensure comprehensive sampling, the rivers were divided into three distinct transects (upper, middle, and lower courses) with a 100-meter interval between each. Sampling was conducted over two seasons (wet and dry) to capture seasonal variations. pH levels were measured using a Hach HQ11 pH Meter, calibrated to values of 4, 7, and 10. Total alkalinity (mg/L as CaCO₃) was determined in-situ using the Hach Alkalinity Meter AL-100, while total hardness (mg/L as CaCO₃) was measured using a Thermo Scientific Orion 9600 Hardness Meter. For ichthyofauna assessment, cast nets and seine nets were employed for fish capture, and species were identified using a freshwater fish chart. The fish species recorded include *Oreochromis niloticus*, *Clarias gariepinus*, *Hepsetus odoe*, and *Malapterurus electricus*. The study found that during the dry season, pH values ranged from 8.8 to 9.5, whereas in the wet season, they ranged from 7.5 to 8.5. Total alkalinity was highest during the dry season (100 mg/L as CaCO₃), while the wet season exhibited values between 50–100 mg/L as CaCO₃. Similarly, total hardness was significantly higher in the dry season (150–300 mg/L as CaCO₃) compared to the wet season. These physicochemical parameters were found to be within acceptable ranges for sustaining the health of the ichthyofauna. The study also revealed that seasonal rainfall during the wet season diluted the rivers' mineral and ion content, while evaporation in the dry season concentrated these elements, leading to elevated levels of alkalinity and hardness. This study underscores the influence of seasonal changes on river water chemistry and its implications for aquatic life. It recommends further research into these parameters in other regions for a broader understanding of their impact on freshwater ecosystems.

THE TRIPLE NEXUS: ADVANCING AQUACULTURE AND REGIONAL DEVELOPMENT FOR NATIONAL SECURITY IN KENYA

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Understanding the key drivers of the blue economy and regional development presents a strategic opportunity for enhanced security and sustainable growth in Kenya, particularly in the Lake Victoria Basin. This region, home to more than 10 million Kenyans, is endowed with vast aquatic resources and holds immense potential for an ecosystem-based approach to aquaculture expansion. Such an approach can significantly enhance food security, improve nutrition, catalyze economic development, and promote security and environmental sustainability.

By fostering regional development through improved infrastructure, market access, and local capacity building, aquaculture can generate employment, alleviate poverty, and reduce resource-based conflicts. Integrating this approach with Kenya's national security priorities ensures that the region's stability and prosperity are safeguarded, mitigating the risks of illegal fishing, environmental degradation, and cross-border tensions.

This paper explores the interconnected pathways through which aquaculture can be leveraged to advance regional development in the Lake Victoria catchment area while contributing to Kenya's broader national security objectives. It emphasizes the promotion of aquaculture through Integrated Technology Transfer Centres (ITTC) of the Lake Basin Development Authority (LBDA), which provide a platform for transferring technologies to fish farming communities, access to certified high-quality fish fingerlings at subsidized rates, and collaboration with other institutions, including security agencies.

IMPROVING NUTRIENT UTILIZATION AND ANIMAL HEALTH IN AQUACULTURE THROUGH GENETIC SELECTION

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Even though fish meal and fish oil have proven to be ideal protein and oil sources for aquaculture, as production continues to grow the paucity of these fish derived products makes them less than ideal as protein and oil sources in aquaculture feeds. Through genetic selection we have generated a strain of rainbow trout that grows well on an all plant-based diet containing high levels of soy protein. Utilizing our unique strain of selected rainbow trout, we have been able to distinguish differences in the physiology of non-selected trout versus selected trout when fed soy-based plant feeds with and without fish oil. Most discernible is amino acid utilization, changes in pathogen resistance and development of intestinal enteritis in non-selected fish reared on these high soy feeds. Evaluation of transcriptomic, proteomic, histologic, and microbiota data generated from dietary comparative studies between selected and non-selected strains reveals distinct changes related to nutrient utilization and metabolism. These changes are also reflective in microbiota colonization throughout the entire intestine. Correlative changes in gene and protein expression reveal some of the underlying regulation related to the phenotypic changes in regard to nutrient utilization and lipid deposition.

EMISSIONS FROM BRAZILIAN AQUACULTURE IN BOTH RESERVOIRS AND OCEAN ENVIRONMENTS

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Intensive aquaculture has increased worldwide in recent decades coupled with growing awareness of sustainable development of this activity. One of the main concerns with the growth of the activity is the greenhouse gases (GHG) emissions. Methane (CH₄), carbon dioxide (CO₂), and nitrous oxide (N₂O) produced in the sediment and water can be emitted to the atmosphere through diffusive or ebullitive transport across the water column. In this study, we measured the diffusive and ebullitive fluxes of CO₂, CH₄, and N₂O at the water-atmosphere boundary layer in both aquaculture and control areas in reservoirs and the ocean. The study area includes reservoirs with Nile tilapia (*Oreochromis niloticus*) farmed in net cages, as well as large-scale commercial production of brown mussels (*Perna perna*) and Pacific oysters (*Crassostrea gigas*) in marine aquaculture in Brazil.

Two different methods can be used to collect gas samples for each type of transport. The GHG diffusive emission at the water-atmosphere interface was measured using static polyvinyl chloride (PVC) chambers with an internal volume of 1 liter, equipped with floats and protection at the bottom to prevent any ebullitive influence. Four gas samples were taken from the inside of the chambers seven minutes apart (0, 7, 14, and 21 minutes) with plastic syringes. The GHG ebullitive emissions were measured using inverted collector funnels equipped with a volumetric bottle connected at its vertices to retain the bubbles released from the sediment.

The diffusive GHG flux in reservoirs with fish farming in net cages was 40.1 ± 83.8 kg CO₂eq m⁻² year⁻¹ (control = 9.8 ± 16.5 kg CO₂eq m⁻² year⁻¹) while the ebullitive GHG flux was 153.9 ± 268.2 kg CO₂eq m⁻² year⁻¹ (control = 30.6 ± 221.9 kg CO₂eq m⁻² year⁻¹). The diffusive GHG flux in marine aquaculture was 0.7 ± 2.2 kg CO₂eq m⁻² year⁻¹ (control = 1.0 ± 2.3 kg CO₂eq m⁻² year⁻¹) while the ebullitive GHG flux was 0.0 ± 0.0 kg CO₂eq m⁻² year⁻¹ (control = 0.0 ± 0.0 kg CO₂eq m⁻² year⁻¹). Emissions were higher in fish farming areas compared to their respective controls, while emissions from bivalve farming areas were similar to those of the corresponding controls. The GHG emission in reservoirs was higher than in marine areas, primarily due to the diffusive and ebullitive CH₄ emissions. The diffusive GHG flux in reservoirs was 33.7 ± 78.4 kg CO₂eq m⁻² year⁻¹ (control = 5.5 ± 12.3 kg CO₂eq m⁻² year⁻¹) while the ebullitive GHG flux was 153.6 ± 265.4 kg CO₂eq m⁻² year⁻¹ (control = 30.6 ± 221.9 kg CO₂eq m⁻² year⁻¹). The higher emissions in fish farming areas are primarily related to the organic matter content beneath the net cages. The comparable emissions in bivalve and control areas suggest that environmental factors exert a greater influence on emissions than the production of oysters and mussels.

HOW TO REDUCE AQUACULTURE EMISSIONS

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Greenhouse Gasses Emissions (GHG) associated with aquaculture accounts for approximately 0.5% of global anthropogenic GHG emissions but they can become more important as the sector continues to grow. Most of aquaculture-related emissions are associated with the production and transportation of aquafeeds (50-60% of the carbon footprint). Extraction of fishmeal and fish oil, main ingredients in aquafeeds, is very energy consuming. Moreover, raw materials are often sourced in continents different from where they are used and the carbon footprint associated with transportation is significant.

Nitrous oxide (N_2O) from microbial nitrification and denitrification is another source of GHG associated with aquaculture. Moreover, energy use in the fish farm (pumps and lights) and to transport the fish harvested also generates emissions. The most effective way to reduce aquaculture-related emissions is the use of sustainable and locally-sourced ingredients for feed. Use of extractive species to remove nitrates from the effluents, use of renewable energy sources, correct by-products management and use of AI and remote sensing tools for standard operations are other interventions that help to reduce emissions. Different research projects aimed at developing solutions to improve aquaculture sustainability are presented. Alternative sources of protein and lipids for aquafeeds were tested on different Mediterranean species. Fish farming was coupled with production of additional biomasses, consisting of extractive species, with the aim of removing nutrients from the aquaculture effluents. This has the double benefit of reducing water pollution and N_2 emissions. AI tools to automate feeding and biomass assessment were tested in a farm in Tunisia, powered by solar panels. Finally, emissions associated with production of fishmeal and fish oil from tuna by-products, were estimated through life cycle assessment and compared with the emissions of traditional sources of proteins and lipids. GHG produced through incineration of by-products (alternative management method) were also estimated.

In Tunisia, live streaming from the cage allowed operators to visualize the conditions inside the cages remotely, limiting boat trips and improving the performance of the farm. Using AI estimation software also helps farmers to save approximately 56 hrs of work per cage/cycle.

Extractive species grown on aquaculture effluents can remove more than 90% of nitrogen from the water, drastically reducing the release of N_2 and producing additional valuable biomass. Incineration of 6 tons of tuna by-product has a single score of 176 Pts, while the use of the same biomass to produce fishmeal and fish oil has a single score equal to 112 Pts. Replacing fossil fuel with solar energy in the processing plant, allows 90% reduction of emission. Seabass and whiteleg shrimps fed with aquafeed including tuna by-products as a source of protein and lipids, performed as well as when fed with commercial aquafeeds.

Overall, all the approaches taken were successful in improving the sustainability of aquaculture. Emissions from this sector can be reduced substantially by integrating new available technologies in the production process.

MEDITERRANEAN AQUACULTURE ADAPTING TO CLIMATE CHANGE

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The climate crisis is causing significant physical changes in marine systems, including warming, ocean acidification, thermal stratification, and more extreme weather events¹. The Eastern Mediterranean, a climate change hotspot, is expected to see heat waves occur seven times more frequently and last three times longer by the century's end. These changes can directly affect farmed species, such as when sea temperatures exceed their thermal limits, or indirectly through eutrophication and species invasions. Impacts on aquaculture include reduced growth, widespread die-offs, increased disease risks, reproductive cycle disruptions, and infrastructure damage².

Experimental studies show that the thermal tolerance for key species in the Mediterranean is narrow. *E. seabass* performs best around 26°C and above this, performance drops while the lethal limits for the species is at 33°C³. Gilthead sea bream presents reduced growth above 28°C, stop feeding above 32°C and has lethal limits at 34°C⁴. While generalized models have been developed⁵, gaps remain regarding the effects of combined stressors in real-world production, where multiple factors in open sea environments may lower these tolerance thresholds. Climate change is exacerbating bacterial and parasite issues in Mediterranean aquaculture. Warmer waters favor pathogen growth while stressing aquatic organisms, weakening their immune systems. Cascarano et al.⁶ found that rising temperatures extend the transmission period of key pathogens, increasing disease outbreaks from spring to autumn. This presents a major challenge for fish health management, alongside the risk of new pathogens invading the warming Mediterranean.

Mitigation strategies for the sector in the Mediterranean ought to focus on enhancing sustainability, scientific innovation, regulatory frameworks, and investment. Sustainable production systems are crucial, and together with novel feed ingredients may promote economic and social sustainability. Data collection on the current state for timely monitoring, combined with robust forecasting tools, and prediction models targeting small geographical areas, is essential for adaptive management. Collaboration between the industry and the scientific community is vital to improving animal health, developing alternative fish-feed raw materials, promoting species diversification, and advancing selective breeding. Regulatory action at the EU and Member State levels is necessary for the planning and design of adaptation strategies⁷, implementing mitigation actions. Supporting mechanisms, at European (CFP, EMFAF) and regional level (GFCM) also play a critical role. Investment in climate-adapted engineering, robust insurance schemes, business model diversification, risk mitigation, and innovation—especially in energy transition—is essential to strengthen the sector's resilience and ensure its sustainable future in the region.

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AN ASSESSMENT OF BREEDING, GROWTH AND SURVIVAL OF *Oreochromis macrochir* IN COMPARISON WITH *Oreochromis niloticus* REARED IN EARTHEN PONDS UNDER COOL TEMPERATURE

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The trial assessed breeding performance of green headed bream *O. macrochir* in comparison to *O. niloticus* during winter at Henderson Research Institute in Mazowe. The experiments were carried out from the 5th to the 28th of July 2024. Hapas measuring 2m x 2m x 1.5m were constructed using 80% shade cloth material and stocked at 3 fish per square meter. The two species were divided into three different weight cohorts and each cohort was replicated three times. Each replicate was made up of 12 fish, four males and eight females. The breeders were grouped in the following categories; 50 – 80g, 80 – 105g and 105 – 135g. The breeding ratio adopted were one male per two females. Hapas were inspected for fry at the end of the 21-days breeding cycle. It was observed that breeding did not take place in all hapas during the breeding cycle and a high number of breeders died. The first two sizes categories had the maximum number of mortalities. The failure to produce fry and a higher death could have been due to the too low temperature experienced during the breeding period. The findings of this study demonstrated that both *O. Macrochir* and *O. Niloticus* cannot breed at water temperature below 15 degrees Celsius. Therefore, the study will generate some information to the farmers which will help to choose the best fish species that that performs well in their area. The trial will need to be repeated, checking the impact of feed and other variables to the trial. If a different species that suits and covers the gap left between trout, a cold tolerant species and *O. niloticus*, a warm water species, productivity would be optimized in Zimbabwe.



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THE OPTIMIZATION OF FISH FEED FORMULATION USING BLACK SOLDIER FLY (*Hermetia illucens*) AND SEAWEED (*Ulva lactuca*): EFFECT ON GROWTH PARAMETERS OF MOZAMBIQUE TILAPIA (*Oreochromis mossambicus*)

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Aquaculture's growth is constrained by the unsustainable reliance on fishmeal for fish feed, driving the need for alternative solutions. This study explores Black soldier fly larvae (BSFL) and seaweed (*Ulva lactuca*) as sustainable feed options for Mozambique tilapia (*Oreochromis mossambicus*). BSFL provides high protein and a robust amino acid profile, while seaweed is rich in essential vitamins, minerals, and bioactive compounds. Both ingredients offer potential to improve fish growth performance while reducing environmental impact.

Fish were fed four diets over 12 weeks: a control diet (traditional fishmeal-based), and two experimental diets with three varying inclusion levels of *Hermetia illucens* and *Ulva lactuca* meal, respectively. The study used a randomized design with various inclusion levels of each ingredient. Each inclusion level was tested with five replicates.

The 40% BSFL diet resulted in the highest weight gain (48.258g) and superior growth efficiency (SGR of 1.092) compared to other diets, while the 30% *Ulva* diet demonstrated the best feed efficiency (FCR of 0.605) and improved fish condition (K). The 40% BSFL also had the highest Protein Efficiency Ratio (PER) of 1.930. Significant differences in weight gain, SGR, FCR, PER, and condition factor (K) were observed across diets ($p < 0.05$), highlighting the effectiveness of both diets for growth and feed efficiency.

Table 1: Summary of growth performance parameters for Mozambique Tilapia (*Oreochromis mossambicus*) feed diets with varying inclusion levels of black soldier fly larvae (*Hermetia illucens*) meal and ulva seaweed (*Ulva lactuca*)

Diet	WG (g)	SGR(%day ⁻¹)	FCR	PER	K
Control	30.19 ^c	0.88 ^{abcd}	0.95 ^{ab}	0.90 ^c	1.57 ^{bc}
20%BSFL	32.25 ^{bc}	0.72 ^{cd}	0.98 ^a	1.08 ^c	1.64 ^{ab}
30%BSFL	34.47 ^{bc}	0.78 ^{bcd}	0.96 ^{ab}	1.33 ^{bc}	1.54 ^c
40%BSFL	48.26 ^a	1.09 ^{ab}	0.61 ^b	1.93 ^a	1.63 ^{ab}
10% <i>Ulva</i>	27.43 ^c	0.63 ^d	1.15 ^a	0.92 ^c	1.58 ^{bc}
20% <i>Ulva</i>	40.21 ^{abc}	0.97 ^{abc}	0.78 ^{ab}	1.36 ^{bc}	1.58 ^{bc}
30% <i>Ulva</i>	44.74 ^{ab}	1.19 ^a	0.60 ^b	1.58 ^{ab}	1.66 ^a

means in the same column with different superscripts are significantly different ($p < 0.05$)

THE ROLE OF REGIONAL AQUACULTURE NETWORKS AND PARTNERSHIPS: LEARNING FROM ASIA AND NACA

Michael Phillips, FutureFish
Rohana Subasinghe, FutureFish
Eduardo Leano, Network of Aquaculture Centers in Asia-Pacific

The presentation provides a short history of aquaculture networks in the Asia-Pacific region, with special attention to the Network of Aquaculture Centres in Asia-Pacific (NACA), a regional intergovernmental network established in 1990. NACA was formed by a formal international treaty agreement with 20 government members and headquarters in Bangkok, Thailand. The organisation is self-supporting with government contributions and provides a networking platform for technical cooperation and between the member states in Asia-Pacific and their research centres, as well as the Food and Agriculture Organisation of the United Nations, which has an advisory role on the NACA Governing Council. The paper presents some major programs conducted and results obtained, identifies some key factors that have contributed to its sustainability, influence and development, and future directions, including building a platform for stimulating innovation and investment, and catalysing greater collaboration between public and private sector stakeholders in the aquaculture industry.

