

BOOK OF ABSTRACTS

International Conference on “Aquatic Resources and Sustainable Management”

August 30- 31, 2023



Venue:
ICAR- Central Inland Fisheries Research Institute
(CIFRI), Barrackpore, West Bengal

Organised By:



International Academy of Science and Research (IASR)
Kolkata, West Bengal

In Association with:



Confederation of Indian Universities (CIU)
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First Edition: August 2023

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Published by:

IASR, Kolkata

West Bengal

E-mail: iasr.conference.info@gmail.com

www.iasr.ind.in

Composed and setting by:

Sindhusarash

Kolkata- 700118

E-mail: sindhusarash@gmail.com



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Confederation of Indian Universities (CIU)

New Delhi

As we approach the Twenty first Century, a number of major challenges face women and men around the world as they interact with one another as individuals, groups, and with nature. Globalisation of trade, of production, and of communications has created a highly interconnected world. Yet the tremendous gaps between the rich and the poor continue to widen both within, and between nations. Sustainable development remains an elusive long-term goal, too often sacrificed for short-term gains.

It is imperative that higher education offer solutions to existing problems and innovate to avoid problems in the future. Whether in the economic, political, or social realms, higher education is expected to contribute to raising the overall quality of life, worldwide. To fulfill its role effectively and maintain excellence, higher education must become far more internationalized; it must integrate an international and intercultural dimension into its teaching, research, and service functions.

The most significant feature of education for mother earth protection in the 21st century is not so much what the French call *li explosion scolaire*, but the knowledge explosion, which has expanded the catchment areas of learning so fast that it takes only a few years now for the state-of-the-art in any field to become obsolete. Different modes and types of communicating for advancement of knowledge are fast changing and becoming more than sophisticated. In this technological era knowledge can easily be dispensed technologically and electronically. Teachers and formal school structures are becoming less important, and the conventional age limits on the learning process are becoming blurred.

Viewing the urgent need for mutual and technical cooperation among the Universities in India, exchange of information, export and import of educational know-how and consultancy, control on duplication of efforts and wastage in higher education, vocationalisation of existing careers besides strengthening the financial health of the existing Universities for implementing educational programmes having social, cultural, technical, economic and positive contents for the optimum development of our country, the “Confederation of Indian Universities (CIU)” has been established with the cosponsorship of selected university level institutions in India.

Abstracts

Value Chain Analysis of Aqua-Horticulture in Marginal Areas of West Bengal

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The optimization of the value chain takes on critical significance in the upliftment of the challenges faced by fish farmers and local communities. The value chain, representing the interconnected processes from production to consumption, plays a pivotal role in determining the efficiency and effectiveness of fish farming endeavors. This study will resolve the complicity in fish farming in the water scarce area. In South-Western part of West Bengal, the challenges include the scarcity of water resources, less water holding capacity of soil, utilization of suboptimal fish seed, and lack of proper knowledge of fish feed formulations, all of which pose formidable constraints to effective aquaculture. In response to these challenges, this study introduces realistic strategies to alleviate the constraints and enhance the value chain. Fish hatchery system have been introduced for production of good quality fish seed. This system has improved the aquaculture practices as well as economic condition. Present study addresses a complete knowledge about the fish feed formulation. Formulated fish feed delivered to the fishers and they got good result by applying this feed. Introduction of makhana cum jeol fish in polythenebased tank yield good result. Makhana (*Euryale ferox*) and jeol fish (*Clarias batrachus*, *Heteropneustes fossilis*) both are highly nutritious. This type of culture will improve the socioeconomic condition as well as support their nutritional requirement.

These collective interventions geared towards value chain improvement bear the promise of substantial socio-economic betterment for farmers and the villagers. By bolstering fish production, creating avenues for income generation, and fostering community advancement through economic engagement, the strategies articulated herein strive to effect positive and sustainable transformations in water-scarce South-Western part of West Bengal.

Keywords: *Water scarcity, Hatchery, Feed, Makhana, Jeol fish, Socio-economic upliftment.*

Online Information System with Distributional Mapping for Crustacean Resources Targeted to Shrimp and Prawns From India

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Online information systems in biodiversity science are rising to tackle problems such as environmental change, species conservation policies, genetically modified species traceability etc. In compliance to objectives of Conservation of Biological Diversity, it is essential to mitigate several issues of the biodiversity by providing the up-to-date information to the naturalists and other stakeholders. In Indian context, at present there is neither a single e-resource featured with management and mapping capabilities for shrimp and prawns known from India. The present study discusses development of an online information system for shrimp and prawns known from the Indian waters. For developing the information system, data was collected from the authentic published sources, screened and curated. The open source computational technologies viz. Django and Python for frontend application and MySQL for backend database development were used for realisation of online information system for shrimp and prawns. The information system currently covers 501 species of shrimp and prawns belonging to 152 genera and 31 families reported from the Indian waters and provides information on taxonomy, common name, synonyms, distribution, population status, conservation status, type specimen, morphology, biology and occurrence. The system featured with data and user management capabilities facilitates to update the database by the registered users and provides the up-to-date information. The occurrence data was downloaded from authenticated online data sources and literature and then curated for mapping the distribution of species and shrimp and prawns using geospatial technology. It is believed that the information system for species of shrimp and prawns can be an inexpensive and valuable resource for protection of the sovereign rights for access and benefit-sharing. Further, the system can be used further for predictive modelling and publishing distributional range maps of commercially important and threatened species.

Keywords: *Crustacean, Shrimp and Prawns; Information System; Database; India.*

Pesticides and Heavy Metal Toxicant's Role on Fish: A Review

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Fishes are important sources of proteins, lipids and micronutrients for human. Pesticide and heavy metal contaminant of surface water bodies is the major concern across the world. Their persistent toxicity and the ability to accumulate in water and sediment allow them to become potent toxins. These stressors affect the growth, survival and reproduction of fishes. Data and information source of this review have been collected from the Department of Fisheries (FIQC Laboratories), BCSIR Laboratories, relevant literature, and related published and non-published grey literature. Characterization, entry of the main pesticides and heavy metal in living organism and impact on fishes health are briefly reported. Appropriate measures and environmental laws and fisheries act should be applied to rationalize the use of pesticide in conjunction with alternate method of pest and heavy metal control to protect water the water quality, and to protect fish and humans to mitigate the health risks associated with the human feeding of fish exposed to pesticides.

Keywords: *Pesticides, Insecticides, Herbicides, Heavy metal, Toxicants, Sustainability.*

Lead Nitrate Induced Oxidative Stress in the Liver of *Channa striatus*

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The aim of this study was to find out the adverse effect of lead nitrate with respect to changes in lipid peroxidation and protein carbonylation in fish at laboratory conditions. We have measured lipid peroxidation and protein carbonylation as measures of oxidative damage, in freshwater murrel (*Channa striatus*) with average length of 20-25 cm and weight of 50-60 gm. The fishes were exposed to different concentrations (8 mg/l, 18 mg/l and 28 mg/l) of lead nitrate for a period of 90 days. The levels of oxidative stress biomarkers assayed were significantly increased in liver of fishes exposed to sub lethal concentrations of lead nitrate in proportion to the length of period of intoxication when compared with control group.

Keywords: *Lipid peroxidation, Protein carbonylation, Channa striatus, Liver, Lead nitrate.*

Use of Plant Extracts for Sustainable Monosex Tilapia Culture: An Overview

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The Global market for tilapia, *Oreochromis sp.* is growing at the rate of 10-12% per year. Sex-specific differences in growth are significant in this fish where males grow significantly faster, larger and more uniform in size than females. Many synthetic steroid hormones and chemotherapeutic agents are used in tilapia culture to produce monosex fish, achieve higher growth, enhance feed conversion ratio and improve lean muscle mass. However, due to consumer concerns and strict regulations in many countries, the use of synthetic chemicals, hormones and antibiotics is becoming unviable and natural compounds are more acceptable to the public. A wide variety of chemical compounds such as alkaloids, flavonoids, pigments, phenolics, terpenoids, steroids and essential oils are found in plants, and many of them have been shown to have beneficial effects on appetite, growth and the immune status of fish. The phytochemicals may also act as endocrine modulators that can be applied for production of monosex tilapia population. Different mechanisms such as the effects at the steroid receptor level, effects on steroid synthesis, distribution and excretion, actions on the hypothalamus–pituitary–gonad axis have been postulated for the reproductive endocrine disruption in fish populations by phytochemicals. But, there are significant variations regarding the efficacy of different phytochemicals for production of all-male fish population and the potential anabolizing and virilizing effects of such plant extracts needs to be clearly documented.

Plants such as *Basella alba* (leaves), *Tribulus terrestris* (seeds), *Mucuna pruriens* (seeds) and *Asparagus racemosus* (roots) have been evaluated for their efficacy to induce sex reversal, growth and immunostimulation in Nile tilapia. Dietary administration of *Basella alba* leaves ethanol extract (1.0 g / kg feed, EB), *Tribulus terrestris* seeds ethanol extract (2.0 g / kg feed, ET) and *Asparagus racemosus* roots methanol extract (0.2 g / kg feed, MA) for 30 days followed by basal diet for 90 days resulted in significantly ($P<0.05$) higher male (%), final weight (g), final length (mm), weight gain (g), specific growth rate (%) compared to control. Interestingly, dietary administration of *Mucuna pruriens* seeds methanol extract (0.2 g / kg feed, MM) could produce ~ 90% males after 30 days of feeding with plant extract fortified diet, but the male percentage reduced to ~55% at the end of 120 days grow-out period. EB and MA showed significantly ($P<0.05$) better immunostimulatory (phagocytic, lysozyme activities, respiratory burst), haematological, antioxidant and hepatoprotective activity compared to other treatment groups. EB, ET and MA showed significantly ($P<0.05$) higher level of GH, IGF-1, 11-KT compared to control and MM.

The growth and health promoting, and immunostimulating efficacy of plant extracts may be attributed to presence of steroidal saponins and polyphenols in them. Hence, the four crude plant extracts were subjected to bioactivity guided fractionation through column and thin layer chromatography (TLC) to identify the androgenic phytoconstituent in the extract. Fractions yielding the highest male percentage for each plant were subject to gas chromatography-mass spectrometry (GC-MS) analysis. The *in silico* docking and SwissADME study were conducted with the components showing higher peak percentage in chromatogram.

After column chromatography and TLC analysis, EB, ET, MM and MA yielded 6 (EB1 - EB6), 8 (ET1-ET8), 14 (MM1-MM14) and 5 (MA1- MA5) fractions, respectively. Fish fed EB2, ET2, MA2 and MM13 fraction fortified diets for 30 days showed significantly ($p<0.05$) higher male percentage (92.32% – 98.39%) compared to other treatment groups. EB2, ET2, MA2 and MM13 fed fish showed significantly ($p<0.05$) higher 11-KT level compared to control male and lower E_2 level compared to control female. Aromatase mRNA expression was significantly ($p<0.05$) down-regulated by all these four fractions (-1.32 – -5.65 fold) with respect to control female. GC-MS analysis revealed the presence of 1-Octadecene (OD) in EB2, Phenol, 2,4-bis(1,1-dimethylethyl) (PD) in ET2 and MA2, 9,12-Octadecadienoic acid (Z,Z)- (ODDA) in MM13. *In silico* molecular docking indicated that PD is more effective than ODDA and OD to inhibit aromatase. In addition, PD showed better pharmacokinetics and more drug-likeness compared to OD and ODDA in SwissADME analysis.

Collectively it can be concluded that ET and MA are more potent to produce all-male tilapia by means of aromatase inhibition. However, EB and MA were more potent in growth promotion, immunostimulation and adaptogenic potential compared to other two plant materials. Thus, administration of *Asparagus racemosus* roots methanol extract (0.2 g / kg feed) fortified diet for initial 30 days followed by basal diet for subsequent grow-out period may be advocated for sustainable monosex Nile tilapia culture.

Keywords: *Oreochromis niloticus*, Sex reversal, Growth, Immunostimulation, Phytochemicals.

Effect of Diplostomulum Infection On Fresh Water Fish Heteropneustes Fossilis in Darbhanga, Bihar

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Fish is the master of aquatic life, which serve as hosts to a range of parasites that are taxonomically diverse and that exhibit a wide variety of life cycle strategies. Many of these parasites are passed directly between ultimate host whereas other need a series of intermediate hosts. Parasites thrive primarily in a dynamic equilibrium with their host(s) and they are often overlooked in fish health assessments. The damage associated with the fish host is relative to the intensity of infection and severity of infection of parasite. Infection with parasite *Diplostomulum metacercaria* can lead to severe skin and other tissue pathology and change the haematological and biochemical parameters of *Heteropneustes fossilis* which may result in host mortality.

Keywords: *Diplostomulum*, *Heteropneustes fossilis*, Haematology, Biochemistry, Skin.

Co-Culture of *water mimosa* with Small Indigenous Freshwater Species (SIF)

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Small indigenous freshwater species normally grow 25-30 cm in mature or adult stage and in habits in rivers, tributaries, floodplains, ponds, tanks, beels, lowland areas, wetland and paddy fields. On the other hand *water mimosa* are edible aquatic medicinal plants grows throughout the year in low laying lands which have a good market demand in Tripura. In the present study we co-culture water mimosa and SIF in earthen ponds 200 m² and depth 2-3 feet in duplicate with a control SIF without water mimosa. The main aim of the experiment was to investigate the effect of *water mimosa* in the total productivity of water body. The SIF of 50±10g and *water mimosa* (70±5g) were stocked in treatment group and without water mimosa in control. The fish were fed with rice bran and mustard oil cake (1:1) ratio twice a day. Feeding was maintained at 5% body weight. After six month of culture period fish were harvested by dewatering the tank. A total of 5.2±0.1 kg of SIF harvested from the all pond i.e both from treatment and control group. Additionally 5 kg of *water mimosa* were produced from treatment pond. The experiment suggests that the seasonal or waste waterlogged water bodies consist depth between 2-3 feet can be utilised for production of SIF and edible aquatic plant like *water mimosa* for sustainable management and maximum aquatic resource utilization. The technology will increase the total productivity of aquatic resources.

Keywords: *Edible aquatic plants, small indigenous freshwater fish, seasonal water bodies, resource utilization, productivity.*

Impact of Sustainable Aquaculture Technologies on the Productivity and Economic Potential in Small-Scale Farming: A Study Framework in the Districts of West Bengal, India

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Food security and poverty have been a central challenge to the world development agenda. The principal themes have emerged considering the growing population and changes in the world economy, technology, and the environment. In recent years, there has been an increasing interest in the principles of the ecological approach to aquaculture for the sustainability of the fishing industry. It implies looking into aspects of aquaculture production from broader social and environmental perspectives. For this purpose, the present paper reviews an integrated ecological-economic modeling framework for sustainable small-scale fish farming. According to reports from FAO of the United Nations, small-scale fisheries make up 40% of global fisheries catch. Small scale means a family-community based, low cost, low technology effort but substantially contributes to job creation and human diet enrichment. This sector needs sustainable resource management with an improved understanding of complex ecological processes and socio-economic drivers shaping human-environment interactions. Although technologies related to sustainable aquaculture have been well-defined, there is a lack of information on how these technologies have been adopted in the small-scale sectors in India. The present paper first reviews small-scale fisheries' sustainability measures and compares their utility. Then it highlights a modeling approach where the farmer's decision was modeled using hydrological, biophysical, and economic determinants. The results indicate the potency of the approach's economic and ecological viability, which reach the optimum goal of sustainability. Therefore this study builds a potential platform for adopting green technology through an integrated modeling approach to benefit the small-scale fisheries sector in the districts of West Bengal, India.

Determination of Withdrawal Period of Antibiotic Enrofloxacin in Catfish *Pangasianodon hypophthalmus* for Consumer Safety

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Enrofloxacin, a third generation fluoroquinolone carboxylic acid derivative, finds its substantial use in Asia in controlling finfish bacterial diseases like Bacillary Necrosis of Pangasius (BNP) and Motile Aeromonad Septicemia (MAS). The current study aimed in determining the withdrawal period of enrofloxacin in intensively cultured catfish *Pangasianodon hypophthalmus*. Fish with average weight of 40 ± 5.5 gm were offered with medicated pelleted feed following the therapeutic dosage regimen of 10 mg/kg body weight for consecutive 5 days. Sampling was done at 0, 4th, 8th, 12th, 16th, 20th, 24th, 28th, 32nd, 36th, 40th, 44th day after cessation of drug administration and the drug residues in fish muscle were analyzed by Liquid Chromatography coupled to Mass Spectroscopy (LC-MS/MS). On last day of treatment, i.e., “zero” day of withdrawal, drug concentration in muscle was 2829.015 ± 243.5 µg/kg which gradually decreased to 212.97 ± 19.43 µg/kg after 45 days. The drug residue level detected till 44 days of withdrawal was above the Maximum Residue Limit (100 µg/kg) set by the Commission of the European Communities and also action level assigned by the US Food and Drug Administration (5 µg/kg) in fish for human consumption. A few other studies also have estimated long withdrawal periods for the antibiotic. Since 45 days is a considerable long time when the fish grows substantially and may reach market size, present study does not recommend use of the antibiotic for health management of *P. hypophthalmus*, or more extended withdrawal period, to be determined by further studies, may be followed for consumer safety.

Keywords: *Pangasius*, *Fluoroquinolone*, *Spectroscopy*.

Traditional Fishing Gears of West Midnapore District, West Bengal, India and Sustainability Issues

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Fishing is a significant economic activity and a primary source of livelihood for many communities in West Bengal, India. The fishers of West Midnapore Districts, West Bengal, use different types of traditional trapping devices to capture fishes. The gears and trapping devices are indigenous in origin, mostly made up of bamboo, nylon threads, cane, jute, rope, metal hooks, metal loads, metal spears, floats etc. The socio-economic condition in rural areas of West Midnapore District is poor. Tribal people of the districts mostly depend on the traditional fishing which is the only source of protein food for the tribal people of the district and backing to the local economy and overall fish production. The study reveals that different types of gill net (koraljal, shahinjal, current jal) with varying mesh sizes contributes most of the capture fisheries of the district in ponds, beels, dams, rivers, irrigation canals. On the other side, seine net (berjal, gherjal, jagatberjal) contributes next to the gill net mostly in ponds, beels and rivers. The cast is also popular to the fishers, locally known as jakijal, kheplajal or bacharijal with varying sizes, used mostly in ponds, rivers, dams, streams and irrigation canals. The traps on the other hand like cylindrical trap (tapa, kuni, baha), box trap (gonda, gui), aerial trap (dolonga), plunge basket (polo, chakjal), shelter trap (tack) are used in shallow water bodies like paddy fields, entry of exit of the small canals, flooded shallow areas of the monsoon season. Hooks and line is also important and preferred to the fishers of the area throughout the year in any water bodies. Spear or wounding gears made from locally available materials are used mostly in monsoon season in shallow areas to capture large fishes. However, introduction of mosquito nets, traps made with mosquito nets other than bamboo, fish poisons in recent decades led to gradual reduction of the fish catch in West Midnapore District, and sustainability of the fishing as traditional livelihood is in stake.

Keywords: *fishing traps, nets, tribal people, socio-economics, sustainable fishing.*

Comparative Studies on Synergistic Effects of Fishmeal Sericilin and Bone dust Sericilin for Controlling Nuclear Polyhedrosis (Grasserie Disease) of Silkworm *Bombyx mori* L

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The study was focused on to find out best combination of cost effective, user friendly as well as eco-friendly bio active compound among available to control Grasserie. Simple rearing conducted in both favourable and unfavourable rearing season using the fishmeal Sericilin and bone dust Sericilin to control Grasserie.

Treatment of fishmeal Sericilin performed better than bone dust Sericilin for both favourable and unfavourable rearing season

As traditionally available disinfectants are of high cost and hazardous to its user as well to the environment, this type study is unique in its application and investigation. The activity of Fishmeal was found to be significantly higher in comparison to bone dust based Sericilin particularly in unfavourable rearing season. Further investigation is in progress at molecular level to assess the qualitative and quantitative impact of Sericilin with Sericilin in controlling Grasserie. The control and prevention of various infections during silkworm rearing helps to increase the silk productivity by preventing the mortality to a great extent. In a view, use of this application of Sericilin with fishmeal during rearing improves the larval growth and development as well as preventing the infections and also improves the productivity of the silk resulting in the sustainable developmental improvement of sericulture industry in Indian subcontinent.

Keywords: Silk worm: *Bombyx mori* L, Nuclearpolyherosis (Grasserie Disease), Fishmeal, Sericilin.

Sub-Lethal Exposure of Bifenthrin Disrupts Cytochrome c oxidase Activity and Changes Mitochondrial DNA Copy Number in *Puntius sophore*

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Bifenthrin (BF), a pyrethroid insecticide renowned for its potent insecticidal activity, photo stability, and low toxicity in mammals, has found extensive use in agricultural production worldwide. Unfortunately, the widespread application of these insecticides has led to the contamination of aquatic environments, posing a significant threat to aquatic organisms and steadily depleting their diversity. Even minute concentrations of BF in aquatic ecosystems raise concerns about potential ecotoxicological effects on non-target animals. This concern arises from the limited activity of metabolizing enzymes like esterases, dehydrogenases, and mono-oxygenases, which are less effective at detoxifying synthetic pyrethroids (SPs) in comparison to birds and mammals. Previous studies have attempted to identify biomarkers of BF-induced toxicity in aquatic species, such as oxidative stress induction, developmental malformations, and neurotoxicity. However, the use of mitochondrial DNA (mt-DNA) variation as a potential biomarker of pesticide-induced aquatic toxicity remains largely unexplored. Therefore, this study aimed to investigate the correlation between BF toxicity and mtDNA copy number variation in the edible fish *Puntius sophore*. The 96-h LC₅₀ of BF in *P. sophore* was 3.4mg/L, then fish was treated with sub-lethal doses (0.34mg/L 0.68mg/L) of BF for 15 days.

The findings of this study revealed a reduction in mtDNA copy number in the muscle, brain, and liver tissues of *P. sophore* following BF exposure through ddPCR analysis. This reduction in mtDNA copy number led to functional impairments in the mitochondrial electron transport enzyme complex IV. BF also induced oxidative stress, evidenced by elevated lipid peroxidation and disrupted antioxidant enzyme activity. BF induced oxidative stress and neurotoxicity were assessed by measuring AchE activity in brain and muscle cells. Additionally, an *in-silico* approach provided insights at the molecular level, confirming that bifenthrin binds specifically to the enzyme cytochrome c oxidase, likely at its active site. This binding partially inhibits the enzyme's activity and expression, resulting in mitochondrial dysregulation. In conclusion, the study suggests that the downregulation of mtDNA copy number and mitochondrial Complex IV activity could serve as potential biomarkers to assess bifenthrin-induced toxicity in aquatic ecosystems. The outcome of the study will help to assess the environmental toxicity customized for widely used pesticides.

Keywords: Bifenthrin, Toxicity, mt-DNA copy number, mitochondrial dysfunction, Molecular docking.

