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Inside...



# Aqua International

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## CONTENTS



## ADVERTISERS' INDEX



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# Govt allows import of 12 lt GM soyameal

Move will help the Covid-hit domestic Livestock industry

**Dear Readers,**

The September 2021 issue of Aqua International is in your hands.

Ms Menaga Meenakshisundaram, Ph.D Scholar, Tamilnadu Dr J. J. Fisheries University and Prof. S. Felix, Former Vice Chancellor, Tamilnadu Dr J. J. Fisheries University and Former Dean, FCRI, Ponneri in their feature titled **Short term strategies to maintain 'Business As Usual' status in Aquaculture amidst COVID-19** discussed useful things to this industry. Over the past 20 years the aquaculture sector has evolved from having a relatively minor role to playing a mainstream part in the global food system. The outbreak of the COVID-19 pandemic largely disrupted health, food and economic systems. Indian Aquaculture is not an exception where millions of people's lives got severely affected.

In their feature, they outlined policy recommendations to mitigate and support recovery from the ongoing shock of COVID-19. These are divided into supply side and demand side recommendations and recommendations that are immediate (aimed at mitigating the ongoing shock) and for longer term (aimed at resilient recovery).

Another feature titled **Four Less-familiar Gobiid fishes as 'Poor man's protein source',** Gobiid fishes found in village ponds and rivers are less-familiar to us, edible and are important component of 'Poor man's protein source' in West Bengal and other states. In February 2021, the author Mr Subrato Ghosh observed and photographed four of them, viz., Glossogobius giuris, Boleopthalmus boddarti, Pseudapocryptes lanceolatus and Trypauchen vagina in small fish markets at Roydighi and Jumai Naskarhat in Indian Sundarbans region, Dist. South 24 Parganas, WB and collected information on these small indigenous fishes is presented in the feature.

In the News section, you may find news about –

**The Marine Products** Export Development Authority ushered into its 50-year of eventful and glorious existence by launching year-long Golden Jubilee celebrations, the first of its kind in the history of the organisation making way for the participation of hundreds, including pensioners, exporters and all its regional divisions and societies, through virtual platform.

**Online Training on NUTRISMART-FISH** to boost nutritional security of rural women. In West Bengal and other states, skilled village women as rural homemakers collectively (as members of established actively-functioning SHGs, members of established Primary Cooperative Societies) and individually undertake different income-generating vocational activities seriously and sustainably in small to medium scale (cottage industry); their contribution to family income and rural development cannot be underestimated.

**India-China Shrimp Row All Set** to Turn Political. India says allegations have no "Scientific basis"; China has shared no test reports. The 'shrimp' has acquired a bitter political taste in the troubled waters of India-China relationship. Both sides are headed for a major diplomatic showdown over China turning down Indian shrimps alleging that the packaging carried Covid-19 virus. India has protested, saying the allegations have no "scientific basis", nor has China shared test reports.

**Farmers Advisory Meet** on Monsoon and Post-monsoon Fish Diseases. The Farmers Advisory Meet on the topic 'Monsoon and post-monsoon fish diseases' was organized by Kolkata Centre of ICAR-Central Institute of Fisheries Education in Zoom platform on 21 August 2021. Dr G. H. Pailan, OIC and Principal Scientist, Kolkata Centre of ICAR-CIFE and Programme Organizer mentioned that Scientists will try to solve the problems related to fish diseases faced by fish farmers (as participants in this Advisory Meet) on field quite often. Ms Husne Banu, Scientist, ICAR-CIFE Kolkata Centre as Programme Coordinator in her talk-cum-presentation on 'Monsoon and post-monsoon fish diseases and their management' spoke about fish diseases not normally observed during summer months.

**Aqua farmers in A. P. sign up** to sell produce through e-Santa. MPEDA officials explain process of online trading to producers and exporters. Many aquaculture farmers in the

*Contd on next page*

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Aqua International

***Our Mission***

*Aqua International* will strive to be the reliable source of information to aquaculture industry in India.

***AI*** will give its opinion and suggest the industry what is needed in the interest of the stakeholders of the industry.

***AI*** will strive to be The Forum to the Stakeholders of the industry for development and self-regulation.

***AI*** will recognize the efforts and contribution of individuals, institutions and organizations for the development of aquaculture industry in the country through annual Awards presentation.