STATUS OF PHYTOPLANKTON BIOMASS AND WATER QUALITY DURING FISH CAGE CULTURE FALLOWING: A CASE STUDY OF SOUTHEAST ARM OF LAKE MALAWI

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The possibility of using fallowing as an ecosystem management measure to restore ecosystem functions in disturbed aquatic environments under cage culture was evaluated in this study. The cage aquaculture site in the Southeast arm of Lake Malawi was studied following the abandonment of cage aquaculture activities in 2022 after 18 years of producing fish. The study found that physical-chemical parameters of water such as temperature, pH, ammonia, turbidity and dissolved oxygen were not significantly different ($p>0.05$) across the cage and non-cage sites and between seasons.

However, ammonia levels recorded in this study were lower than the values reported by studies done when cage culture operations were in progress, an indication that some recovery processes are happening at the site. Chl-a levels were found to be insignificantly different between cage and non-cage sites ($p>0.05$) but were found to be significantly influenced by season ($p<0.05$). The Chl-a levels in this study were higher than those of previous researchers suggesting that the increase is independent of cage aquaculture but rather a response to external inputs that may be linked to agriculture run off considering that high levels were recorded in the wet season. Chl-a was found to be significantly and highly correlated positively with temperature, followed by total suspended solids and pH. Overall, the site is undergoing recovery with respect to the abandonment, but the effect is masked by external inputs of nutrients into the Lake. Although the study found that Lake Malawi is still an oligotrophic lake, the increasing levels of Chl-a are alarming and calls for inclusion of watershed management in agriculture and environmental management programming to sustainably safeguard the health of the Lake.

Table 1. Selected water quality parameters at a cage aquaculture site on Lake Malawi one year after cessation of fish farming

Location	Season	DO (mg/l)	Temp (°C)	TSS (mg/l)	Turbidity (NTU)	pH	Salinity (ppt)	Ammonia (mg/l)	Chl-a (µg/l)
Cage site	Wet	8.06	29.57	16	10	7.25	0.12	0.13	2.35
	Dry	8.66	23.89	0	0.01	8.39	0.12	0.08	0.93
	Mean	8.36±0.42	26.73±4.02	8±11.31	5.01±7.06	7.82±0.81	0.12±0	0.11±0.04	1.64±1.00
Southeast	Wet	8.13	29.45	22	18	7.43	0.12	0.11	2.72
	Dry	8.75	24.27	0	0.01	8.77	0.12	0.13	0.95
	Mean	8.44±0.44	26.86±3.66	11±15.56	9.01±12.72	8.1±0.95	0.12±0	0.12±0.01	1.84±1.25
Northwest	Wet	8.16	29.37	12	11	7.74	0.12	0.07	2.37
	Dry	8.88	23.76	0	0.01	8.36	0.12	0.19	1.16
	Mean	8.52±0.51	26.57±3.97	6±8.49	5.51±7.77	8.05±0.44	0.12±0	0.13±0.08	1.77±0.86

AQUACULTURE INNOVATION AND SUSTAINABLE MARINE PRODUCTION AT EPPO

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The Portuguese Institute for the Ocean and Atmosphere (IPMA) is a public research institute that advises national authorities on oceanic and atmosphere matters. IPMA has a strong cluster of expertise in ocean and marine resource research, namely in aquaculture and fisheries.

The Aquaculture Research Station of Olhão (EPPO, figure 1) stands out for its exceptional experimental facilities, recognized both nationally and internationally. This core marine facility supports aquaculture research at all scales, ranging from bench-top laboratory studies to larger, semi-industrial production trials. EPPO spans approximately 7 hectares and includes over 250 tanks, a fully equipped hatchery for experimental production and various rearing systems such as flow-through, recirculation aquaculture systems (RAS), semi-intensive earthen ponds and intensive concrete and fiber glass tanks, for broodstock, larvae and juvenile rearing. The facility also features a support building with dedicated spaces for trophic chain production, daily operations and biological sampling; three RAS systems; analytical laboratories (biochemical, histological, molecular, microbiological and fish pathology); a seafood packing unit; a pre-fattening area; and 17 earthen ponds. EPPO maintains broodstock of several marine species (e.g., meagre, gilthead seabream, seabass, Senegalese sole and sardine), alongside microalgae and invertebrates, leveraging its expertise in their production.

The research focus at EPPO includes new species development, nutrition, animal welfare, environmentally sustainable production systems, and the evaluation of both onshore and offshore production systems for fish grow-out (Figure 2).

Acknowledgments: To INOVAQUA (MAR-021.1.3-FEAMPA-00004) and SAUDE&AQUA II (MAR-021.1.3-FEAMPA-00018) projects for the financial support.



Figure 1 - Aerial view and RAS system on EPPO

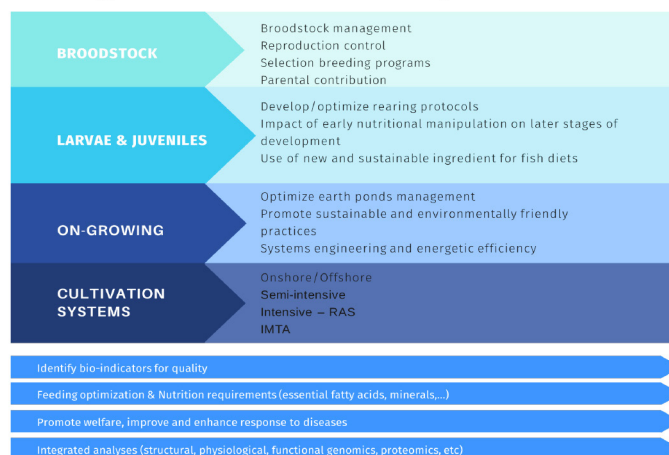


Figure 2 - On going research lines at EPPO

***IN VITRO* SCREENING OF MICROALGAE FRACTIONS FOR ANTIOXIDANT, PROLIFERATIVE, AND ANTIMICROBIAL ACTIVITIES IN AQUACULTURE APPLICATIONS**

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The fish larval stage is a critical step in marine aquaculture, with significant efforts focused on improving survival rates and resilience in recent years. Incorporating bioactive compounds into larval diets has emerged as a promising strategy to enhance survival, resistance to stressors (e.g., transport, handling), and overall performance. Microalgae serve as a valuable source of these bioactive compounds. However, their extraction from microalgal biomass often yields limited amounts, complicating the scaling up for *in vivo* trials and subsequent use at the industrial level.

Due to the costs involved in microalgal extract production and *in vivo* testing, S2AQUA developed an *in vitro* screening system with fish cell cultures and pathogenic bacterial strains, to assess bioactivity more efficiently and streamline decision-making processes. These screenings help to evaluate the bioactive compounds' effects on cell proliferation, antioxidant capacity, and antimicrobial activity against fish pathogens. In this study, we investigated the bioactivity of several fractions (F1-F10) derived from the microalgae *Tetrademus obliquus*, grown using agricultural effluents, on the VSa13 fish cell line proliferation and antioxidant potential. Additionally, we assessed the bactericidal properties of these extracts against *Photobacterium damsela* subsp. piscicida, a common fish pathogen.

Preliminary results indicate that fractions F4 and F6 from effluent-grown *Tetrademus obliquus* significantly enhanced cell proliferation, while fraction F8 demonstrated strong antioxidant potential in cells exposed to H₂O₂-induced oxidative stress.

Additionally, the antimicrobial activity results indicated that the *Tetrademus obliquus* extracts presented antimicrobial susceptibility and bactericidal activity in some extracts with one of the extracts (F5) presenting antimicrobial activity at 1000 µg/mL against all the tested pathogenic bacterial strains.

This systematic *in vitro* approach effectively identified promising microalgal fractions for subsequent *in vivo* testing as aquaculture feed additives. This supports the advancement of sustainable aquaculture through natural, resource-efficient feed solutions that enhance fish health and growth while reducing environmental impact.

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MICROPLASTICS FROM AQUACULTURE: RISKS FOR MARINE ORGANISMS

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Marine ecosystems are recognized as among the most productive in the world and provide a wide range of natural services. Nearly 40% of the world's population lives in coastal areas and depends on the benefits provided by marine ecosystems. Microplastic pollutions have become topic of great interest, they have considered an emerging environmental issue of global concern. Marine plastic waste mainly consists of discarded fishing gear such as nets, lines, traps, etc. that are lost, abandoned or deliberately dumped at sea. Their fragmentation could have potentially harmful effects on marine organisms. Therefore, an understanding of the effects of microplastic pollution is necessary for the safety of the marine environment. This work aimed to compare the acute ecotoxicological effects of polypropylene (PP) microplastic (MPs) and his leachates, derived by mussel nets, in three marine crustaceans *Tigriopus fulvus*, *Gammarus aequicauda* and *Idothea baltica*.

Mussel nets were fragmented in an Ultra Turrax IKAWerkeal (Staufen, Germany) and sieving through a standard series of sieves to obtain particles with a size between 20 and 38 μm . The MPs exposure solutions for individual acute tests were 5, 10, 25, 50, and 100 mg/L, while for *G. aequicauda* 2.5, 5, 10, 25 mg/L. For leaches preparation, mussel nets were cut (1cm \times 1cm) and put in a rectangular glass jar, with 700 mL of filtered natural seawater (FNSW 0.45 μm) and 80g plastic material/L. These were maintained in agitation (100 rpm). At the end of the leaching time (20 days), the water filtered at 0.45 μm and toxicity was tested with the marine species selected.

The negative controls were carried out with FNSW and to evaluates the sensitivity of test species, the positive controls were included for each experiment, by using $\text{Cd}(\text{NO}_3)_2$ as reference toxicant at different concentrations.

Each treatment was replicated 3 times with 20 individuals per concentration placed in 700 mL of test solution for *G. aequicauda* and *I. baltica* and 10 individuals for *T. fulvus* in 3 mL.

The negative controls displayed values of mortality $\leq 15\%$ meeting the acceptability criteria, and LC50 values for the reference toxicants confirmed the sensitivity of the selected species. The responses of all crustaceans tested, even at the highest leachate dilutions (100% dilution), showed no significant acute toxicity effect ($p > 0.05$) of the leachates. On the contrary, PP MPs significantly affect the survival of all crustacean species with LC50 values ranging from 5.27 mg/L for *G. aequicauda* to 75.80 mg/L for *I. baltica* (Tab.1)

PP MPs showed a significant impact on all species already at the lowest tested concentrations ($p < 0.05$) (Fig. 1). These results represent an important advance on this topic. However, further chronic studies are need to assess the potential impact of microplastics on alternative endpoints that are better suited to throughout their life cycle.

Tab. 1. LC50 values (mg/L) for all crustacean species test for leachates and MPs polypropylene (PP).

Test Species	Leachates
<i>T. fulvus</i>	> 100mg/L
<i>G. aequicauda</i>	> 100mg/L
<i>I. baltica</i>	> 100mg/L
Test Species	PP MPs (20-38 μm)
<i>T. fulvus</i>	12.95mg/L (11.06-20.04)
<i>G. aequicauda</i>	5.27 mg/L (3.58-7.76)
<i>I. baltica</i>	75.80 mg/L (54.8-104.8)

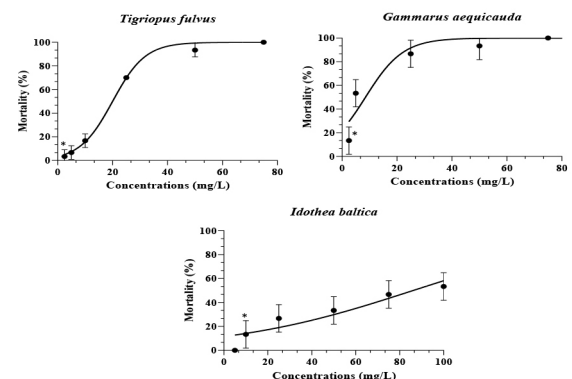


Fig. 1. Concentration-response curves based on the mean (\pm s.d.) mortality rates of the three model species to polypropylene (PP).

BROODSTOCKING OF CULTURED BELUGA, *Huso huso* IN BRACKISH WATER

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Stocks of the great sturgeon, *Huso huso* (Linnaeus, 1758) are highly decreased in the Caspian Sea. Results of the present study about cultured *H. huso* in brackish water earhponds of Bafq in center of Iran showed mean length and weight of the female samples were significantly increased during the three-year breeding period, by HSD Tukey test ($p < 0.0005$). Sex detection of the samples was performed using ultrasonography and laparoscopy methods. Laparoscopic biopsy and microscopic study of the ovaries tissue showed stages II-III, III and atretic follicles in different studied ovaries.

As stocks of the great sturgeon, *Huso huso* (Linnaeus, 1758) are highly decreased in the Caspian Sea, survey about brood stocking of this fish in inland water is necessary. Results of the present study about cultured *H. huso* in brackish water earhponds of Bafq in center of Iran showed mean length and weight of the female samples were 1.28 ± 0.15 m and 12.03 ± 5.16 kg, and 1.68 ± 0.17 m and 33.46 ± 11.23 kg, at the first and the last month of the three-year breeding period, respectively. Mean length and weight of the samples were significantly increased during this time, by HSD Tukey test ($p < 0.0005$). Mean \pm S.D values of the serum enzymes activities of *H. huso* samples were as: AST 502.9 ± 258.2 IU/L, ALT 104.4 ± 35.1 IU/L, LDH 3094.2 ± 1277.5 IU/L, CK 3632.9 ± 2618.7 IU/L, ALP 281.2 ± 112.7 IU/L, and ACP 13.3 ± 2.5 IU/L. Sex detection of the samples was performed using ultrasonography and laparoscopy methods. Females were tagged and stocked separately. Laparoscopic biopsy and microscopic study of the ovaries tissue showed stages II-III, III and atretic follicles in different studied ovaries.

OPTIMIZING CAPACITY BUILDING EFFORTS FOR SCALING IN SUSTAINABLE AQUACULTURE: SUCCESS FACTORS FOR KNOWLEDGE RETENTION

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The aquaculture sector, particularly in developing regions, holds immense potential for enhancing livelihood opportunities, improving nutritional and food security, and contributing to overall sustainability. Small-scale farmers in rural areas are critical role in unlocking this potential, yet their lack of knowledge on scientific farming practices remains a significant barrier. In India, the Community Resource Person (CRP) model for extension service has proven effective in scaling and replicating extension services, facilitating knowledge transfer, and ensuring practical application at the grassroots level.

Optimizing capacity-building efforts to maximize knowledge retention requires a strategic approach. The selection of promising multipliers and Trainer of Trainers (ToTs) is crucial, as is establishing framework conditions that prevent the dilution of efforts. CRPs and their trainers, selected from within the farming community, play a pivotal role in disseminating knowledge and providing continuous on-the-ground support to fellow farmers. Notably, field experiences revealed that younger, more educated CRP trainers showed higher engagement and effectiveness compared to their older counterparts, emphasizing the need for a rigorous selection process that considers technical knowledge, farm size, experience, age, social interaction skills, and commitment to community service.

Key challenges, such as low farmer retention during training sessions, highlight the need for interactive, hands-on approaches and timing sessions to fit farmers' routines. Institutional support and structured incentives are critical to sustaining engagement. Monetary incentives have proven most effective, but non-monetary rewards, such as seeds, equipment, or social recognition, also play a significant role. Moreover, phased training sessions and materials in local languages enhance inclusivity, particularly in tribal areas.

While challenges remain, the CRP model demonstrates that with the right selection criteria, structured incentives, and adaptive training methods, high levels of knowledge retention and application can be achieved. Importantly, the approach must be tailored to the target audience. Whether the focus is upward (towards commercial interests) or downward (towards government programs, particularly within the context of development cooperation), stakeholders must decide what direction aligns best with their goals.

The findings suggest that while scaling and replicating these efforts, careful attention must be given to the context and selection process of those involved to ensure that the knowledge gained is not only retained but also effectively applied in local aquaculture practices. This approach is essential for optimising the impact of capacity-building efforts and addressing the long-term sustainability of knowledge retention in the field.