A Contemplation on the Histopathological Alternations in *Oreochromis niloticus* challenged by Tartrazine Stress

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Tartrazine is a synthetic chemical compound, a monoazo and pyrazolone family dye which is lemon yellowish and orange in color. The IUPAC name of it is chemically expressed as -Trisodium-5-hydroxy-1-(4-sulfonatophenyl)-4-(E)-(4-sulfonatophenyl)diazenyl-1H-pyrazole-3-carboxylate (C₁₆H₉N₄Na₃O₉S₂). Its molecular weight is 534.3 KD. It is water soluble with maximum absorbance at 425 nm in aqueous solution. It is also commercially known as ISN No 112, FD&C Yellow No. 5, E 102, CAS No. 1934-21-0, CI 19140. It is used in ice creams, desserts, Biryani, Pulaw or sweet yellow rice, mountain dew, popcorn, chewing gums, fruit cordials, fruit fermented alcohol based beverages, cotton candy, puddings, laddu-modaks, jelly, pickles, marmalade, Maggie masala, instant soups, custard faluda powder and many more as it brings yellowish and greenish brown color.

Our focus is on the exposure of fishes in the medium contaminated by tartrazine concentration significantly. From public hotels and restaurants, a huge amount of left over stale foods as well as processed by product liquids from public hotels and restaurants, a huge amount of left over stale foods as well as processed by product liquids from kitchens are discarded into local streamlines on a regular basis.

Tartrazine is a chemically proven strong mutagen and carcinogen. Fishes, upon exposure might show variable histopathological symptoms and genetic anomalies & alternations, might be a strong indication of necrosis, which is yet to be discovered.

In order to study the histopathological effects of tartrazine, the fishes of lentic wetlands to be studied as experimental population in comparison to those of the fishes of lotic zones as control group. As fishes generally either intake water contaminated with tartrazine through gills and mouth or by their food directly mixed up with this chemical. Generally it falls under naturally biodegradable products, still they are recalcitrant and bio-accumulative, so they cause biomagnifications in fishes, getting incorporated into genetic level.

Our aim is to study the alternations in histochemistry of various organs tissue of *Oreochromis sp.* of both sexes in order to establish any probable relation between the concentration of tartrazine consumption and organum dystrophy, atrophied changes, induced atresia, changes in fecundity schedule, gametes viability and general ethological responses against this chemical in a dose dependent manner. These alternations in histochemistry and physiology clearly indicate the effect of exposure of food colorants in fish health.

Environmental Risk Assessment of Aquatic systems under Sewage Enriched Aquaculture in Relation to Public Health

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Patterns of Environmental Risk Assessment (ERA) evaluate the likelihood of ecological hazards to organisms or communities upon exposure to toxic contaminants. For regulatory purpose, a safe Human concentration level as benchmark can be calculated for a given environment. In aquatic systems used for fish culture, such benchmark values must be established as a safeguard measure for human consumption of fish as a source of protein. The development of aquaculture as a food production sector poses certain risks to the natural environment and human health. A thorough review of existing research in this direction has been undertaken in the present study to highlight the current information at a global scale. Although a detailed account is available in various publications and studies over last few decades, the use of analysis to identify potential hazards and to assess and manage environmental risks associated with aquaculture development is relatively very few, particularly in Indian context. It is opined that the risk analysis is a tool to achieve sustainable aquaculture in a most effective manner. Since such analysis is site specific, this present research design envisages a quantitative and qualitative assessment from sewage fed aquaculture systems of various concentration regions for toxic metals. Initially, an ecological risk assessment is attempted, that mainly covers the hazards on ecosystem and organisms of different trophic levels of ecological value. This can further be extended for a human risk assessment for better policy formulation. From our study, we conclude that the potential hazards from aquaculture and their impacts depend upon the species, culture technology, and management practices as well as other non-technical issues like human capacity and institutional capacity. Therefore, the risk assessment becomes difficult to quantify given the present state of scientific knowledge and lack of skill. Thus, this paper not only addresses the technology involved but also develop a method for effective communication to explain how sustainability of aquaculture development can be coupled with ERA as a good measure.

Plankton Diversity in and Hydrobiological Parameters at Tajewala Barrage in Yamuna River, Haryana

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The plankton community plays a significant role in the stability of freshwater and marine ecosystems. They serve as key players in marine food webs. Plankton can be categorized into two major groups: Phytoplankton and Zooplankton. The present study investigated plankton diversity and hydrobiological parameters at Tajewala barrage in the Yamuna river. The qualitative analysis of samples found that phytoplankton in the Barrage consisted of a total of 59 genera belonging to five major classes: Bacillariophyceae (21 genera), Chlorophyceae (24 genera), Cyanophyceae (10 genera), Euglenophyceae (2 genera), and Dianophyceae, which is represented by one genus. The zooplankton comprised a total of 16 genera belonging to Protozoa (2 genera), Rotifera (4 genera), Copepoda (6 genera), and Cladocera (4 genera). The percentage variation of phytoplankton in different groups, i.e., Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, and Dianophyceae, was 41 percent, 36 percent, 17 percent, 4 percent, and 2 percent, respectively. The zooplankton showed a percentage variation of different species groups: Cladocera (50 percent), Copepoda (25 percent), Rotifer (17 percent), and Protozoa (8 percent). The range of the Shannon and Weaver Diversity Index for phytoplankton varied from 1.081 to 1.283, and the Diversity Index for zooplankton varied from 1.261 to 1.370. The temperature ranged from 17.48 ± 0.04 to 26.39 ± 0.02 °C, pH ranged from 7.12 ± 0.02 to 7.62 ± 0.04 , salinity ranged from 0.125 ± 0.01 to 0.156 ± 0.01 ppt, Dissolved oxygen ranged from 5.32 ± 0.08 to 6.57 ± 0.18 mg/l, Electrical Conductivity ranged from 182.70 ± 4.64 to 323.75 ± 14.91 μ S/cm, Total Dissolved Solids ranged from 36.6 ± 2.115 to 100.15 ± 9.895 mg/l, and Ammonia ranged from 0.188 ± 0.05 to 0.348 ± 0.02 mg/l. The presumptive coliform count ranged from 43 to 93 Most Probable Number per 100ml, and the differential coliform count was 4 to 15 Most Probable Number per 100 ml of water sample.

Keywords: *Plankton, Diversity, Phytoplankton, Zooplankton, Coliform.*

Assessment of Land Use Change Impact on Wetland Surface Water Quality Scenario through WQI and Prediction through Artificial Neural Network

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The present study deals with water quality assessment and estimation of the Water Quality Index (WQI) for three different seasons. Topographic sheets from Survey of India and ArcGIS 9.3 software have been used for generating interpolated maps. Inverse Distance Weighted (IDW) method has been used to derive the spatial distribution of WQI. Water samples have been collected from fifteen different sites across Suraha Tal. Physicochemical parameters like Temperature, pH, Electrical Conductivity, Total Alkalinity, Total Hardness, Total Suspended Solid (TSS), Biological Oxygen Demand (BOD), Total Dissolve Solids (TDS) and Dissolve Oxygen (DO) have been analyzed. The WQI result signified the water samples under the bad or poor category using two well-known methods and thereby suggesting the wetland water to be unsuitable for drinking purposes and also a threat to the flora and fauna nourishing there. Simulation of the 10 water quality parameters has been made using Artificial Neural Network (ANN) from year 2000-2018 applying Feed Forward Back propagation network architecture. A socio-economic survey has been made to bring awareness among the local people towards the sustainable management of the wetland and identification of the potential sites for the construction of a constructive wetland has been made as a measure of mitigation. On a priority basis wetland management through scientific filtration techniques is in urgent need for refining the water quality as well as for maximum utilization of water resources of the aforesaid wetland by the thriving organisms and habitats.

Keywords: *Water Quality Index, Geographical Information System, Physicochemical Parameters, Surface Water Management, Inverse Distance Weighted, Suraha Tal.*

Azolla: An Alternative Solution in Nutrition and Environment Management in Aquaculture

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In the last decades, the demand for healthy food like protein from aquaculture has increased in the global. In 2020, the global apparent per capita consumption was 20.2 kg, a rate almost twice that of annual world population growth for the same period, and following this market demand the total world aquaculture production registered 178 million tons of aquatic animals (FAO, 2022). Aquaculture is the fastest in food producing sector. Success of an aquaculture system depends upon some important factors. Nutrition and environment are top two crucial factor. In Nutrition we have to maintain proper balance diet with sufficient protein. Fish feed quality and cost mainly depend upon protein sources. From conventional protein sources the cost of fish feed increased day by day and it leads the loss in aquaculture sectors. Water quality also deteriorated by the conventional feedstuffs. In this situation Azolla is a solution. Azolla is a genus of aquatic ferns and small leafed floating plants, native to the tropics, subtropics, and warm temperate regions of Africa, Asia, and America. It is very sensitive to lack of water in aquatic ecosystems such as stagnant waters, ponds, ditches, canals or paddy fields. Azolla is the one of the world's fastest growing aquatic macrophytes which can be doubling in only 2-5 days. Azolla can be used either directly or indirectly in the fish pond, due to higher percentage in nutrients composition on dry weight basis and other constituents such as minerals, chlorophyll, carotenoids, amino acids, and vitamins. It can be used as fish food in Azolla-fish Pond culture and contributes directly to weight gain of macro phytophagous fish. It has been reported that, Azolla tends to increase production of fish faeces which directly consumed by bottom dwellers which in turn used as an organic (nitrogenous) fertilizer to increase overall pond productivity. Azolla seems to be good substitute of protein up to certain percentage in place of expensive sources such as fish meal depending on feeding habits of the species. Azolla will help to manage the environment of pond in low hazards and sustainable way. The dietary Azolla supplementation has a positive effect on growth performance of fish and reduce the cost of feeding due to fish meal and fish oil diet.

Keywords: *Azolla, Pond environment, Aquaculture, Management.*

Spatio-Temporal Variation of eggs and Larval Fishes Concerning Environmental Variables in a Tropical Mangrove Estuary, Karanja, India

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Unambiguous identification of ichthyoplankton (eggs and larval) can provide vital information about preferential spawning and nursery grounds, reproductive period, and migratory routes of commercially important and ecologically endangered species. This study aimed to identify fishes' potential spawning and nursery grounds in the Karanja mangrove estuary and their relationship with the environmental variables. A total of 25 ichthyoplankton taxa were identified using morpho-meristic and molecular methods. The present finding revealed the evidence of *Osteomugil perusii*, *Tridentiger barbatus*, *Planiliza tade*, *Lutjanus johnii*, *Mugilogobius rambai*, *Terapon jarbua*, *Acanthopagrus latus*, and *Dendrophysarusselii* species, not usually reported from the Karanja estuary, implying that these species might have migrated for spawning in the estuarine ecosystem. Canonical correspondence analysis (CCA) revealed that temperature, salinity, pH, and essential micronutrients (phosphate and nitrite) influence the estuary's ichthyoplankton dynamics and recruitment process. Based on the above finding, we can pinpoint Karanja estuary as a potential breeding and nursery ground for many commercially important fish species, and proper conservation efforts must be addressed to protect the matured individuals during the breeding season. The present findings also confirm the efficacy of DNA barcoding in identifying ichthyoplankton and strengthening the nucleotide databases in poorly studied areas along the Indian coast. The DNA sequencing of the COI gene indicates over 98% similarity. This information will serve as baseline data in ecological monitoring, environmental impact assessment, and the development of effective conservation and management plans for the sustainability of the resources.

Keywords: *Ichthyoplankton, Breeding ground, Ecological monitoring, Migratory routes, COI gene.*

Effect of *Moringa Oleifera* Extract on Quality of Minced Meat from *Pangasianodon hypophthalmus* During Frozen Storage (-18±2°C)

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Fish is one of the most nutritionally valuable and highly perishable food stuffs. The rapid deterioration of quality of fish and shellfish is mainly due to the various mechanisms of spoilage leading to reduction in quality attributes and wastage. *Moringa oleifera* commonly known as drumstick, is native to India, Africa and South East Asia which is used as antimicrobial and antioxidant bio-preservatives. *Moringa oleifera* contributes taste and aroma to the food and it also contains a variety of bio active substances helping in extending the shelf life of food products. In the present study, three different concentrations (5%, 10% and 15%) of *Moringa oleifera* leaves extract were used as antimicrobial and antioxidant agent to study the shelf life of minced meat prepared from *Pangasianodon hypophthalmus* during frozen storage. Extract of fresh leaves was observed to have a wide range of antimicrobial activities against both gram positive and gram-negative bacteria in disc diffusion assay. The meat samples treated with crude extract of drumstick leaves showed significantly improved values of the quality parameters such as TVBN, TMA, TBARS as compared to control throughout the frozen storage period. Microbial load in terms of Total Viable Count (TVC) was also found to be reduced significantly ($P < 0.05$) in treated samples. This indicates that the phenolic compounds of leaves extract resulted in microbial inhibition, reduction in lipid oxidation, protecting muscle against the internal protease and finally inhibit protein breakdown as well as amine production. It may be concluded that 15% concentration of the leaves extract of *Moringa oleifera* gave the best result in minced meat prepared from *Pangasianodon hypophthalmus* during frozen storage (-18±2°C) and hence could be used as an effective natural and herbal preservative.

Keywords: Drumstick, antimicrobial, Total Viable Count, preservative.

Impact of Extended Oral Enrofloxacin Administration on Safety, Plasma Biomarkers and Erythro-Morphology of *Oreochromis niloticus*

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The fisheries industry has a notable impact on the economy, as well as on the security of food and livelihoods. It contributes to earnings and prosperity by providing nourishing food. Currently, the cultivation of tilapia is gaining significant interest across various Southeast Asian nations. As a result, tilapia stands as the second most commonly farmed fish, right after carp, in this region. This research investigated the safety implications of administering enrofloxacin (ENF) orally for a period of 15 days, at 0, 10, 30, 50 and 100 mg/kg biomass/day, i.e., 0 $\times$, 1 $\times$, 3 $\times$, 5 $\times$ and 10 $\times$ the therapeutic dose ($\times$: 10 mg/kg body weight/day) in *Oreochromis niloticus* juveniles. The study focused on observing changes in behaviour, feed consumption, mortality rates and biomass. Additionally, it analysed various parameters such as plasma glucose, calcium, chloride, creatinine, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase levels and the morphology of blood cells at designated time intervals. Administering oral ENF for a duration of 15 days led to mortality rates ranging from 1.33% (1 $\times$) to 6.67% (10 $\times$) dose. The fish with therapeutic dose experienced a 3.6% increase in biomass, whereas the control group exhibited a higher increase of 8.4% in biomass over a span of 15 days. This process also resulted in decrease in feed consumption in a dose-dependent manner. During the 15-day ENF-dosing period, the decrease in feed intake was approximately 8% higher in the 10 $\times$ group when compared to the group receiving the therapeutic dose. Erythrocyte morphological changes in the 1 $\times$ group showed few noteworthy changes compared to the control. However, distinct morphological alterations like crenations in cell membrane, teardrop-like cells, cytoplasmic degeneration, vacuolation and nuclear aberrations increased in severity with both dose and time dependent manner, suggesting a potential cytotoxicity linked to higher ENF doses. All plasma biomarkers exhibited a significant increase on both day 5 and day 15 of ENF-dosing, following a dose-dependent pattern. However, there were exceptions with calcium and chloride, which experienced significant reductions during the dosing period. Upon cessation of ENF-dosing, plasma biomarker levels began to revert to their normal levels with calcium and chloride levels fully returned to normalcy. Except The recovery of biomass, mortality, feed intake, plasma biomarker levels and erythrocyte morphological changes indicated that the alterations caused by ENF were reversible. As a result, this study confirms the safety of ENF at the therapeutic dose in *O. niloticus*.

Keywords: Nile tilapia, Antibiotic, Biosafety, Haematology, Erythrocytes.

Enhancement of Fish Production by Qualitative Improvement of Planktons Using Organic Manures in Carp Culture

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Organic manure is widely utilized directly as food for invertebrate fish-food organisms and fish, but they are intended primarily to release inorganic nutrients for phytoplankton and zooplankton growth. Phytoplankton and zooplankton are rich source of protein, is sufficient to support excellent fish growth. The present experiment was undertaken to study both qualitative and quantitative analysis of various groups of phytoplankton and zooplankton, their protein concentration and also the growth performance of the experimental fish *Cirrhinus mrigala* receiving different organic manures. Cemented cisterns (180 L) were treated with 2 different types of organic manures viz., cowdung (T_2) and poultry manure (T_3) along with control without manure (T_1). Each cistern was provided with an uncontaminated soil base of 15 cm with borewell water. The amount of different organic manures was applied on isonitrogen basis considering 10,000 kg/ha of each as the initial dose. Periodical manuring was done at the rate of half of the initial dose at monthly intervals. No supplementary feed was applied during this period. Total phytoplankton and zooplankton volume were found to be higher in poultry manure followed by cow dung and control. The highest average protein concentration ($\mu\text{g/ml}$) in plankton was recorded in poultry manure (0.5154 ± 0.007) followed cowdung (0.2072 ± 0.0007) and lowest in control (0.0318 ± 0.0002). The total yield of fish was also highest in the system with poultry manure (4963.2 kg/ha/90 days) as compared to cowdung (2440.8 kg/ha/90 days). The present study thus clearly demonstrates that carp production under similar culture conditions can be greatly enhanced using poultry manure and cowdung by increasing nutrient availability to fish.

Keywords: *Cowdung, poultry manure, natural food, protein, fish yield.*

Comparative Evaluation of Toxicity of Chlorpyrifos and Cypermethrin to Fresh Water Major Carp, *Labeo rohita*

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Chlorpyrifos (organophosphate) and Cypermethrin (synthetic pyrethroid) are two most commonly used insecticides in agricultural fields to control insect pests. Agricultural run-offs carrying these two insecticides contaminate natural water bodies on a regular basis. Therefore, an attempt has been made to evaluate toxicity of these insecticides to freshwater major carp, *Labeo rohita*. 96h LC_{50} of chlorpyrifos and cypermethrin to *L. rohita* was 36 μ g/L and 2.90 μ g/L respectively. When the LC_{50} values of both insecticides were compared, it was revealed that cypermethrin was more toxic to *L. rohita* than chlorpyrifos. There was almost no difference between the two insecticides in terms of stress-induced changes in behaviour, haematological profile, carbohydrate metabolism, hepatic enzyme activity, and tissue architecture in *L. rohita*. The fish developed anaemia when exposed to sub-lethal concentrations of both the insecticides. Increased activity of aspartate aminotransferase and alanine aminotransferase in the liver suggested increased protein catabolism. Additionally, hepatocellular damage was likely the cause of the elevated hepatic acid phosphatase and alkaline phosphatase activities, whereas oxidative stress was likely the cause of the decreased catalase activities. Both insecticides inhibited acetylcholinesterase activity, and paralytic activities of the mouth lowered the food intake rate of *L. rohita* treated to these insecticides. These findings between the two insecticides showed that the mode of toxicity of chlorpyrifos and cypermethrin to fish was identical. However, long term exposure to 10, 25, and 50% of LC_{50} dose of chlorpyrifos exerted a more negative impact on growth of *L. rohita* (42.55-98.62% weight gain) than the 10, 25, and 50% of LC_{50} dose of cypermethrin (51.79-106.01 % weight gain). The present study also found that LC_{50} value of cypermethrin to *L. rohita* did not change beyond 72 hours. Yet even 10 % of LC_{50} value of cypermethrin considerably decreased growth of *L. rohita*, though in less intensity than chlorpyrifos. The long-term bioassay was performed using pulse treatment, with 20 % of the test water being renewed every 10 days. This condition assured that toxicity was renewed every 10 days and caused some stress, which was reflected in the growth of *L. rohita*.

Keywords: Organophosphate, Synthetic Pyrethroid, toxicity, fish, freshwater.

The Breeding of Angelfish (*Pterophyllum Scalare*) (Schultze, 1823) in Home Environment with Synthetic Hormone

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India offers enormous potential for capturing both freshwater and marine ornamental fish resources, but these breeding units are unable to produce varieties that are in demand on the global market due to a lack of adequate infrastructure and essential inputs like suitable feed and quality stock. The suitable climatic conditions, availability of labour force needed for collecting, ease of breeding and rearing, and high market demand are the variables that play a significant role in luring individuals from many industries to choose to cultivate and propagate freshwater angel fish. In West Bengal, a continual migration from rural to urban areas in search of employment and income led to urban overpopulation and a corresponding decline in the labour force in rural areas. In such a situation, ornamental fish culture and breeding could be an additional source of revenue for the rural populace. An appealing option to preventing such migration is the breeding and culture of ornamental fish, which is an extremely profitable endeavour. Induced spawning experiments on fresh water angelfish, *Pterophyllumscalare* was carried out for the first time using synthetic hormone (sGnRH+ Domperidone). The optimum dose of hormone was standardized based on three experiments, viz., fecundity (relative fecundity) at different doses, response time (hrs.) at various doses and fertilization rate at different doses. Maximum fecundity (665.66) obtained at the dose of 0.35ml/kg of body weight and a significant relation was observed between doses and response time (hrs.) of spawning at 1% level. It was seen that, the hatching rate (%) varied from in different dosages of the synthetic hormone. During this study, a negatively significant relation between dosage of hormone and reaction time was recorded. Hence, the reaction time is much lower after application of hormone. After different dose (ml/kg. of the body weight) of the injection, spawning behaviour of angelfish was seen in the laboratory condition. At higher doses 0.55 spawning was not done as the fishes become severely stressed. Lower numbers of eggs were laid in the doses @ 0.50 ml/kg of Ovaprim, compared to 0.35 ml/kg. of the body weight.

Keywords: Ornamental fish, breeding, sGnRH, induced spawning.

Parasitic Infection of Ornamental Fishes in West Midnapore District, West Bengal in Relation to Water and Soil Quality Parameters

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The present study is based on the identification of common ectoparasites found in ornamental fish from West Midnapore District and the correlation of them with water & soil quality parameters. Exotic ornamental viz. Goldfish (*Carassius auratus*) and Angelfish (*Pterophyllum scalare*) were chosen because they are the most popular ornamental fishes. Total 355 parasites were found fewer than 9 genera. Small white spots were observed and 0.5-0.9 mm round along with crescent shaped nucleus were identified as *Ichthyophthirius* sp. (parasitic prevalence = 16.94%). Cup-shaped with concentric rows of cilia, *Trichodina* sp. was recovered during the study with parasitic prevalence of 6.11%. Sedentary flagellate *Piscinoodinium* sp. (parasitic prevalence = 2.36%) causing velvet diseases, having attachment disc, round and granular, amber coloured body. *Tetrahymena* sp., having single macro and micronucleus, hundreds of cilia and oval shaped body, recorded from different fish host externally. The monogenean *Dactylogyrus* sp. (parasitic prevalence = 6.39%), having 2-4 distinct eye spots and 7 pairs of attachment hooks, found dominant. Another monogenean *Gyrodactylus* sp. (parasitic prevalence = 7.50%), without any eye spot, having 8 pairs of attachment hooks, was recorded from the skin of infected fishes. Anchor shaped large parasite under crustacean *Lernaea* sp. (parasitic prevalence = 3.19%), with large anchor like head, was recorded from the sample fishes. Dorsoventrally flattened, oval and lice like *Argulus* sp. (parasitic prevalence = 1.25%) was found from the skin of infected fishes. Very few *Ergasilus* sp. (parasitic prevalence = 0.28%) were recovered from the gills of infected fishes. Total 93 (12.92%) numbers of ornamental fishes out of 720 selected samples. It was observed that *Carassius auratus* is the most infected ornamental species during the study followed by *Pterophyllum scalare*. Significant correlation was found between the occurrences of parasites and the water parameters like pH, alkalinity, ammonia and nitrite concentration. Though, no significant correlation had been established between the occurrences of parasites and water parameters like electrical conductivity (EC), total suspended solids (TDS), dissolved oxygen content (DO), carbon dioxide (CO₂), hardness, phosphate and nitrite ($P > 0.05$). Additionally, the pH and organic carbon content of soil was found significantly correlated with the occurrences of the parasites in each month during the study period ($P < 0.05$).