***AI*** will strive to maintain quality and standards at all times.

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***Send a letter:*** *Letters to the Editor must include writer's full name, address and personal telephone and mobile numbers. Letters may be edited for the purposes of clarity and space. Letters should be addressed to the Editor:*

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State are planning to update the details of their produce online and market their stocks through e-Santa, an electronic marketplace to export marine products. E-Santa is a platform to connect aqua farmers and buyers across the country, to avoid middlemen. Producers and exporters who registered with Marine Products Export Development Authority (MPEDA) can trade online on the platform.

**A boon to the aqua** industry. The Andhra Pradesh state government has taken steps to further increase production in the state, which is a leader in fisheries production in the country. The government, which has revolutionized the aquaculture sector for two years with the aim of sustainable development, is preparing to implement more programs to boost farmers from cultivation to marketing. Government aims to double the production in five years. It has decided to increase the cultivable area by 48,000 hectares in three years.

**MANAGE, Hyderabad** organized a national webinar on Entrepreneurship Opportunities in Aquaculture sector on 23 August 2021 on Webex platform and in this programme, Dr Manoj Sharma, shrimp farmer and aquaculture expert in India based at Surat, Gujarat spoke and gave a presentation on 'Entrepreneurship opportunities in aquaculture industry'. He highlighted six facets of shrimp farming development namely - Wasteland converted into best Productive land; Self-employment opportunity for millions of coastal fishers; Infrastructure development in coastal villages – reverse migration; Labour intensive employment; Support food and safety through aquaculture; Foreign revenue earner through exports.

CLFMA organized a webinar on "**Animal Husbandry Infrastructure Development Fund"** in association with the Department of Animal Husbandry & Dairying on 28 July 2021.

**Centre allows import** of 12 lt GM soyameal. Move will help the Covid-hit domestic poultry industry. The government on August 24 relaxed norms to allow import of 12 lakh tonnes of de-oiled and crushed genetically-modified (GM) soyabean (as poultry feed) with the Environment Ministry (MoEF) clarifying there was no concern from the environmental angle as it does not contain any living organism, a statement issued by the Ministry of Commerce and Industry said.

**In favour of Farmers,** Central Government announced Soya meal Import. "On behalf of entire Indian Poultry Farmers, Aqua Culture Farmers (fisheries and shrimp), Diary Farmers would like to thanked Prime Minister and other Union Ministers for making this historic decision of allowing GM Soya Meal Import, for the first time in favour of Livestock Farmers.

In the Articles section -- Article titled ***Introducing the Predators (BALOs) of the Challengers (Vibrios) to Shrimp Farming,*** written by R. Dinesh highlighted that BALOs are small obligate gram-negative predatory bacteria that feed on other gram negative bacteria. As shrimp farming is seriously hampered by Vibrios, these BALOs, owing to their unique lifestyle and natural ability to eliminate Gram-negative microbes, have a great potential as a bio-control agents in shrimp farming and other aquaculture practices.

Another article titled ***Endocrine disrupting compounds/ chemicals (EDCs) in aquatic environment: Effects and possible consequences on fish,*** written by Pramod Kumar Nanda and other authors highlighted that Endocrine disrupting compounds/chemicals (EDCs) include synthetic and natural hormones, plant metabolites, phthalates, pesticides and aromatic compounds. EDCs are mainly absorbed into the body of aquatic organisms through various ways like respiration, maternal transfer in the lipid reserves of eggs, osmoregulation etc. EDCs have the ability to interrupt the normal functioning of the endocrine system, as they can copy actual hormones, alter the expressions of specific receptors, and disrupt their form of synthesis and metabolism.

The other article titled ***Fish Transcriptomics: Workflow and its Applications,*** written by Deepak Agarwal and other authors highlighted that Transcriptomics is a highly performed experimental technique recently used in fishes to identify the differential expression of important genes at various developmental stages and time points. The workflow of transcriptomics from RNA isolation to Bioinformatics analysis to understand the physiology of fish at molecular level. Several applications of transcriptomics in aquaculture. Transcriptomics is a recent state of the art technique to develop molecular markers in huge numbers for important commercial fish species. Transcriptomics helps in enriching the genetic resources of candidate and novel fish species to make better fruitful breeding strategies of fishes.

Readers are invited to send their views and comments on the news, special feature and articles published in the magazine which would be published under "Readers Column". Time to time, we shall try to update you on various aspects of Aquaculture sector. Keep reading the magazine Aqua International regularly and update yourself. Wish you all fruitful results in your efforts.