EFFECT OF AGRICULTURAL CARBON SOURCES ON GROWTH PERFORMANCE OF NILE TILAPIA (*Oreochromis niloticus* Linnaeus, 1758) AND ASIAN RICE (*Oryza sativa* Lejeune 1753) IN A FLOCPONIC SYSTEM

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Floponic technology uses carbon to create value-added products, contributing to aquaculture's economic diversity and sustainability. Carbon products promote microbial floc, which controls fish disease and reduces nutrient discharges. The availability, low cost, and chemical composition of agricultural carbon sources make ideal substrates for floponic application. The study evaluated how agricultural carbon sources affect floponic Nile tilapia and rice growth, water quality, and the economic viability of floponic production. A complete randomized design was employed in five treatments (wheat-bran, Rhodes-hay, maize-cob, maize-stables, lucerne-hay) and control (no carbon source), each in triplicate. Each treatment and control had Nile tilapia and rice densities of 98 fry m³ and 250 rice m², respectively. Fish weight and length trends varied significantly between treatments and control ($p < 0.001$). The lucerne-hay had the highest final weight (2.94 ± 0.15 g), length (7.52 ± 0.08 cm), SGR (2.80), and weight gain (2.67 g), whereas the control had the lowest. The FCR was highest in the control (1.12) and lowest in the lucerne-hay. Rice growth parameters differed significantly ($p < 0.05$) between treatments and control. The lucerne-hay had the highest rice tillers (1.28 ± 0.04), leaves (0.84 ± 0.02), heights (34.59 ± 0.83 cm), grain weight (189.82 ± 5.20 g), and stable weights (346.60 ± 43.5 g), while the control had the lowest. The water parameters (dissolved oxygen, temperature, and TDS) did not differ between treatments and control ($p > 0.05$). Ammonia, nitrite, nitrate, soluble reactive phosphorus (SRP), pH, and electrical conductivity differed ($p < 0.05$) between treatments and control. The lucerne-hay had the lowest ammonia (0.27 ± 0.02 mgL⁻¹), nitrite (0.25 ± 0.01 mgL⁻¹), and the highest nitrate (0.91 ± 0.06 mgL⁻¹) and SRP (0.642 ± 0.05 mgL⁻¹) levels. The floponic system's profitability varied between the treatment and control. Lucerne-hay (KES 1338.39) generated the highest positive net income, followed by wheat-bran (KES 474.69) and Rhodes-hay (KES 266.1). The return on investment was positive in lucerne-hay (72.19), wheat-bran (25.13), and Rhodes-hay (14.39). The simple sugars and solubility nature of wheat-bran, lucerne-hay, and Rhodes-hay have directly or indirectly improved floponic rice, fish growth, and water quality. The study concludes that wheat-bran, lucerne-hay, and Rhodes-hay are the best carbon sources and most economically viable for floponic production and are therefore recommended for small-scale farmers.

Table 1: Fish, rice growth parameters and profitability ratio (KES) at different treatments and control in a floponic system

Parameters	Wheat-bran	Rhodes-hay	Maize-bran	Maize-stables	Lucerne-hay	control
Fish growth parameters						
Final length (cm)	6.29±0.12	5.28±0.08	4.84±0.08	4.80±0.11	7.52±0.08	4.31±0.11
Final weight (g)	2.41±0.17	2.18±0.1	1.99±0.11	1.86±0.12	2.94±0.15	1.53±0.13
SGR	2.61	2.51	2.42	2.36	2.80	2.17
FCR	0.88	0.92	1.08	1.15	0.79	1.12
Rice growth parameters						
No Tillers	0.47±0.03	0.53±0.03	0.39±0.03	0.15±0.02	1.28±0.04	0.07±0.01
No leaves	0.73±0.02	0.72±0.01	0.67±0.01	0.65±0.01	0.84±0.02	0.62±0.01
Heights (cm)	26.54±0.57	23.23±0.51	23.02±0.49	21.78±0.45	34.59±0.83	19.72±0.37
Chlorophyll (pg)	33.62±0.57	33.48±0.60	30.31±0.66	30.59±0.59	38.15±0.33	25.82±0.42
Grain weight (g)	113.63±6.55	110.26±2.94	85.37±3.18	78.54±3.81	189.82±5.20	69.57±0.80
final weight (g)	278.90±23.40	241.9±16.70	159.04±8.23	120.33±7.57	346.60±43.5	104.3±0.94
Profitability ratio						
Benefit-cost ratio	1.25	1.14	0.88	0.74	1.72	0.69
Expense Structure ratio	0.88	0.92	0.92	0.92	0.91	0.92
Gross revenue ratio	79.92	87.42	113.29	135.01	58.08	145.39

EFFECTS OF GRADED DIETARY LEVELS OF SOLID-STATE FERMENTED SOYBEAN MEAL ON GROWTH, IMMUNITY, AND INTESTINAL HEALTH IN EUROPEAN SEABASS *Dicentrarchus labrax* JUVENILES

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Fishmeal (FM) is considered to be the ideal protein source for fish production. However, due to its limited availability worldwide and its negative environmental impact, there is a need to focus on sustainable alternatives to reduce the reliance on fishmeal. Recently, fermented soybean meal (FSBM) has attracted considerable interest due to its improved nutritional profile, reduced anti-nutritional factors (ANFs), improved digestibility and associated health benefits. The aim of this study was to evaluate the potential of FSBM as an alternative protein source in the diet of European seabass (*Dicentrarchus labrax*) and to investigate its effects on feed efficiency, growth performance, immune response and intestinal health.

For this purpose, a 13-week trial was performed to investigate the effects of different inclusion levels of FSBM (INOLASA, COSTA RICA) replacing FM. Six isonitrogenous (46.5% crude protein) and isolipidic (16% crude lipid) diets were formulated, a control diet containing 30% FM and five experimental diets replacing FM by 15, 30, 50, 70, and 80%. All diets (3.5 mm pellets) were produced by cooking extrusion. Juvenile European seabass were obtained from a commercial fish farm and transferred to the HCMR research facilities where they were randomly distributed into 18 cylindroconical experimental tanks of 1,000 L, 35 fish per tank, with 3 replicates for each diet.

The average initial weight of the seabass was 30.48 ± 0.14 g (SD). Fish were hand-fed to apparent satiation twice daily, and uneaten feed was collected in the waste collector of each tank to calculate daily feed consumption. Similarly, feces were collected and stored at -20 °C pending digestibility analysis. The average seawater temperature was 20.2 ± 5.6 °C. At the end of the study, three fish per tank were randomly sampled and tissues from the intestine (anterior and mid) and liver were collected and immediately fixed in 10% buffered formalin for histological analysis. In addition, blood was collected from the caudal vein of the fish, and serum was used for immunological assessments.

This study showed that the tested FSBM could replace at least up to 50% of the FM in the diets of European seabass without affecting growth performance and feed utilization. Digestibility of protein and lipids was found to be lower in the 70% and 80% diets compared to the control. Overall, the FSBM diets didn't induce severe immune responses that would indicate adverse effects on fish physiology. However, the high inclusion rates of FSBM in the 70% and 80% groups significantly reduced fish serum lysozyme levels compared to the control group.

Finally, the histological evaluation of fish tissues from the anterior, midgut, and liver showed no statistically significant differences between the diets, and no enteritis or signs of inflammation or cellular damage were observed.

CENTESIMAL COMPOSITION OF PICKLED AMAZONIAN-SHRIMP *Macrobrachium amazonicum* IN DIFFERENT SAUCES

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Introduction

Fish is highly regarded as a nutritious meat product due to its abundance in polyunsaturated fatty acids, particularly omega-3, along with high-quality protein, digestibility, biological value, and a rich source of vitamins and minerals. In the Amazon region, fishing serves as the cornerstone of the economy in several cities and traditional communities, owing to the abundant variety of fish species exploited annually. Efforts have been directed towards enhancing preserved fish products through value-added technologies such as new cuts and sauces, aimed at improving human consumption and nutrition. Moreover, there's a growing importance placed on understanding the centesimal composition of these processed foods, particularly canned Amazonian shrimp (*Macrobrachium amazonicum*) in various sauces, to assess their dietary contributions effectively.

Material and methods

Shrimp from the Amazon region (*Macrobrachium amazonicum*) was sourced from artisanal fishermen in the Eastern Amazon. These shrimps were then processed for preservation by gutting and washing in chlorinated water. Artisanal preservation involved placing the shrimp in glass jars and adding regional sauces (tomato sauce and spice sauce). The jars underwent a cooking process in a pressure cooker for 50 minutes to ensure microbial safety and prevent lid bulging. Centesimal analysis of the preserves included determination of moisture, mineral residues, total lipids, total proteins, carbohydrates, and caloric value, with six replicates per sample.

Results and discussion

After comparing with the literature, it was concluded that CCMT exhibited low levels of proteins, total lipids, and mineral residues, along with high moisture content, moderate amounts of carbohydrates, and low-calorie values. Conversely, CCMER showed moderate levels of moisture, carbohydrates, and lipids, high values of total proteins and calories, and low levels of mineral residues. The humidity value for CCMER aligns with literature standards, resembling a cooked product. Protein levels in fresh shrimp (*Macrobrachium amazonicum*) are typically around 22 g/100g, exceeding the values found in both preserves in this study, 10 g/100g (CCMT) and 17 g/100g (CCMER).

Conclusion

Thus, the preserve prepared by this work is easy to prepare and handle, and can be replicated without much cost, since materials and ingredients are used that can be easily found in markets and fairs. Both preserves have shown to have good dietary standards, as they have nutritional components that can be used in diets that require high levels of proteins and lipids, and low levels of minerals, which nutritionally justifies a stimulus to the consumption of artisanal canned fish.

Table 1. Proximate composition of artisanal preserved amazonian-shrimp (*Macrobrachium amazonicum*) in tomato sauce and regional spice sauce.

Parameter	Product	
	CCMT ¹	CCMER ²
Humidity (g/100g)	81,29±1,18	65,60±3,37
Mineral waste (g/100g)	0,20±0,11	0,53±0,45
Total lipids (g/100g)	2,39±0,56	13,85±3,00
Total proteins (g/100g)	10,54±1,01	17,00±0,97
Carbohydrates (g/100g)	6,46±0,40	5,14±0,80
Caloric value (Kcal/100g)	91,39±1,35	198,56±31,57

¹Canned amazonian-shrimp in tomato sauce

²Canned amazonian-shrimp with regional spice sauce.

USE OF SWOT ANALYSIS TO EVALUATE THE VALUE CHAIN OF AMAZONIAN SHRIMP *Macrobrachium amazonicum* IN THE STATE OF AMAPÁ, EASTERN AMAZON, BRAZIL

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Introduction

Fish is highly regarded as a nutritious meat product due to its abundance in polyunsaturated fatty acids, particularly omega-3, along with high-quality protein, digestibility, biological value, and a rich source of vitamins and minerals. In the Amazon region, fishing serves as the cornerstone of the economy in several cities and traditional communities, owing to the abundant variety of fish species exploited annually. The identification of the *Macrobrachium amazonicum* value chain is extremely important to promote the sustainable development of this species, enhance its potential as a fishing resource and boost the growth of the fishing industry. Thus, the objective was to carry out evaluations in the *Macrobrachium amazonicum* value chain using the SWOT analysis, which is an analysis and strategic planning tool.

Material and methods

The SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) is widely acknowledged as a crucial strategic tool for assessing scenarios, delineating strengths and weaknesses, and pinpointing opportunities and threats within a specific context. Its effectiveness in acquiring knowledge and understanding, both internally and externally, has propelled the adoption of the SWOT matrix as a cornerstone practice in strategic planning. The intrinsic attributes of the organization, encompassing strengths and weaknesses, alongside external factors such as opportunities and threats from the environment, form the foundational elements of the SWOT matrix. Consequently, the matrix was employed to scrutinize the value chain of Amazonian shrimp (*Macrobrachium amazonicum*) in the state of Amapá, situated in the Eastern Amazon region of Brazil.

Results and discussion

In examining the strengths of Amazonian shrimp (*Macrobrachium amazonicum*), it was found to be a highly nutritious food source, rich in highly digestible protein and boasting a low saturated fat content, rendering it an abundant resource in the Amazon region with significant market potential. However, weaknesses in its production chain were also identified, including its comparatively low productivity in relation to other shrimp species, as well as the lack of adequate infrastructure such as roads and ports, hindering the transportation and commercialization of both raw materials and processed products. Furthermore, the absence of standardization in the capture, production, and certification processes poses a challenge, potentially affecting the quality and consumer confidence in Amazonian shrimp products.

On the other hand, opportunities abound for Amazonian shrimp in the global market, driven by the increasing demand for natural and sustainable products. The shrimp's export potential further amplifies these opportunities, as consumers increasingly seek out products with a traceable origin. However, amidst these promising prospects, threats loom, including competition from other shrimp species and the looming specter of climate change. These factors pose significant risks to the quality and yield of Amazonian shrimp production, underscoring the importance of strategic planning and adaptation to mitigate potential adverse impacts.

Conclusion

Thus, based on the analysis made from the SWOT analysis of the *Macrobrachium amazonicum* value chain, it is possible to identify strategies that can be used to maximize strengths, minimize weaknesses, take advantage of opportunities and avoid threats. By leveraging its strengths, such as its nutritional value and abundant availability, while addressing weaknesses such as low productivity and inadequate infrastructure, the Amazonian shrimp industry can capitalize on opportunities in the global market for natural and sustainable products. Investments in technology aimed at enhancing productivity, coupled with product certification and standardization processes, are crucial steps towards bolstering consumer confidence and securing a competitive edge in the marketplace. Additionally, the exploration of new export markets holds immense promise for expanding the reach of Amazonian shrimp. Moving forward, strategic implementation of these identified strategies will be essential to unlocking the full potential of the *Macrobrachium amazonicum* value chain and ensuring its long-term sustainability and success in the dynamic seafood industry.

DIETARY TRYPTOPHAN EFFECT ON MEAGRE, *Argyrosomus regius*, JUVENILES GROWTH, PROTEIN DEGRADATION AND ANTIOXIDANT ENZYMES ACTIVITY

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Tryptophan has been shown to affect fish feed intake and growth performance. Moreover, is the precursor of several bioactive molecules such as serotonin, which can be converted into melatonin. Melatonin is a potent antioxidant that directly neutralizes free radicals and reduces oxidative stress. Diets rich in tryptophan can lead to lower free radical production due to the calming effect of serotonin and the antioxidant effect of melatonin. In this study, three diets containing different contents of tryptophan: 0.5 (Trip1), 0.7 (Trip2) and 0.8 % (Trip3), were tested in triplicates in 112 days old meagre with an initial weight of 32.6 ± 3.4 g and 14.4 ± 0.5 cm length for 57 days. Although the results showed no significant differences for growth and FCR between treatments, there was a tendency to an increase of growth and decrease of FCR in meagre fed higher levels of tryptophan. However, the main protein degradation systems in the liver and white muscle showed that the activity of the tested proteases in the muscle were unaffected by the levels of dietary tryptophan. A decrease in oxidative stress was also observed as the level of tryptophan in the diets increased, although not statistically significant. A trend of decreasing superoxide dismutase, catalase and selenium-independent glutathione peroxidase levels in tryptophan-rich diets were also observed.

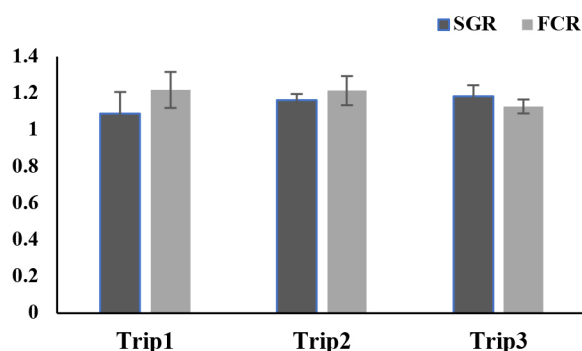


Fig. 1. Specific growth rate (SGR) and Food conversion ratio (FCR) of meagre juveniles fed a diet with 0.2 % (Trip1), 0.5 % (Trip2) and 0.9 % (Trip3) of dietary tryptophan. Values are mean and standard deviation

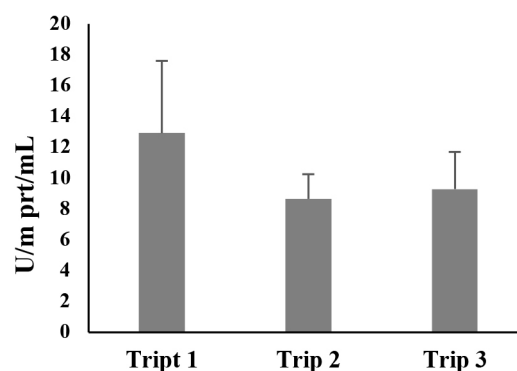


Fig. 2. Antioxidant capacity of meagre juveniles (*Argyrosomus regius*) fed experimental diets (Trp1, Trp2 and Trp3) observed by superoxide dismutase activity

HANDS ON AQUAPONICS: FOOD SECURITY STARTS AT SCHOOL

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The role of aquaculture in the supply of fish in the future is undeniable. Aquaponics is a sustainable method to rear fish (aquaculture) and plants (hydroponics). The water enriched with nutrients from fish and feed wastes are used as a natural fertilizer to plants while these purify the water that goes back to fish. It is a water cycle that results from a symbiotic ecosystem and a good example of good water use and circular economy. School farming is a project developed for schools that was launched in 2022 in Lisbon, Portugal, aiming to be a learning tool to stimulate children's motivation and interest in sustainability, water usage, healthy food eating habits and food security. The project consists of building an aquaponic system which includes a fish tank, a plant growing bed and a set of filtration and pumping equipment in a classroom which all students can have access to. Each class will follow the growth of different vegetables such as lettuce, basil and peri-peri, depending on the school level as different plants require different levels of care. At the same time, they will feed the fish and observe that fish waste works as organic fertilizer for plants. At the end of the cycle, students will measure the biomass of plants they have grown and compare the results with other classes and schools through a school farming mobile digital network. The implementation of these projects in developed countries has specific goals but its application in developing countries, where food insecurity is higher, can have a major importance as it will provide children knowledge and tools that can have a higher impact not only in their own homes, by replicating small scale farms, but to their future as it can stimulate their entrepreneurship skills to reduce poverty and foster food resilience. In this study, the results obtained by a secondary school will be presented in terms of fish growth and vegetable harvested during the first six months of the project. Carp juveniles of approximately 20 g were introduced in 500 L plastic tanks in December 2023. The grown vegetables included lettuce, cabbages, rocket, aromatic herbs, among others.