Keywords: Aquarium fishes, goldfish, angelfish, parasite, parasitology.

A Serine Alkaline Protease from *Bacillus tropicus* Y14: Screening, Characterisation, Structural Elucidation and Evaluation of Its Application in Nutraceutical Production

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This study was aimed at evaluating the biochemical potential of a serine alkaline protease isolated from kitchen wastewater bacteria *Bacillus tropicus* Y14 for its application in nutraceutical production. The optimum activity of the protease was observed at pH-9.0, temperature 30°C, and after 96hrs of incubation. The purified protease (PrA) was a monomeric protein with a molecular weight of 35kDa. The protease activity of PrA protease was 10.47 folds that of crude protease. The peptide sequence of 45 amino acid residues was obtained from LC ESI MS/MS analysis. The 3D structure was generated by homology modelling. The quality of the model was validated by the Ramachandran plot. The enzyme shows its stability in a wide range of pH, and temperature. The enzyme displays great stability towards inhibitors, organic solvents, surfactants, oxidizing agents, and polyols but it is negatively influenced by Hg²⁺ and PMSF. Inhibition by PMSF, confirms that the protease belongs to the serine protease family. In the presence of 1mM Ca²⁺, thermal activity and stability of the protease get enhanced. The kinetic parameters like V_{max}, and k_{cat}/K_m explain that the enzyme has superior catalytic efficiency which was higher than that of some commercial food grade enzymes. The molecular docking study supported the catalytic efficiency of the protease with the three substrates. The PrA protease also has a promising ability in producing short peptides of fish protein. It hydrolyses fish protein with 26.61±0.16% of the degree of hydrolysis after 240mins which is quite comparable to Alcalase 2.4L (25.13±0.31%) and pepsin (12.15±0.16%). The fish protein ultrafiltrates possess excellent antioxidant and antihypertensive potential.

Keywords: Kitchen wastewater, specific activity, kinetics, molecular docking.

Rodlet Cell and Macrophage Interaction within Olfactory Neuroepithelium can Indicate the Health Status of the Aquatic System?

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In fish chemosensory research, rodlet cell (RC) and macrophage interaction within the olfactory neuroepithelium against pathogenic invasion are not truly addressed in present-day research. Within the neuroepithelium of *Labeo rohita*, the LM and ultrastructure of the rodlet cells and macrophages have been analyzed, and correlate their function with the neural protection of the species. Semithin sections are stained in 2% toluidine blue and viewed under a light microscope (LM: Primo Star; Carl Zeiss Microscopy, GmbH, Germany) and ultrathin sections (70 nm.) are processed and viewed under the transmission electron microscope (TALOS-HR TEM, THERMO SCIENTIFIC) at 200 kV. In *L. rohita* the rodlet cell shows three different stages (viz., immature RC, mature RC, and degenerative RC.) and macrophages are well distributed in the different levels of the olfactory neuroepithelium. Degenerative rodlet cells show holocrine secretion and they prevent pathogen penetration to the nasal passage of the fish. In the advanced stage rodlet cells and macrophages jointly interact against the invasive pathogen for the inactivation of the very foreign substances (antigens). Functional macrophages also act as scavengers within the olfactory neuroepithelium of *L. rohita*. The rodlet cells and macrophages jointly participate in the cell-mediated, non-specific interaction against the invasive pathogens within the olfactory neuroepithelium of fish. This interaction may focus on the status of the aquatic system and its ecology as a whole.

Keywords: *Labeo rohita*, Chemosensory, Neuroepithelium, Macrophage, RC (Rodlet cell), Light Microscope (LM).

Disruption of Ecological Harmony by Bisphenol A via Altering Epigenetics in Ichamati River

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Flowing through the Sundarbans Biosphere Reserve, which is home to many rare species of plants, fish, and birds, Ichamati is a major biodiversity hotspot. Basirhat, Duttaphulia, Hasnabad, and Taki have all experienced significant population growth. At these points, the Ichamati River is especially susceptible to the influx of trash, plastic, and other forms of solid waste from homes, businesses, and factories, as well as abandoned and discarded fishing equipment. Bisphenol-A (BPA), a plasticizer commonly found in municipal wastewater, is toxic to wildlife in the wild. In 2021-22, the Ichamati River in Taki, Hasnabad was sampled at five sites along a 15-kilometer stretch for BPA levels in river water and fish. Detectable quantities of BPA were present in all samples collected from the research location. Site 5 was located further downstream in the river, and its BPA levels ranged from 8.22 ± 2.01 to 31.22 ± 7.14 ng/L on average. Fish (*Labeorohita*, *Labeo catla*, and *Ompok pabda*) were found to have BPA in their livers, muscles, and gills. The highest levels of BPA in the liver were found in *L. catla* (282 ng/g dw) while the lowest values were found in *O. pabda* (15.2 ng/g dw). The average BPA concentration in *L. rohita* muscles was 327.7 ng/g-dw, but in *O. pabda* it was only 86.22 ng/g-dw. BPA levels in the gills of the examined species varied between 25 and 197 ng/g-dw. We measured total DNA methylation and histone modification. Wild-caught fish displayed much more epigenetic variation than commercially-reared fish. Our work is the first to measure BPA in Ichamati River surface water and native fish. The study found that BPA altered epigenetics and caused river ecological disruption, recommending additional monitoring and holistic methods to safeguard aquatic species.

Keywords: *plasticizers, contamination, DNA methylation, histone modification, riverine fish.*

Dynamics of a Bio-indices and Diet Composition of *Pomadasys maculatus* (Bloch, 1793) in Hooghly-Matlah Estuarine Belt of West Bengal, India

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An attempt was made to study seasonal dynamics of bio-indices and diet composition of *Pomadasys maculatus* (Bloch, 1793) in Diamond Harbour estuarine belt of West Bengal. The study was conducted for a period of one year (February 2022 to January 2023) by analysing 492 samples of fish with size ranges of 97 mm to 190 mm (14.07 g to 123.31 g). RLG values varied from 0.6584 to 0.8005 with no significant difference within sex and season. The Hepato-Somatic Index (HSI) varied from 0.4027 to 1.7536 and it exhibited significant difference ($p < 0.05$) during different seasons. The gastro-somatic index (GSI) varied considerably from 0.5666 to 2.8275 with significant difference ($p < 0.05$) in different seasons. The gonado-somatic index (GSI) exhibited significant difference ($p < 0.05$) with values ranging from 0.2740 to 5.9634. SFI varied from 0.0871 to 1.8635 and it differs significantly ($p < 0.05$) between the seasons. The VI varied from 10 % to 75 % with average value of 40.87 %. The stomach of the samples was examined in which, 59.15 % were with food and 40.85 % were empty. The feeding intensity varied considerably both season wise and size wise. Fish with the higher feeding intensity occurred in December for male and that of female in January. The main food items in the gut content were shrimp remains followed by fish remains, semi-digested shrimp, *Acetes* sp., semi-digested fish, etc. Other items like ribbon fish, pony fish, *Bregmaceros* sp., *Sepia* sp. etc. were also found little amount in the gut indicating its carnivorous feeding habit.

Keywords: *Pomadasys maculatus*, feeding intensity, Diet composition, gastro-somatic index, hepato-somatic index, gonado-somatic index.

Diet Composition and Feeding Dynamics of *Ilisha megaloptera* (Swainson, 1839) Occurring from Hooghly-Matlah Estuary, West Bengal, India

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In the lower portion of the Hooghly estuary, *Ilisha megaloptera* (Swainson, 1839), locally referred to as “Dhela,” makes a considerable contribution in the total fish landing. The species is popular and profitable in the Hooghly estuary system because of its superior taste. Adequate studies on biology of this species are lacking in east coast of India, therefore an attempt was made on the study of its food and feeding habits from February 2022 to November 2022. The study was based on 289 samples of *Ilisha megaloptera* ranging from a total length of 191 mm to 360 mm and total weight of 46.4 g. to 284.37g. The overall percentage composition of diet revealed that crustaceans (49%) dominated the stomach content of *Ilisha megaloptera*, followed by fish remains (16%), semi-digested matter (16%), Nematode worms (10%) and Polychaete worms (9%). Throughout the year, relative length of gut (RLG) values for both sexes were less than one, indicating that *Ilisha megaloptera* is a carnivore. The monthly mean RLG values varied from 0.42559 ± 0.04022 to 0.45223 ± 0.07584 in male and 0.40216 ± 0.01838 to 0.42946 ± 0.023966 in female. The observations on feeding intensity revealed that overall full stomachs were observed more in June (24.32%), $\frac{3}{4}$ full stomachs in March (8.57%), $\frac{1}{2}$ full stomachs in August (13.33%), $\frac{1}{4}$ full stomachs in February (37.83%), and empty stomachs were more pronounced in November (90%). The mean GSI (Gastro-somatic index) values of males ranged from a low in June (1.086225 ± 0.229346) to a high in April (1.54437 ± 0.608032), while female's values were lower in November (0.943623 ± 0.206315) and higher in August (1.766056 ± 1.012131). The HSI (Hepato-somatic index) values for both males and females were highest in October (male- 0.89923 ± 0.31475 , female- 0.965965 ± 0.39397) and the lowest in February (male- 0.319732 ± 0.25224 , female- 0.377329 ± 0.2583). In females, the maximum Index of fullness was recorded in March (0.31817 ± 0.39228) and the minimum in November (0.0065 ± 0.014422) and in the case of males, the highest and lowest values were observed in April (0.38749 ± 0.52826) and September (0.02414 ± 0.050085), respectively. The total Vacuity index (VI) from all the samples collected was observed to be 58.58%, and it was noticed that the vacuity index varied month-wise, with the lowest in March (31.42%) and the highest in November (90%). The current findings show that *Ilisha megaloptera* is a carnivorous fish with preference to crustaceans and teleosts.

Keywords: Dhela, Feeding intensity, Relative length of gut, Gastro-somatic index, Monthly variation.

Addressing the Non-Point Source (NPS) of Pollution on Aquatic Ecosystem: A Systematic Review

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Non-point source (NPS) pollution directly impacts the water quality of aquatic bodies. Eutrophication of lakes and reservoirs is another effect of it. NPS pollution, which affects a body of water from diffuse sources like polluted runoff from agricultural lands dumped into a river, is a type of water pollution. The primary components of NPS pollution in rural areas were sediment, erroneous animal feeding practices, poorly managed irrigation water and fertilizer operations, and improper pesticide use. Numerous diseases affect hundreds of millions of people due to NPS contamination, billions of dollars in investments in economic development are lost, and trillions of dollars in environmental cleanup costs are amassing for future generations to deal with. Only recently has the severity of this harm become completely understood. Therefore, the purpose of this study is to thoroughly review the main effects of NPS pollution on aquatic ecosystems and to provide some best management practises for dealing with the problem. This study uses a systematic review methodology that has been developed by other researchers. To make this study comprehensive, the information on usages of chemicals in fisheries and aquaculture across the globe were gathered from 82 research articles published in different peer-reviewed national (26) and international journals (56), books (6), technical paper (15), and other beneficial scholarly study materials (12), and they were grouped, analyzed, and summarized at par with the objectives of the study. In the study, agricultural runoff and rainfall-runoff volume were discussed as the main sources of NPS pollution load and their effects on water bodies' water quality. Numerous studies have shown that agricultural runoff, pesticides, and fertilisers can bio-accumulate in aquatic animal tissues and pose a risk to the safety of food. For a better understanding of the creation, evolution, and migration of NPS pollution, it is crucial to establish long-term monitoring and modelling systems. Additionally, in order to further reduce the NPS pollution load and maintain a pollution-free environment, public awareness of source reduction should be fostered and associated legislation should be implemented.

Keywords: *nonpoint source pollution, rain water runoff, agricultural runoff, modeling, and best management practices.*

Unveiling the Stock Structure of *Labeodussumieri* (Valenciennes, 1842) from the Rivers of Western Ghats, India Using Otolith Shape Analysis

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Labeodussumieri is a cultivable carp that is known to be distributed in the Narmada River and the rivers of Western Ghats. It is an important food fish and a delicacy of central Kerala, India. However, there have been no attempts to investigate the stock structure of *L. dussumieri* using otolith shape analysis. The present study aimed to differentiate the stocks of *L. dussumieri* from three rivers of the Western Ghats (Achankovil, Kundalika and Chalakudy River) using otolith shape analysis in the *ShapeR* package. Multivariate statistical analysis was performed on the Elliptic Fourier descriptors (EFDs) and Wavelet coefficients (WCs), and the findings revealed that there was a significant variation in average otolith shape among sampling sites, with the highest variance occurring between 0° to 60°. PERMANOVA analysis of otolith shape revealed significant differences between sampling sites ($p < 0.001$). The results obtained showed that the otolith shapes of *L. dussumieri* from nearby locations (Chalakudy and Achankovil River) were more similar to each other than those from distant locations (Kundalika River). The Linear discriminant analysis (LDA) based on Elliptic Fourier descriptors and Wavelet coefficient showed an overall classification success of 89.82% and 78.04% respectively. This study highlights the efficiency of otolith shape analysis, as a phenotypical marker to study the stock structure of cyprinid fishes. This information will be helpful in effective management of this species.

Keywords: *Otolith shape; ShapeR; Stock structure, Linear discriminant analysis, Western Ghats.*

Sustainable Approaches to Fisheries and Aquaculture Considering Climate Factors in India

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Agriculture and related sectors of the nation's economy are vulnerable to climate change and its variability and disproportionately affect poor and marginalised groups. The change is an inevitable event that obstructs the output of aquaculture farms and culture-based fisheries in open waters. It poses a serious threat to global food security, alternating biodiversity, ecosystem and global fish output by displacing fish stocks from their natural habitats. The aquaculture and fisheries sector supports millions of stakeholders, both directly and indirectly, who largely belong to the economically disadvantaged strata. These individuals rely on the sector for their livelihoods, often engaging in unorganised employment with lower incomes and facing heightened socio-economic vulnerability. Frequently, they are marginalised and primarily impacted by the unpredictable changes brought about by climate shifts. Fluctuating temperature and precipitation trends, surges in storm-related water, intrusion of salinity, rising sea surface temperatures, oceanic acidification, and the contamination of freshwater resources resulting from tropical cyclones like Aila, Fani, Bulbul, and more recently, Amphan and Nisarga, have wreaked havoc on the fisheries and aquaculture industry. This impact has been felt along both the eastern and western coasts of India. Hence, it's important to grasp the significant connection between the diverse effects of climate change on both fisheries and aquaculture. Aquaculture should safeguard the people relying on robust aquatic systems, ensuring the industry aids sustainable growth, boosts aquatic food production, and minimises resource use. Encouraging innovation and nurturing entrepreneurial prospects within the fisheries and aquaculture field could serve as the catalyst for expansion and advancement. Further exploration into enhancing seed and feed quality, maximising bio resource utilisation, and advancing technology and genetics is imperative. This approach can also assist other developing economies dependent on fish and aquaculture resources in adopting a comprehensive strategy along similar lines. Concrete steps should be established to ensure that the most susceptible countries, production systems, communities, and individuals can develop and employ dependable climate-smart methods.

Keywords: *Climate change, Food security, Responsible fisheries & Climate smart.*

Spatio-Temporal Variation in Phytoplankton Abundance in the Manori Creek, India: A Generalized Additive Model approach To Environmental Interaction

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The spatio-temporal variation in abundance of phytoplankton in relation with the environmental parameters of Manori Creek was assessed in this study. Surface water samples were collected monthly at three designated stations from January 2022 to February 2023. A total of 114 phytoplankton species were identified, categorized into 67 genera, 53 families, and nine distinct classes. These classes include Bacillariophyceae (29.8%), Mediophyceae (25.4%), Dinophyceae (19.3%), Coscinodiscophyceae (15.8%), Cyanophyceae (4.4%), Chlorophyceae (2.6%), Eustigmatophyceae (0.9%), Noctilucopephyceae (0.9%), and Zygnematophyceae (0.9%). Cluster analysis and non-metric multidimensional scaling (NMDS) identified three distinct spatial and temporal clusters. The estuarine region at station 2 displayed the highest species richness, while the riverine region at station 3 exhibited the highest species diversity and dominance. The study also revealed that phytoplankton diversity, richness, and evenness indices reached their peak during the monsoon season and hit their lowest point during the pre-monsoon. The Generalized Additive Model (GAM) analysis revealed that water temperature (WT), total suspended solids (TSS), nitrate (NO_3), nitrite (NO_2), chlorophyll-a (Chl-a) and chlorophyll-b (Chl-b) are the deterministic environmental variables to characterize the spatio-temporal pattern of phytoplankton community. Canonical Correspondence Analysis (CCA) demonstrated that the abundance of dominant phytoplankton is primarily influenced by variables such as transparency, pH, total phosphate, nitrite, temperature, silicate, and chlorophyll-a concentration. The outcome of the present study contributes to the global body of knowledge by showcasing how phytoplankton communities respond within this unique ecosystem. The results can be used for comparative analysis with other coastal ecosystems worldwide to identify common patterns and region-specific dynamics. Climate change and human activities have a global impact on coastal ecosystems, this research provides data and insights that can improve the accuracy of predictive models, helping academics and policymakers worldwide.

Keywords: *Phytoplankton, Diversity, Environmental variables, Generalized Additive Model, Canonical Correspondence Analysis.*

Safeguarding East Kolkata Wetlands for Sustainable Development: A Comprehensive Approach

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The East Kolkata Wetlands stands as a unique exemplar of a hybrid ecosystem that intertwines natural processes with human intervention to achieve efficient and environmentally sustainable resource recovery. The convergence of various factors has led to the exceptional practice of utilizing sewage-fed fishery techniques to treat urban wastewater. This symbiotic relationship has given rise to a distinct livelihood pattern within the region, where a network of interdependent vocations has established a complementary rapport between the Kolkata ecosystem and the East Kolkata Wetlands (EKW). However, the past few decades have witnessed challenges in the form of unauthorized land acquisition, wetland conversion, depletion of aquatic species, and sedimentation, threatening the EKW's survival and adversely impacting the populace reliant on it. In light of this context, this study centres on examining the changes in land use and land cover within the East Kolkata Wetlands from 1991 to 2021, aiming to comprehend the current factors at play and their repercussions, with the ultimate goal of formulating conservation strategies for its preservation. The methodology entails generating a land-use map from 1991 to 2021 using Landsat imagery. Furthermore, the Key Informant Technique (KIT) was employed in non-sampled regions to glean suggestions for the conservation and advancement of the EKW, aimed at sustaining the livelihoods of the traditional sewage-fed fish farming communities. Data analysis reveals a noteworthy increase in the area designated for settlements, expanding from 22.59 square kilometres in 1991 to 35.29 square kilometres in 2021, primarily attributed to population growth. This expansion is accompanied by a concurrent reduction in open spaces and water bodies, diminishing from 12.11 square kilometres in 1991 to 4.13 square kilometres in 2021 due to urbanization and developmental endeavours. Regarding conservation and development strategies, the survey results highlight that 'Abundant supply of sewage water to promote sewage-fed fish farming' ranked first (with a score of 86.23) among eight selected statements. This underscores its importance in sustaining both the ecosystem and its traditional livelihoods. It can be said that, harmonizing the exploitation of the EKW's ecological potential with improving the local quality of life presents an attainable balance. Through such an approach, it becomes plausible to secure the future of this invaluable natural resource while simultaneously benefiting the communities that depend on it.

Keywords: *Livelihood, Socioeconomic, Conservation, Key Informant Technique (KIT).*

Reproductive Biology of Panther Electric Ray (Pisces: Torpedinidae) Represented in the Catches of Coastal Waters of India, Western Bay of Bengal

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Torpedo electric rays (Pisces: Torpedinidae) constitute one of the most vulnerable group of bottom dwelling rays due to their life history strategies and unique biological traits. These are represented in a variety of gears albeit in small numbers along the inner half of continental shelf off Visakhapatnam (16°98'N/82°19'E-17°83'N/82°29'E to 20°02'N/86°53'E-20°N). Basic knowledge of species composition of these rays in the catches and their biology is either deficient or entirely lacking. For proper management of these resources - monitoring, abundance estimates and collection of basic biological data is urgently needed. Among species of genus *Torpedo*, *T. panthera* is regularly represented in the catches of central eastern coast of India. As this species was assessed as “Endangered” by IUCN group, during the present study maturity stages, fecundity, gestation period, length at first maturity, sex ratio and size at birth of *T. panthera* were determined. A total of 92 specimens were collected with 37 females and 55 males. All pregnant females were caught during December, January and March. Gestation period was estimated to be six months approximately. Gestation begins in November and ends in April/May. Ovarian fecundity is higher than uterine fecundity. Oocytes and/or eggs, embryos and fully developed fetuses were more numerous on the right side than on the left side. Length at first maturity for females and males was estimated as 338 and 322 mm TL respectively. Males were more abundant than females and the pooled sex ratio was 1:0.6. The approximate size at birth would be 98-113 mm TL. This information on reproductive biology of *T. panthera* plays an important role in the quantitative analysis of populations, providing data to support stock, demographic, ecological risk assessments and for management actions. To the best of our knowledge this is the first study to report reproductive biology of this species from world waters.

Keywords: *Torpedo panthera*, reproductive cycle, ovoviviparous, gestation, ovarian - uterine fecundity, pups.