**M.A.Nazeer**
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# MPEDA enters 50 year of its existence; launches year-long Golden Jubilee celebrations

**Kochi, August 25:** The Marine Products Export Development Authority (MPEDA) ushered into its 50 year of eventful and glorious existence by launching year-long Golden Jubilee celebrations, the first of its kind in the history of the organisation making way for the participation of hundreds, including pensioners, exporters and all its regional divisions and societies, through virtual platform.

The function, which began on August 24, was live-streamed on MPEDA's social media platform also

The function commenced with an invocation followed by a silent prayer in remembrance of the departed souls of the organisation. Mr K. S. Pradeep, Secretary, MPEDA & President, MPEDA Staff Club, made the welcome address.

Mr Mohammad Yousaf, Commissioner of Customs, Kochi, who was the

ChiefGuest, inaugurated the Golden Jubilee celebrations by lighting the lamp in the presence of Mr K. S. Srinivas, Chairman, MPEDA, who presided over the function.


*Mohammad Yousaf, IRS, Commissioner of Customs, Kochi, lighting the lamp to mark the inauguration of MPEDA's Golden Jubilee celebrations in the presence of K. S. Srinivas, IAS, Chairman, MPEDA at MPEDA Headquarters in Kochi on 24 August 2021.*

In his presidential address, Mr Srinivas made a presentation on the growth and achievements of MPEDA in the past five decades and gave insights into a road map for the next 50 years. He emphasised the hard work and efforts of existing and retired employees of MPEDA, exporters and other stakeholders for the exponential growth of seafood exports. Felicitations were offered by Dr M. Karthikeyan, Director, MPEDA; Mr Aditya Dash, Vice Chairman; and Dr Ram Mohan M. K., Joint Director (Quality Control), besides Mr Jagadish V. Fofandi, National President, SEAI and Mr Elias Sait, Secretary General, SEAI.

The employees, who completed 25 years of service in MPEDA, were honoured on the occasion.

The Rajeswari Memorial Endowment Awards instituted in remembrance of Mrs M. Rajeswari, a former employee of MPEDA, were awarded to the children of MPEDA employees who secured highest marks in the board examinations for 10 and 12 classes.

To mark the occasion, MPEDA has come out with an e-STAT package which automates the export statistics collection and analysis. Mr Anilkumar P., Joint Director (Marketing), MPEDA, gave a brief introduction on the package followed by a presentation on the same

Mr Mohammed Yousaf, IRS, launched the 'e-STAT' package, marking a giant leap for MPEDA.

Mr Nishanth K. N., Joint Secretary, MPEDA Staff Club, proposed a vote of thanks, marking the conclusion of the event.


*From left to right: Dr M. Karthikeyan, Director, MPEDA; K. S. Srinivas, IAS, Chairman, MPEDA; Mohammad Yousaf, IRS, Commissioner of Customs, Kochi; and K. S. Pradeep, IFS, Secretary, MPEDA & President, MPEDA Staff Club at the inauguration of MPEDA's Golden Jubilee celebrations at MPEDA Headquarters.*

# Aqua farmers sign up to sell produce through e-Santa

*MPEDA officials explain process of Online trading to producers and exporters*

**Vijayawada, July 21:** Many aquaculture farmers in the State are planning to update the details of their produce online and market their stocks through e-Santa, an electronic market place to export marine products.

e-Santa is a platform to connect aqua farmers and buyers across the country, to avoid middlemen.

Producers and exporters who registered with Marine Products Export Development Authority (MPEDA) can trade online on the platform.

"Online marketing, e-Santa (shandy), will be very helpful for the farmers. The system will provide direct connectivity to farmers and exporters and the producer will get a good price, depending upon the quality of the produce," said MPEDA Chairman K.S. Srinivas.

Many fish, shrimp and crab farmers were suffering losses due to lack of knowledge on marketing facilities and are getting deceived by middlemen.

MPEDA and National Centre for Sustainable

Uni-President

# AQUACULTURE PROBIOTICS EXPERT

Nu Ri
NET 200 g **BSL**

**Probiotics for water treatment**

## 1. WATER QUALITY CONDITIONING

Best choice of *Bacillus* spp. that rapidly decompose uneaten feed, feces and other organic substances in pond water, keeps water quality optimal


## 2. HIGH ACTIVITY OF SPORES

No cultivation is needed. Easily adapt to the changes of surroundings and grow fast in freshwater or seawater culture farming, even under low oxygen environment

## 3. DECREASE AMMONIA CONTENT

Prevent the accumulation of toxic substances such as $NH_3$, $NO_2$, etc.