EFFECT OF MONOSEX NILE TILAPIA (*Oreochromis niloticus*) STOCKING DENSITY ON THE BATAVIA LETTUCE (*Lactuca sativa*) GROWTH PERFORMANCE IN A SANDPONIC SYSTEM

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This study determined how using monosex Nile Tilapia (*Oreochromis niloticus*) at different stocking densities can increase the Batavia lettuce (*Lactuca sativa*) crop production, while adjusting the water effluent flow between fish tanks and sand grow-beds. The experimental design included three replicates for each of the sandponic systems stocked at densities of 100 and 150 fish/m³ with an average initial weight (25.4 ± 2.3 g) for a rearing period of 45 days. Each treatment had three fish tanks (2 m³ water volume per tank), integrated with a one-meter width sand grow-bed (total area 10 m²). The density of Batavia lettuce is 12.5 lettuce/m². The fish were fed to satiation three times a day using a 30% crude protein (CP) commercial formulated diet. The water quality parameters were monitored daily (dissolved oxygen - DO, pH and temperature were checked daily (and water chemistry parameters were monitored weekly (total ammonia nitrogen - TAN, nitrite, nitrate, potassium, and soluble reactive phosphorus - SRP). In addition, other main culture parameters were monitored (plant/fish biomass growth, fish feed consumption, fish survival, final lettuce/fish production at harvest, water and electricity consumption), while maintaining a flow rate of 1.5 L/min every 2 – 3 hours between fish tanks and sand grow-beds. The water lost through transpiration, evaporation, and periodic flushing was replaced weekly. The water quality parameters in both experiments were within the acceptable range for tilapia and all increased as fish stocking density increased (3.1–5.3 mg/L for DO, 7.2-8.4 for pH, 0.012- 0.029 mg/L for TAN, 0.030–0.034 mg/L for nitrite, 0.001-0.002 mg/L for nitrate, 1.2-3.1 mg/L, potassium, 5.2-5.6 mg/L and SRP, 2.4-4.9 mg/L).

The final weight of fish at harvest was 71.5 ± 3.2 g and 69.2 ± 5.1 g for 100 and 150 fish/m³, respectively. Specific growth rate (SGR) and survival rate was reduced with increasing stocking density, whereas food conversion ratio (FCR) increased at the higher stocking density. Sandponic systems with the lower fish stocking densities (100 fish/m³) performed better than 150 fish/m³. The growth performance of Nile tilapia fingerlings in terms of SGR, survival rate and FCR were significantly influenced by the stocking density. The SGR was estimated at 2.3% and 1.8% at 100 and 150 fish/m³, respectively. The survival rate was 95% and 91% at 100 and 150 fish/m³, respectively. The FCR was reported to 1:1.5 and 1:1.7 at 100 and 150 fish/m³, respectively. The biomass at harvest was 6.8 kg fish/m³ and 8.2 kg fish/m³ at 100 and 150 fish/m³, respectively. The water chemistry with fish in both experiments was significantly different for nitrate, potassium, and SRP in high fish density, which as impacted positively on the mean of plant weight at harvest, 520 gm/lettuce head and 400 gm/lettuce head in 100 and 150 fish/m³, respectively. Also, the presentation will report on the actions needed to achieve efficient production and economic returns.

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THE EGYPTIAN AQUACULTURE SITUATION AND PREDICTIONS FOR THE FUTURE

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Egyptian aquaculture has shared 78.7% of the total aquatic species landing, with over 1,576 thousand tons of finfish and shrimp in 2021, (99% from private farms and 1% from government farms), with a total market value of about \$USD 4.22 billion (1 \$USD = 15.74 Egyptian pounds-EGP) ((GAFRD,2012-2020 and LFRPDA, 2021)). The remaining of fish landing 21.3% percent are captured from the wild (Nile river, coastal lakes, inland lakes, Mediterranean Sea and Red sea) for a total production 426 thousand tons. In the last 10 years (2012-2021) the aquaculture activity has been tremendously increased 54.8% percent, where in 2012 aquaculture production was 1,018 thousand tons and became around 1,576 thousand tons in 2021 versus the fisheries which have increased only 20.4% percent, where in 2012 fisheries production was 354 thousand tons and became 426 thousand tons. The average yearly consumption of fish during 2012 to 2021 in Egypt has increased from 20.6 kg fish/capita in 2012 to 23.1 kg fish/capita in 2021. Most of fish farms are located in Delta region, with four different Egyptian aquaculture production system types (semi-intensive earthen ponds, cages, paddy field and intensive tanks, producing 87.1%, 12.4%, 0.4% and 0.1% respectively). The main farmed fish species are (Tilapia, Mullet and Carp), ranking 61.2%, 22.3% and 9.2% respectively. The remaining species represent in total 7.3%, those species are catfish, marine finfish and shrimp. In 2021 the total fry finfish/shrimp seeds produced from hatcheries were 900 million (76.6% shrimp and 23.4 % finfish). The total registered number of fresh and marine hatcheries have reached 136 (76% and 23% produced from the private and government sectors respectively), with more than 500 tilapia hatcheries from the private sector are not registered. In addition, 50 million of mullet fry (*Mugil cephalus*, *Liza ramada* and *Liza carinata*) were collected from the wild. Different constraints and obstacles facing the Egyptian aquaculture industry (tilapia extruded feed 30% crude protein price has increased around three times in the last seven years from 9,100 EGP/ton in 2018 to 26,100 EGP/ton in 2024 due for the use of imported ingredients feed. In addition, the US dollar exchange rate rose to EGP 48.4 in 2024 compared to EGP 17.80 in 2018 due to the flotation decision. Also other shortage in marine finfish fry; the far distance between the academic research with real field problems and preventing the export of aquaculture product to the European Union due for non-completing the EU requirements. The Egyptian aquaculture industry can develop rapidly in the coming decades if the government and NGO bodies could optimizing water productivity through multiple use of water with encouraging the Integrated Agriculture Aquaculture concepts; high quality of fry; enhancing high quality low cost formulated feed, adopting the use of renewable energy mainly solar energy; high labor skill; approved aquatic drugs; adopting of innovating modern technologies; determining the cultured fish and shrimp new candidates; following up the value production chain; support the capacity building of the aquaculture stakeholders; developing a Best Management Practices with achieving the applied scientific research; orienting the E-marketing; facilitating access to the private aquaculture farms for soft loans; enabling gender participation, facilitating the procedures for licensing aquaculture projects with all concerned authorities and provide extension services to improve the sustainability aquaculture. Also, the presentation will report a deep point of view for a future Egyptian aquaculture production sustainable predictions.

DEVELOPING AN AQUACULTURE INDUSTRY STRATEGY IN THE LIBYAN BLUE ECONOMY CONTEXT

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The aquaculture sector is considered highly promising due to its substantial impact on food security, national income, employment, and biodiversity conservation. This study concentrated on aquaculture and aimed to develop a comprehensive strategy for the sustainable expansion of the aquaculture sector. Despite aquaculture's significant role in the economic frameworks of various countries worldwide, it has not played any part in the Libyan economy, whether in terms of food security or national revenue.

The aim of this research is to create a complete plan to guide the growth and promotion of aquaculture industry. The researcher conducted desk research on the topic and interviews with professionals. The results of the study showed that the aquaculture industry in Libya faces several challenges, including investment barriers, institutional development, and legal and regulatory issues. Based on the findings, the researcher developed a plan that includes both strategic goals and areas of intervention to achieve the goals. According to the results, the initial goal was to create institutions, then create a database, then establish strict regulations aimed at achieving sustainability in its three main forms: biological sustainability, social sustainability and economic sustainability.

The findings also highlighted the importance of private investment, building primary and supporting industries, knowledge development and technology transfer. The results highlighted the urgent needed for collaboration and integration with international organizations in all aspects of the aquaculture industry.

DEMONSTRATION OF THE AQUACULTURE VALUE CHAIN ACHIEVEMENTS AND CHALLENGES IN THE LIVELIHOOD IMPROVEMENT FAMILY ENTERPRISES PROJECT (LIFE-ND), NIGER DELTA, NIGERIA

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LIFE-ND Project
Nigeria

The Livelihood Improvement Family Enterprises Project in the Niger Delta (LIFE-ND) is a joint initiative funded by the Federal Government of Nigeria, IFAD, and the Niger Delta Development Commission (NDDC). It seeks to enhance the livelihoods of rural youth and women by promoting sustainable agribusiness development across nine states in the Niger Delta. With a \$90 million budget, the project targets 25,500 beneficiaries, offering agribusiness incubation, training, and infrastructure support to improve income, food security, and job creation. The project operates in 900 communities across 90 Local Government Areas (LGAs), focusing on high-value commodities such as rice, cassava, fish, poultry, and oil palm. LIFE-ND's innovative incubation model equips beneficiaries with hands-on agribusiness skills, enabling them to establish their own enterprises. Financial inclusion is promoted through cashless credit systems and off-taker pre-financing arrangements, which provide access to capital for rural entrepreneurs. A key focus of the project is the aquaculture value chain, which is critical given the riverine geography of the Niger Delta. Fish farming initiatives in five states—Bayelsa, Cross River, Delta, Edo, and Ondo—have empowered 1,263 fish farmers, who utilize earthen ponds, cage culture, and tarpaulin ponds in flood-prone areas. The project promotes catfish and tilapia cultivation, using juveniles to increase productivity, allowing beneficiaries to complete four production cycles annually. In addition to aquaculture, LIFE-ND supports fish processing, marketing, fingerling production, artisanal fishing, and the sale of fish inputs, with over 2,911 beneficiaries engaged in various stages of the fish value chain. An analysis of project data shows that fish ranks second in beneficiary engagement, representing 21% (2,911) of the total 25,500 participants, following cassava (26%), with poultry in third place (20%). These trends reflect market demand and the preferences of beneficiaries. LIFE-ND partners with organizations like WorldFish, USAID Feed the Future, and Orisha Farms to provide technical support, capacity building, and access to genetically improved farmed tilapia (GIFT) and cage culture training. The project integrates climate resilience and environmental sustainability into its operations, contributing to the long-term development of the Niger Delta region. Despite its achievements, the project faces challenges such as limited funding, insecurity in the region, beneficiaries abandoning projects after empowerment, unstable economic policies, and insufficient financial support for rural fish farmers. Addressing these challenges is crucial for sustaining the project's impact on rural development and aquaculture in the Niger Delta.

EDUCATIONAL PROGRAMS TO ENSURE A WELL-TRAINED AFRICAN AQUATIC VETERINARY WORKFORCE

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With increasing impacts of diseases on aquaculture production in all countries, the need for a well-trained aquatic veterinary workforce (including veterinarians and para-veterinarians) has become a global imperative. Numerous educational efforts are underway ensure that sufficient personnel are available to support aquaculture industries, producers, governmental agencies and a myriad of supporting industries that provide services or products to prevent, control or eradicate diseases. Without this infrastructure, sustainable and economically viable aquaculture will simply not thrive or grow.

Several International and National veterinary organizations (WVA, CIVME, WOAHO/OIE, NAVMEC, FVE) have developed processes to determine, evaluate, harmonize and accredit veterinary education and extracurricular continuing education and professional development (CEPD) programs throughout the world, to ensure an adequately trained veterinary workforce to meet contemporary and societal needs. However, two organizations are focusing on aquatic veterinary education needs: the World Aquatic Veterinary Medical Association (WAVMA), and the International Partnership on Aquatic Veterinary Education (i-PAVE).

The WAVMA has developed two Aquatic Veterinary Certification Programs to certify veterinarians (CertAqV) and para-veterinarians (CertAqVNT) who have Day-1 competency (equivalent to competencies required of individual receiving a veterinary or Nursing/Technician degree) to provide aquatic veterinary services has identified 9 preclinical or clinical core subject areas or domains: (**Preclinical**) **1.** Anatomy and physiology of aquatic species/taxa; **2.** Environmental factors affecting aquatic animal health; **3.** Structure and function of aquaculture and ornamental (pet) industries; (**Clinical**) **4.** Pathobiology and epidemiology of important aquatic animal diseases; **5.** Clinical and laboratory diagnostics used for diagnosing aquatic animal diseases; **6.** Availability and appropriate use of therapeutic and biologic agents in aquatic veterinary medicine; **7.** Public health, zoonotic diseases and seafood safety issues important in aquatic veterinary medicine; **8.** International and national legislation, regulations and policies affecting aquatic veterinary medicine; and, **9.** Principles of welfare and humane treatment of aquatic animals. Approximately 300 veterinarians and 11 para-veterinarians have been certified, and 60-80 more are in the process of documenting their credentials.

To build on WAVMA's CertAqV efforts, i-PAVE has embarked on a multi-year project to verify and validate the aquatic veterinary knowledge, skills and experience (KSEs) needed in any country, using a DACUM/SCID Process. The process involves workshops in N. and S. America, Europe, Africa, and the Asia-Pacific, to verify the KSEs needed, using veterinarians actively practicing aquatic veterinary medicine.

Interestingly, preliminary surveys suggested ~60% of N. American and EU veterinary schools included some aspects of aquatic veterinary medicine in at least one course, most emphasizing finfish, but no veterinary curriculum covered all WAVMA Day-1 subjects. Therefore, i-PAVE is in the process of distributing additional surveys of all veterinary schools in Africa and other global regions, to determine which of the core aquatic veterinary subjects are covered in their curricula or CEPD programs. Also in development is an i-PAVE program to have on-line and on-demand aquatic lectures and publications by subject-matter experts, available to any veterinarian or para-veterinarians wanting to obtain the KSEs necessary for them to provide services to aquatic animal owners and industries. The WAVMA CertAqV and CertAqVNT, and i-PAVE programs are or will be available to all African veterinarians and para-veterinarians in Africa or any other country.

INNOVATIONS IN THE IAEA AQUAVAC-IR PROJECT: ADVANCING AQUACULTURE VACCINES THROUGH INTEGRATED MULTI-PROCESS APPROACHES

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The International Atomic Energy Agency (IAEA) Technical Cooperation Project TUN5032, also known as AquaVac-ir (<http://www.aquavac-ir.tn/>), seeks to establish Tunisia's first national certified pipeline for the production of aquaculture vaccines using irradiation technology. This ambitious initiative integrates five distinct processes, each contributing innovative approaches to advance the field of aquaculture vaccine development and application. In Process 1, comprehensive immune response assessment is achieved by integrating proteomics, transcriptomics, and flow cytometry techniques. This novel approach offers a holistic view of the immune response in *Dicentrarchus labrax* (European seabass) following vaccination with irradiated nodavirus. Process 2 focuses on utilizing radiation-inducible promoters and expanded bacterial periplasms in selected radioresistant strains to produce nodavirus capsid proteins. In Process 3, strategies are developed to preserve epitopes of lethally irradiated nodavirus, including the use of native *in silico*-predicted radioprotective decapeptides from *Deinococcus radiodurans*. Process 4 applies artificial intelligence (AI) algorithms to predict the immunogenicity and reactogenicity signatures of irradiated vaccines, enhancing the efficacy and safety of vaccine development. Finally, Process 5 employs systems biology to construct a metabolic interaction model between European seabass and nodavirus, providing a deeper understanding of host-pathogen dynamics. Through these five innovative processes, the AquaVac-ir project aims to revolutionize aquaculture vaccine development, setting a new standard for the creation of highly effective and precisely engineered vaccines. This project represents a significant leap forward in aquatic health and vaccine production technologies.