Longitudinal Connectivity through the River Barriers: An Important Ecohydrological Process Towards Sustainability of River Ecosystem

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River continuum concept has been considered to be the central organizing paradigm in the river ecology. This provides an appreciation of terrestrial and aquatic interface especially those governed by the riparian zone as well as the primary influences of geomorphology and physical conditions in flowing river channels on energy sources and energy flow through the food webs. Therefore underlining the importance of the river flow continuation for the energy flows, including sediment, water and aquatic lives. Connectivity can be defined as a functional exchange pathway of matter, energy and organisms. Within the stream/river system, longitudinal connectivity refers to the flow or water regime that brings exchange of materials (physical, biological or chemical) along the entire pathways of a stream/river, specifically referring to longitudinal dimension, without disturbing the river/stream continuum. While, Longitudinal connectivity is regarded as the most important connectivity dimension for silt transportation and fresh-water fish species, because it allows upstream and downstream fish migration cycles to occur. To obtain this, sufficient water should be released downstream of the dam/barrage. The flow patterns needed to maintain important aquatic ecosystem services are known as environmental flows. If longitudinal connectivity is lost, the aquatic ecosystem will be disturbed. The current paper describes the importance of longitudinal connectivity pertaining to water, sediment and fish in the river ecosystem towards achieving the sustainability.

Keywords: *Longitudinal connectivity, Dams, barrarriers, Fisheries.*

Genetic Structure and Differentiation of Minor Carp (*Labeogonius*) from Indian Rivers Revealed Through Mitochondrial ATPase6/8 and D-Loop Region Analysis: Implications for Conservation and Management

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India is the habitat of many freshwater fish species that make a significant contribution to endemism. However, the native species population is declining very faster rate due to pollution, habitat loss or degradation, new species introduction, hydrologic alterations, and overfishing. The minor carp, *Labeogonius* is one of the important fish species in the Indian River system and holds enormous potential in culture fisheries. Therefore, the precise status of population structure is a prerequisite for the management of the species. In the present study, we assessed the potential of mtDNA ATPase 6/8 and D-loop region as a marker to determine the genetic diversity and phylogeography of *Labeogonius* from Indian rivers. We have selected five Indian major rivers for investigation which could represent geographically distant populations of the studied fish. A total of 210 ATPase6/8 sequences (842 bp) and 203 D-loop region sequences (683 bp) of *L. gonius* belonging to the five Indian major rivers were submitted to NCBI. Results revealed that the ATPase6/8 has 17 haplotypes, 70 polymorphic sites with overall haplotype diversity 0.560 ± 0.036 and nucleotide diversity 0.00347 ± 0.00 . Furthermore, D-loop analysis revealed 58 haplotypes, 67 polymorphic sites, overall haplotype diversity 0.954 ± 0.006 and nucleotide diversity 0.01914 ± 0.00 . The hierarchical AMOVA analysis indicated that a high proportion of the genetic variation (76.46% and 70.22% for D-loop and ATPase6/8 region, respectively) was attributed by among-population variation under gene pool-1 (considering all the Ganga, Brahmaputra, Teesta, Narmada and Mahanadi stocks as a single pool). Furthermore, under gene pool-2, among populations within groups genetic variations (70.65% and 53.48% for D-loop and ATPase6/8 region, respectively) (where samples were grouped into two groups, Group 1 (Himalayan rivers)-Ganga, Brahmaputra & Teesta; and Group 2 (Peninsular rivers)-Narmada, Mahanadi). Haplotype network analysis revealed that there were significant differences in distributions and frequencies. The observed unique haplotypes might be useful for differentiating the stocks. In brief, the present study suggested that D-loop and ATPase6/8 region were a potential marker and represents a significant contribution to the genetic characterization of minor cap *L. gonius* from Indian major rivers. The results would facilitate a scientific basis for the assessment of fisheries resources and management of this important species.

Keywords: Genetic diversity, *Labeogonius*, ATPase, D-loop, Indian rivers.

Comparison of Lethal concentration of Lead acetate in Rosy barb (*Pethia sp*) and Buenos Aires Tetra (*Hyphessobrycon sp*)

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From the beginning of twenty-first century, the occurrence of heavy metal in the aquatic system becoming a great matter of concern as they can be detected in critical quantities and are prevalent everywhere in the environment. The test for quantifying the diversified effects of this toxicant is thus immensely essential to maintain the water quality standard and to assume the effects of toxicant to the aquatic organism. In this study, two ornamental fishes i.e., *Pethia*, commonly called as rosy barb that belongs to order- cypriniformes and *Hyphessobrycon* commonly known as Buenos Aires Tetra that belongs to order-characiformes were used as test organisms. They were exposed to different concentrations of lead. Rosy barb was exposed to 250, 275, 300, 325, 350 mg/L of lead and 365, 375, 385, 395 and 405 mg/l in case of tetra along with control in both the species having no metal toxicant and with all the conditions constant. The 50% lethal concentration (LC50) was 565mg/l after 24h, 525mg/l after 48h and 389mg/l after 72h for Rosy Barb and 380 mg/l after 24h, 355 mg/l after 48h and 347 mg/l after 72h for BA Tetra. Rosy Barb was detected with higher LC50 values and showed higher resistance than BA Tetra. Presence of more keratinized structure and having larger body size than tetras may be the possible cause behind this.

Keywords: Heavy metal, toxicity, cypriniformes, characiformes, LC50.

Studies on the Effect of Commercial and Formulated Probiotic Application in the Growth Performance and Intestinal Microbial Flora of the Cat Fish (*Pangasianodon hypophthalmus*)

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Probiotic bacteria confer beneficial effect to the host animal. Probiotic diets are being incorporated together with probiotics in recent years. Probiotics with synbiotics elicit synergistic and more favorable actions. Administration of probiotic feed *Lactococcus spp.*, *Saccharomyces cerevisiae* in the diets kept the histo-architectural structure intact and promoted regeneration in the intestine of fish to increase the functionality of fish. This increased advantage of formulated probiotic and its benefits in maintaining good water quality and rapid increase in growth of *Pangasianodon hypophthalmus* were evaluated in this study. Feeds with commercial probiotic feed obtained were evaluated with the isolated probiotic feed. The adherence of isolated probiotic feed in the intestine of *Pangasianodon hypophthalmus*, alter the enzymes, microbial metabolism and improve the weight gain and survival rate.

Keywords: Probiotic, *Pangasianodon hypophthalmus*, fish feed, water quality.

Toxicological Effects of Nodularin on Reproductive Endocrine System of Female Zebrafish (*Daniorerio*)

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The reproductive system of fish, like mammals, is regulated by different endocrine factors. Any alteration in these endocrine factors will affect the reproductive fitness of fish which ultimately affects their population size. Nowadays due to anthropogenic eutrophication the incidence of harmful algal blooms (cyanobacteria) are occurring more frequently. Different secondary metabolites, mainly cyanotoxins released from these blooms in aquatic environment are a major concern and their abundance posing threat to the fishes and other aquatic animals. Nodularin is a cyanotoxin classified as potent hepatotoxin with worldwide distribution. Nodularin have been reported in several aquatic environments as well as in body parts of aquatic animals. The effects of nodularin on reproductive endocrine system are still unexplored which brings our attention to investigate its effects on female zebrafish (*Danio rerio*). To fulfill our study adult female zebrafish were acclimatised in laboratory condition for 7 days and exposed to environmentally relevant doses of nodularin (0, 2.5, 5 & 10 µg/L) for 14 days. After exposure histological studies of zebrafish ovary were done and gonadosomatic index (GSI) was measured. Gonadotropins (LH and FSH) and steroids (estradiol and testosterone) levels from blood serum were measured using ELISA. To study the direct effects of nodularin on oocyte maturation, germinal vesicle breakdown (GVBD) assay were done after *in vitro* exposure of nodularin. The mRNA expression of different genes related to hypothalamus pituitary gonadal liver (HPGL) axis and oxidative stress were measured using quantitative real-time PCR (qPCR). From the experiments it was found that nodularin inhibit both oocyte growth and maturation by lowering the FSH and LH level. We found decrease in GSI of female zebrafish and observed more number of pre-vitellogenic oocytes in histological examination in treated groups. Disruption in *gnrh2*, *gnrh3*, *cyp19a1a* & *1b*, *vtg1,2&3* gene expression also indicates that nodularin interrupts HPGL axis, which is accomplished by enhanced oxidative stress as observed by altered expressions of *sod*, *cat*, *gpx* etc in female zebrafish. This study reveals that nodularin is an effective endocrine disruptive compound which may exhibit toxicity toward reproductive endocrine system of exposed organisms.

Keywords: Endocrine disruptive compound, cyanotoxins, HPG axis, reproductive toxicity.

Decreased Abundance of Gut Microbiota and Its Metabolite Impairs Reproductive Physiology and Endocrine System in Female *Danio rerio*

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An underappreciated endocrine organ, the gut microbiota regulates the host physiological processes like growth, metabolism and immunity. Antibiotic use drastically lowers the gut microbiota triggering miscellaneous physiological disorders like gastrointestinal, neurological and cardiovascular problems. Gentamicin owes its ability to bioaccumulate in fish gut and disturb the gut microbiota with no influence on HPG axis draws our attention to decipher the impact of gut microbiota deterioration in the female zebrafish's reproductive physiology. Adult female zebrafish were exposed to 50 µg/L gentamicin for gut microbiota disruption. After exposure, the gut microbiota metabolite, short-chain fatty acids (SCFA) were quantified by GC/MS. The gonadosomatic index (GSI) was measured and histological alterations of zebrafish ovaries were observed. LH & FSH levels were measured by ELISA and the expression levels of GnRH-2&3, leptin and kisspeptin 2 were examined by qRT-PCR. Gentamicin (50 µg/L) treatment lowered the gut microbiota abundance in female zebrafish, along with the gut microbiota metabolites. The concentrations of short chain fatty acids, specifically acetic acid, propanedioic acid; valeric acid were reduced in gentamicin treated zebrafish intestine. Gentamicin treated zebrafish ovary exhibited reduced GSI and more number of previtellogenic follicles than vitellogenic and postvitellogenic ones. Also, the gut microbiota lowering indicated downregulated expression of GnRH-2&3 followed by downregulation of host-specific hormones, leptin and kisspeptin-2. This indicates the disturbance of the female reproductive physiology as observed with lowered concentrations of gonadotropins (LH and FSH). The results indicated that compared to control, 50 µg/L gentamicin treatment has decreased the abundance of gut microbiota and its metabolites, specifically the SCFA in female zebrafish. This hampers the reproductive physiology of female zebrafish exhibited by reduced GSI and accumulation of more immature follicles. Gut microbiota alteration induced by gentamicin also showed downregulated expressions of GnRH 2&3, leptin and kisspeptin 2 which designates the disturbance of the hypothalamo-pituitary-gonadal axis. It is reflected by lowered concentrations of gonadotropins (LH and FSH). This study showed that lowering gut microbiota and its metabolite negatively impacts the endocrine and reproductive physiology of female zebrafish by interacting with specific host associated hormones.

Keywords: *Gentamicin, Intestinal microbiota, Short chain fatty acids, HPG axis, Reproduction.*

**Molecular and Morphological Study of *Thelohanellus* (Kudo, 1933)
and *Myxobolus* (Bütschli, 1882) from Freshwater Farmed Fish
Labeo rohita (Hamilton, 1822)**

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Myxozoans are microscopic, metazoan, obligate parasites, belonging to the phylum Cnidaria. In contrast to the free-living lifestyle of most members of this taxon, myxozoans have complex life cycles alternating between vertebrate and invertebrate hosts. Vertebrate hosts are primarily fish, although they are also reported from amphibians, reptiles, trematodes, molluscs, birds, and mammals. *Myxobolus rocatlae* and *Thelohanellus caudatus* is a spore-forming myxosporean parasites. They are prevalent in *Labeo rohita* (Hamilton, 1822), which produces innumerable cysts in the gill lamellae, and caudal fin and leads to massive fish mortality. The isolated parasites were screened thoroughly in morphological as well as molecular analyses. The infected parasites were identified as *Myxobolus rocatlae* and *Thelohanellus caudatus* based on morphological, molecular (18S rRNA), and Sanger sequencing. Since, *Myxobolus* and *Thelohanellus* caused the fish significant harm, specifically obstruction of the gills, and act as a barrier to innate immune parameters, it finally led to malnutrition and even death. The mature spores of *Myxobolus rocatlae* and *Thelohanellus caudatus* accumulated in the gill lamellae and caudal fins of *L. rohita*, and form cysts of different sizes, and burst outs into the body upon rupture, leading to the next phase of growth, and morphological clarity scanning electron microscopy (SEM) is performed. Finally, sequences were submitted in NCBI GenBank accession numbers of *Thelohanellus caudatus* (OM866193), and *Myxobolus rocatlae* (ON975000) as future documentation. Our collective research lays the groundwork for future investigation into parasite infections and the creation of efficient treatment methods.

Keywords: *Myxosporean, cysts, 18S rRNA, SEM, and GenBank.*

Ultrastructure of the Light Organ of Squid *Uroteuthis duvaucelii*

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Squids, member of class cephalopod (Phylum- Mollusca), have the ability to produce bioluminescent displays. Among their interesting features is the light organ, a specialized gland responsible for generating and controlling luminescence. The light organ of squids is a complex organ situated within the mantle cavity. Composed of intricate arrangements of specialized cells, it houses bioluminescent bacteria *Photobacterium leiognathi* in a mutualistic relationship. Squids are believed to acquire these bacteria from the environment early in their lives, which then colonize the light organ. The bacterial colonization is demonstrated by specific structural features of the organ that facilitate bacterial attachment and maintenance. High-resolution microscopy has unveiled the detailed anatomical structure of the light organ and its associated bacterial colonies, various structure that are responsible for light emission as inspite of internal presence, the light produced by bacteria is visible to outside of the cavity. The light producing organisms are not only surviving but also getting continuous oxygen and nutrients. Luminescence in squid light organs serves multiple purposes. Predominantly, it is employed as a form of camouflage, known as counter-illumination, to mitigate their silhouette against the backdrop of moonlight or sunlight filtering through the water's surface, communication, mating displays, and predator avoidance. This study shows the structure, function, and ecological significance of squid light organs. The light organ of squids represents an extraordinary adaptation in the area of marine bioluminescence. Therefore, there must be strong relationship between the structure of the gland and behaviour of the animal to be able to demonstrate bioluminescent. A comprehensive understanding of its structure, function, and ecological significance unveils not only the mysteries of this captivating organ but also sheds light on broader themes of symbiosis, communication, and survival strategies in the depths of the ocean.

Keywords: *Bacteria, Bioluminescence, Light organ, Squid, Ultrastructure.*

Integration of Indigenous Traditional Knowledge with Modern Knowledge System for Hill Stream Fisheries and Agriculture

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Traditional knowledge is an extensive body of information, skills, customs, and representations that have been upheld and developed by groups of people interacting with the environment. The indigenous people are the keepers of the knowledge that are influenced by their beliefs, spirituality and cosmology. Numerous indigenous communities live in Himalayan region, and the majority of them have their own distinct traditional knowledge and technological foundation. They have helped the indigenous populations to live comfortably and independently. The entire socio-economic growth of the communities has benefited greatly from this ancient knowledge. Due to their unique biophysical and socio-economic circumstances, farming communities of the Himalayan area are among the most vulnerable to climate change. The Himalayan economy is based primarily on traditional agriculture. Most of them utilise a rotation of grains and millets including wheat, barley, paddy, finger millet, barnyard millet, soyabean, horsegramme, and a few vegetables and develop three crops in two years. Small farmers may choose to make a living by producing dairy products and vegetables. The small holding farmers in the area currently use a family farming method, but there are some integrations at various levels. Rice and fish can be combined to produce high-quality protein, nutritional security, and income for rural populations on a modest scale. Rice-fish farming reduces the quantity of fertiliser, pesticides, and herbicides used in the rice field by not adding artificial fish feed to the water. The most important aspect of any rice-fish farming system is the quality of the water of the feeder canals and connected rivers. The abiotic conditions of the water in the rice-fish terraces of the regions are favourable for rice-fish farming and with in the ideal range. All of these steps will give traditional indigenous knowledge a monetary value and encourage the locals to preserve, practise, and spread their expertise.

Keywords: *Indigenous Traditional Knowledge, Indigenous Community, Socio Economic Growth, Knowledge, Integration, Rice-Fish farming system, Integrated farming.*

Constraints Faced by the Farmers Culturing *Penaeus vannamei* at Purba Medinipur District, West Bengal, India

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Shrimp aquaculture is a billion-dollar food-producing industry. The shrimp commodity has high demand in the local and international markets due to its adorable taste and high nutritional value. It is being exported to numerous developed countries including Japan, the United States of America, and the European Union. *Penaeus monodon*, commonly known as tiger shrimp, was raised only in India until 2009. When WSSV arrived on the Indian coast, the Supreme Court of India restricted shrimp farming in coastal water. Then shrimp industry started finding an alternative species of *Penaeus monodon* and in 2008, India introduced SPF and SPR *Penaeus vannamei*. The study was conducted in three blocks like Patashpur-II, Egra-II and Contai-III for three months. A pre-tested questionnaire scheduled was developed to collect the data through personal interviews. The constraints they are facing are social constraints, economic constraints, technical constraints, and marketing constraints. Under social constraints, significant conflicts are interference of anti-social elements, undue harassment by neighbors, poaching of fish, and poisoning of fish. Economic constraints are visible as lack of money, inadequate quantity of loan provisions, reluctant behavior of bank personnel in advancing loans, and complicated procedures for obtaining loans from the credit organization. Insufficient quantity of loan provision is the least important factor in Patashpur II (60%), Egra II (66.66%), and Contai III (86.66%) block. Lack of technical knowledge, lack of quality fish seed stocking, absence of soil and water testing facilities, unavailability of water during summer, and lack of quality feed and manure are the main technical problems faced by shrimp farmers. Technical knowledge is the least important factor in Patashpur II block (66.66%) and Egra II (53.33%) block. The absence of a wholesale market and price fluctuation data of any market are the main conflicts for the marketing of *P. vannamei* by farmers. Constraints such as non-availability of quality seed and feed, very low financial support from the Government agencies, lack of market facilities, lack of labour availability, and higher input costs are to be addressed with appropriate existing measures which include the adoption of Better Management Practices (BMP) and HACCP principles to produce zero defect shrimp products.

Keywords: *Whiteleg Shrimp, P. vannamei, Constraints, Purba Medinipur.*

Supplementation of Fish Protein Hydrolysate Improves Fishmeal Replacement Efficacy of Poultry By-Product Meal In Diets of Stripedmurrel (*Channa striata*) Juveniles

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A 60-day feeding trial was conducted to examine the effects of replacing fish meal protein with graded levels of poultry by-product meal (PBM), with or without supplementation of fish protein hydrolysate (FPH) on growth performance, nutrient utilization, whole-body composition, digestive enzyme activities, intestinal morphology and haemato-biochemical responses of Striped murrel (*Channa striata*). Five isonitrogenous (44%, crude protein), isolipidic (11%, crude lipid) and isoenergetic (18 MJ/Kg) diets were formulated to replace 0%, 25% and 50% of fish meal protein with poultry by-product meal and poultry by-product meal supplemented with FPH and the diets were designated as control, 25 PBM, 50 PBM, 25 PBM+FPH and 50 PBM+FPH. Triplicate groups of 20 striped murrel juveniles with an average initial weight of 10.02 ± 0.15 g were fed with test diets daily thrice until apparent satiation (08:00, 12:00 and 18:00 H). Among the dietary groups, significantly higher ($p < .05$) weight gain (41.05 ± 1.38 g), specific growth rate ($2.71 \pm 0.05\%$ day⁻¹) and better feed conversion ratio (1.30 ± 0.03) were found in fish fed 50 PBM+FPH diet compared to other diets including control. No significant difference ($p > .05$) were observed in whole-body composition, such as crude protein, crude lipid and total ash content of striped murrel fed different experimental diets. Significantly ($p < .05$) higher protease content was observed in fish fed 50 PBM+FPH diets than other diets. However, the digestives enzymes like amylase and lipase were not affected by different levels of PBM and supplementation of FPH. Moreover, dietary inclusion of PBM and PBM supplemented with FPH diets did not affect the intestinal morphology and haemato-biochemical responses of Striped murrel. It is concluded that, 50% fish meal protein can be replaced by PBM with the supplementation of FPH in Striped murrel diets without any negative impact on growth, nutrient utilization, whole-body composition, digestive enzyme activities, intestinal morphology and haemato-biochemical responses of Striped murrel (*Channa striata*).

Keywords: Digestive enzymes, Freshwater sustainability, Hydrolysate supplementation, Intestinal morphology, and Protein.

Aquatic Resources and Sustainable Management: Ornamental Fish Culture

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Ornamental fish culture is a subset of aquaculture, comprises of breeding, rearing and trading of appealing aesthetic fish species. Ornamental fish are also called living jewels due to their attractive colour, design and varying range of sizes. The breeding of ornamental fish began 1000 years ago with the domestication of goldfish in China. Harilal Chaudhri-an Indian Bengali Fisheries scientist is the father of ornamental fish in the world. India has now become the main exporters of ornamental fish in the world due to high demand of indigenous species collected from rivers of north east and southern states that contribute 85% to total export of ornamental fish from the country. On the other hand, the western ghats of India is one of the 34 bio diversity hot-spot areas of the world which produces about 40 species of ornamental fish in which 37 species are endemic to western ghats. Singapore is the number one ornamental fish exporter with 1000 fish species to more than 80 countries due to which Singapore is the Ornamental fish capital of the world while US being the largest importer. There is a huge domestic market in India worth about Rs 555 crore with an estimated potential of 5000 crore. Indian domestic fish is growing at a rapid pace of 20% annually and demand at domestic level is higher than supply.

There are mainly two varieties 1 Indigenous 2 Exotic which are bred in this burgeoning industry. About 200 indigenous species are reared and more than 300 exotic species are covered in ornamental fish trade with about 400 species from marine ecosystem also contribute to this field of ornamental fishes. Indian ornamental fish trade mostly deals with freshwater fish (90%) of which 98% are cultured and 2% captured from the wild. Ecologically, Ornamental fish culture can contribute to biodiversity conservation by reducing pressure on wild population through breeding. All aquarium fish today do not exist in nature but are bred by adopting selective methods, genetic enhancement and innovative reproduction methods, Ornamental fish farmer can produce vibrant and unique specimens that meet market demand while minimizing negative impacts on natural ecosystem.

Ornamental fish culture is an emerging industry due to its simplicity and sustainable practices. It can be started at home on small scale at a low budget and can be profitable due to its huge demand. According to some reports an investment of about 1.25 Lakh can lead to a monthly income of 8K to 9K and if done on a large scale with an investment of 25 Lakh can produce monthly income in the range of 1.25-1.5 lakh. The demand of ornamental fishes is increasing day by day due to their aesthetic appeal, educational value, therapeutic benefits, creative outlet, and community engagement. The challenges involved in this type of fish culture include disease management, appropriate tank condition (1/3 Oxygen supply, 1/2 water supply according to container size), need of live feed (earthworm) for these fishes to retain their colours, quality of brood stocks etc for running a profitable business.