## 4. IMPROVE WATER COLOR

Improve water color regulate the algae and bacteria balance in water, turning your pond from green to clear


## 5. ESTABLISH BALANCED POND BACTERIA SYSTEM

Compete nutrition with vibrio and inhibit them to grow. Provide nutrition for probiotics in the pond, to establish a well-balanced farming system.


## 6. INCREASE AQUACULTURE PRODUCTION

Good quality of water prevents fish/prawn infections, making high profit of production

## * COMPOSITION:

| | |
|---|---|
| *Bacillus* spp. > 1x $10^{11}$ cfu/kg | 15% |
| *(Bacillus subtilis, Bacillus amyloliquefaciens, Bacillus licheniformis)* | |
| Carrier (rice bran, corn gluten) | 75% |
| Moisture | 10% |


## * STORAGE:

Keep at dry, well-ventilated condition. Avoid direct sunlight exposure and use as soon as possible once opened for best quality.

## * DIRECTION OF USE:

No cultivation is needed. Apply Nuri BSL with water-soluble bag near to the working water wheel or pour into the pond evenly. Recommend apply Uni-Light PSB together with Nuri-BSL on sunny day to achieve a clear pond more efficiently.


### UNI-LIGHT PSB Funtion:

- Decompose pond bottom
- Inhibit the growth of *Vibrio* spp.
- Purification of water quality

### BSL Dosage:

| /10,000 m² Quantity | 10 - 30 pl/m² tiger prawn or < 80 pl/m² Vannamei | For >30 pl/m² tiger prawn or > 80 pl/m² Vannamei | For > 150 pl/m² Vannamei |
|---|---|---|---|
| 7 days before stocking | 800 g - 1,000 g | 1,200 - 1,500 g | 1,200 - 1,500 g |
| Day of stocking | 300 g - 500 g | 800 g - 1,000 g | 800 g - 1,000 g |
| Every 7 - 10 days after stocking | 300 g - 500 g | 800 g - 1,000 g | 3 - 5 days / use 1,000g - 2,000g |

****Dosages can be adjusted according to the water conditions and practices.*

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*NaCSA CEO K. Shanmuka Rao explaining the details of e-Santa to farmers at an AOC lab in Krishna District, Andhra Pradesh.*

Aquaculture (NaCSA) officials were helping farmers make use of e-Santa, Mr Srinivas said. Farmer will enter the crop particulars, expected quantity, pictures of the pond and shrimp, expected harvesting date, lab reports certifying the quality of the produce and other details on the portal. Buyers will then contact the farmers and negotiate with them directly, list the price details and make 25% online payment after the deal is struck, said NaCSA Chief Executive Officer (CEO) K. Shanmuka Rao. The producer will get the entire payment within three working days after the stocks are handed over to the exporter.

# India-China Shrimp Row All Set to Turn Political

*India says allegations have no "Scientific basis"; China has shared no test reports*

**New Delhi, July 31:** The 'shrimp' has acquired a bitter political taste in the troubled waters of India-China relationship. Both sides are headed for a major diplomatic showdown over China turning down Indian shrimps alleging that the packaging carried Covid-19 virus. India has protested, saying the allegations have no "scientific basis", nor has China shared test reports.

India is the largest exporter of shrimps in the world and China is the second biggest importer of seafood from India, of which over 46% are frozen shrimps. The biggest exporters are in Andhra Pradesh, besides in Gujarat and Odisha. The trade row has been on since November 2020 when China placed phytosanitary restrictions on Indian shrimps, which has taken up with relevant committees of the World Trade Organisation. But matters escalated a few notches last week, when China withheld 1,000 containers of Indian shrimp, saying it had detected SARS-COV 2 nucleic material in the outer packaging, mostly polythene and corrugated boxes.

India has strongly contested the Chinese position, citing detailed studies on how the virus does not survive on packaging material. The Indian side also sought technical reports from China, which were not shared, sources told Economic Times.

Now, from the Marine Products Export Development Authority (MPEDA) and the Commerce Ministry to the Ministry of External Affairs are preparing to take up the issue strongly– both diplomatically as well at WTO alleging distorted trade tactics by China, ET has gathered.

"China is invoking unilateral decisions on Indian seafood exporters on arguments that lack evidence and scientific basis. MPEDA has already requested the Department of Commerce to raise this issue in the WTO to expose the trade distorting tactics of the Chinese", MPEDA said in response to queries from Economic Times.