SEA CUCUMBERS (*Holothuroidea*) AS ENVIRONMENTAL BIO- INDICATORS TO DETERMINE THE HEALTH OF THE MARINE ENVIRONMENT OF WESTERN LIBYAN COASTS

Sharif

Background: the quality of the marine environment is essential for maintaining of public health. The marine environment may get contamination from sewage discharges from human- animal origin reach to the sea. Contaminants carried by sewage to the marine environment can also reach to the food chain of fish. Several Mediterranean countries are dumping their wastewater into the sea shores without treatment. Also, The Libyan Coasts are suffering from continues dumping of untreated sewage into their shores for many years, which may be leading to negative impacts on natural marine environment and introduce of zoonotic pathogens from the land to the sea. Microbiological pollution in the marine environment can occur.

Methods: the sea cucumbers collected freshly from the Western Libyan Coast. They collected throughout different seasons.

Bacteriological examination: After clinical examination, under complete aseptic condition, the sea cucumbers will be dissected to separate viscera and longitudinal muscle bands. Bacteriological swabs technique carried out for coelomic fluid, viscera of sea cucumbers. And spread onto enriched media under complete aseptic condition Tryptic soy agar (TSA) supplemented with 2 % NaCl and striking on selective media (Thiosulphate- citrate- bile salt- sucrose agar- TCBS) supplemented with 2% NaCl. Isolates identified by MALDI- TOF mass spectrometry. Antimicrobial resistance patters from the isolates of interest assessed with minimal inhibitory concentration (MIC) by broth dilution method.

Virological analysis including COVID: The collected sea cucumbers will be desensitization with ice- immersion baths for 3 h and then dissect to extract the main internal organs: left and right respiratory tree, gonad, longitudinal muscle bands, anterior intestine and cloaca.

Histopathological examination: The muscle, tube feet, intestine and gonads will be dissected out of the animal and fixed in 10% formalin.

Determination of heavy metals: Body wall samples, at least 20g, collected for analysis of cadmium (Cd), copper (Cu), zinc (Zn) and lead (Pb). The samples will be analyzed by inductively coupled plasma mass spectrometer technique according to standard method UNI EN 15763:2010 and FDA Method 4.7 Version.

Determination of microplastic: A portion of body wall tissue (20g) sampled without the use of any plastic materials and immediately frozen within aluminum foil. Microplastic extracted by solvents and chemically characterized.

Nutritional characterization: A portion of single sea cucumbers body wall (about 5g d.w.) will be analyzed for proximate composition. A peculiar analysis of single fatty acids profile by gas chromatography carried out to assess potential differences of animals: FAs from different sites and eventually to identify lipid biomarkers. Moreover, sea cucumbers could effectively be used are bio indicators for monitoring the presence of heavy metals and other types of contamination in the marine environment of Western Coast of Libya. Thus, creating publishable data about the sea cucumbers that relating to estimating the pollution rates and heavy metal in Western Libyan coast will shape the future plane for effective control of such zoonotic pathogens with stop fishing from polluted areas. Also, monitoring of the occurrence of infectious diseases in both marine animals and humans can facilitate the detection of new infectious agents. Also, to find out how safe the Western Coast of Libya is for fish farming.

ALGAL BIOTECHNOLOGY TO REMEDIATE THE FOOD GRADE WASTEWATER AND PRODUCTION OF EPA RICH BIOMASS FOR FISH FEED AQUACULTURE IN THE CONTEXT OF THE CIRCULAR BIOECONOMY

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Agricultural and food industry (brewery) waste treatment is one of the key elements of environmental impact with direct effects on the economy and society. Algal technology is designed to enable effective recycling and valorisation of water nutrients including carbon, nitrogen, and phosphorus (Silkina 2019, Fernandes et al, 2022). In the context of the European ALGAEBREW¹ project the integrated evaluation and optimisation of the sustainability of an algal biorefinery including mass and energy balances, carbon, water and nutrient use and impact analysis was assessed, and valuable EPA rich biomass was produced. A biorefinery approach of waste remediation using algal cultivation was developed at Swansea University, focusing on nutrient recovery via algal biomass in pilot facilities. Mass cultivation (up to 5,000 L) was developed with a 99% nitrogen and phosphorus uptake by microalgal cultures and production of valuable biomass. Cultivation in batch mode was followed by semi-continuous and continuous mode. *Nannochloropsis oceanica* (marine species) was used as a biological model and grown on nutrients waste sources. The obtained biomass was rich in nutrient content, especially for fatty acids composition. The algal biomass was used as component of aquaculture feed nutrition trial and for the extraction of valuable compounds, e.g EPA. Additionally, biomass residue was used as a biofertilizer component for soil improvement. Conclusions were drawn on the high potential of algal biotechnology for waste remediation and nutrient recovery in the context of circular bioeconomy, despite the need for further development and scalable applications of this new technology.

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ENHANCING AQUACULTURE BIOSECURITY AND BIOSAFETY IN AFRICA: A REGIONAL COLLABORATION APPROACH FOR CLIMATE-RESILIENT AND SUSTAINABLE DEVELOPMENT

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BACKGROUND

Africa's aquaculture sector faces significant challenges from climate change, environmental degradation, and demographic pressures, threatening aquatic ecosystems, animal health, and food security.

OBJECTIVE

To explore the merits of regional collaboration in strengthening aquaculture biosecurity and biosafety, ensuring sustainable development and transforming Africa's aquaculture sub-sector into a robust Agrifood system.

METHODOLOGY

This study examines the African Union Commission's continental Aquatic Animal Health Strategy, Policy Framework and Reform Strategy for Fisheries and Aquaculture (PFRS), and Africa Blue Economy Strategy (ABES). It analyzes the role of transboundary approaches, water-basin management, and multisectoral collaboration in mitigating environmental stressors.

EXPECTED OUTCOMES

1. Enhanced understanding of regional collaboration's impact on aquaculture biosecurity and biosafety.
2. Identification of key strategies for strengthening aquatic animal health and biosecurity control.
3. Recommendations for policy frameworks supporting sustainable aquaculture development.

RELEVANCE

This research contributes to the development of climate-resilient and sustainable aquaculture practices, ensuring food security, economic growth, and environmental conservation in Africa.

SUSTAINABLE FISH NUTRITION FOR AQUACULTURE IN A CHANGING CLIMATE

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The escalating impact of climate change on aquaculture necessitates innovative approaches for maintaining sustainable fish production. This presentation outlines recent strides in fish nutrition aimed at fortifying aquaculture practices in the face of evolving climatic conditions. Novel feed ingredients and formulations are being developed to enhance fish resilience and growth. These ingredients encompass alternative protein and lipid sources, bioactive compounds and probiotics shown to bolster immunity and stress adaptation. Globally, there is a greater focus on the integration of byproducts and sustainable feedstocks, which not only curtails resource depletion but also contributes to the economic viability of regional aquaculture production. This latter piece is critical for the development of aquaculture in areas where lack of quality feeds constrains stronger aquaculture growth. Climate change will only add to the availability challenges for common ingredients and formulated feeds. Solutions need to be regionally focused, and the toolbox of ingredients must be expanded and paired with novel functional feed additives, better production practices and improved fish genetics. Globally, progress in fish nutrition underscores the potential for sustainable aquaculture amid shifting climates. In conclusion, the advancement of sustainable solutions to fish feeds and feeding is vital to navigate the climate challenges constraining aquaculture but especially in areas where aquaculture development lags behind other regions.

TOLERANCE TO AMMONIA, NITRITE AND DISSOLVED OXYGEN IN POSTLARVAE AND JUVENILES OF WHITE SHRIMP *Penaeus setiferus* AND *Penaeus vannamei*

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DEVELOPMENT AND ADVANCES IN AQUAPONICS AT STELLENBOSCH UNIVERSITY

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Stellenbosch University is making significant strides in aquaponics technology, particularly through its hybrid learning programs and research initiatives. The university combines aquaculture and hydroponic technology to grow fish and plants together in a closed-loop system, promoting sustainable food production. These efforts are especially relevant for addressing food security challenges in semi-arid regions in parts of South Africa and on the African continent.

The university offers a comprehensive postgraduate diploma in aquaponics, which began rolling out in 2023 and is fully accredited. This program is designed to equip students with interdisciplinary knowledge across fields such as biology, chemistry, aquaculture, and engineering. It includes both online coursework and hands-on training workshops, making it accessible to students in various locations.

Stellenbosch also plays a key role in research and education related to aquaponics in South Africa and the wider SADC region. This includes collaborations with industry partners to develop digital and interactive study programs aimed at promoting aquaponics as a sustainable agricultural practice. The research focuses on using aquaponics to reduce environmental impact and enhance productivity in water-scarce regions.

These developments are helping to establish Stellenbosch University as a leader in aquaponics education and technology, positioning it as a crucial player in advancing sustainable farming practices across Africa.

AQUAPONICS-BASED SOCIAL ENTERPRISES IN SOUTH AFRICA, A REVIEW:

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Aquaponics has significant potential for social enterprise development in South Africa, offering a sustainable solution to food insecurity, unemployment, and environmental challenges. In general Aquaponics offers an innovative form of therapeutic horticulture, which can provide employment and promote well-being for people with disabilities. If implemented as a program to be managed by local communities, aquaponic systems also have the potential to address issues such as food security and food sovereignty, especially in urban areas. Increasing public familiarity with aquaponics has seen a number of social ventures being set up around the world. However, the viability of these depends not only on stakeholder commitment, thorough market analysis, clear governance structures, and a robust business plan but also on external factors, such as the local political context and regulations. Aquaponics-based social enterprises can play a crucial role in addressing both economic and environmental challenges, offering sustainable, inclusive, and community-driven solutions for development in South Africa.

THE BLUE HORIZON EMPOWERMENT INITIATIVE BY AQUAFIN ENHANCED AQUACULTURE AND COMMUNITY RESILIENCE IN TAMILNADU, INDIA

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India

The Blue Horizon Empowerment (BHE) Model, conceptualized by the Aquaculture Technology Research Foundation (ATRF), represents a robust socio-economic framework designed to augment aquaculture productivity while fostering social inclusion and equity in Kanniyakumari District, Tamil Nadu. From 2020 to 2023, the BHE Model engaged 500 stakeholders, comprising 300 youth (60%) and 150 women (30%), by facilitating the adoption of cutting-edge aquaculture technologies and implementing entrepreneurship training initiatives. The integration of innovative practices, including biofloc systems, recirculating aquaculture systems (RAS), and aquaponics, resulted in a 25% enhancement in production efficiency. The establishment of 30 demonstration farms served as critical loci for technology dissemination, with 80% of farmers adopting these innovations within the first year of implementation. The model provided targeted training to 300 youth, which culminated in the establishment of 50 youth-led enterprises that collectively produced 200 metric tons of fish annually, generating revenue amounting to INR 2 crore (\$240,000 USD). The provision of 100% access to microfinance facilitated the scaling of these entrepreneurial ventures.

Additionally, the model significantly bolstered women's economic participation by training 150 women, leading to the establishment of 30 women-operated fish farms and 15 fish processing units. This intervention contributed to a 30% increase in household incomes and a 25% rise in female participation within the aquaculture sector. The formation of 10 cooperatives enhanced market linkages and minimized post-harvest losses by 15%, which in turn increased farm profitability by 12%. The model also emphasized sustainability through the integration of local feed resources and the rehabilitation of 20 hectares of degraded ecosystems via mangrove restoration efforts. Overall, the implementation of the BHE Model resulted in a 25% increase in aquaculture productivity and a 40% rise in participant incomes. The model influenced 80% of the local community to embrace modern aquaculture practices, thereby significantly improving food security and socio-economic stability in the region.

EFFECT OF DIFFERENT INCLUSION RATES OF YEAST *Candida utilis* AS PROTEIN SOURCE IN HYBRID AFRICAN CATFISH *Clarias gariepinus* x *Heterobranchus longifilis* STRESS RESPONSE AND LIPID METABOLISM

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As aquaculture continues its decade-long growth, ensuring the supply of sustainable alternative feed ingredients is an urgent need. A promising new protein source is single cell proteins notably yeast, due to its high protein content with suitable amino acid profile, probiotic properties, and the capacity of production via valorising agro-industrial wastes. This study aimed to assess the effect of dietary replacement of plant-based ingredients with yeast (*Candida utilis*) on stress response, plasma metabolite, and lipid metabolism in hybrid African catfish.

Fish (77.7±0.25 g) were allocated between 3 isoenergetic and isonitrogenous diet treatments in freshwater RAS. All diets contained 5% of fishmeal alongside plant-based ingredients (PBI) which were partially substituted with yeast in the other diets: **Diet 1** (control, 0% yeast); **Diet 2** (10% of yeast, 12% PBI replacement); **Diet 3** (20% of yeast, 25% PBI replacement). At the end of the trial (10 weeks), some fish from each group were subjected to acute challenge test (ACT) by increasing density. Liver and intestine histology was performed. Plasma cortisol, ions and metabolites related to energy, stress responses and lipid metabolism were quantified. Lipidomic analysis was carried out in the liver and gene expression of brain plasticity measured in the telencephalon.

Growth performance (final body weight approx. 421 g) was unaffected by the diets. ACT had limited effects, as for cortisol and plasma ions. Since catfish are notoriously rustic to the environment, it is likely that the stressor type, duration, or intensity was insufficient to trigger a marked stress response. Alternatively, this may suggest replacing PBIs with yeast has little apparent welfare effects, pointing to the suitability of this novel ingredient. Conversely, metabolites related to lipid metabolism showed significant changes among diets. Triglycerides were significantly higher in Diet 1, probably due to the higher content of grain and cereals. TAG and LDL plasma concentrations significantly decreased while HDL increased with larger inclusion of yeast in the diet, pointing to significant effects on lipid metabolism and transport mechanisms. Elevation in HDL may signal improved cardiovascular performance compared to the control diets. In line, since elevated plasma creatinine levels are linked to impaired kidney functions, the lower creatinine level in the fish on yeast diets could indicate improvements to these processes, perhaps due to a reduction in anti-nutritional factors associated with soy.

All in all, this study did not only show no negative effect of replacing PBI with yeast but was associated with some improved parameters. However, changes in lipid metabolism highlights the need of further studies targeting the liver lipid content, compositional profiles and associated molecular mechanisms, that are currently being analysed. Also, we are currently finalizing histology analysis to explore any potential effects on liver and gut health, in terms of vacuolization lipids or (improving) signs of irritation and inflammation, respectively. Additionally, we are working on data analysis of expression of brain plasticity markers to evaluate potential effects of these diets on fish stress resilience and welfare. All these will be included into an updated version of the abstract to be presented at the conference.

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EVALUATING THE EFFECT OF ECONOMIX TO IMPROVE PROTEIN & AMINO ACID DIGESTIBILITY OF MARINE FISHES

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Fishmeal remains the primary protein source in aquaculture feeds, but its price has surged due to limited supply caused by overfishing and climate change. With demand exceeding availability, high costs are likely to persist. To mitigate this, the industry is exploring alternatives like plant-based proteins, insect meals, and single-cell proteins. However, these options often have lower digestibility, which can hamper growth and feed efficiency. Enhancing their digestibility is essential to ensure they meet the nutritional needs of farmed species without compromising their health.

Economix is a plant-based feed additive produced by TECHNNA FRANCE NUTRITION (Couëron, France) that aims at enhancing protein digestibility. It offers a promising solution for reducing fishmeal use and substituting it with more affordable plant proteins.

This study held at Sparos, Portugal, was undertaken to evaluate the effect of Economix on apparent digestibility coefficients (ADC) of protein, amino acids, fat, phosphorus, and energy in diets fed to European seabass (*Dicentrarchus labrax*). The trial comprised 2 experimental diets (Control and Economix), both containing 0.02% yttrium oxide as an inert digestibility marker. Each diet was tested in triplicate groups of 13 fish (mean body weight: 73 ± 5 g), maintained in 60 L tanks at a constant water temperature of $20.0 \pm 0.43^\circ\text{C}$. Feces were collected in tanks equipped with a fecal decantation column (Guelph system).

The results showed that the inclusion of 0.2% Economix significantly improved the amino acids digestibility of 13 out of the 17 analyzed amino acids, including lysine, methionine, and threonine ($p < 0.05$). This trial also indicated numerically higher values, although not statistically significant, for protein, fat and energy digestibility.

To conclude, Economix, with its ability to enhance amino acid digestibility, offers a viable solution by enabling the reduction of fishmeal and the incorporation of cheaper, more sustainable protein sources.