Now, the key difference between fish culture and ornamental fish culture lies in their respective goal. Fish culture is centered around producing fish for human consumption and Ornamental fish culture is centered

around producing visually appealing fish for pet trade or aquarium. Aquarium fishes are very easy to raise and train, they quickly recognize and learn. They can sense colours like humans that even primates can't recognize. Ornamental fishes like Arowana is believed to bring Goodluck, wealth and prosperity. There is a huge demand for ornamental fishes like Goldfish, Discus, Guppy. Faith in Vastu and tourism also accelerated the growth of this trade in developing country like India. Ornamental fishes have been a boon to boost the economy of India as ornamental fish trade is contributing 0.4%(US\$1.4million) of the total ornamental fish trade of the world. Increased awareness about ornamental fish can stimulate more demand and promote responsible sustainable practices in the industry.

Keywords: *Ecological Impacts, Indian and International context, Characteristics, challenges, advantages and sustainable growth of ornamental fishes.*

Role of Pheromones in Fisheries and Aquaculture: A Systematic Review

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The study of fish pheromones is particularly relevant because of the conserved nature of chemoreception in vertebrates. A pheromone is a chemical or chemical combination that one organism releases into the environment and that elicits a certain response in a receiving organism of the same species. Pheromones, chemical cues released by conspecifics, regulate social behaviors in the majority of fish species. Pheromones play a crucial part in the majority of fish's important behaviors, including alarm signaling, sex attraction and synchronization of reproduction routines, individual identification, among groups, parent-offspring recognition, territorial marks, and migration. Several experimental research and reviews demonstrate fish behaviors in lab microcosms that are odorant-mediated. Fish pheromone study is very productive and enable carefully planned experimental designs for various experiments. Importantly, studies showing a relationship between behaviour and pheromones in freshwater fish have led to a broad range of management applications. The effective application of pheromones in pest insect management suggests that they may be useful in the management of wild fishes. For example, the sea lamprey *Petromyzon marinus* releases pheromones (3-keto-petromyzonal sulphate) that are useful in pheromone traps, indicating how chemical communication can be utilised to regulate invasive species. Sex pheromones are utilized by many fish to attract partners of the opposite sex or to stimulate reproductive behavior. In fish, steroids, prostaglandins, bile acids, and amino acids have all been demonstrated as a sex pheromone. The first vertebrate pheromone to be field-tested as a pesticide is the sea lamprey (*Petromyzon marinus*) pheromone (3-keto-petromyzonal sulphate).

Keywords: *Communication , Invasive Species Management, Reproduction, Synchronization.*

Marine Pollution including Plastic Waste and Oil Spills

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Marine pollution is a pressing global environmental issue that has far-reaching consequences for the world's oceans and marine ecosystems. This Abstract is to explore two major sources of marine pollution - plastic waste and oil spills - examining their origins, impacts, and potential solutions.

Plastic waste has turned dangerous to the environment, with an estimated 8 million tons entering the oceans each year. As plastics break down into microplastics, they disturb the marine food chain, leading to harmful consequences for marine life and, ultimately, human health. Marine animals ingest microplastics by fish and seabirds.

This topic is very important for discussion.

Equally Oil spills are also dangerous, which release vast amounts of petroleum into marine environments, leading to catastrophic consequences. Oil spills coat marine habitats, suffocating marine organisms, and disrupting their ecosystems. These spills pose long-term threats to coastal communities and industries, impacting tourism, fisheries, and overall economic stability.

The abstract also give information about the challenges of mitigating and preventing these dual threats. Effective waste management strategies, increased public awareness, and policies promoting sustainable practices are crucial to reducing plastic waste. In contrast, advancements in spill response technology and strict regulations are essential to prevent and respond to oil spills effectively.

To safeguard the health of our oceans, urgent action is needed to address both plastic waste and oil spills comprehensively. Through collaborative efforts at local, national and international levels, we can combat marine pollution and preserve these precious ecosystems for future generations.

Juvenile Estimation of *Lepturacanthus savala* (Cuvier, 1829) from Dolnet Catch at Manori Creek, North Mumbai

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The species *Lepturacanthus savala* plays a significant role in the dolnet fishery of the Mumbai coast, serving as essential components of the local catch. This species holds importance as a crucial food source, whether consumed fresh or in dried form within the local community. Additionally, their ecological significance extends to maintaining a balanced oceanic food web. The local fishermen from Manori employ traditional single-day dolnetters in their fishing practices, utilizing nets with remarkably small mesh sizes, typically ranging from 8mm to 12mm, leading to the excessive capture of juveniles. The monthly juvenile proportion of *Lepturacanthus savala* from Manori was estimated to predict the loss due to growth overfishing of the species. The study was based on 387 specimens of *Lepturacanthus savala* collected from January 2023 to June 2023 from the traditional dol net fishing grounds of Manori at North Mumbai. Length at first maturity for *Lepturacanthus savala* is 38cm. The specimens below this length were observed to be juveniles. The month-wise contribution of juveniles in the catch of *Lepturacanthus savala* was January'23 (61.54%), February'23 (45.45%), March'23 (49.91%), April'23 (55%), May'23 (54.16%), June'23 (60%). This study focused on the percentage of juveniles, serves as a valuable tool to assess the impact of growth overfishing attributed to dolnet usage. The findings of this research have the potential to contribute to a deeper understanding of the extent of losses incurred and aid researchers in formulating strategic management interventions aimed at preserving and regulating the targeted species effectively.

Keywords: *Dolnet, Growth overfishing, Lepturacanthus savala, Mesh size, Month-wise Juvenile contribution.*

Reservoir Fisheries Management and Sustainability

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The abstract introduces the unique ecosystem of reservoirs, discussing their distinct characteristics resulting from a synthesis of riverine and lacustrine systems. Temporal and spatial variations in habitat variables create coexisting fluviatile and lentic zones within reservoirs. Changes in water levels, inflow, and outflow contribute to the reservoir's dynamic water renewal pattern. Unlike their parent rivers, reservoirs experience altered hydrology due to dam construction, leading to shifts from lotic to lentic environments. Reservoir ecology diverges significantly from parent rivers, marked by shifts in community structure and secondary succession triggered by the obstruction of river flow and inundation. Initial changes result in altered biotic communities, with some organisms perishing, others adapting, and enhanced nutrient availability promoting plankton and benthic communities. Effective management of reservoir fisheries aims to maintain a consistent fish harvest while increasing production. Techniques encompass ecosystem modification, fisheries control, and fish population management. Understanding changing fish population dynamics, biomass, and maximum yields are crucial for successful management strategies. Focusing on India, the abstract details current and potential fish production from various reservoir categories. Management approaches differ based on water body size, ranging from extensive interventions in aquaculture to limited manipulation in large reservoirs. Critical management processes include environmental management, stock monitoring, stocking programs, predator control, and unconventional production systems like cage and pen culture. Timber clearance's impact on habitat and exploitation systems is also explored, with diverse practices observed among states. Fisheries management varies from departmental fishing to leasing, cooperative societies, and crop-sharing arrangements. Overall, the abstract provides a comprehensive overview of the intricate ecosystem dynamics and challenges associated with managing reservoir fisheries in India, highlighting the need for sustainable practices that balance ecological and socio-economic considerations.

Keywords: *Reservoir, Fisheries Management, Ecosystem, Lacustrine, Ecology.*

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Microbial Skirmishes: Understanding How Xenobiotics Affect Gut Microbiota in Fish

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The microbial communities residing in the digestive tracts of fish have gained increasing attention due to their crucial role in various physiological and ecological processes. This overview examines the many bacteria, fungi, protozoa, and viruses that may be found in fish digestive systems. It is investigated how these microbes affect fish health, nutrition metabolism, and xenobiotic metabolism. The microbiota in the fish gut is essential for the digestion of nutrients, the maturation of the immune system, and the metabolism of medications and pollutants from the environment. Environmental contaminants, pH, temperature, food, and other variables all have an impact on the makeup of these microbial communities. The gut microbiota has a considerable impact on xenobiotic metabolism, which affects the bioavailability, effectiveness, and toxicity of medications. Fish are exposed to a number of contaminants, including as pesticides, heavy metals, and microplastics, which can change the make-up of the gut microbial populations and affect the metabolism of xenobiotics. On the gut microbiota of several fish species, the impacts of particular xenobiotic substances are described. The paper also explores the intricate relationships between xenobiotics, gut microbiota, and the physiological alterations in fish hosts. The possibility of using gut microbes for environmental issues, including plastic breakdown, and therapeutic purposes is highlighted by modern developments. The future prospects of manipulating gut microbiota to influence drug interactions, neurological recovery, aging, and disease treatment are also discussed. Advances in understanding microbiome interactions have the potential to revolutionize pharmacokinetics and open innovative avenues for personalized medicine and ecological management.

Keywords: *Gut microflora, Fish gut, Microbiota, Xenobiotics, Zebrafish, Gastro-intestinal.*

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Mangrove Integrated Aquaculture: An Ecosystem-Based Approach to Ensure Healthy Mangroves and Thriving Coastal Communities In Indian Sundarban

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Sundarban had its own mangrove ecosystem function based aquaculture known as “Bhasa-Bandha” fisheries, where mangrove and aquaculture co-existed. Introduction of input intensive mono-culture of black tiger shrimp brought an abrupt change in this practice resulting in degradation of mangroves and unsustainability in aquaculture there. In this context, Sustainable Aquaculture in Mangrove Ecosystem (SAIME) is an ecosystem-based, conservation-linked and climate adaptive aquaculture practice focusing on the integration of mangroves with aquaculture as a basis for mangrove protection in order to emerge a thriving coastal community in the Indian Sundarban in the context of climate change induced global sea level rise (SLR). NEWS has been implementing SAIME from 2020 in a pilot scale at two locations of Indian Sundarban covering 29.84 hectares of area integrating 42 shrimp farmers. Under SAIME, a polyculture of finfish and shellfish in a modified extensive mode is being practised with no supplementary feed input integrating black tiger shrimp (*Penaeus monodon*) as one of the major candidate species. The culture gives an annual average yield of 535 Kgs/ hectare where black tiger shrimp amounts to average 200 Kgs/ hectare with a survival rate of the 50% of the mangrove saplings which were planted in the aquaculture farms. It was observed that after the implementation of SAIME, the annual average gross profit and net profit of farmers increased in aquaculture to 151 % and 307 %. Results show that the practice could be upscaled in the other parts of the Sundarban as a conservation linked sustainable aquaculture practice.

Keywords: *Bhasa-Bandha, Sustainable, Black tiger shrimp, Conservation-linked, Sea Level Rise.*

Unveiling Constraints and Cultivating Sustainability: A Stakeholder Perspective on Ornamental Fisheries Development in India

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The ornamental fisheries industry in India is rapidly emerging as a promising and financially rewarding aqua-venture. However, despite its considerable potential, this sector faces numerous challenges and remains disorganized. To address this issue, a comprehensive study was conducted in three primary ornamental trading location of the country Viz. : Kolkata (West Bengal), Kolathur (Tamil Nadu), and Mumbai (Maharashtra). The primary aim was to identify the prevailing constraints, as perceived by stakeholders, and propose strategic interventions to foster the sustainable advancement of ornamental fish production and trade across India. Employing a meticulously designed questionnaire compatible with SPSS software, the survey was personally administered through face-to-face interviews. A total of 150 respondents were engaged, with 50 participants from each of the three pivotal locations for ornamental fisheries activity. The degree of significance attributed to distinct constraints was gauged using a 5-point Likert scale. Subsequently, the data was subjected to Principal Component Analysis (PCA) for in-depth analysis. Despite holding significant promise in both domestic and global markets, the ornamental fish trade continues to unorganized, primarily stemming from ineffective marketing strategies and insufficient awareness among stakeholders and institutions. The variations between the locations were clearly discernible. For instance, Kolkata displayed a conventional livelihood structure with strong local networks, whereas Mumbai featured a contemporary, commerce-oriented approach. In sharp contrast, Chennai presented an intriguing amalgamation of time-honored methods and cutting-edge technologies within its ornamental fisheries pursuits. Henceforth, coordinated efforts involving all agencies and stakeholders could pave the way for the breeding of indigenous and exotic ornamental fish species, opening up new horizons for the horizontal and vertical expansion of the sector. By addressing these challenges collectively, the ornamental fish industry can further flourish and contribute to the socio-economic development of the country.

Keywords: *Ornamental fisheries, potential, trade, marketing techniques, stakeholder.*

Optimal Use of Freshwater Resources for Aquaculture and Role of Wastewater

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The pisciculture is an intrinsic part of the agriculture sector which is the highest water consumer globally. The water used for pisciculture is both marine and freshwater. The water which is a limited resource in the form of surface water bodies required especially for aquaculture which involves utilization of freshwater resources at mass scale for fish cultivation raises a question mark for its sustainability in the future and hence the prospect of aquaculture practices all around the world. The present study levitates on status of surface water resources in India, aquaculture production in practice within the country with special emphasis on existing government schemes and facilities in this regard and the various implementation techniques in practice with a view of optimum utilization of existing freshwater resources for aquaculture. The role of wastewater in this regard is prominent and demand enormous cost involvement in its treatment prior use in aquaculture. The study brings to notice about the major types of fishes under cultivation in India, fish health and problems encountered in general by the fishery industry in India including bioaccumulation in the food chain and health risk assessment of human who consume these fishes as a part of their lifestyle on regular basis. Present study envisages for the loophole in existing policies and deliberation of other influencing factors in association with the problems encountered during execution of different techniques in optimum utilization of available freshwater resources and probable mitigation measures that may be taken to curtail the problem.

Keywords: Aquaculture, Optimum use of resources, Sustainability, Wastewater, Policies, Health risk

Assessment of Fish and Fisheries Pattern of Kusheshwar Asthan Protected Wetland Complex: Recognizing Its Fisheries Potential and Conservation Needs

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The Kusheshwar Asthan wetlands (KAW), Darbhanga, Bihar is a group of seasonally flooded wetlands of various sizes (locally known as Chaur) with a total area of 2921.4 ha interspersed with private land and was notified by the Government of Bihar as Kusheshwar Asthan Bird Sanctuary in 1994 under Wild life Protection Act, 1972. The wetlands of Kusheshwar Asthan are hotspots of freshwater fish diversity but less explored, also support artisanal fisheries and livelihoods for many families. The present investigation was carried out to assess the fish diversity of KAW and their dominance pattern in wet and dry seasons of 2021-2022. It is a rainfed wetland system and monsoon run off with flow from a network of rivers like Kamala, Balan, Bagmati and Kareh are the prime source of water. Distinct seasonality has been observed and also shifting of cropping pattern from fisheries to agriculture (Maize). A total of 72 species of fin fish and 3 shell fish was recorded during the study of which some are under Near Threatened (6.94%), Vulnerable (4.16%), and Endangered (1.39%) categories as per IUCN Red data list. Most dominant fish diversity in KAW complex catch is Cypriniformes (40.3%) followed by Siluriformes (26.4%) and Anabantiformes (12.5%). Among the different species supporting the KAW fisheries *Wallago attu* (7%) dominated by weight in wet season and *Channa striata* (13%) in dry season. Total fish production (thousand metric tonnes) of Darbhanga district of Bihar is 53.8 and demand is 42.54 in 2021-2022 and the catch from KAW system contribute a major share in fulfilling the demand of fresh fish consumption in Darbhanga district. A portion of catch from KAW is also exported to West Bengal (mostly prawns and SIFs). Multivariate ordinations revealed strong associations between assemblage structure and habitats based on vegetation coverage. Local assemblages in shallow-vegetated habitats varied seasonally in association with gradients of rainfall and water quality parameters. Although KAW complex providing huge ecosystem service to the society, the system is at verge of greater threats. Suitable sound policy guidelines and regulations need to be implemented strictly to protect this wetland system and its fisheries.

Keywords: *wetland, fisheries, vulnerability, fishermen, ecosystem services.*

Cytobacillus firmus* Mediated Synthesis of Silver Nanoparticle (AgNPs) with Potential Antimicrobial Properties Against *Edwardsiella ictaluri

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The aquatic environment is the source of diverse array of microorganism. The pathogenic bacteria found in this environment cause high mortality in fishes. Conventional approach, such as antibiotics had limited success, additionally their usage is under severe scientific and public scrutiny due to development of multiple antibiotics resistance. Hence, there is a need for the development of alternative control technique, with the emphasis on prevention, which is likely to be more cost-effective. In this study, a potential bacterial strain *Cytobacillus firmus* (ITO), was isolated from polluted river sediment and characterized using biochemical, 16S rRNA sequencing and antibiogram assay. The pathogenicity of the bacteria was carried out in vivo on the *Labeo rohita* fingerlings found as non-pathogenic. Further, the bacteria were found to synthesize silver nanoparticles (AgNPs) using AgNO₃ as substrate. The AgNPs were characterized by UV-vis spectroscopy, FTIR (Fourier transform infrared spectroscopy) and the Transmission Electron Microscopy (TEM). The analysis revealed that the average size of the AgNPs was 20 nm. The antimicrobial activity of synthesized AgNPs was investigated against the model freshwater pathogenic bacteria, *Edwardsiella ictaluri* and both the MIC (Minimum Inhibitory Concentration) and MBC (Minimum Bactericidal Concentration) were 0.156 µM, while biofilm inhibition activity was also observed at 0.156 µM. The AgNPs showed no haemolytic activity at 0.313 µM and the concentration of AgNPs that causes lysis of 50% RBC (HC50) was 1.213 µM. Our findings suggest that *Cytobacillus firmus* mediated bacteriogenic AgNPs modulate the activity of common pathogenic bacteria *Edwardsiella ictaluri*. Hence, applying AgNPs in aquaculture might be a considerable strategy to control the *Edwardsiella ictaluri* infection.

Keywords: FTIR, silver nanoparticle; biofilm; TEM.

Indigenous Practices of Fish Seed Producers in Bankura District of West Bengal – An Exploratory Study

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Farmers do experiment with their limited resources to tide over production related issues. Over the years, through trial and error, farmers develop indigenous practices which are transmitted by word of mouth. These practices are cost worthy, make use of local resources and are sustainable on the long run. In fisheries and aquaculture several such practices are prevalent among small scale fish farmers. Documentation and validation of such practices would go a long way in developing appropriate technology package by merging with the formal science. The present study was conducted at Bankura district of West Bengal, India to document the indigenous practices used by the fish seed producers over years that has potential to improve fish seed production. A variety of methods e.g., systematic observation, triangulation and focus group discussion were used. As many as 9 indigenous practices viz., to improve water quality of breeding pool;reducing the production cost for small farmers; repairing the brood pond dyke, cost effective water lifting device, use of bamboo to provide artificial breeding environment;reducing the muddiness of water etc were documented and discussed with scientific rationale.

Keywords: *Innovations, broodstock, bundh breeding and fish seed production.*

Fish Disease Diagnosis with Artificial Intelligence

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Aquaculture industry is gradually increasing the production in world fisheries sector. Fish plays a significant role in food and nutritional security in our country as well as the whole world. Owing to this reason, it becomes essential to increase the production of fish. But it is diminishing due to numerous diseases which can deteriorate the national economy. Recognition of disease-attacked fish at an early stage can help us take necessary steps to prevent from spreading of the disease. In-depth analyses of expert systems that can continue with an image captured with the help of smartphones and identify the disease. Two set of features is selected then a segmentation algorithm is employed to detect the disease attacked portion from the disease-free portion. Furthermore, eight prominent classification algorithms are implemented accordingly to measure the performance using performance evaluation matrices. Manual identification of fish disease is not an error-free task by amateur farmers. Therefore, a computer vision-based automated approach can be a considerable solution for the reduction of disease. The necessity of computer vision-based fish disease recognition has been investigated intensely.

Keywords: *Fish, Images, Data. Algorithm, Disease, Identification.*

A Novel Paradigm in Aqua Feed Formulation

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Aquaculture is the fastest growing food production sector in the world. Efforts have been made in the last three decades to increase the efficiency of fish growth by manipulating fish feed formulation. Feed is one of the main cost factors in aquaculture production and several studies have been conducted to reduce this cost. An economically interesting alternative is the use of agro industrial residues in the generation of bioactive compounds, biofuels along with enriched fish and livestock feed. However, many of these residues have characteristics that make this purpose difficult or impossible, such as the presence of toxic or nutrient-hostile compounds or an insufficient content of essential amino acids. In this aspect, solid-state fermentation technology is an alternative footstep for using such residues as a nutrient medium for microbial growth, allowing their use in aqua and livestock feed. Single-cell organisms such as bacteria and yeasts grow as biofilm, while multicellular filamentous organisms grow in the form of mycelium, which is used in fermentation process depending on the desired end product. Specially in monogastric species like fish fermented *Jatropha curcus*, sweet potato leaf, soybean meal, rubber seed, *Hygrophila spinosa* leaf meal could be a promising alternative in fish feed formulations through solid-state fermentation (SSF) established by many researchers. It can be used in fish feed formulation, leads to improved nutritional quality, enhanced protein quality, diversification of raw products, cost-effectiveness, and sustainability. Technologies such as solid-state fermentation (SSF) for the bioconversion of lignocellulosic wastes offer both economic and environmental benefits. The versatility of application and interest in applying the principles of the circular economy make this technology one of the valorization strategies that can significantly impact the environment of the broader community. It is important to note that the success of solid-state fermentation for fish feed production depends on factors such as substrate selection, microorganism choice, fermentation conditions, nutrient analysis, and proper monitoring. Implementing quality control along with monitoring growth rate and overall health determine the effectiveness of the fermented feed. Researchers and entrepreneurs need to have a holistic understanding of the various ways in which the performance of SSF technology can be improved and its scaling formulated at the community and field levels. Thus, solid state fermentation technology enables us to use non-traditional feed stuffs in the aquaculture nutrition sector for cost-effective feed formulation strategies.

Keywords: *Aquaculture, Biofilm, Sustainability, Lignocellulosic, Quality Control.*

Seaweed Cultivation in India with Special reference to West Bengal- A Sustainable Approach

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Seaweed, or macroalgae, refers to thousands of species of macroscopic, multicellular marine algae inhabiting the littoral zone near rocky shore, sandy or clayey bottom or even sometimes floats freely. Seaweed cultivation offers benefits such as Carbon sequestration, deacidification of the ocean, preserving food security due to its high nutritional value like proteins, fat, vitamins, minerals, antioxidants, and is also a source of non-food items like toothpaste, shampoos, etc. Several types of medicines are also being produced using these seaweeds. Thereby also affecting the economy by adding \$17.65 billion in 2022 at a compound annual growth rate (CAGR) of 12.1% in the world and generating employment. There are three main types of seaweed found across the globe: Phaeophyceae, Rhodophyceae, and Chlorophyceae, with the most significant production from China, followed by Indonesia, South Korea, and Philippines. In contrast, the largest exporter is China, followed by Philippines and Japan. Although India has long coastline of 7,516 km with large potential seaweed resources but its culture and production are limited to 34,000 tons in 2021 due to lack of proper infrastructure and policy support. Additional 317 suitable sites, including five locations, namely Fraserganj (Bakhali), Sagar Island and Sundarban Dhanchi in South 24 Paragans; Mandarmani and Shankarpur in Purba Medinipur district of West Bengal have been identified with the potential of 9.7 MT per year in near future. At present Indian government has sanctioned 640 crores for the promotion of seaweed culture in India under the PMSSY scheme, in addition respective state fisheries department also offers subsidies for seaweed processing unit under the NFDB scheme. However, there is no such remarkable step or action opted by the West Bengal government for upliftment of this farming till now. Thus, keeping in view of the present status and its important contribution toward socioeconomic as well as ecological development; proper physicochemical and biological parameters must be studied and analyzed using Geographic Information System (GIS) mapping in the selected sites. The seaweed cultivators should be trained properly by the scientific personnels with adequate practical knowledge on culture and diseases. Besides mass awareness program and cooperation among political leaders, administrator and farmers is utmost needed and schemes to be introduced with a focus on mass scale sustainable utilization of Seaweed resources in the state.