"So far, 23 units have been indefinitely suspended by General Administration of Customs, China (GACC) alleging the SARS-COV 2 virus nucleic material of the consignments shipped by those units, Another 17 units were suspended temporarily for a week citing the same reason", disclosed MPEDA.

Further, the Chinese side has shared no details of findings despite repeated requests. "GACC has neither shared the sampling and testing protocols.

As a result of these non-tariff barriers, shrimp exports to China have declined by 34% in quantity and 32% in USD earnings this year. The stakes for India are high since China is a big market for Indian shrimp industry.

The president of the All India Sea Food Association, Jagdish Fofandi was, in fact, in New Delhi on Friday to apprise the ministries of fisheries and commerce on the huge impact of the China decision. "We have informed the government of the huge financial impact of this on both the industry and the livelihood of fishing community," Fofandi told ET

# Farmers Advisory Meet on Monsoon and Post-monsoon Fish Diseases

**Kolkata, August 21:** The Farmers Advisory Meet on the topic 'Monsoon and post-monsoon fish diseases' was organized by Kolkata Centre of ICAR-Central Institute of Fisheries Education in Zoom platform on 21 August 2021.

Dr G. H. Pailan, OIC and Principal Scientist, Kolkata Centre of ICAR-CIFE and Programme Organizer mentioned that Scientists will try to solve the problems related to fish diseases faced by fish farmers (as participants in this Advisory Meet) on field quite often. Ms Husne Banu, Scientist, ICAR-CIFE Kolkata Centre as Programme Coordinator in her talk-cum-presentation on 'Monsoon and post-monsoon fish diseases and their management' spoke about fish diseases not normally observed during summer months.

Monsoon brings hormonal change in fishes conducive for breeding, environmental change {lower temperature (T) and higher turbidity in water bodies}, altered virulence and higher possibility of horizontal disease transfer in pond farmed fishes. T, photoperiod, precipitation have influence upon fish immune system; antibody titre in fishes falls during monsoon and winter with lower disease resistance power. Viral diseases occurs more at lowered water T (less than 25°C); monsoon season helps in multiplication of pathogenic protozoan parasites and Argulus sp in fishes, whereas bacterial diseases less observed during monsoon.

Ms Banu spoke about clinical signs and treatment methods of monsoon fish diseases, namely EUS (water from rivers and beels / wetlands mixes with pond during monsoon and less than 25°C T helps multiplication of fungus Aphanomyces sp), Tilapia Lake Virus, Carp Edema Virus (necrotic gills in Koi carp and others) and post-monsoon diseases, namely Cyprinid Herpes Virus-2, Nervous Necrosis Virus (in Lates calcarifer, fish turns thin and blackish), protozoan and helminth ectoparasitic infection (Ich causes excessive fish mucous secretion). This disease can be treated with either of NaCl @ 4-5gm / lit, $CuSO_4$ @ 1mg / lit, $KMnO_4$ @ 2 – 5 mg / lit, Praziquantel @ 1 mg / lit.

Ms Banu emphasized on Better Management Practices in aquaculture that should be followed as remedy for viral fish diseases in India; water quality management (calcium hypochlorite or sodium hypochlorite use in pond, aeration and dechlorination in pond water); feed management (use of mineral supplement and Vitamin with fish feed); fish health monitoring (sampling netting and fish health check-up); bisecurity (netting / fencing of pond on all sides); quarantine; pond management (pond drying, ploughing, quicklime application @ 100 kg / ha); disinfectant dip of procured fish seeds and quarantine maintained for 14 days before stocking; use of disinfectant Microdon (mixture of Benzalkonium chloride and iodine).

Antibiotics must not be preferred for disease treatment, oxygen depletion must not occur in early morning and afternoon hours in intensive fish culture system, to start aeration, stocking density to be reduced in case of disease incidences.