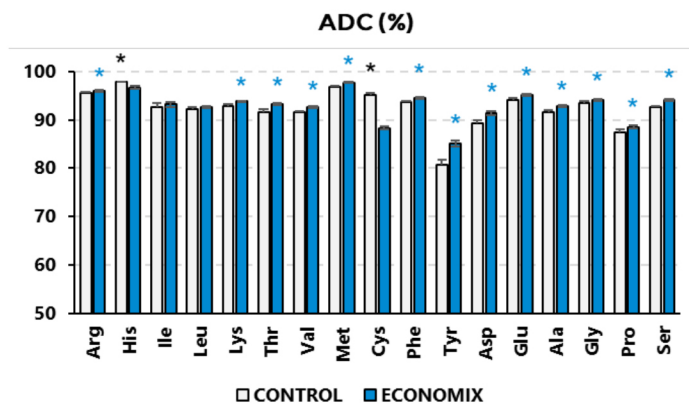


Figure 1. Effect of Economix on amino acid digestibility of European seabass *Dicentrarchus labrax*

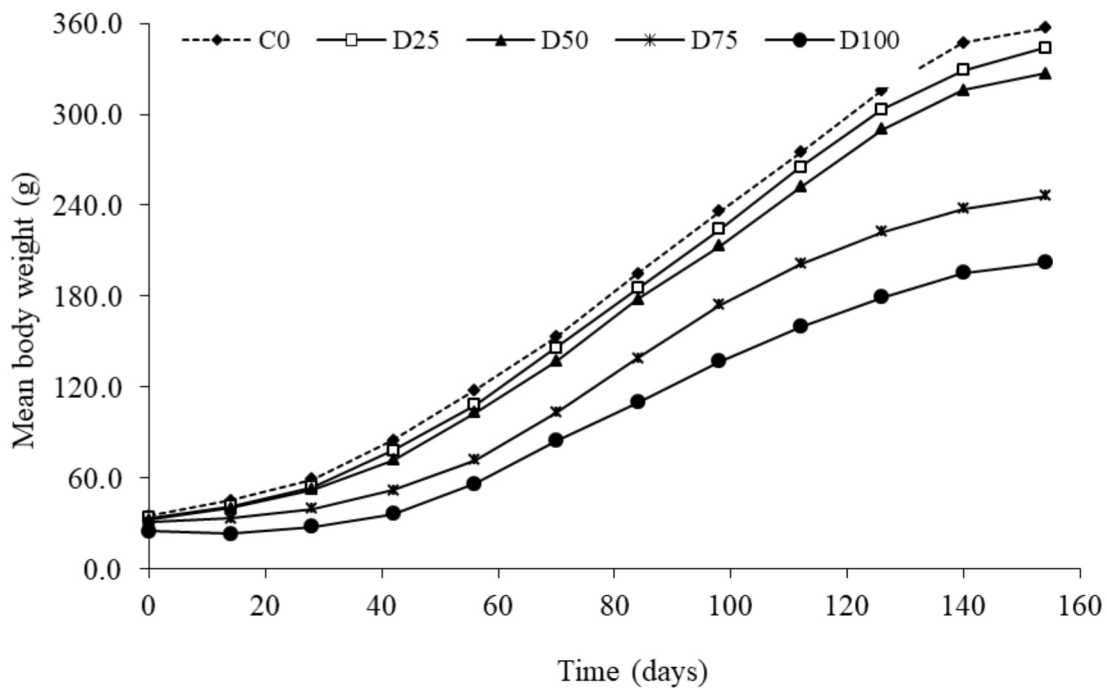
EFFECTS OF REPLACEMENT OF FISHMEAL WITH A MIXTURE OF COWPEAS *Vigna unguiculata* AND AMARANTH *Amaranthus cruentus* IN LABEO VICTORIA *Labeo victorianus* CULTURE

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The study evaluated the suitability of replacing fish meal with a mixture of two plant proteins: cowpeas (*Vigna unguiculata*) and *Amaranthus cruentus* as a protein source in the diet of three weeks old *Labeo victorianus* on growth performance, nutrient utilization and carcass proximate composition. Fishmeal was replaced with the mixed vegetables at a ratio of 25%, 50%, 75% and 100% and the substitution effects compared with control diet containing fish meal as the sole protein source. The five dietary treatments were tested in triplicate in static flow through tanks for 90 days. The fish were fed four times a day at 4% body weight. After 160 days of feeding, growth, nutrient utilization and FCR in fish fed at 25% and 50% *Vigna unguiculata* and *Amaranthus cruentus* were better than those fed 75% and 100% *Vigna unguiculata* and *Amaranthus cruentus* but not significantly different from those fed with fish meals diets alone ($F = 17.002, P = 0.002$). Growth reduction, increased FCR and reduced nutrient utilization occurred with increasing plant inclusion in the diet beyond 50% inclusion levels. Thus it is possible to replace up to 50% of fish meal with a mixture of *V. unguiculata* and *Amaranthus cruentus* in the diets of *L. victorianus*. This will reduce the cost of production as fish meal is increasingly becoming expensive as its demand outweighs its supply.

This finding lends credence in the continued research into areas of utilization of alternative plant proteins sources in place of fishmeal based feeds as protein sources in improving aquaculture.



HABITAT, GROWTH AND REPRODUCTION OF THE CLAM *Galatea Paradoxa* (BRUGUIÈRE, 1797), ENDOGENOUS BIVALVE IN THE LOWER SANAGA, CAMEROON

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To help improve knowledge of African freshwater clams in the wild, the ecology, growth and reproduction of the endogenous clam *Galatea paradoxa* (Bruguière, 1797) were studied in the lower Sanaga river (LN: 3 ° 14 ' - 3 ° 50' and LN: 9 ° 34 ' - 10 ° 03 ') in Cameroon. A total of 4095 clams were collected monthly from March 2018 to March 2019 in Bolounga-Mouloungo, Mpombo-Boloy and Maldjedou-Bonapembe. Physico-chemical characteristics and the chlorophyll a of water; the particle size of the substrate; the phaneroptic characteristics and morphological measurements of clam were taken in situ and in the laboratory, then evaluated. A significant variation ($p < 0.05$) was observed in the main physical characteristics: TDS (19.0 ± 3.5 ppm), temperature (29.6 ± 1.7 °C), conductivity (35.0 ± 6.8 μ S/cm) and chemical (mg/l): phosphate (2.3 ± 1.9), nitrate (13.6 ± 5.6), calcium (2.8 ± 2.2), and chlorophyll a (1.03 ± 0.94). The proportion of sand ($89.5 \pm 12.7\%$) predominated over that of clay ($6.9 \pm 7.0\%$) and silt ($3.6 \pm 6.2\%$) in all sites. Bolounga-Mouloungo and Mpombo-Boloy have similar habitat characteristics but different from those of Maldjedou-Bonapembe, which influenced the biological characteristics. In fact, almost all the growth parameters were influenced by sites and seasons ($p < 0.05$). Bolounga-Mouloungo and Mpombo-Boloy were very close by their growth characteristics while Maldjedou-Bonapembe differed from the other two by the values of its higher biometric and bromatological characteristics. Reproductive characteristics varied depending on site and period ($p < 0.05$). Five stages of maturation were observed in both males and females with 36 mm and 40 mm respectively as size at sexual maturity (L_{50}). These clams are gonochoric with protandrous hermaphroditism, sex ratio in favor of females and significantly influenced ($p < 0.001$) by period and site. The mode of reproduction is iteroparous with asynchronous oogenesis with the emission of gametes between May and November. The results of this study may contribute to the development of a domestication program and sustainable management measures of *Galatea paradoxa*.

THE IMPACT OF AQUACULTURE IN ENHANCING FOOD SECURITY IN ZIMBABWE

Elijah Tembo

Fish For Better Livelihoods Zimbabwe

Food security has become a widespread global phenomenon especially at the turn of the twenty-first century. According to the 1996 World Food Summit, 'food security is when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This paper investigates the impact of artisanal fisheries as a pathway to food security for communities in Zimbabwe. The study area received inadequate rainfall for food production. The study based on qualitative research methods and triangulation of data collection, which provides comprehensive understanding of the impact of fisheries to food security in the study area. The study revealed that the fish industry is an invaluable source of food security for rural communities in Zimbabwe; and has also improved the standard of living of the locals. It also revealed challenges facing the industry and they include lack of infrastructure development and poor social services inhibit the viability of the industry. Another challenge is the disintegrated and inconsistent legislation in the fishing which hinder the viability of the sector. The chapter concludes that the fishing industry, especially aquaculture has the potential of contributing overwhelmingly to food security, however, there is need for infrastructure development such as roads within the fishing communities; and, alignment of fishing policies.

UPDATE AND EXPANSION OF A COMMERCIAL TRAINING PROGRAM WITHIN THE PRIVATE SECTOR FOR EMERGING AQUACULTURE INDUSTRIES IN WESTERN SUB-SAHARN AFRICA

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Fish products are an important source of food for the people of sub-Saharan Africa, traditionally from wild catch from both marine and freshwater sources. The growing number of people on the sub-continent now located in urban areas along with the decline in available wild catch has created both an economic opportunity and environmental need for the expansion of responsible and sustainable aquaculture production to sustain and improve livelihoods. A trained labor force is needed to advance the commercial aquaculture sector in Western Africa. There is currently a deep divide in the needs of the commercial sector and the services provided by the local universities and federal government ministries. The general lack of practical farm knowledge and experience in the training of students and government personnel often hampers commercial sector growth and advancement, and the lack of sound best aquaculture practices on the commercial farms have resulted in severe economic losses at all levels of the aquaculture supply chain. The World Initiative for Soy in Human Health (WISHH) has been developing a training program within the private sector for a training program designed to create a high-level internship training program on a commercial farm where students would be held to a higher level of responsibility to address multiple issues and basic management practices on fish (e.g. husbandry, feed management, spawning, fry cultures, transportation, water quality, and overall fish health management) through a well-structured internship and practical training approach. Through funding by the US Soybean Board Checkoff Program, 29 individuals have gone through this intensive training program at Flosell Farms, Ltd. in Ghana over the 2 years. We have also begun a similar program in Nigeria in cooperation with Sej Farms and completed an 8-week pilot program with plans for expansion in 2025. Job placement and program impacts are being monitored for improvements in economic sustainability and survey results from participants will be presented.

FEEDING PATTERN OF THE AFRICAN BIG BARB *Labeobarbus intermedius* (RÜPPEL, 1836) (PISCES: CYPRINIDAE) IN RIBB RESERVOIR, LAKE TANA SUB-BASIN, ETHIOPIA

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The purpose of this study was to investigate the feeding pattern of *Labeobarbus intermedius* at Ribb Reservoir Lake Tana Sub-basin, Ethiopia. A total of 498 specimens were collected using gillnets. Of these, 302 (60.6%) fish had different foods, while 196 (39.4%) were empty. The fish were dissected, their stomachs were removed, and stomach contents were preserved in a 5% formalin solution. Frequency of occurrence, volumetric method, index of preponderance, and geometric importance index were used to study the feeding pattern. Detritus was the primary food, accounting for 61.6% of the guts by volume. Mud, zooplankton, and phytoplankton were the second most important food items comprising 24.4%, 3.9%, and 2.8% by volume respectively. Feeding pattern differed with the size classes of fish. The smallest fish (<16.5 cm Fork length) consumed detritus, mud, and insects comprising 64.2%, 18.7%, and 7.3% by volume, respectively. The adult fish (>17.0 cm FL) majorly consumed detritus followed by mud. The importance of mud increases when the fish grows more except (>31.5 cm FL) size class. The proportions of food items of *L. intermedius* significantly varied with respect to the dry and wet seasons. Detritus and mud were mostly consumed in the dry season, contributing to 47.8% and 32.4% by volume, respectively. Detritus was the most preferred food item during the wet season, contributing 97.2% of the total guts and 75.6% by volume. Generally, *L. intermedius* feeding pattern depending on size classes and seasonal variations this may be linked to food availability in the reservoir.

THE AGRICULTURAL RESEARCH COUNCIL (ARC) INNOVATIVE TECHNOLOGIES ENHANCING FRESHWATER AQUACULTURE AND AQUAPONICS PRACTICES IN SOUTH AFRICA

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The Agricultural Research Council (ARC) has implemented innovative technologies to promote and enhance freshwater aquaculture and aquaponics practices in South Africa, which are critical for sustainable food production and efficient management of water resources. These tools include an ArcGIS program, a pond site suitability model, a potential beneficiary's SWOT analysis, and a tracker of vegetable price patterns. These tools include a freshwater aquaculture mobile app, a pond site suitability model, a potential beneficiaries SWOT analysis, and a fresh produce market vegetable price trends tracker.

An essential tool for farmers, the freshwater aquaculture smartphone app offers real-time system monitoring and management features. By optimizing system health, overall productivity, and water quality, this program minimizes the potential risks associated with fish farming.

The most suitable locations for aquaculture systems are identified using the pond site suitability model using geospatial analysis. This tool helps farmers choose locations that improve odds of success and resource efficiency by assessing logistical variables, environmental conditions, and water availability.

The Potential beneficiaries to receive a government assistance are assessed based on their strengths, weaknesses, opportunities, and threats using a SWOT analysis. By ensuring that resources are distributed to the most potential beneficiaries, this study improves the overall impact of aquaculture and aquaponics projects.

By analysing past and present vegetable price trends, the fresh produce market vegetable price trends tracker offers farmers insightful information on market dynamics. With the use of this technology, farmers can increase profitability and market responsiveness by selecting which crops to plant and when to market them.

When combined, these ARC technologies provide South African farmers with comprehensive support, covering everything from market analysis and resource allocation to site selection and management of systems. The development, applications and potential impact of these tools in promoting sustainable aquaculture and aquaponics technologies in South Africa are addressed in this research.

IMPACTS OF *Physella acuta* ON *Oreochromis niloticus* FINGERLINGS IN AQUACULTURE PRODUCTION

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Aquaculture faces challenges, including interactions among aquatic organisms within production systems. The Pilot Aquaculture Center (P.A.C) in Ghana is an aquaculture demonstrating site which produces *Clarias gariepinus* and all-male *Oreochromis niloticus* fingerlings. Fish farmers source their catfish and Nile tilapia fingerlings from this center. Nevertheless, the center harbors *Physella acuta*, an aquatic invasive snail in their concrete tanks and these invasive aquatic snails might be transported to other farms. This study investigated the impact of *P. acuta* on *O. niloticus* fingerlings in aquaculture production.

The experiment involved 100 *O. niloticus* fingerlings (mean weight 4.6g) and 200 *P. acuta* (mean shell height 7.54mm) from P.A.C. It was conducted in the Wet Laboratory of the Kwame Nkrumah University of Science and Technology (KNUST), with two treatments, three replicates, and a control. Growth and rate of egg capsule production were recorded.

After 8 weeks, *O. niloticus* fingerlings exposed to *P. acuta* exhibited slightly higher growth rates than the control, attributed to the nutritive value of *P. acuta*'s egg capsules.

Setups with fish and snails had lower reproduction of egg capsules compared to the snail-only (control), indicating that Nile tilapia fingerlings controlled the growth of egg capsules. *P. acuta*'s presence reduced the need for cleaning holding facilities due to its biofilm-feeding behavior.

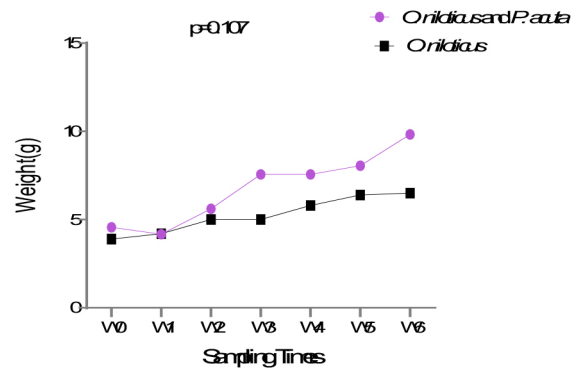


Figure 1: Impact of *P. acuta* on the growth of *O. niloticus* fingerlings

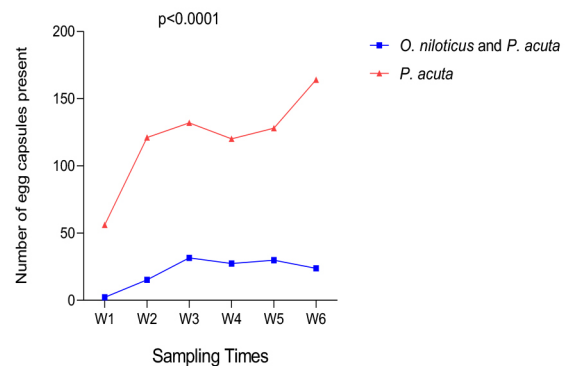


Figure 2: Impact of *O. niloticus* fingerlings on the production of egg capsules of *P. acuta*

CONSUMERS' ATTITUDES TOWARDS PRAWN CONSUMPTION IN BANGLADESH: AN INVESTIGATION ON PERCEIVED VALUE AND WILLINGNESS-TO-PAY

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This study assessed consumer preferences and consumption patterns for prawns in Bangladesh, underscoring the economic and nutritional significance of prawns in the local diet. A total of 120 respondents were interviewed following random sampling technique from four districts. Data analysis employed descriptive statistics alongside mathematical and statistical methods. The findings indicate a strong preference for fresh and large-sized prawn among consumers. Income level substantially influenced prawn purchases, with high-income consumers more likely to buy premium prawn products, while low-income consumers showed sensitivity to price changes. The primary concerns that significantly influenced consumers' purchasing decision were found to be size, freshness, taste, price, market availability and income. Additionally, consumers' perceived value and willingness-to-pay for prawns were significantly driven by size, freshness, environmental sustainability, and income levels. Policy recommendations include promoting sustainable prawn farming and improving accessibility for low-income consumers to enhance both nutritional intake and economic resilience. This research offers valuable insights for stakeholders in the prawn industry, facilitating the development of targeted marketing strategies and informed policy-making for sustainable industry growth.