Keywords: *GIS, Seaweed cultivation, PMMSY, sustainable production, Carbon sequestration.*

The Effect of Petals of Marigold (*Tagetes erecta*) on Growth Performance and the Carotenoid Deposition in *Xiphophorus maculatus*

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Six experimental diets were prepared by adding marigold petal powder: control D1 (0g), MD2 (1g), MD3 (2.5g), MD4 (5g), MD5 (7.5g), MD6 (10g). The tenure of the experimental trial was 130 days. At the end of this experiment survivability, Weight gain (WG), Specific growth rate (SGR), Feed conversion ratio (FCR), and deposition of carotenoid were estimated. The carotenoid deposition in the skin and the tissue of *Xiphophorus maculatus* was estimated highest in MD4 ($8.72 \pm 0.09 \mu\text{g/g}$) and lowest was in the control group D1 ($3.57 \pm 0.04 \mu\text{g/g}$). The diet group MD6 and MD5 showed poor carotenoid transfer through diet, although these two diets group has higher amount of marigold petal powder. MD4 diet which contains 5g marigold would be the suitable dose for maximum carotenoid accumulation in the tissue of *X. maculatus*. There was no significant difference in survivability. The highest survival rate was in the diet group in MD5 and MD4, and the lowest was in the control group D1. The highest weight gain WG was achieved in the diet group MD4 and the lowest was seen in the control group D1. The highest SGR was found in the MD3 and MD4 diet groups, and the lowest was seen in MD2. The highest FCR was observed in the diet group MD5 while the lowest was found in the control group D1. There is no increasing trend in survivability, weight gain (WG), specific growth rate (SGR) and food conversion ratio (FCR) with increasing inclusion of marigold powder.

Keywords: *Marigold, Xiphophorus maculatus, growth, carotenoid.*

Biofilm Formation and Virulence Genes Characterization of *Vibrio parahaemolyticus* Isolated from Diseased Shrimp Post-Larvae

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Biofilm is the aggregate of microbial cells attached to the surface of a biotic or abiotic substance. The biofilm-forming capability serves as a strategy for survival, virulence, and persistence in communities of bacteria. Among the various biofilm-forming bacteria, *Vibrio parahaemolyticus* is a gram-negative, halophilic, opportunistic pathogen, diverse and abundant in aquatic environments. In the present study, *V. parahaemolyticus* was isolated from infected shrimp post-larvae in nursery tanks. *V. parahaemolyticus* was confirmed through biochemical and molecular characterization of virulence genes. Furthermore, the growth curve and biofilm formation were assessed under different temperatures (27°C, 30°C, 37°C) at 24 hours through Spectrophotometry and Crystal violet assay respectively. Molecular identification of *V. parahaemolyticus* carrying virulence marker genes (tox-R, tdh, trh, tlh) and biofilm-related genes (AphA, Mot-X, LuxR) were achieved through PCR amplification. Results showed that under different temperature conditions, the growth range increased in the order of 27°C < 30°C < 37°C, and quantification of biofilm formation was higher under 37°C, followed by 30°C and 27°C conditions at 24 hours. Here, the biofilm ability of *V. parahaemolyticus* is positively correlated with temperature. Moreover, PCR amplification yielded positive results for tox-R, tlh, AphA, Mot-X, and LuxR, while it was negative for trh and tdh encoding genes in *V. parahaemolyticus*. These studies provide evidence that isolates of *V. parahaemolyticus*, exhibiting biofilm capability, pose an increased potential risk for pathogenesis in shrimp culture.

Keywords: *Vibrio parahaemolyticus*; Growth curve; Biofilm; Pathogenesis.

Study on the Helminth Parasites Infection and Pathogenicity of Freshwater Fishes at Tamluk, East Medinipur, West Bengal, India

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Fish culture plays a crucial role to provide quality protein to the human beings. Helminth parasites of fishes are the significant group of pathogens which causes infection and fatal diseases of fishes and responsible for the fish mortality. The reasons of the Helminthic diseases are due to the intensive culture system, high stocking densities and poor water qualities. These factors causes the poor health, poor growth of the Gangetic Koi fish (*Anabas testudineus*). Ultimately invites the death of the fishes havocly and enhanced the production cost of the fish farms. As a result, it brings great loss in the fishery farms. The helminth parasitic disease infection is a major problem of intensive fish farming in the freshwater culture. The fishes from the polluted environment exhibited the higher parasitic abundance and rapid infestations. The symptoms are the production of more slime, damage of fins, fading of the body colour. Helminths attack on the body, fins, gills, skin, muscles, liver, kidney and in the intestine causes weight loss, scale loss, dermal lesion, ulcer, reproduction abnormality and loss of caudal fin. The pathological changes are Necrosis, Pyknosis, Inflammation, Haemorrhage, Hypertrophy, Hyperplasia, missing of primary and secondary gill lamellae cause severe diseases ultimately mortality of fishes. Helminth worms found in the fishes included Nematodes such as *Contracaecum* sp., *Porrocaecum* sp., Trematodes included *Clinostomum complanatum*, Acanthocephalans recorded in fishes included *Pallisentis* sp., *Neochinorhynchus* sp. The parasites start appearing in the freshwater sources during the rainy season (July-Sept). But their prolific multiplication takes place during the winter (December-February) season. Increasing abundance of helminth parasites causes a great health problem to the fishes. Besides, it causes a significant loss in fishery business also. So details study is needed to understand the pathogenicity of the helminth parasites to overcome the fish diseases.

Keywords: *Helminth infestations, Fish pathogenicity, Diseases, Seasonal effects.*

Acute Toxicity and Behavioural Biomarker of Mercury to Fish *Tilapia nilotica*

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In recent years, freshwater ecosystem has experienced serious threats from human activities such as industrial effluents, agricultural activities, urban waste management issues, and increase in urbanization. Consequently water pollution caused by urban sewage and agriculture, and also the pollution events from industries have become a significant stress on aquatic ecosystem health. The most important pollutants are the heavy metals in aquatic network because of their toxicity, accumulation and bio-magnification. Domestic, industrial and anthropogenic activities may broadly become the source of natural aquatic systems contamination of heavy metals. Among them, Mercury is a highly toxic heavy metal frequently found in the polluted aquatic ecosystem. In aquatic environment, mercury pollution is of great concern because of their adverse effect in aquatic organisms which can also transfer to humans through food-chain. Mercury toxicity causes damage in vital organs like, Liver, bone, kidney and also causes cancer. Mercury in fish comes mainly from their diet, and levels of bioaccumulation of contaminants are higher in fish which comes higher in food chain. The aim of this present work is to assess the toxicity of Mercuric chloride on *Tilapia nilotica* as a biomarker. Acute toxicity of mercuric chloride was analyzed by measuring the 24 h-96 h LC₅₀ value. Physical observations revealed that excessive mucous secretion and hyper-excitability was recorded at the higher concentrations of test chemical, The equilibrium of fish was lost at the higher concentrations of the toxicant.

Keywords: *Tilapia nilotica*, mercuric chloride; acute toxicity; heavy metal pollution, LC₅₀

Indigenous Technical Knowledge Associated With *Penaeus Vannamei* Farming in West Bengal, India

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Farmers rely on their knowledge for their livelihood, so it has always 'put to work' in the most practical sense. This is based on intimate experience possessed by fish farmers is characterized by practical skills and wisdom developed at a local scale through earning livelihoods over generation after generation. Study of indigenous knowledge held by the fish farmers will help in its recognition and preservation, besides generating important information base and pinpointing essential future research needs. Fish farmers' communities of the West Bengal are precisely innovative and skilful to use traditional knowledge in *Penaeus vannamei* farming and its management. The study attempted at compilation and documentation of indigenous technical knowledge (ITK) related to shrimp pond water quality maintenance, health management and growth of *Penaeus vannamei*. The objective is achieved through primary survey using semi-structure interview schedule with observation method at village level in Purba Medinipur district. A total of 200 shrimp farmers were selected from the district by using simple random sampling method for sharing their knowledge. Study discussed traditional techniques of using mixture made from mainly jiggery, rice flour & maida, milk whey, neem juice under pond water quality maintenance. Besides study identified traditional techniques of controlling diseases using turmeric, garlic and ginger paste, juices made by doob grass and jamrul leaves. Their unique practice for growth of *Penaeus vannamei* was also documented.

Keywords: *Indigenous technical knowledge, Pond water quality maintenance, Health management, Penaeus vannamei.*

The Addition of *Lamellidens Marginalis* and *Lemna Minor* ameliorates Water Nutrient Quality in Freshwater Integrated Multi-Trophic Aquaculture System

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The current study was conducted to assess the GIFT tilapia's production capabilities in a freshwater-integrated multi-trophic aquaculture system. In order to evaluate the growth, survival, water quality, and physiological response of GIFT-fed fish in 1000 l outdoor tanks, the experiment was conducted over 60 days using floating weed *Lemna minor* as an inorganic extractive and bivalve *Lamellidens marginalis* as an organic extractive. Only GIFT was designated as the control (C) treatment, followed by T1 with GIFT and *L. minor*, T2 with GIFT and *L. marginalis*, and T3 with GIFT, *L. minor*, and *L. marginalis*. In contrast, *L. minor* was transplanted to cover 25% of the tank's surface area. The stocking densities for GIFT and *L. marginalis* were 4,00,000 fingerlings ha⁻¹ and 750 kg ha⁻¹, respectively. At a 4% body weight rate, the fish were given floating pelleted feed containing 30% crude protein. Among different water nutrient quality parameters, calcium was found to be reduced in systems where the presence of *L. marginalis* was there. Potassium was lowest in FIMTA System. The control group observed a significantly lower level than the treatments. The presence of *L. marginalis* in T2 and T3 reduced the calcium levels of water. BOD and COD varied significantly ($p < 0.05$) among different treatments and the lowest values were observed in the FIMTA system. The ammonia, nitrite, nitrate, and phosphorous content in the control group was the highest and the lowest in the FIMTA system. Overall, results indicate that the FIMTA of GIFT with *L. Minor* and *L. marginalis* can ameliorate water quality and enhance productivity.

Keywords: FIMTA, Extractive organisms, IMTA, GIFT, *Lemna minor*, *Lamellidens marginalis*.

Preliminary Survey on Fishermen Co-operative Societies (PFCS) of Nadia District of West Bengal

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In our country, the fishing industry has great potential. West Bengal, one of the states that produces the most fish in India, has a very rich fishery. In keeping with the Indian cooperative movement, fishing cooperatives are being created in this state. According to the number of PFCS in India, West Bengal is ranked fourth. Nadia District has total 98 PFCS out of which 53 PFCS are dormant and 45 PFCS are active or functional. Fatepur Anchal MSS Ltd. Under Tehatta-I block has highest no (1245) of members out of which 203 are active members. In District Nadia Impounded water area (Tank/Pond): 6208.74 ha. Potential Area and Cultural Area 15,338.17. Brackish water fisheries, Reservoir fisheries, estuarine/ Cold fisheries are nil, Sewage fed fisheries are 4.54 ha, Total seed production (in million) 3380.46. A preliminary investigation on how the PFCS operates in this district has been conducted. This study suggests some potential actions for PFCS improvement in the Nadia District.

Keywords: Fishery, PFCS, Nadia.

DNA Barcode a Tool for Genetic Identity and Phylogeography Study: Case Study of Barilinae fish *Opsarius bendelisis*

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The present study investigated the genetic identity and phylogeography of *Opsarius bendelisis* reported from South Asia i. e. India, Nepal, and Bangladesh. Bayesian phylogenetic approach, species delimitation, and genetic divergence estimate based on cytochrome oxidase subunit (COI) sequence along with morphometric and meristic data established the identity of *O. bendelisis* from widespread geographical location. For 160 COI sequences, reported from North-Eastern India, Eastern India, Northern India, Central-Western India, Southern India, Bangladesh, and Nepal, 28 haplotypes were identified by Dna SP v6. h3 and h14 were the most frequent haplotypes and were shared by individuals from North-East India, Eastern India, and Bangladesh. Analysis of molecular variance (AMOVA) showed significant differences among and within the population. Most of the populations of *O. bendelisis* showed less gene flow and high differentiation. Neutrality tests showed no significant demographic expansion, except for Central-Western India. A median-joining network analysis and Maximum Likelihood (ML) phylogeny of haplotypes displayed an apparent geographical pattern suggesting a significant phylogeographic structure in the population. The findings provide valuable information for accurate estimation of diversity, conservation, and management of *O. bendelisis*.

Thymocyte Act As A Tool To Demonstrate the Immunological Function of A Fish (*Anabas testudineus* Bloch, 1792)

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The thymus is a primary lymphoid organ of fish. It is functionally significant for lymphoid cell maturation and development. Where thymopharyngeal epithelial cells typically plays a vital role in sub-cellular organelle-based interaction with the developing thymocytes as well as other lymphoid cells. The lymphoid and non-lymphoid cells interact in a bidirectional way. The incorporation of adipocyte cells in between the inner thymus gland and outer thymopharyngeal epithelial cell layer may functionally significant for thymic tissue homeostasis in fish? The model specimen, *Anabas testudineus* (Bloch, 1792) is a freshwater air-breathing fish of South-East Asia. Under a polarized light microscope, the thymus gland consists of pharyngo-thymic epithelial cells, developing thymocytes, thymoblast, plasma cells, adipocyte cells, myoid cells, dendritic epithelial cells, mast cells, macrophages, etc. The frequency of thymocytes within the thymus gland and the outer adipose tissue significantly indicate the physique of the gland as well as the meagerness of immunological function of the experimental species. The outer region of the adipose tissue layer (region of pharyngeal cleft) has been surrounded by mucus secreting goblet cells and some other types of lymphoid and non-lymphoid cells. The thymic trabeculae are significantly identified within the thymic tissue environment of the fish. The fibroblast and endothelial cells are clearly identified at the thymopharyngo-adipoepithelial (TPAE) zone of the respective thymus gland of fish. Apart from that, lymphoid cells are frequently noted within the thymopharyngo-adipoepithelial tissue layer of the extra thymic tissue mass.

Keywords: *Anabas testudineus*; *Thymus*; *Thymoblast*; *Adipocyte*; *Trabeculae*; etc.

A Study on Antibacterial Resistance in Consumable Fish Species of Kawardha, Chhattisgarh

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The purpose of the study was to assess the prevalence and antibiotic resistance of bacteria isolated from retail fish market from Kawardha, Chhattisgarh. Around 79 fish samples were evaluated including 26 Tilapia (*Oreochromis niloticus*), 25 Rohu (*Labeo rohita*), 14 Catla (*Catla catla*) and 14 Silver carp (*Hypophthalmichthys molitrix*). Physical characteristics, standard biochemical tests, and analytical profile index were used to identify the isolates using test kits. The antibiotic susceptibility of specific microorganisms was determined using the disc diffusion method. Out of the samples examined (79 samples) 95.22% were infected with 9 distinct harmful bacterial species. *E. coli* was the most prevalent bacterium (35%), followed by *E. faecalis* (20%), *Aeromonas hydrophila* (15%), and *P. aeruginosa* (10%)., *Enterococcus* spp. (7%), *B. subtilis* (4%), *B. firmus* (3%), and *S. aureus* (1%). Antibacterial sensitivity test was performed using 15 antibiotics viz. Penicillin G, Aztreonam, Vancomycin, Polymixin B, Erythromycin, Cefotaxime, Ceftazidime, Nalidixic Acid, Ceftriaxone, Cefpodoxime, Norfloxacin, Sulfurazole, Chloramphenicol, Gentamicin, and Trimethoprim. The results showed that Aztreonam was completely resistant to *S. aureus*, *Bacillus subtilis*, *Bacillus firmus*, *E. Coli*, and *E. faecalis*. Trimethoprim demonstrated resistance against *B. firmus*, *E. coli*, *E. faecalis*, *P. aeruginosa*, and Nalidixic acid demonstrated resistance against *E. faecalis*, *Aeromonas hydrophila*, and *P. aeruginosa*. *Aeromonas hydrophila* was the most common pathogen with 70% resistance to 14 of the 15 antibiotics tested.

Keywords: Antibacterial test, Retail Market, Pathogenic bacteria.

Assessment of Effects of Use of Antibiotics in Ornamental Fishes: A Systematic Review

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The farmed fish market has a growing segment called the ornamental fish trade. Disease occurrence, antimicrobial use, and the development of antibiotic resistance are key issues in the production of ornamental fish. Infections with *Aeromonas* and the resulting antibiotic resistance are very common in ornamental fish. It was described as one of the main infectious agents in the ornamental fish industry from the early period on. The aquaculture sector is forced to utilize antibiotics frequently due to the prevalence of numerous infectious diseases. Antibiotics are frequently used in aquaculture as growth enhancers in addition to illness control. As a result, the current study's major goals are to identify the impacts of antibiotic use in ornamental fishes and to offer some best management practices for solving the issue. The systematic review methodology used in this study was developed by previous researchers. For the purposes of making this study thorough, data on antibiotic usage in ornamental fishes around the world were gathered from 82 research articles that were published in various peer-reviewed national (26) and international (56) journals, books (6), technical papers (15), and other useful scholarly study materials (12). These articles were then grouped, analyzed, and summarized in accordance with the study's objectives. Any antibiotic misuse can result in the development of resistant bacteria in an environment. Some farms will change the antibiotics they use every few months or once a year in an effort to prevent this. The best course of action, however, is to positively identify the bacteria by performing sensitivity and culture tests, thereby avoiding needless, expensive, and perhaps hazardous therapies. The development of new-generation antibiotics, adoption of efficient preventive measures, and implementation of monitoring programs are only a few of the new efforts that may be taken into account in aquaculture systems once the patterns of antibiotic resistance of fish infections are known. To help with accurate diagnosis, conduct culture and sensitivity tests, and offer the best advice on dosages and treatment intervals, one should speak with a fish health specialist.

Keywords: *ornamental fishes, antibiotic resistance bacteria, monitoring programme.*

Perceived Effectiveness of Indigenous Technical Knowledge (ITK) among the Fish Farmers of FFPO Members: A Study from Purba Medinipur District in West Bengal

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Indigenous Technical Knowledge (ITK) encompasses the practical knowledge, techniques, and practises developed over time to effectively interact with situations. Typically, ITK is held by traditional or marginal farmers. With growing education and awareness, fish farmers now opt for collective approaches. A notable example is the Fish Farmers Producer Organization (FFPO), under the PMMSY scheme in 2020, offers flexibility for profitable businesses. A study was conducted in Purba Medinipur district, West Bengal from 2022 to 2023, to assess the perceived effectiveness and rationality of Indigenous Technical Knowledge (ITK) among a randomly selected group of 120 fish farmers from four specific FFPOs. The research used a descriptive research design and was based on personal semi-structured interviews, focus group discussions, and observation methods. Eight ITK practices were documented and assessed by the farmers based on seven traits using a 3-point continuum, resulting in Mean Perceived Effectiveness Index scores. The rationality of each ITK was also evaluated on a 4-point continuum based on expert opinions. The study identified that among eight documented ITKs, one practice was highly rational and highly effective: use of Organic Juice (a mix of groundnut oil cake, molasses, bran/flour, and yeast) in the pond water (51.68%), with rationality score 3.7 and MPEI score 2.68. One practice was found rational and highly effective: placing feed in a gunny bag (to reduce loss of excess food and use as a substrate for ectoparasites in water), practiced by 63.34 per cent of respondents (rationality 3.3; MPEI 2.72). Two practices were found rational and effective: the use of a mixture of wheat flour, urea, and yeast to maintain the colour of the pond (rationality 3.1; MPEI 2.35) and the use of raw cow dung on any side of the pond as natural fertilizer (rationality 2.9; MPEI 2.17). Another two practices were found rational but less effective: the use of organic matter for increasing the water holding capacity of soil (rationality 2.8; MPEI 1.71) and the use of bamboo sticks in the side of the pond for retention of the dyke (rationality 2.7; MPEI 1.76). The use of banana stems was found irrational and less effective. The research evaluates the effectiveness of ITK in promoting ecological stewardship among fish farmers. While ITK offers several benefits, its synergy with contemporary scientific insights can enhance outcomes. By combining indigenous wisdom and modern advancements, a comprehensive and sustainable approach to fish farming in India can be achieved.

Keywords: *Indigenous Technical Knowledge (ITK), Fish Farmers Producer Organization (FFPO), Perceived effectiveness, Fish farmers.*

Taxonomy, Distribution and Biology of Ocean Sunfish, *Mola* Koelreuter, 1766 from Indian Waters

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Taxonomy of the ocean sunfishes (Tetraodontiformes: Molidae) has a long history of taxonomic uncertainty that has led to several misidentifications which continues to this day. Currently, the family Molidae comprises five valid species: *Ranzania laevis* (Pennant 1776), *Masturus lanceolatus* (Liénard 1840), *Molamola* (Linnaeus 1758), *M. alexandrini* (Ranzani 1839) and *M. tecta* Nyegaard et al. 2017, last of which is a new species of ocean sunfish described using genetic and morphological tools. *M. alexandrini* previously synonymized with *M. mola* was resurrected and redescribed as valid species and considered a senior synonym of *M. ramsayi*. Study on molids from Indian waters is limited to distributional records based on morphologic and photographic evidence, lacking detailed taxonomic description, and biological and molecular data. Therefore, the present study aimed to investigate the biology and taxonomy of ocean sunfish *Mola* species by applying an integrative taxonomic approach based on both morphological and molecular data. Fresh specimens were collected both from the east coast (West Bengal and Odisha) and west coast (Maharashtra) of India during 2022-2023. We reviewed the whole published literature from Indian waters depicting 34 specimen records of *Mola* spp. Based on previous studies, morphological examination of fresh specimens, and comparative phylogenetic analysis based on two mitochondrial regions – the D-loop and COI gene sequences were carried out. Our study confirmed that the specimens from the Indian EEZ belong to *M. alexandrini* and cannot be attributed to previously misidentified *M. mola* or *M. ramsayi*. This study also revealed the complete absence of *M. mola* from Indian waters. *M. alexandrini* is widely distributed throughout the Indian coastline and inhabits both coastal and offshore waters caught in water depth ranges from 20 to 1937 m. Gut content analysis revealed that the fishes mostly feed on octopus (*Cistopus* sp.), cuttlefish (*Sepiella inermis*), clupeids (*Setipinna* sp.), prawns (*Solenocera* sp.), and jellyfish. All the specimens examined are heavily infested with parasites in the intestines, liver and gills. Gonad shape varies between the sexes. The ovary is single-lobed and ball-shaped whereas the testis has a bilobed structure, elongated and rod-like. Future studies on feeding and reproductive biology with a wide size spectrum of such charismatic species are highly essential for the successful implementation of Ecosystem-Based Fisheries Management.