In responding to questions raised by fish farmers from Jalpaiguri, Meghalaya, Balasore, parts of Bihar and other parts of India, CIFE scientists Ms Banu, Dr Md. Aklakur, Dr S. Munilkumar, Dr Pailan, Dr S. Dutta and Dr G. Biswas gave some useful practical recommendations. For infection in Heteropneustes fossilis cultured in tanks from early fingerling stage, Microdon (product from Andhra Pradesh) to be used in tanks as disinfectant @ 2 – 5 lit / ha; Rotenone or alternatively Sodium hypochlorite @ 150 kg / ha for killing unwanted fishes in carp ponds;

Microdon application if granules observed over body of Catla catla under culture; Sanmolt-F may be used for treating fungal infection in fishes; Bi-Larv insecticide at proper dosage to control heavy Argulus infestation in ponds; NaCl @ 5kg / acre or dip treatment in $KMnO_4$ @ 5 gm / 1000 lit to control lesser degree of Argulus infestation in fishes; it will be good if Microdon is applied to fishes in tanks/cement cisterns and not directly in pond;

live feed tubifex or Artemia to be given to lethargic goldfishes in aquarium and mineral mix (Frankzole, Liv 52 Protec, Osmin, Kalvimin Gold, MV - 24) given as food supplements; instant commercial product of 'APC nutrients' used @ 5 lit / acre to increase plankton production in fish ponds, commercialized ICAR-CIBA product Plankton-Plus prepared from fish waste (hydrolysate) may be used for same purpose.

A formulation to increase plankton production naturally in shrimp ponds is mixture of rice bran, molasses and yeast (5 – 6 gm) in 10 lit water, further diluted to 100 lit. After continuous aeration for 24 hours, the extract produced should be applied over pond once in a week. For 1ha pond, mixture of 60kg whole paddy flour, 20kg molasses, 5kg yeast in 200 lit freshwater kept in airtight container, allowed to ferment and sieved after 48 hours to get the extract and applied in pond, which acts as plankton enhancer and probiotic.

In case of Microdon (to control H. fossilis infection) i.e., iodine application in ponds, it should be done at a lower dose @ 250 – 300 ml / acre and probiotic to be used after 12 - 14 hours, it leads to plankton growth and plankton crash doesn't occur. BKC is a broad-spectrum antimicrobial.

Mizuphor as commercial Iodate may be applied @ 2 – 3 lit / acre. To increase plankton production in 1 acre pond, 10 kg Agrimin may be used along with

20kg of each of rice bran and molasses, 500gm yeast in 120 lit water; the juice produced after fermentation is applied.

For lesions and reddish discoloration of IMC above 500gm size, Microdon @ 500 - 1000 ml / acre may be used; Sanmolt-F to control heavy mucous secretion from fish body. For both these products, sufficient aeration must be given in ponds and pH should not drop below 6.5, dissolved oxygen should not deplete.

To eradicate Chanda sp (glass perch) from ponds which tears off scales and skin portions of major carps, mixture of NH4OH and lime or 60ppm bleaching powder to be used before carp seed stocking as alternative to Mohua oil cake.

In aquarium conditions, pH correction of water may be done by adding citric acid/ acetic acid (1 gm in 1 lit water) drop by drop once in 2 hours. Fish farmers were advised to stock major carp yearlings of 150 – 200 gm size @ 4000 nos / acre in grow-out ponds that will attain 1 – 2 kg in next 5 - 6 months of culture. It was overall a very active and fruitful discussion between fish farmers and Scientists; News communicator Subrato Ghosh could learn a lot while listening to it carefully.

# Online Training on NUTRISMART-FISH to boost nutritional security of rural women

**12 August 2021, West Bengal:** In West Bengal and other states, skilled village women as rural homemakers collectively (as members of established actively-functioning SHGs, members of established Primary Cooperative Societies) and individually undertake different income-generating vocational activities seriously and sustainably in small to medium scale (cottage industry); their contribution to family income and rural development cannot be underestimated.

Such activities include cloth stitching, value-added food product preparation and flower-based products, tailoring, embroidery, handicraft making, poultry farming and importantly women-appropriate homestead pisciculture (farm-made formulated pelleted fish feed preparation; aquarium fish breeding and propagation; rearing of carp fry till fingerling stage in small properly-managed ponds; fish pickle, fish silage preparation from small-sized prawn, shrimp and small fishes; salting and sun drying of less economically-important marine/estuarine fishes; desi Magur farming in rectangular cement cisterns).

In many parts in India, chronic illness and lower overall health status of women in distant villages have been observed in comparison to urban women. Consumption of inland foodfish (considered nutritionally-superior food) and more fish production via pond farming, i.e., rural aquaculture, can eradicate malnutrition in rural India and does provide food and nutritional security sustainably to village inhabitants of all age.

ICAR-Central Inland Fisheries Research Institute, Barrackpore and MANAGE, Hyderabad jointly organized a very informative and enriching collaborative training programme in Cisco Webex platform on the topic 'NUTRISMART-FISH to boost nutritional security of rural women' during 10 - 12 August 2021.