DIETARY EFFECT OF ATAMA *Heinsia crinita* LEAVES EXTRACT ON GROWTH, PHYSIOLOGY AND ECONOMIC FEED CONVERSION RATIO OF NILE TILAPIA

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Feed additives are known for their economic importance in aquaculture. However, the aftermath of using synthetic additives on fish could lead to antibiotics resistance, altered behavior and reproductive issues in aquaculture species. Therefore, extract of Atama *Heinsia crinita* leaves with known medicinal value, was used in the diet of Nile tilapia *Oreochromis niloticus* as substitute to assess its relevance on the growth and haemato-biochemical, as gut bactericide, and its economic feed conversion ratio.

Nile tilapia (4.0 ± 0.63 wt., $n = 180$) were conditioned and fed 35% crude protein isonitrogenous diets with graded levels of Atama leaves extract at 0.0g, 2.0g, 4.0g and 6.0g per 1000g DM for 8 weeks. The growth, haemato-biochemical and gut bactericidal effect, and the economic feed conversion ratio (EFCR) of production were assessed using standard weighing, analytical and microbiology procedures, and also profit equations respectively.

The weight gain (g) of Nile tilapia fed diet-based Atama leaves extract was significantly ($p \leq 0.05$) improved from 2.0–6.0g/1000g DM diet inclusion by 34%. The FCR was significantly reduced, while the SGR (%/g/day) increased with the addition of dietary Atama leaves extract. The haemato-biochemical changes indicated significant improvement from the controlled diet. There was significant decrease in monocytes, eosinophils and basophils from 0.0g–6.0g/1000g DM. Similarly, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and creatinine declined. The gut bacterial isolates

(10^6 CFU/g) significantly declined with increased dietary inclusion of Atama leaves extract. In addition, the EFCR significantly reduced in the 6.0g/1000g DM diet by 23% from 0.0g/1000g DM diet. In conclusion, Atama leaves extract-based diets had substantial effect on the growth, physiology and distribution of gut bacteria in Nile tilapia.

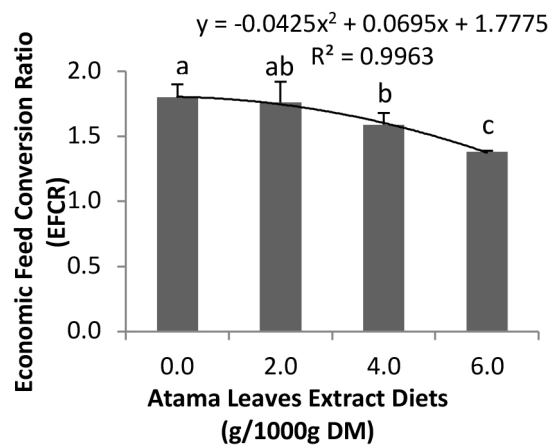


Figure 1 Responses of Economic Feed Conversion Ratio to the graded levels of Atama Leaves Extract Diets

THE EXPERIENCE OF REGIONAL AQUATIC ANIMAL HEALTH NETWORKS IN AFRICA

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The surveillance and control of aquatic animal diseases is among the weak links affecting the sustainable expansion of aquatic animal production and safe intra-regional fish trade in Africa. All stakeholders across the fisheries-aquaculture value chain must play an active role in the control of aquatic animal diseases and associated public health and environmental concerns. However, recent studies on aquatic animal disease mapping by the African Union - Interafrican Bureau for Animal Resources (AU-IBAR) indicate that there is no functional system linking and coordinating aquatic animal producers, traders, fishery sector and animal health services at both national and regional level. This is impacting negatively on the reporting, biosecurity and trade in compliance with international standards, and leaves the continent in a very precarious situation in the event of outbreaks of emerging diseases.

Fortunately, experiences gained in other regions have demonstrated the value and positive impact of so-called Regional Aquatic Animal Health Networks (RAAHN), such as the Network of Aquaculture Centres in Asia and the Pacific (NACA), in facilitating the harmonization and reinforcement of animal disease surveillance and control and improving access to markets.

The World Organisation for Animal Health (WOAH) has a long tradition of supporting technical and geographic networks and commissions in the fields of animal health and welfare, often in close collaboration with AU-IBAR. The adoption of its Global Aquatic Animal Health Strategy in May 2021, on the occasion of its 88th General Session, calls for the implementation of key actions and concepts, many of which can best be conducted at regional level, in close partnership with regional partners, in order to improve aquatic animal health and welfare worldwide, contributing to sustainable economic growth, poverty alleviation and food security, thereby supporting the achievement of the Sustainable Development Goals (SDGs).

By adopting a phased approach, WOA, in collaboration with AU-IBAR, supported the establishment of two sub-regional aquatic animal health networks, one for North Africa (RAAHN-NA), and one for Southern Africa (RAAHN-SA), arguably the two African sub-regions with the best developed aquaculture sectors and prospects for high impact deriving from the implementation of such coordination networks. In addition, to address the diagnostic capacity constraints of national and regional laboratories, a third network has been established (Regional Aquatic Animal Health Laboratory Network for Africa - RAAHLN-AF), specifically directed at uniting diagnosticians from Reference Laboratories and Collaborating Centres, with a view of scaling up its range at a later stage.

SUPPORTING HEALTH AND DISEASE TOLERANCE IN FISH AND SHRIMP

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Achieving high performance from aquaculture species reared in conditions very different from their natural habitat is extremely demanding. A lot of energy is focused on growth performance while maintaining a healthy immune system is often overlooked. Farm conditions can induce a lot of stress, making it easier for opportunistic pathogens to exploit a moment of weakness. There are various approaches to supporting the immune system, one of them is through using beta-glucans.

Beta-glucans widely used

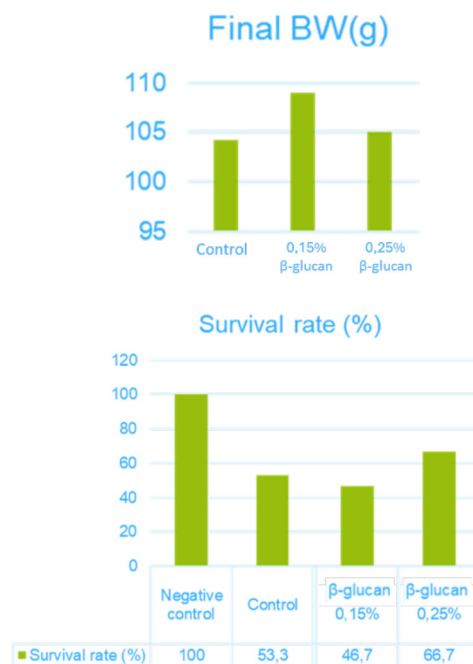
Beta-glucans are probably the most commonly used additive to help maintain an efficient immune system because they share similar molecular patterns as on the cell membranes of pathogens. Recognition by various innate immune cells, like macrophages, dendritic cells and neutrophils, can trigger a cascade release of cytokines and chemokines which can initiate an immune response. The amount, level of polymerization, molecular weight and branching influence biological activity on immune cells and their viability.

In-vivo and *in-vitro* trials confirm innate immunomodulation

The application of StimmunoGuard in an *in-vivo* tilapia trial showed that at lower inclusion rates there were improved growth rates and higher stress tolerance. While at higher inclusion rates, there was still improved stress tolerance but also higher survival rates when challenged by *S. agalactiae*.

Chitin delivers added benefit

StimmunoGuard has a naturally high level of beta-glucans, however it also contains a high percentage of chitin as well. Chitin acts similarly to beta-glucans and is predominantly active in the intestinal tract. In addition, when chitin is broken down in the intestinal tract of animals it produces chitosan which can damage the cell membrane of harmful microbes.



TACKLING THE THREAT OF ANTIMICROBIAL RESISTANCE IN AQUACULTURE IN ASIA AND AFRICA USING A ONE HEALTH APPROACH

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Antimicrobial resistance (AMR), a true One Health challenge, is declared by the World Health Organization (WHO) as one of the top 10 public health threats facing humanity. AMR bacteria, and the AMR genes and mobile elements that confer resistance, can readily transfer between human, terrestrial and aquatic systems. Antibiotics are widely used in aquaculture, as in other animal production systems, to control bacterial diseases. There is a concern that antimicrobial use (AMU) in many countries is not well controlled, posing potential risks that this will drive the emergence, maintenance and transfer of AMR. The steps that need to be taken in Africa and Asia to build the capacity to better assess, contain and mitigate these threats will be discussed. These include the development and implementation of effective regulations to control the sale and use of antibiotics in this sector. Effective surveillance is also needed to more accurately understand what antimicrobials (e.g., antibiotics) are being used, assess AMU drivers, determine the distribution of resistant bacteria, and identify new and emerging AMR bacteria and genes in the aquaculture systems of these countries. To achieve these aims, it is critical that effective diagnostic capacity is available in countries to accurately identify and characterise AMR bacteria. Effective mitigations and interventions need to be developed and implemented, such as improved farming practices and biosecurity, effective vaccines and other treatments. Examples of how these capacities are being strengthened in major aquaculture-producing countries in Asia and Africa will be presented through various projects and initiatives led by WorldFish and partners.

UPDATE ON DOUBLE-USE OF WATER IN THE SAHEL: FISH BEFORE IRRIGATION (FBI) BY WOMEN'S GARDEN GROUPS IN SENEGAL.

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Andando is an NGO based in Oregon that works with women's cooperative gardens in Senegal since 2008. Groups consist of about 100-150 women who share plots on 1 hectare of land. Each garden has a hand dug or borehole well and solar pump that fills a 5000L reservoir during the day which distributes water to 6 basins throughout the garden. The women fill their watering cans at these basins and water their small vegetable plots by hand daily. Fish are a vital component of the Senegalese diet both nutritionally and culturally, but access to fresh fish in inland areas is limited and often prohibitively expensive for smallholder farmers. In the hopes of improving access to fish in the area, In 2020, Andando's local leadership along with women from 4 cooperative gardens in Andando's Keur Soce region of operation came up with a plan to try adding fish production tanks upstream, of the existing watering basins. In this system water already destined for irrigation purposes can pass through fish holding tanks before flowing to watering basins, thereby facilitating fish production and increasing vegetable outputs due to increased nutrients in the water, without necessitating any increase in daily water usage. The fish holding tank is larger than the watering basins so that only half of the water is removed daily and replenished by the solar pump each afternoon. The fish tanks are each plumbed to two watering basins with water coming from the bottom of the tank to facilitate the evacuation of nutrient rich fish waste.

Thanks to a small grant from the Tankersley Endowment managed by Auburn University, two such fish tanks per garden were installed in each of 4 gardens in the center of Senegal. Additional funding was provided by the Tomberg Families Philanthropies for construction of more fish tanks in gardens in northern Senegal, in Podor, near the border with Mauritania. Improvements were made to facilitate the women entering the tanks to harvest and sample fish and to provide a nursery tanks for nursing fingerlings. A re-training program is planned for 2025 for the original group of 4 gardens and the new groups, who have completed construction.

Production has reached about its maximum possible at 4 kg of marketable fish per square meter (not counting reproduction), given that there is no aeration and the groundwater comes out at only a dissolved oxygen of 3mg/l. The revenue management has also changed to function on a "break-even" basis, based on feed costs. For example, the selling price is calculated at: $\text{kgs feed used} \times \text{feed price/kg} \div \text{kgs fish harvest} = \text{selling price per kg fish}$. This allows women to purchase fish locally at the lowest possible price. So far, no noticeable increase in kgs of vegetables produced per garden with fish has been documented but the value of the production has increased in gardens where there are fish. Various improvements such as switching to clarias and adding solar-powered aeration have been discussed but the women are risk-averse and have decided to stick with tilapia for now, given the constraints in feed supply, clarias fingerling supply and security.



OPTIMISING THE LARVAL STOCKING DENSITY AND USE OF EDTA ON THE SURVIVAL, DEVELOPMENT AND SWIMMING ACTIVITY OF THE PACIFIC OYSTER, *Crassostrea gigas*

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Oyster farming is a growing sector within the South African aquaculture industry, and good aquacultural practices are necessary to ensure high quality and economically feasible yields. During their early life-history stages, oyster larvae are highly sensitive to the surrounding environment which impacts on their success during settling and metamorphosis. When the chelating agent, EDTA, is added to seawater, the chelation of heavy metal complexes occurs, resulting in reduced metals being available for biological uptake. The potential impact of EDTA toxicity on development and swimming speed have not been determined.

The optimal larval stocking density is important from an economic perspective however this should not come at the cost of oyster survival and quality. Deformities may occur when larvae are stocked at high densities, resulting in reduced feeding and shell damage due to the contact between larvae. At low stocking densities, yields may negatively impact a hatchery's economic viability. This study aimed to evaluate the effect of EDTA (0,01 mL/L and none) and larval rearing density (10, 20, and 30 larvae/mL) on the survival, development, and swimming activity of *C.gigas* larvae over a 48 hour period. Results are currently being analysed and will be presented at the conference. If allowed, an updated abstract will be provided prior to the conference.

CO-OCCURRENCE OF EMERGING PATHOGENS ISOLATED FROM INFECTED FARMED TILAPIA IN THE LAKE VICTORIA REGION, UGANDA: *Aeromonas sp*, *Edwardsiella sp* and *Francisella sp*

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Tilapia production from aquaculture is growing fast in Uganda to meet the increasing demand for fish. Farm yields and profits are increasingly reduced by periodic disease outbreaks in land and water-based systems. High mortalities experienced within hatcheries and cage systems with infected fish presenting signs of lethargy, exophthalmia, granulomatous spleen, fin rot, ulcerations and haemorrhages. Histopathological reports showed gill hyperplasia with epitheliocystis, and granulomatous head-kidney, spleen, liver with melanomacrophages. However, asymptomatic fish samples showed recovery stages of populations as exhibited in granulomas spleen and kidney. Molecular identification revealed unique strains of *Aeromonas veronii*, *A. hydrophila* of *Edwardsiella ictaluri*, *E. anguillarum*, *Francisella philomiragia*, *F. noatunensis* and *F. tularensis* from infected farmed tilapia in Uganda. These were resistant to Ampicillin and Amoxicillin, erythromycin and sulphamethoxazole trimethoprim, respectively. Identification of co-occurrence of these emerging pathogens presents strategies to reduce further economic losses in the tilapia industry.

FEED THE FUTURE INNOVATION LAB FOR FISH: SUPPORTING SUSTAINABLE AQUATIC FOOD SYSTEMS FOR ECONOMIC GROWTH AND FOOD SECURITY

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The Feed the Future Innovation Lab for Fish, funded by the U.S. Agency for International Development (USAID), works to reduce poverty and improve nutrition, food security, and livelihoods in partner countries by supporting research on sustainable aquatic food systems. The Fish Innovation Lab is managed by the Global Center for Aquatic Health and Food Security at Mississippi State University. It is one of 16 Feed the Future Innovation Labs which are leveraging the expertise of U.S. universities and developing country research institutions to tackle some of the world's greatest challenges in agriculture and food security.

The Fish Innovation Lab supports research and capacity-building activities targeting three program areas: climate-smart aquatic system innovations, nutrition and food systems, and inclusive access to improved inputs. To enhance the development impact of Fish Innovation Lab research, each funded activity is also expected to incorporate cross-cutting themes related to gender equity and social inclusion, resilience, and capacity development.

From 2018-2023, the Fish Innovation Lab supported 24 research activities, 15 of which were in Africa: Ghana (1), Kenya (3), Nigeria (6), and Zambia (5). The lab also supported work in Bangladesh, Cambodia, and a four-country study across Madagascar, the Pacific Islands, Peru, and the Philippines. The Fish Innovation Lab received a 5-year extension in 2023, and in 2024, it launched six 1-year Startup and Scaling Activities in Bangladesh, Kenya, Nigeria, and Zambia. These activities aim to scale up work funded during the first 5-year phase and identify new approaches to improve sustainable aquaculture and fisheries. Following a competitive selection process, the Fish Innovation Lab anticipates awarding 14 additional activities in 2025.