Keywords: Molidae, Indian EEZ, Integrative taxonomic approach, D-loop, COI.

The Evaluation of Plankton Diversity in Blue Bird Lake at Hisar Haryana

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The study was carried out in Blue Bird lake which is situated in close to Hisar Airport on National Highway 10 in the town of Hisar, in the Hisar district of Haryana State, India. Evaluation and quantification of plankton of diversity of Blue Bird Lake were monitored from September 2022 to February 2023. The findings from the analysis of the plankton population indicated the presence of 42 different genera of plankton. Among these, there were 29 genera of phytoplankton categorised into eight main groups: Bacillariophyceae (6 genera), Chlorophyceae (9 genera), Cyanophyceae (4 genera), Dinophyceae (3 genera), Hymenomonadaceae (1 genus), Zygnematophyceae (1 genus), Trebouxiophyceae (2 genera), and Euglenophyceae (3 genera). Additionally, there were 13 genera of zooplankton classified into six major groups: Copepod (4 genera), Cladocera (2 genera), Rotifers (4 genera), Ascarididae (1 genus), Protozoa (1 genus), and Tubulinea (1 genus). When observing the distribution across various months, it was observed that the highest number of species of phytoplankton (84 species) were found in sites 1, 2, and 3, with Chlorophyceae being the dominant group. In contrast, in Site 4, Cyanophyceae was the dominant group. For zooplankton, the most dominant species were found in sites 1, 2, 3, and 4, with Rotifers being the dominant group. Quantitative analysis of the total plankton in different months revealed that in sites 1, 2, 3, and 4, the maximum quantity of phytoplankton was observed in October (66800 plankton per litre), while the minimum quantity was observed in November (28400 plankton per litre). Similarly, for zooplankton, the maximum quantity was observed in September (53000 zooplankton per litre), and the minimum quantity was observed in February (22400 zooplankton per litre). The Shannon and Weaver diversity index was calculated to assess the diversity of zooplankton and phytoplankton. The highest diversity index for zooplankton was found in site 3 (1.74), while the lowest was in site 1 (1.37). In the case of phytoplankton, the highest diversity index was observed at site 4 (2.47), while the lowest was at site 2 (1.47). The overall diversity index for plankton was highest in sites 3 and 1 (2.28) and lowest in site 2 (2.23).

Keywords: *Phytoplankton, Zooplankton, Shannon – Weaver diversity index.*

The Negative Influence of Chronic Exposure to Nonylphenol at Eco-Relevant Doses on Zebrafish Ovary and Its Impact During Early Embryonic Development

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Nonylphenol (NP), a potent estrogen receptor (ER) agonist, is widely used as surfactants in wastewater treatment plants and to optimize manufacturing of products like plastics, lubricants, detergents, cosmetics, and herbicides. Using adult female zebrafish (*Danio rerio*) as the model, the present study examined the effect of chronic, sub-lethal exposure to NP at environmentally relevant concentrations (50, 100 µg/L; for 28 days) on reproductive parameters and embryotoxicity. Our results show that congruent with a significant decrease in body weight in both the treatment groups, NP (100 µg/L) exposure could attenuate gonadosomatic index (GSI). Ovarian histopathology reveals a sharp increase in follicular atresia corresponds well with significant reduction in full-grown (stage IV) follicles in NP-exposed groups. Further, congruent with a significant increase in reactive oxygen species (ROS) accumulation and H₂O₂ level, NP exposure could alter the ovarian antioxidant defence system (ADS) and promotes lipid peroxidation (MDA level) and membrane damage. Following 28-day exposure, NP-treated females were mated with normal males to determine the number of eggs laid per female and the fertilization rate. Fertilization rates dropped in parallel with the fall in the average number of eggs laid by females from NP-exposed groups. Importantly, the significant negative influence of NP exposure *in vivo* on zebrafish ovary could impede the early embryonic development in F1 generation, suggesting a transgenerational effect. A significant increase in delayed development and other developmental malformations, e.g., abnormal cleavage, cardiac and yolk sac oedema, poorly developed eye, as well as a marked reduction in heart rate and hatchability with elevated mortality in maternally NP-exposed embryo/larva indicate embryotoxicity. Morphological changes in the developing embryo/larvae may originate in disrupted redox balance (oxidative stress), nitric oxide signalling and elevated apoptotic response. Thus, the adverse impact of NP on reproductive performance in maternal zebrafish may impair the developmental potential in F1 offspring.

Keywords: *Nonylphenol, zebrafish ovary, oxidative stress, nitric oxide, developmental malformation.*

Isolation and Characterization of *Saprolegnia* sp. from *Pangasianodon hypophthalmus* and Evaluation of Antifungal Activity of Different Chemicals and Drugs

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Saprolegnia is a serious pathogen of many freshwater fish. In this study, we isolated *Saprolegnia* sp. from naturally infected *Pangasianodon hypophthalmus* fingerlings in experimental facility of ICAR-CIFRI. Identification of the isolates were carried out by microscopic observation of different life stages of the fungi and PCR amplification of internal transcribed spacer region (ITS) using universal primers ITS 1 and ITS 4. The infected fish were lethargic, swimming near the surface of the water and exhibiting a white or grayish cotton-like appearance on the body surface. To date, there is no effective treatment to control fungal infection in fish. We evaluated the potential of five different chemical compounds having antifungal properties against zoospore and hyphae of *Saprolegnia parasitica*. The chemical used is fluconazole, clotrimazole, copper sulfate, boric acid, and malachite green evaluated in a dose-dependent manner (1, 10, 50, and 100 ppm) *in vitro* conditions. Malachite green and copper sulfate completely inhibited the hyphae growth at 1 ppm, and 10 ppm, respectively. Boric acid had no significant effect on reduction of hyphal growth. Fluconazole could partly reduce the hyphae growth only at 100 ppm, whereas clotrimazole completely inhibited at 1 ppm indicating higher anti-fungal activity of clotrimazole *in vitro*. The information could serve as an effective treatment and control measure against *Saprolegnia* infection in fish.

Keywords: *Saprolegnia*, *Pangasius*, Antifungal, Chemical, Drug.

Ichthyofaunal Diversity and Eco-Fishery Status of Kulia Beel, Kalyani, Nadia District, West Bengal

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Floodplain wetlands (beels) constitute one of the major aquatic resources of West Bengal contributing significantly to the state's inland fish production. The present study was carried out to study Ichthyofaunal diversity and eco-fishery status of a closed oxbow lake Kuliabeel, Kalyani, Nadia district, West Bengal. Kuliabeel situated between latitudes 22°52' N and 24°12' N and 88°07' E and 88° 48' E in the Chakdaha CD block in the Kalyani subdivision, Nadia district in the state of West Bengal, India. The river Saraswati's meandering pattern has created this beel. The total area of the beel was recorded to be 56.24 ha and the average depth was 10 feet. The present investigation reveals an ichthyofaunal diversity of 35 species belonging to 13 orders and 19 families. Among the families encountered, Cyprinidae dominated with 31% species followed by Channidae (8%). Maximum fish species found in the beel were carnivores, followed by omnivores and remaining were herbivores. On the basis of usability and fishery importance it was found that 85% have food as well as commercial value and 20% were found with ornamental value. As per global IUCN red list status it was found that (76%) fishes are Least Concern (LC), 12% and (11%) fishes were respectively Near Threatened (NC) and Vulnerable (VU) and remaining only one species is data deficient. The important physico-chemical parameters of water such as temperature, pH, dissolved oxygen, total alkalinity, total dissolved solids, electrical conductivity and nitrate-nitrogen, were studied. Although, all the parameters were found to be within the tolerable limits of fishes, pH was on the higher side. The range of Shannon Diversity Index of fish population during the study period from Kuliabeel is 2.765 to 3.07. It was found that the range of Species Richness index (d) or Margalef's index of fish population during study period varied from 3.655 to 3.882 and the range of Simpson Diversity Index of fish population varied from 0.9083- 0.946. The range of Pielou's Evenness Index(J') during study period from this experimental water body varied from 0.5883 to 0.7976. Studies in Kuliabeel showed that it is moderately infested with weeds. *Eichhorniacrassipes* is dominated followed by *Colocasiaesculenta* and *Lemna minor*. The annual fish catch recorded in the year 2019-20 in Kuliabeel was 6800.00 Kg and the average fish production was found to be 121 kg/ha/year. In 1991 Kuliabeel received the best production award. Most abundant fishes included *Hypophthalmichthysmolitrix*, *Oreochromisniloticus* and *Catlacatla* which generally contributed about 52% (on weight basis) of the total catch. Stocking densities are generally maintained at 30000-40000 fingerlings per ha and it is done mainly in the months of April-June. Fishing is normally done by using traditional boats (Dinghi), Chat Jal, Gill net with mesh of 5 cm size. The marketing channels noticed in the Kuliabeel involve auctioneer, wholeseller and retailer. Fishes are sold in local markets (Kanchrapara, Halisahar, Gokulpur) through or markets away from Kuliabeel through whole-seller. 80% wastewater released to the beel from factories and other industries is untreated which leads to eutrophication and thus loss of oxygen in the aquatic eco-system. Various management strategies have been formulated by Saguna Union Fishermen Co-operative Society Limited and Freshwater Fisheries Research Training Centre (F.F.R.T.C) for sustainable benefits from the beel.

Keywords: *Ichthyofauna, Biodiversity, Beel, Sustainable Development, Fisheries.*

Effect of salinity on Embryonic Development and Hatching of Knight Goby (*Stigmatogobius sadanundio*): A Brackishwater Ornamental Fish from Indian Sundarbans

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The potential of brackishwater fish species for ornamental fish export from the country is yet to be recognized. Brackishwater ornamental species can be easily adapted to any salinity as per the requirement of the clientele. The knight goby (*Stigmatogobius sadanundio*), is a potential estuarine fish that is found in Indian Sundarbans and traded internationally. It is an omnivore that accepts formulated feed in captivity and is easy to maintain in aquaria with other fish species. Adults ($n = 108$) of knight goby (ABL: 5.1 ± 1.24 cm) were collected from tidal-fed water bodies of Sundarbans. These fishes were maintained in captivity (FRP tanks: 500 l) and fed with formulated feed (30% Crude Protein) for maturation. Sexual dimorphism was evident after 4 months of domestication. Spawning, embryonic development, and hatching were evaluated in salinities of 0 (T1), 3 (T2), 6 (T3), and 9 (T4) by pairing 1 female: 3 male in FRP tank (100 L). Spawning was observed in all the treatments. Females laid 1500 – 2000 eggs. There was no significant difference in egg sizes (Total length: 1.2 – 1.4 mm; Diameter 0.59 – 0.67 mm) in all the treatments. The latency period was shortest in T2 (68 hours) followed by T1 (72 hours). The longest latency period (95 hours) was recorded in T4. Hatching (%) was significantly highest (98.83 ± 1.97) in T2 and lowest (61.28 ± 5.32) in T4. Hatchling survival (%) was estimated at 24 hours. The significantly highest survival on 24-hour post-hatch was recorded in ($99.12 \pm 0.5\%$) T2 and lowest in ($76.28 \pm 6.19\%$) T4. Deformity in hatchlings ($5.12 \pm 4.65\%$) was observed only in T4. The present study revealed that optimum water salinity should be 3 ppt during spawning to achieve mass-scale breeding of knight goby under captivity.

Keywords: *Knight goby, salinity, breeding, hatchlings.*

Estimation of Optimum Dietary Carbohydrate Requirement of Katli (*Neolissocheilus hexagonolepis*, McClelland) Fingerlings Fed on Isoenergetic Semi-Purified Diets

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A feeding trial for a period of 90 days was conducted to estimate the optimum carbohydrate requirement for growth, survival, effective feed conversion in *Neolissocheilus hexagonolepis* (Katli) fingerlings (5.00 ± 0.16 g). Six isoenergetic semi-purified diets namely D 12.54% (T1), D 17.12% (T2), 21.7% (T3), D 26.28% (T4), D 30.86% (T5) and D 35.44% (T6) were formulated with graded levels of carbohydrates using dextrin. Different feeding trials at a rate of 3% of total body weight were fed twice daily, in triplicate. Survival in all treatments was high (95 to 99%) and no significant differences were observed ($p > 0.05$) among the treatments. Specific Growth Rate (SGR) to varying levels of dietary carbohydrate provided an estimate of 25.33% (around T4) when dietary protein is around 40% (CP 40%) for maximum growth of *N. hexagonolepis* fingerlings. Feed conversion ratio of *N. hexagonolepis* fed dietary carbohydrate levels 21.7% (T3) was significantly lower than that of rest of the treatments. Protein efficiency ratio significantly increased with dietary carbohydrate (dextrin) level, increasing from 12 to 26.28%, with no significant differences among the treatments with over 26.28% dextrin. The findings, therefore, provided prerequisite information for feed formulation with locally available ingredients at lowest possible cost as well as formulating further strategies for their artificial propagation, while conserving the natural stock.

Keywords: *Neolissocheilus hexagonolepis*, Specific Growth Rate, Feed Conversion Ratio, Survival Rate, Feed Formulation.

Impact of Self-Help Groups (SHGs) In Improving Socio-Economic Status of Tribal Women

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Self-Help Groups (SHGs) have emerged as significant catalysts for the empowerment of tribal women, fostering socio-economic progress and inclusive development. These collectives provide a platform for tribal women to pool their resources, share knowledge, and engage in collective decision-making. This is particularly important as tribal communities often face multifaceted challenges, including isolation, poverty, a lack of education, and limited access to resources. The study was conducted among 280 randomly selected respondents from 28 SHGs in two tribal blocks, namely Khatra and Taldangra, of Bankura district, West Bengal. An *ex-post* facto research design was employed to study the impact of SHGs in improving the socio-economic conditions of tribal women. Data were collected through structured interview schedule and observational techniques. Primary data were interpreted using suitable statistical tools, and inferences were drawn. The findings of the study revealed that the majority of the respondents (69.64%) had medium level of empowerment across five dimensions of women's empowerment- personal, decision-making, economic, socio-psychological and lego-political empowerment. There were significant differences in the annual income of respondents before and after joining the SHG ($t = -23.728$, $P < 0.001$), indicating that joining the SHG led to an increase in the annual income of respondents. After joining the SHG, there was a statistically significant changes in occupation ($Z = -11.643$, $P < 0.001$), which suggests that respondents learned about diversifying their occupations and improving their soft skills through SHG participation. Correlation analysis revealed that there were positive and significant correlations at 1 percent level of probability between women's empowerment and factors such as education, number of trainings attended, occupation, type of house, size of land holding, size of livestock holding, annual income, extension agency contact, mass media exposure, credibility of sources of information, economic motivation, and innovation proneness. Multiple regression analysis showed that innovation proneness, annual income, mass media exposure, and extension agency contact significantly explained the variability in the extent of women's empowerment. Notably, extension agency contacts alone contributed to 92.0 percent of the variability in explaining the extent of women's empowerment. The study also identified major constraints faced by respondents, including inadequate training facilities (mean score of 74.90) and delayed supply of raw materials (mean score of 73.74). Moreover, the sustainability of SHGs relies on effective governance structures, regular training, and ongoing support from governmental and non-governmental agencies. As the global development agenda emphasizes inclusion and gender equity, SHGs stand out as an effective strategy to uplift tribal women and create a more equitable society.

Keywords: Tribal women, Empowerment, Self-Help Groups (SHGs), Collective decision-making, Sustainability, Gender equity.

Assessment of the River Health Using Fish as Ecological Indicators: A Case Study of River Godavari

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River Godavari is the largest of the peninsular rivers and the second longest river in India next to Ganga with a total length of 1,465 km. As Indian rivers are facing tremendous anthropogenic pressures, despite their ecological, economic and cultural relevance in the country, an effort was done to identify the major environmental stressors on the ecosystem of this very important river and to assess the ecological health of the river stretches using fish-based index of biotic integrity (F-IBI). The ecological stressors impacting the system were identified and prioritized ranking of the identified stressors were done based on key informants' perception and also on the researchers' understanding. The F-IBI with metrics to reflect the impacts of identified stressors considering the ecological and ichthyofaunal characteristics, were adopted to assess the ecosystem health as fishes being excellent indicators of river health. The study on fish faunal diversity and abundance studies in river Godavari indicated that despite all of its ecological stresses, the river still supports rich fish diversity yet there is notable shift in the fish assemblage pattern, with respect to the ecological stressors such as river fragmentation and pollution. The upper stretches of the river traversing through Maharashtra were mostly under Severely impaired integrity class, the Telangana stretch in Moderately Impaired class and Andhra Pradesh stretch was a mix of Moderately and Slightly Impaired integrity classes. The rivers are germplasm reserves of native fish fauna and immediate measures are to be taken to conserve the declining fish diversity. There should be efforts to improve upstream/downstream accessibility of migratory fishes; it should be ensured that the rivers have at least the minimum required environmental flow of water after the river water gets diverted by various projects.

Protection of Hilsa Fisheries through Aquaculture Initiatives

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The Hooghly-Matlah estuary has a prominent position for its contribution in the fish production among the Indian estuaries and hilsa was the most important species in its catch due to high economic returns. Unfortunately, its catch is decreasing very rapidly in the Indian waterbodies although in the neighboring country Bangladesh, the production has been steadily increased and the present production level is more than 5,50,000 ton. Anticipating the future scenario, a comprehensive project was conceived by the researchers from the fisheries Institutes of ICAR to conduct a detailed study during 2012-17. After obtaining the leads from the first phase of the project, a second phase of the project is under operation targeting gonadal maturity of hilsa and its breeding in the captive condition. The present participating institutes are ICAR-CIFRI, ICAR-CIBA, ICAR-CIFA and ICAR-CIFE. The captive stocks have initially been built from the breeding activities performed from the matured broods collected from nature. Management practices have been developed for fry, fingerlings and gradually, for grow-out culture under different salinity regime. Due care has also been taken to develop feed for different life stages of hilsa. After obtaining the desired gonadal maturity stage, captive breeding is the goal for completing the life cycle under inland condition. Once the hurdles are crossed, the successful aquaculture practice would be able to re-establish the depleted stock in the targeted waterbodies.

Keywords: *Conservation Aquaculture, Hilsa Fisheries, Captive Breeding.*

Plankton Assemblage Pattern and Zooplankton Supplementation in Hilsa Culture Ponds

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Hilsa, *Tenulosa ilisha* is an important commercial fish of the Indo-Pacific region. Stomach content analysis established that though hilsa is a zooplankton feeder during their early life cycle but they gradually shift their diet preference towards diatoms in the adult stages of their life cycle. Fortnight analysis of plankton content of hilsa culture ponds led to the culture of zooplanktons at the pond experimental site and add them in the culture system to maintain the constant availability of zooplanktons for the grow-out stage of pond reared hilsa. Gut content analysis revealed that fingerlings to sub-adult hilsa preferred rotifers whereas sub-adults to adults (< 50cm length) preferred copepods and hence the emphasis was given on the mass production of zooplanktons belonging to the class *Rotifera* and *Copepoda*. Based on the fortnight analysis of plankton concentration in the culture water, zooplanktons were supplemented in the culture water. Month-wise zooplankton concentration was maintained at 1431 ± 110.6 to 3602 ± 185.3 nos./L. Phytoplankton concentration was maintained at 16643 ± 1612.9 to 32153 ± 4051.05 units/L which include *Microcystis* population also. *Microcystis* was a great concern for the hilsa culture system which affected the growth of some planktonic communities. Its population was also controlled using a microbial consortium which also proved good results after application. Water quality parameters analysis also revealed that whenever there was a bloom of *Microcystis* in the culture pond, the nitrate and phosphate values also varied significantly with the impact of *Microcystis* in the hilsa culture environment.

Keywords: *Hilsa, Rotifera, Copepoda, Microcystis, Microbial Consortium.*

Nuisance to Nutrient: An Innovative Solution for Converting Aquatic Weed from A Drinking Water Unit into Microalgal Media

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Aquatic weeds are one of the emerging concerns globally due to its rapid expansion in the aquatic ecosystem and its invasive nature. This has immensely affected the sedimentation tank of Indira Gandhi Drinking Water Treatment Plant which receives the floating macrophytes along with water sources from Ganga River. *Salvinia molesta* (SM) is a floating aquatic fern and a rapidly growing competitive plant which has manifested in the steady and slow-moving environment of the siltation tank. The excessive growth of the weed hampers the sedimentation process which indirectly affect timely supply of drinking water and its removal is a labour-intensive process. Hence in the present study, these weeds were first converted into vermicompost manure and its extract (aerobic and anaerobically digested) was prepared and tested as nutrient source to enhance growth performance and lipid production from a freshwater microalga (*Graesiella emersonii* MN877773). The efficacy of the extract was then tested in combination with BG11 medium. Further, the SM based extract was compared with commonly available vermicompost (garden-wastes) based extract (GW). The result revealed that SM-based extract yielded higher microalgal biomass productivity (0.03 g/L/day) as compared to the GW extract (0.02 g/L/day) and BG11 (0.01 g/L/day). However, the lipid productivity microalgae grown SM based extract was 1.2 and 1.4 times lesser than the BG11 and GW based extract. The present study offers an ecofriendly and economically viable solution to the aquatic weed management in the drinking water unit by valorization of the wastes into nutrient rich green microalgae. More lucidly, it also paves a way for proving the concept of “waste into wealth”.

Keywords: *Salvinia molesta*, Weed management, Vermicomposting, Microalgae, Lipid production.

Abiotic and Biotic Drivers of Temporal Dynamics in Spatial Heterogeneity of Zooplankton Community in A Tropical Reservoir India

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The present study assessed the temporal dynamics of zooplankton community structure and diversity using GIS platform, and their ecohydrological interactions of a tropical reservoir located in Eastern India. Altogether, 34 taxa of zooplankton belonging to 12 species and 15 genera under four taxonomic groups were recorded whose average annual abundance was 5541.50 ± 1345.62 ind/l. Rotifera absolutely dominated in the total zooplankton compositions and contributed a major share of 37.28% at the annual average level, which was ranked one in terms of species richness and numerical abundance. In total, twelve zooplankton taxa emerged as dominant ($\gamma = < 0.02$) across seasons. The diversity indices indicated the greater zooplankton diversity in the semi-lotic zone, showing significant variations ($p < 0.05$) across seasons. PERMANOVA analysis exhibited a significant temporal variations of zooplankton abundance ($F=3.66$, $P=0.0001$). Canonical Correspondence Analysis (CCA) depicted the environmental factors such as water temperature, total alkalinity, total hardness, TDS, specific conductivity, DO, transparency, depth and nutrients ($\text{NO}_3\text{-N}$, $\text{PO}_4\text{-P}$ and $\text{SiO}_4\text{-Si}$) were the effective variables for the distribution of whole zooplankton population including the dominant species in the Derjang reservoir. The findings provide a better understanding of the influence of ecohydrology on zooplankton community of a community managed reservoir and discuss management and researchable issues which was further useful for ecosystem-based conservation and management.