In the inaugural programme, concept on the subject of training and importance were nicely presented by Dr B. K. Das, Director, ICAR-CIFRI and Programme Director; Dr P. Chandrasekhara, Director General, MANAGE and Dr S. Phand, Assistant Director, Centre for Extension in Agri-Allied Sector, MANAGE; Principal Coordinator, Agri-Clinics and Agri-Business Centre, MANAGE and another Programme Director.

In above four hours duration of training (class) in each of the three days of programme, expert speakers who delivered talks were Dr A. K. Das, Principal Scientist, ICAR-CIFRI, Barrackpore on 'An introduction to activities of ICAR-CIFRI' (since inception); Dr (Mrs) A. Roy, Programme Coordinator and Senior Scientist, ICAR-CIFRI on 'Assessment of nutritional needs of rural people with special emphasis on women';

Dr K. Brahmachari, Physician, ESI, PGIMSR and ESIC Medical College, Joka, Kolkata on 'Importance of nutritional intervention during pre-natal and post-natal stage to improve childhood development'; Dr A. K. Bera, Principal Scientist, ICAR-CIFRI and Programme Co-coordinator on 'Common nutrient deficiency disorders in women and preventive measure using plant, animal and fish products'; Dr B. P. Mohanty, ADG (Inland Fisheries), ICAR, New Delhi on 'Fish as health food';

Dr (Mrs) S. Das Sarkar, Scientist, ICAR-CIFRI on 'Orientation on nutri-smart fish species'; Dr (Mrs) A. Roy on 'Small Indigenous Fishes to boost nutritional security – CIFRI's experience'; Ms. Supriti Bayen, SRF at ICAR-CIFRI on 'Nutrifish – a potential avenue for nutritional security'; Dr B. K. Das on 'Nutrifish to address Hidden Hunger'; Dr (Mrs) S. R. Senapati, Asst. Fisheries Officer, District Fishery Office at Bhadrak, Odisha on 'Nutritional requirement-based value addition on fish and fishery products';

Mrs P. R. Swain, Scientist, ICAR-CIFRI and another Programme Co-coordinator on 'Cost effective nutrition sensitive innovations to address nutritional security'; Dr S. Phand on 'Innovations in Agricultural Extension and MANAGE initiatives'.

A very good assessment/ examination online covering 25 questions was conducted for the participants (News communicator Subrato Ghosh participated and given opportunity to speak in short in Valedictory Session) towards end of the programme on 3rd day. An e-Book containing extended Abstracts of the lectures / presentations delivered by eminent invited persons in three days was released on 1st day. All various topics covered on three days were very relevant and clearly explained in detail by speakers.

# A boon to the aquaculture sector in A.P

**Amaravati:** The Andhra Pradesh state government has taken steps to further increase production in the state, which is a leader in fisheries production in the country. The government, which has revolutionized the aquaculture sector for two years with the aim of sustainable development, is preparing to implement more programs to boost farmers from cultivation to marketing. Aqua aims to double the production in five years. It has decided to increase the cultivable area by 48,000 hectares in three years.

Aquaculture sector is looking to set up processing and pre-processing units at a cost of Rs 546.97 crore across the state and hand over management responsibilities to farmers' associations. Production is projected to be 46.23 lakh metric tonnes (MTL) in 2020 – 21 and 50.85 lakh MT in 2021 – 22. Already 11.36 lakh MT of fisheries has been produced. It is setting up processing and pre-processing units with the aim of providing additional income to the farmers along with marketing where the crop is harvested. The state currently has 92 processing units with a total capacity of 4,813 MT per day and 30 pre-processing units with a total capacity of 300 MT. These are not sufficient to process the fish and prawns produced in the state. As a result, farmers are losing out as they have to move to neighbouring states. At the beginning of the season, farmers are losing out as traders are

buying at lower prices, showing the international market as buccaneering. To check these conditions, 23 pre-processing units at a cost of Rs 6.39 crore each and 10 processing units at a cost of Rs 40 crore each will be set up in the coastal districts where aqua sage is high. It is estimated that these with a capacity of at least 2,000 MT, will directly and indirectly provide employment to at least 10,000 people. The state has 974 km of coastline. Aquaculture is grown in 54,500 hectares of saltwater and 1.44 lakh hectares of freshwater ponds. Among the prawns being exported from the country Our state accounts for 70 per cent and 38 per