Fish Innovation Lab activities in Africa have addressed major issues in aquaculture and fisheries. In Nigeria, teams investigated different ways to improve aquaculture production and provide better quality fish products to consumers. New work in Nigeria aims to assess fish supply from inland water bodies and potential impacts from climate change. In Kenya and Ghana, teams worked to improve the sustainability of local fisheries and provide nutrition training and information to promote consumption of aquatic foods for better nutrition amongst fishers, mothers, and children. Recently launched activities in Kenya will analyze fish health and antimicrobial resistance in aquaculture and use climate-smart solutions to integrate agriculture and aquaculture. Activities in Zambia captured a wide range of work, from fish vaccine development to reduce aquaculture losses to assessing population ecology and current distribution of introduced invasive crayfish. Additionally, ongoing work in Zambia developed and is now scaling a dried fish powder along with recipes for enhanced nutrition, particularly benefiting mothers and infants in vulnerable households.

To learn more about the activities of the Fish Innovation Lab, visit our website at www.fishinnovationlab.msstate.edu and subscribe to our newsletter at <https://rb.gy/j17i6>.

WORLD FISH RESEARCH PROGRAM ON AQUATIC FOOD BIOSCIENCES

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The International Center for Living Aquatic Resources Management (ICLARM), also known as WorldFish, is headquartered in Penang, Malaysia. WorldFish's mission is to end hunger and advance sustainable development by 2030 through science and innovation. The organization aims to transform food, land, and water systems with aquatic foods to create a healthier planet and people.

The Aquatic Food Biosciences group is one of the two science groups within WorldFish. This group focuses on driving sustainable aquaculture through innovations in genetics, nutrition, and health. It works on context-adapted farming practices for developing resilient fish strains, sustainable feeds, improved health management, and advanced reproduction and hatchery technologies. Focusing on Africa, Asia, and the Pacific, the Aquatic Food Biosciences group is organized around four science teams, (1) Aquatic Animal Genetics: Develops faster-growing, more resilient fish strains for climate-smart production with a reduced environmental impact; (2) Aquatic Animal Feeds and Nutrition: Creates information for formulating and sustainably producing local, cost-effective feeds for aquaculture; (3) Aquatic Animal Health: Enhances disease management in aquatic food systems through better diagnostics, management practices, and farm-level biosecurity under the One Health framework; and (4) Aquatic Farming Practices: Integrates improved technologies and innovations to optimize biological and technological aspects of aquaculture, enhancing productivity and ensuring sustainability.

To support the sustainable growth of the aquaculture sector and meet the increasing demand in the global south, the Aquatic Food Biosciences group collaborates with internal peers and global, regional, and local partners. Together, we build on collective strengths to fulfil our commitments.

A POCKET GUIDE TO SCIENTIFIC WRITING IN AQUACULTURE RESEARCH

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As the former Editor-in-Chief of the Journal of Applied Aquaculture, I have experienced firsthand how difficult it is for many students and inexperienced aquaculture scientists to write aquaculture manuscripts. While I am of the opinion that there is no acceptable justification for poor writing skills, I have come to realize that not every aspiring aquaculture scientist (writer) has access to the training and exposure that are required to gain and strengthen scientific writing skills. Relating to my own academic path, which involved studying in Cameroon, Belgium, The Netherlands, Vietnam, Canada and the USA, I can say that being taught by Professors who actively publish scientific articles and studying at Universities where the library (physical and online) puts at the disposal of students and researchers tons of literature can substantially contribute to inspiring and motivating aspiring scientific writers and allow them to quickly acquire writing skills and tools. Given that not everyone would have the chance to follow the same path as me and learn how to write scientific manuscripts through international studies, editorial work and professional experiences across the world, I thought I would disseminate my insights with anyone who is wondering how to write good aquaculture publications.

My journey on the sharing of scientific writing skills started in 2014, when I published the paper titled “Writing a scientific manuscript from original aquaculture research” that was published in 2014 in the Journal of Applied Aquaculture. I then followed up in 2015 with other papers titled “Toward the Professionalization of Aquaculture: Serving as Peer Reviewer for an Academic Aquaculture Journal” that was published in World Aquaculture magazine, and “Misuse of multiple comparison tests and underuse of contrast procedures in aquaculture publications” that was also published in Aquaculture. Furthermore, I was invited to deliver a training workshop on “Improving scientific Writing and tools for research organization” at the World Aquaculture Society annual meeting and conference in Cape Town, South Africa, in 2017. All the experience gained through these science communication activities are collated in this book, in order to better equip the readers with the tools and methods required to write quality aquaculture manuscripts, and increase their chances of getting their aquaculture findings into print.

ETUDE DE LA BIODIVERSITE DE LA FAUNE ASSOCIEE A *Perinereis cultrifera* SUR LE LITTORAL CENTRE ET EST ALGERIEN

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La façade méditerranéenne de l'Algérie, qui s'étend sur 1622,48 km, se distingue par la variété de son environnement physique et naturel, ainsi que par la diversité de ses ressources naturelles, telles que la faune et la flore. Toutefois, les régions côtières sont de plus en plus exposées à la pression démographique, industrielle et tourisme.

Nous avons sélectionné cinq sites pour évaluer l'état de la diversité écologique de la faune liée aux annélides du littoral ouest algérien.

La plage El-Mordjane (El-Kala) est le premier site d'échantillonnage, tandis que la plage Saint-Cloud (Annaba) est le deuxième site. Le troisième site est la plage de Stora (Skikda), le quatrième site est la plage de Figuier (Boumerdes), et le cinquième site est la Pointe-Pescade (Alger).

De février 2017 à janvier 2018, les échantillons d'eau, de Polychètes et de la faune associée ont été prélevés mensuellement. Il y a un total de 25314 individus de 25 taxons répartis dans les groupes zoologiques suivants : Annélides Polychètes, Arthropodes, Mollusques, Plathelminthes, Sipuncula et Echinodermes.

La comparaison de la richesse spécifique montre une variation entre les différents prélèvements en saison et selon les sites. En effet, les Arthropode et les Mollusques représente le plus de diversité sur tous les sites.

Le regroupement des sites (Analyse en composante principale et dendrogramme inter-sites) est comparable à celui des paramètres physiques et chimiques : les caractéristiques physico-chimiques de l'eau sont des facteurs déterminants dans la distribution spatiale des espèces.

La situation montre que les sites qui se ressemblent de point de vue de la composition faunistique présentent les mêmes conditions écologiques.

CARACTERISATION DE L'ETAT ENVIRONNEMENTALE DE QUELQUES SITES D'ELEVAGES AQUACOLES EN TUNISIE

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Malgré le développement de l'aquaculture, ce dernier reste confronté à des nombreux défis essentiellement en termes d'interactions environnementales. Le développement des nano-technologies couplés aux progrès des techniques d'intelligences artificielles n'exclue pas le monitoring environnemental qui reste primordial pour évaluer les écosystèmes aquacoles et garantir la durabilité du secteur.

Dans le cadre de caractérisation environnementale des écosystèmes d'élevage en Tunisie, des prospections ont été menées dans des projets d'élevages en mer ouverte, dans la région nord (Golfe de Hammamet) et dans la zone centrale (nord et sud de la Baie de la Monastir) (voir carte).

Cette étude a consisté à analyser un ensemble de caractéristiques hydrobiologiques et bactériologiques du milieu qui ont concerné 3 strates de la colonne d'eau (surface, mi-colonne et à 1m du fond) et le sédiment et ceci à travers des stations représentatives pour chaque site (élevages et témoins).

Ces prospections menées durant l'été 2023 dans le site situé au Golfe de Hammamet révèlent des eaux de bonne qualité, caractérisant un environnement oligotrophe. Les niveaux d'azote, de phosphore minérales et organiques indiquent un état favorable selon les critères d'évaluation DCE. Les résultats bactériologiques, montrent une prédominance de la flore mésophile halotolérante et une faible présence de la famille des *Vibrionaceae*. Les faciès sédimentaires, composés principalement de fractions fines à très fines, présentent une faible charge en matière organique avec des variations dans les taux d'azote et de phosphore organiques.

Les sites au niveau de la Baie de Monastir montrent des valeurs normales pour le pH, la turbidité, l'oxygène, l'azote et le phosphore minéral. Cependant, une concentration plus élevée de phosphore organique est constatée pour l'ensemble des sites diagnostiqués y compris les stations témoins. De point de vue sédimentologie, deux faciès granulométriques se distinguent une fine de taille inférieure à 0,2 mm pour les sites situés au nord de la baie et une seconde composée de fraction moyenne supérieure ou égale à 0,5 mm pour les sites situés au sud.

La qualité physico-chimique du sédiment révèle une faible teneur en matière organique ainsi que des niveaux acceptables en azote et en phosphore organique associées à un potentiel Red/Ox négatif. Les charges bactériennes moyennes indiquent une prédominance de la flore halotolérante ; néanmoins, la famille des *Vibrionaceae* est peu représentée dans les sédiments.

Les différences observées entre les stations d'élevages et les témoins restent peu significatives pour la majorité des paramètres et des sites et ceci dans les deux écosystèmes étudiés.



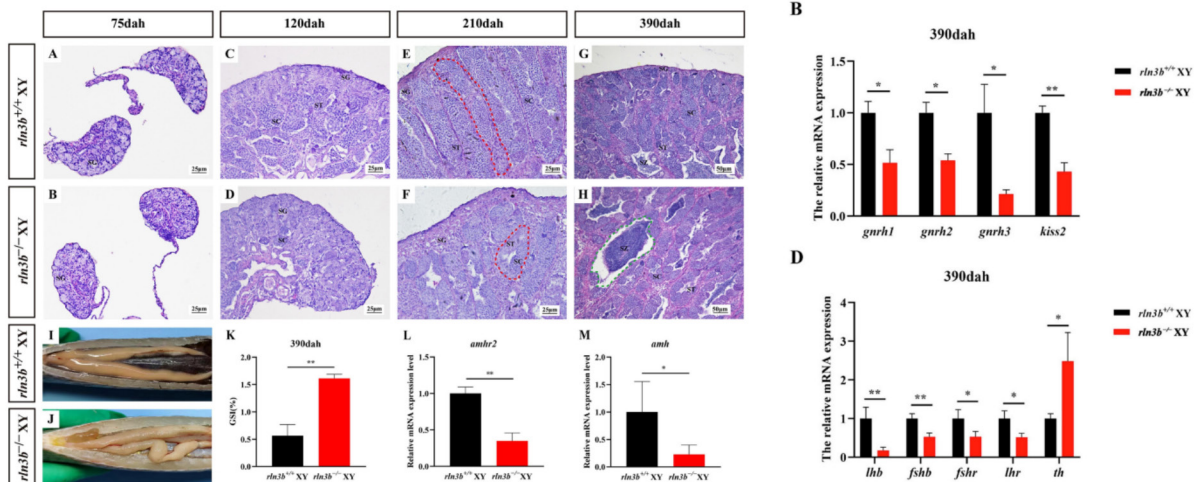
HYPOGONADOTROPIC HYPOGONADISM IN MALE TILAPIA LACKING A FUNCTIONAL *rln3b* GENE

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Relaxin 3 is a neuropeptide that plays a crucial role in reproductive functions of mammals, however, its roles in fish reproduction remain to be elusive. To understand the significance of *rln3b* gene in male fertility, we generated a homozygous mutation line of *rln3b* gene in Nile tilapia. Our findings indicated that *rln3b* mutation delayed spermatogenesis and led to abnormal testes structure. Knocking out *rln3b* gene resulted in a decrease in sperm count, sperm motility and male fish fertility. TUNEL detection revealed a small amount of apoptosis in the testes of *rln3b*^{-/-} male fish at 390 days after hatching (dah). TUNEL detection revealed a small amount of apoptosis in the testes of *rln3b*^{-/-} male fish at 390 days after hatching (dah). RT-qPCR analysis demonstrated that mutation of *rln3b* gene caused a significant downregulation of steroid synthesis-related genes such as *Cyp17a1*, *Cyp11b2*, germ cell marker gene, *Vasa*, and gonadal somatic cell marker genes of *Amh* and *Amhr2*. Furthermore, we found a significant down-regulation of hypothalamic-pituitary-gonadal (HPG) axis-related genes, while a significantly up-regulation of the dopamine synthetase gene in the *rln3b*^{-/-} male fish. Taken together, our data strongly suggested that *Rln3b* played a crucial role in the fertility of XY tilapia by regulating HPG axis genes.



AQUACULTURE FEED, PROCESSING AND NUTRITION

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“Fish nutrition is vital in aquaculture, supporting growth, health, and product quality. Essential nutrients include proteins, lipids, carbohydrates, vitamins, and minerals. Feed production utilizes ingredients like fish meal, soybean meal, corn, and oils for balanced diets. The process involves grinding, mixing, extrusion, and coating to create nutrient-dense pellets. Quality feed minimizes waste and enhances sustainability, supporting efficient fish growth and reducing environmental impact in aquaculture operations.”

Aquaculture feed nutrition and processing are central to sustainable fish farming, directly influencing fish growth, health, and the efficiency of production. Nutritional requirements in aquaculture focus on essential components such as proteins, lipids, carbohydrates, vitamins, and minerals, each supporting vital physiological functions and optimal growth rates. Protein, often sourced from fish meal and plant-based alternatives, is critical for muscle development, while lipids provide energy and essential fatty acids, crucial for cell function and immunity. Feed formulation must balance these nutrients to meet species-specific needs, prevent nutrient deficiencies, and minimize waste.

The feed production process involves carefully selecting high-quality raw materials like fish meal, soybean meal, and grains, each chosen for its nutritional profile and cost-effectiveness. Processing steps include grinding, mixing, extrusion or pelleting, drying, coating with oils or vitamins, and cooling. These stages enhance pellet durability, digestibility, and nutrient stability. Recent advances in feed technology also focus on alternative protein sources to reduce dependency on fish meal, address environmental concerns, and enhance sustainability. Efficient feed production not only improves growth performance but also reduces waste discharge into aquatic environments, promoting ecological balance and the long-term viability of aquaculture practices.

INTEGRATED AQUACULTURE, VEGETABLE AND GOATS PRODUCTION FOR SUSTAINABLE HOUSEHOLD ECONOMICS. A CASE FROM VHEMBE DISTRICT, LIMPOPO SOUTH AFRICA

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Sustainable development can be achieved by enabling households to pursue a mix of livelihood options (Sachs et al. 2023; Marini Govigli et al., 2022). The mix of options should be integrated in a systematic fashion as was determined by Norman et al (1995). One of the possible innovations is the integration of aquaculture into vegetable, chicken and goats' production system at household level. There growing evidence showing positive correlation between the pace of innovation, rate of economic growth and competitiveness (Walsh et al., 2020) and contributes significantly towards the achievement of the Sustainable Development Goals (SDGs). Integration of aquaculture into conventional farming practices of livestock and vegetable production systems presents smallholder farmers with sustainable ways, options and processes to create value and be competitive within the complex socio-economic environment. Harnessing aquaculture by smallholder farmers creates opportunities for them to be integrated into the green growth and markets (Denicoló & Zanchettin, 2016) through widening their products, optimally utilising the scarce water and land resources in a more efficient way as was also noted by Bock, Eisengerich, Sharapoy & George (2015).

The integration of aquaculture by smallholder farmers is beneficial as it will mitigates the effects of climate change and variability, water scarcity, and the current low productivity challenges (Gulnara and Ramona, 2024). Such innovations will diversify their economic options through increased food production, availing new food products and income that can strengthen households' food and nutrition security and food systems. This ultimately have long-term social and environmental benefits within the "meeting the needs of present generations without compromising the needs of future generations" context.

Aquaculture is an intensive fish and vegetable production system and recycles water at a rate up to 95 to 99%. The system produces fish and crustaceans in fishponds with water from the ponds used to irrigate the vegetables cultivated in a medium other than the soil. This innovation produces fish and vegetables using less land and water and gives households control over their food systems. The vegetables can as well be used to feed goats with the manure from the goats being used as fertiliser for the vegetables/ Aquaculture system has potential to contribute to nutrition security challenge in Africa where more than half of the population cannot afford a healthy diet (WWF, 2019). This innovation can ultimately contribute towards the continent's strategy to produce 50% more food by 2050 to meet its food and nutrition needs (WWF, 2019) and can be a solution to persistent climate change and variability challenges.

The aim of this paper is to share the findings from integrated aquaculture, vegetable and goats production projects that were implemented with selected households in Vhembe District Municipality of Limpopo Province in South Africa between 2017 and 2023. The specific objective of the paper is to quantify the socio-economic benefits from the integrated projects on participating households' food systems and economy. Data was collected using a structured questionnaire was administered to participating households as well as discussions with the participating farmers. The results show that there are positive and strong and significant economic gains from the project as well as improvements in household food systems. There are also positive impacts on the environment as water use is being optimised. It is concluded that the integration of aquaculture has beneficial short- and long-term socioeconomic outcomes. Therefore, it is recommended that this can be considered a candidate innovation which can contribute significantly to household sustainable development and ultimately the achievement of selected SDGs.