Keywords: Reservoir; Zooplankton Community; Assemblage; Ecohydrology; Species Dynamics; GIS; Management.

Geospatial Distribution, Contamination Levels of Potentially Toxic Elements in the Sediment of Mirik Lake, India

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Most of the inland open-waters, especially lakes, have been the victim of enhanced man-induced perturbations and are in a critical phase of ecological transition. Lakes function as long-term sinks for many pollutants including Potentially Toxic Elements (PTE), so the problems would further be accentuated due to environmental degradation and impending climate change scenario. Sediment act as a sink of heavy metals due to their complex physical chemical mechanism. Hence, the study was designed to evaluate the distribution of PTEs in sediments of Sumendu (Mirik) Lake situated in the Eastern Himalayan part of India. In this study, total of 33 sediments samples from 11 sampling points were collected to characterise spatial distribution, potential risk and potential sources of PTEs (Fe, Mn, Zn, Cu, Cr, Co, Cd, Ni, Pb, and As) by means of inductively coupled plasma mass spectrometry. The geostatistical prediction map showed the range of Fe, Mn, Zn, Cu, Cr, Co, Cd, Ni, Pb, and As in sampling stations were 13007-61029 µg/g, 128.3-629.9 µg/g, 95.0-282.4 µg/g, 24.2-47.1 µg/g, 32.1-84.7 µg/g, 4.8-17.5 µg/g, 0.02-0.48 µg/g, 18.9-49.8 µg/g, 3.80-20.8 µg/g, 2.61-10.16 µg/g respectively. Due to wastewater and other rubbish disposal, PTE concentrations (Mn, Ni, Pb, Cu, Fe, Cr, Cd, Co, and Zn) were higher especially at the inlet side of the wetland according to the spatial distribution maps. Ecological risk assessment indicated that Cd and As were the most polluted PTEs in sediments and need greater concern. The findings of the CA and PCA indicated that there was a substantial positive association between the concentrations of PTEs and were mostly influenced by the texture of the sediments in the research area. The findings of this study provide detailed information about level of contamination of PTEs in sediments that could help in establishing rational ecological protection measures.

Keywords: *EKW, Potentially Toxic Elements, Geoaccumulation index, Anthropogenic waste.*

“Ecopath” A Tool for the Trophic Interaction Study: A Scenario in Chilika Lagoon Ecosystem

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Tropical coastal lagoons are one of the productive ecosystems in the world. They possess a strong network in terms of complex trophic interaction process for easy flow of matter among its components. Accessing the trophic interaction directly is a tedious process. However, some key ecological concepts like “keystone species”, “niche overlap” and “electivity or selection of diet” can be used for accessing the trophic interaction indirectly. Continuing to this, Ecopath – the mass balanced module is a renowned tool of Ecosystem based fisheries management strategy and the module itself is based on the trophic interaction among the functional groups of any ecosystem. Also, it possesses the ecological network analysis indices along with trophic indices within the module. In this investigation, the feeding interaction of the Chilika lagoon ecosystem has been appraised. Chilika lagoon is a well-known tropical ecosystem having a complex food network system of various flora and fauna including more than 200 species of finfish and shellfish. In this study, the “keystone species of the Chilika lagoon ecosystem”, “niche overlap pattern” and the “electivity” through the mass balanced ecopath model were investigated. In the keystone analysis, three keystone indices (KS1, KS2 and KS3) were applied and the groups like Irrawaddy dolphin, croakers and perches were identified as keystone species by more than two keystone indices. Based on the niche overlap study, 108 pairs were identified. Groups like prawns and crabs were found as the most niche overlapping group among all the organisms and contributed about 13 and 11 number pairs among the 108 niche sharing pairs. Similarly, the electivity of the ecological groups was analysed, and interestingly, almost all groups were showing negative index values for detritus and macrophytes. Benthic groups like prawns and crabs play a crucial ecological role in the food web dynamics of Chilika lagoon. This study will be helpful to understand the complex interaction among different trophic groups of Chilika.

Keywords: *Ecopath, Chilika, Niche overlap, Keystone species, Electivity.*

Ameliorative Effect of Natural Floating Island As Fish Aggregating Devices on Heavy Metals Distribution in A Freshwater Wetland

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Growing human population and climate change are leading reasons for water quality deterioration globally; and ecologically important waterbodies including freshwater wetlands are in a vulnerable state due to increasing concentrations of pollutants like heavy metals. Given the declining health of these valuable resources, the present study was conducted to evaluate the effect of natural floating island in the form of fish aggregating devices (FADs) made of native weed mass on the distribution of heavy metals in the abiotic and bio compartments of a freshwater wetland. Lower concentrations of surface water heavy metals were observed inside the FADs with a reduction of 73.91 %, 65.22 % and 40.57 to 49.16 % for Cd, Pb and other metals (viz. Co, Cr, Cu, Ni and Zn), respectively as compared to outside FAD. These led to 14.72 to 55.39 % reduction in the heavy metal pollution indices inside the FAD surface water. The fish species inside the FADs were also found less contaminated (24.07 to 25.07 % reduction) with lower health risk indices. The study signifies the valuable contribution of natural floating island as FADs in ameliorating the effect of heavy metals pollution emphasizing the tremendous role of the natural floating islands in sustainable maintenance of freshwater wetlands for better human health and livelihood.

Keywords: *Heavy metal, Floating Island, Fish aggregating device, Wetland, Potential ecological risk.*

Domestication and Captive Breeding of Golden Barb, *Pethiagelius*(Hamilton, 1822) through Bio-mimicry

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The present practice of exporting native ornamental fish is mainly based on natural collection which is uncertain and unsustainable due to overexploitation of particular varieties of fish from natural waters. Therefore a standard captive breeding technology is required to fulfil the trade demand. Among them the Golden barb, *Pethiagelius* is a potential ornamental fish and popular among the hobbyists due to their attractive ornamental criteria.

Under these backgrounds, the detail study on ecological aspects and biology of indigenous Golden barb, *Pethiagelius* was undertaken. For domestication, fishes were collected from Dihing river of Assam, India. Eco-biological condition of the natural habitat was studied to simulate the natural condition for captive rearing. The preferred food and feeding habit of these fishes were also studied through gut content analysis. Semi-natural conditions were created in the laboratory by performing the bio-mimicry of the natural habitat. The fish were fed with Plankton, *Artemianauplii*, *Tubifex* and *chlorella* twice a day. The optimum water quality was maintained throughout the period with the temperature range between 18- 28 °C.

By only performing the habitat simulation *P. gelius* got mature in captive condition. The breeding season is during May to October. Successful maturity was obtained at the age of 4+ months in captivity. The minimal length and weight at first maturity of female fishes were 3.9 cm and 0.8 g whereas male attained maturity with a length of 2.4 cm and weight of 0.2g. Since the eggs of the *Pethia* species fish are sticky in nature, amazon plants were used as mats. The spawning tank maintained about 18 cm of water, temperature of 22-26 °C, with gentle aeration. A water pH of around 7-7.5 was maintained which gave good results. For spawning gravid male (6 nos.) and female (4 nos.) were put together in breeding tank (60cm×30cm×30cm). Generally within one or two days female laid eggs attached with plant leaf. The number of eggs from a single spawning act varies from 500 to 1200. Fertilization and hatching were 80% and 65-71%. The fertilized eggs were demersal, slightly sticky in nature, translucent, un-pigmented, light yellowish in colour and spherical in shape. The eggs hatch out within 24-26 hours. The hatchlings took 40-42 hours to absorb their yolk sac. The spawn were fed with green water for 4 days. After that larval rearing is done and fed with small zooplankton for a week. Gradually they were weaned with larger plankton and chopped *tubifex*.

Keywords: *Indigenous Ornamental Fish, Habitat simulation, Golden barb, Captive breeding.*

Small-Sized Copepods Structuring Meso-Zooplankton Assemblage Pattern in A Tropical Estuarine System, Indian Sundarbans

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The present study investigated the role of small copepods in structuring the dynamics of the meso-zooplankton community in the Indian Sundarbans estuarine system (SES). To elucidate this, seasonal sampling was carried out at the six predefined sampling points in the SES. In total, 46 taxa of zooplankton were recorded which are dominated by Copepoda (42%). Small-bodied copepods have been found to be higher than large-bodied copepods. Species *Bestiolinasimilis* and *Oithona* spp. ranked their maximum abundance in the overall copepod population. The PERMANOVA analysis with Monte Carlo test (p) depicted a significant difference in zooplankton composition between stations ($F=2.9525$; $p=0.027$) and seasons ($F= 3.345$; $p=0.015$). Analysis of the feeding guild revealed the dominance of herbivory ZP (75.7%) which could be a good indication of the maximum utilization of the strata's trophic energy. Altogether, holoplankters contributed maximum (42-65%), followed by meroplankters (35-58%) of the total ZP. Results of regression analysis with different zooplankton diversity indices (H' , J') showed the significant role of small copepods in the zooplankton/copepod community in the SES. The ecological guilds (feeding), carnivory was negatively correlated with water temperature. The detritivores have been associated with transparency, salinity and pH; and omnivory with dissolved oxygen, which emerges from Canonical Correspondence analysis. The key factors behind the prevalence of small copepods might be correlated to efficient foraging at low food concentration, low predation by visual predators compared to larger copepods, high egg production rate and rapid growth rate.

Keywords: *Small copepods, dynamics, feeding guild, Sundarbans.*

***Ompokbimaculatus* cultured in Cages as An Intermediate Host to a Helminth Parasite, *Isoparorchishypselobagri*: First Report from Maithon Reservoir, India**

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Isoparorchishypselobagri is a trematode parasite having different host to complete its life cycle. Fishes are one of its important intermediate hosts. The present finding reports the infestation of *I.hypselobagri* in *Ompokbimaculatus* during 6 months monitoring of cages at Maithon reservoir, India by a team of Scientist at ICAR-Central Inland Fisheries Research Institute. The metacercarial parasite were identified through morphological characteristics observed under microscope. The molecular identification was done through partial sequencing of 18S rRNA and cytochrome oxidase subunit 1 (COI) gene. The intensity, mean intensity and prevalence of *I. hypselobagri* in *O. bimaculatus* was analysed. Using Generalised linear model, the influence of size of host, season and water quality on infection rate was tested. The metacercarial parasite was found to be primarily located near air bladder, around kidney and near kidney of the host. The result showed that size of *O. bimaculatus* influenced the intensity of infection by *I. hypselobagri*. Further, 7 species of snails were identified in cage fouling and they might have probably acted as first intermediate host to the parasite. The study represented implications for understanding the ecological and taxonomic patterns of *I. hypselobagri* infections and pathology in *O. bimaculatus* cultured at cages in Maithon reservoir, India. The study draws the attention for parasitic disease management in open cage culture practices.

Keywords: *Isoparorchishypselobagri*, *Ompokbimaculatus*, Intermediate host, molecular identification.

Amino Acids Profile of Anadromous Hilsa, *Tenualosa ilisha* (Hamilton, 1822) is Related to Age and Sex

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The amino acids composition of different size groups was examined in order to better understand how the nutritional makeup of Hilsa (*Tenualosa ilisha*) varies with growth and how it affects human health. In this study, the quantities of essential and non-essential amino acids in muscle and Hilsa serum were analyzed for both male and female weight groups. Essential amino acids (EAA) were discovered to be much higher in Hilsa muscle than non-essential amino acids (NEAA), and there were 17 amino acids found in the hilsa, which are regulated by age. The levels of amino acids were higher in mature male Hilsa (300-400g) than in females, but there were no differences in the lower weight group. Leucine, Lysine, Threonine, Phenylalanine, Glutamic acid, Aspartic acid, and Alanine were found to be particularly abundant in the analysis of Hilsa amino acids. Glutamic acid (0.772 ± 0.57), the most abundant essential amino acid in muscle, was followed by Lysine (0.379 ± 0.27), Leucine (0.379 ± 0.28), Threonine (0.378 ± 0.33), and Phenylalanine (0.194 ± 0.15). Among the non-essential amino acids, Aspartic acid (0.471 ± 0.34), and Alanine (0.249 ± 0.18) were found in minute levels, although there was a little less muscle in the female than in the male, they nonetheless followed the same pattern. Males under 300g had significant levels of Proline and Valine as well. The number of amino acids in serum was less than in muscle, and a few amino acids, namely Aspartic, Threonine, Proline, Tyrosine, and Glutamic acid, were higher in females. In comparison to males, females had a considerably lower concentration of Histidine. Arginine (over 300g), Glycine, and Leucine were prevalent in the male genus. Therefore, these amino acids play a major role in human nutrition and intake of Hilsa will directly benefiting the human health besides its role in fish.

Effective Extension Methods to Empower the Women of Beel Dependent Community

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A comprehensive system is required for a successful developmental programme. As per the classical “extension method,” the first step to any developmental programme is to create awareness and to sensitize the target populace. Working with the target group, giving priority to their needs has always been proven a practical and efficient approach. An initiative was taken in Khalsi beel area for empowering the women of beel dependent community. Four interventions were introduced and for the diffusion of those farm innovations, the following extension methods were initially adopted: awareness and sensitization, group meetings, exposure visit, and on-farm trainings. Through the households survey, it was found about 80% of the sampled populace was below the poverty line and almost 87% were enrolled in the “Self Help Group”. However, they had little mass media exposure and less extension contact. To motivate the women of fisherfolk community participatory demonstration of Pen culture technology was done. It was found the majority of the fishers (53%) watched and learned the pen culture technology implementation process. About, 17% of the fishers paid their labour for pen demonstrations. The women beneficiaries of the project monitored the pen and were also involved in the management process. However, only 4% of the fishers, particularly the Cooperative Society Governing body members participated to make decisions in the process. Fishers’ Field School approach was also implemented in Khalsi beel area. It is a group-based adult learning approach that enlightened the fishers and community members to solve their problems by themselves. It was also perceived by 69% of the respondents that Fisher’s Field School is an effective extension method to empower them technologically as well as economically. This implies that an increase in the use of these extension methods will help to boost in the adoption of farm innovations in the target areas.

Keywords: *Fisher’s Field School, Technology demonstration, Khalsi beel.*

Fish Diversity and Assemblage Structures in the Selected Waterfalls of the Chhota Nagpur Plateau in Relation to Environmental Parameters

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The picturesque waterfalls region of the Chhota Nagpur plateau in eastern India besides travellers delight might be aquatic biodiversity hotspots. A total of four waterfalls, such as Hundru Falls on the Subarnarekha River, Dassam Falls on the Kanchi River, Jonha Falls on the Raru River, and Panchghagh Falls on the Banai River, were surveyed during post-monsoon of 2021 for study of fish assemblage structure in relation to environmental variables. Fish were mostly captured using cast nets, gill nets (20–40 mm mesh size), traps, and other methods. A total of 35 finfish species from 6 orders and 13 families have been identified in four designated waterfalls. Order Cypriniformes (22 species) dominated the groups, followed by Siluriformes (04 species), Anabantiformes (4 species), Synbranchiformes (3 species), etc. According to the IUCN Red List status, 1 species is classified as near threatened (NT), 3 species are vulnerable (VU), 3 species are not evaluated (NE), and 28 species are classified as least concern (LC). The butter catfish species *Ompok bimaculatus* was found to be in the vulnerable category in the studied systems. Water flow fluctuated between 0.6 and 0.8 m/sec, while water temperature ranged from 20.5 to 23.8 °C, and turbidity ranged from 23.4 to 37.3 NTU. The pH of the water was alkaline and ranged from 8.35 to 8.65, there was also free CO₂ (0.3–1.2 mg/l) at all the waterfalls and was enough dissolved oxygen (8.0–8.1 mg/l), which may have been caused by the rapid flow and turbulence below the falls. Higher sp. conductivity revealed some anthropogenic influences from Ranchi city sewage effluents in Hundru and Jonha waterfalls, one of the major threats. Barbs, murrels, and Genus *Garra* were subsequent in abundance (available in the live condition), and this indicated the potential for the development of an ornamental fishery using brooders of local riverine fishes. The presence of several native fish species in a comfortable aquatic environment and the absence of any exotic fish species suggested that those river segments might be used as examples of undisturbed river habitat.

Keywords: *Fish assemblage structure, environmental parameters, water falls, Chota Nagpur plateau, ornamental fishery.*

Small Indigenous Fish for Nutritional Security and Marketing: A Case Study of Duma Wetland in Lower Gangetic Plains

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Duma is the largest horse-shoe shaped wetland in Asia in the lower Gangetic plains, and SIFs are a very crucial part of the diet of the fishers. Data about role of SIFs in Duma wetland for the nutritional security was collected from 101 fishers. 71.45% of the fish harvest in Duma comprised of SIF. The fishers harvest SIF during their daily fishing schedules in the wetlands either individually or in small groups. The SIFs consumed by fishers and their families in Duma are Punti (Pool barb; *Puntius sophore*), Morola (Molacarp; *Amblypharyngodon mola*), Chanda (Glass fish; *Chanda nama*), Kholse (Banded gourami; *Colisafasciata*), Aor (Long-whiskered catfish; *Sperata aor*), Singhi (Stinging catfish; *Heteropneustes fossilis*), Baim (Zig-zag eel; *Mastacembelus armatus*), Tengra (Gangetic mystus; *Mystus cavasius*), Folui (Bronze Featherback; *Notopterus notopterus*), Gajal (Bullseye snakehead; *Channamarulius*), Leta (Spotted snakehead; *Channa punctatus*), Kuchia (Rice eel; *Monopterus albus*), Koi (Climbing perch; *Anabrus testudineus*), Chang (Dwarf snakehead; *Channa argus*) and Bele (Tank goby; *Glossogobius aureus*). 33% of the SIF catch is consumed by the fishers in their families for their nutritional requirements. The remaining 67% is disposed for sale in nearby markets. Seasonal changes in the dietary pattern of SIF consumption in fisher families have been also observed. The highest consumption is noticed during pre-monsoon period during January to May months where 79.5% of fisher families consume SIF. This is followed by consumption in the post-monsoon season where 49.1% of the families consume SIF during October to December months. The lowest consumption is in the monsoon season during June to September months where 31.95% families consume fish. The price of SIF is highest in the summer season during the months April through June @ ₹ 275 per kg. The price becomes the lowest in the monsoon months from July to September at ₹ 150 per kg due to glut in the harvest. The price is also considerably high in winter during January through March @ ₹ 200 per kg. There is no catch or profit-sharing mechanism with the Fishers' Co-operative Society. The average monthly income of the fishers is about ₹ 6,750 per month. The markets where the SIF are sold are Tau Bazar, New Market, Rail Bazaar, Chand Para Fish Market, Kali Tala and Angrail Fish Market in and around Duma wetland through three kinds of marketing channels.

Keywords: Duma, SIF, nutritional security, marketing, consumption.

Livelihood Diversification of the Fisher Households: A Comparative Analysis of River and Estuary

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Livelihood diversification is a process by which households engage in multiple income generating activities. The resource-poor fishers adopt livelihood diversification to cope up with the uncertainty and inadequateness of the fisheries as a profession. The present study is an attempt to assess the socio-economic conditions together with livelihood diversification of the fishermen households of Mahanadi and Hooghly-Matlah estuary. Data were collected by personally interviewing 100 fishermen from 25 villages along the entire stretch of Mahanadi and from 50 fishers of 13 villages along the estuarine stretch of Hooghly-Matlah in 2022.

Analysis of data indicated that the average family size was 5.2 and the sex ratio was 943 females per 1000 males in Mahanadi, the corresponding figure for Hooghly Matlah was 5.5 and 974, respectively. 42.3% and 56% of the respondents had pucca houses in these two resources. The agricultural land holding was better in Mahanadi. Fishing was the main occupation of around 81% and 86% of the respondents. Average number of income generating activities per household was 2.2 in Mahanadi and 3.14 in Hooghly-Matlah. Further, it was found that their level of diversification was quite low. The Simpson's index of income diversification was found to be 0.238 in Mahanadi and 0.407 in Hooghly-Matlah. No fishermen family possessed diversification index of more than 0.66. Further, the study revealed that among other factors the Simpson index contributes positively and significantly towards per capita income of the fisher households. Declining fish catch, pollution, destructive fishing practices, difficulty during fishing ban period, declining income were the major constraints reported by the Mahanadi fishers. While declining fish catch, declining hilsa, pollution, siltation were the major constraints reported by the estuarine fishers. In absence of suitable supplementary opportunities, the resource is under pressure. There is need to develop appropriate strategies to facilitate successful livelihood diversification. Facilities for fish marketing kiosks, agro-processing, fish landing centres, fishing logistics, e-rickshaws may be created. They may also be trained in some other non-fishing activities like carpentry, masonry, electrical services, embroidery, dress making, driving etc for better livelihood of the poor fishers.

Keywords: *Socio-economy, livelihood diversification, Simpson index, fishers, Mahanadi, Hooghly-Matlah.*

Accumulation and Reproductive Toxicity of Cypermethrin at Sub-Lethal Level on *Labeo catla*

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Cypermethrin (CYP), a pesticide belonging to synthetic pyrethroids is abundantly used in agriculture, aquaculture and fisheries. As a consequence, it has become an environmental stressor posing toxic hazards to different non-targeted aquatic organisms including fishes. Pyrethroids are identified as endocrine disrupting chemicals (EDC) by the United States Environmental Protection Agency (US EPA). Exposure of CYP leads to development of oxidative stress and endocrine disruption in fish and other animals (Jin et al., 2011; Ye and Liu, 2018). In this context, the present study was conducted to evaluate the effect of exposure of CYP at sub-lethal doses on reproductive disruption in a commercially important food fish *Labeo catla* (Catla). Catla fishes were exposed to CYP at 0.014 (1/50th LC₅₀) and 0.7 µg/L (1/10th LC₅₀) dose with untreated control for 30 consecutive days in a static renewal manner. After the exposure period was over, the level of antioxidants superoxide dismutase (SOD) and catalase (CAT); difference in sex steroids in serum viz., 17 beta estradiol (E2), 11-ketotestosterone (11-KT), vitellogenin (Vtg); and brain hormonal level viz. gonadotrophin releasing hormone (GnRH), follicle stimulating hormone (FSH) were analysed. Accumulation of CYP residues in exposed water and fish samples were analysed by gas chromatography and mass spectrometry (GC/MS). The antioxidant enzyme (SOD and CAT) activity significantly increased ($p < 0.05$) in the higher dose. Significant decline ($p < 0.05$) in serum E2, 11-KT, Vtg, brain GnRH and FSH were observed. Residue bioaccumulation of CYP in exposed fishes was below the detectable level; however, CYP residues were detectable in the exposed water, but only in the 1/10th LC₅₀ group. Therefore, the present study showed that CYP may be harmful even at low doses for reproductive development of fish and thereby indicating the need for toxicity evaluation of pesticides for environmental risk assessment.



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