> ***Our aim is to get remunerative price to Aqua Farmers***
> *- K. Kannababu, Commissioner, Fisheries, A.P*

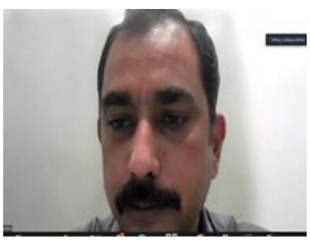
The government aims to provide additional income to farmers by getting better prices for aquaculture products. To that end, it has decided to set up processing and pre-processing units in aquaculture districts. We have prepared proposals for these. We will take steps to implement as soon as we get the approvals from the government, said Mr K. Kannababu, of the Commissioner, Fisheries Govt. of A.P, according to a report published in Sakshi.

# Webinar on Animal Husbandry Infrastructure Development Fund

**28 July 2021:** CLFMA organized a webinar on **"Animal Husbandry Infrastructure Development Fund (AHIDF)"** in association with the Department of Animal Husbandry & Dairying on 28 July 2021 from 15:00 hrs / 3:00 pm onwards. Dr O.P. Chaudhary, Joint Secretary (NLM/PC) Department of Animal Husbandry & Dairying, Govt. of India, Dr S.K. Dutta, Joint Commissioner, Department of Animal Husbandry & Dairying, Govt. of India, Dr Lipi Sairiwal Assistant Commissioner, Department of Animal Husbandry & Dairying, Govt. of India, Shri Sadique Akhtar, Team Leader, PMA (Manager, Grant Thornton Bharat LLP), Shri Udit Paliwal, Program Management Expert, PMA (Consultant, Grant Thornton Bharat LLP) from GOI showed their valuable presence for the Webinar. Dr O. P. Chaudhary, Joint Secretary (NLM/PC), Department of Animal Husbandry & Dairying, Govt. of India was unable to connect the Webinar.

*Dr S.K. Dutta, Joint Commissioner, Department of Animal Husbandry & Dairying, GoI*

CLFMA's Second Online Webinar on the AHIDF with Government of India started with Opening Remarks & Introduction by Dr S.K. Dutta, Joint Commissioner, Department of Animal Husbandry & Dairying, Govt. of India. He briefed on the AHIDF (Animal Husbandry Infrastructure Development Scheme) of Rs 15,000 Crores, under which, animal feed component was also included. He said that, the scheme enables the beneficiary to take the benefit of 90% the loan from the Bank, on which, 3% interest subvention is provided by the GOI., apart from this there is also a provision for availing 25% of the total borrowings as credit guarantee.



A short movie on AHIDF scheme was played during the Webinar to give a glimpse of the entire Scheme. Shri Sadique Akhtar, Team Leader extended his thanks to the participants. He welcomed Shri Neeraj Kumar Srivastava, Hon'ble Chairman of CLFMA. Shri Suresh Deora, Hon'ble Secretary of CLFMA. He has also thanked Mr Divya Kumar Gulati, Dy. Chairman of CLFMA and all the participants & Dr Lipi Sairiwal, Assistant Commissioner, Department of Animal Husbandry &

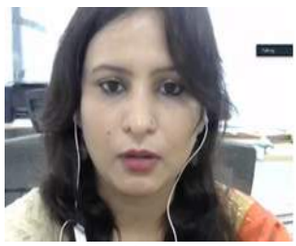
Dairying, Govt. of India to participate in this program. He welcomed all the participants and the member of CLFMA for giving their valuable time to participate in the webinar.

*Neeraj Kumar Srivastava, Hon'ble Chairman, CLFMA of India*

Chairman, Mr Neeraj Kumar Srivastava introducing CLFMA OF INDIA to the panellists and participants and gave a presentation on "Emerging Trend and Prospects of Feed Manufacturing". He said that, CLFMA was very enthusiastic about this Webinar as the AHIDF scheme of Rs 15,000 Crores floated by GOI., and the same is very beneficial for the upliftment of the Livestock Industry. He also briefed on CLFMA policy, which included three core values viz.

1. Membership Value
2. Visibility and Credibility of the Organization
3. The recognition and influence.

Chairman, Mr Neeraj Kumar Srivastava also briefed on the Poultry Feed Scenario & Industrial Scenario, current soaring price of the grains, especially the soybean meal & other protein sources which has created a huge havoc in the livestock industry. He gave an outlook of the challenges / difficulties faced by Livestock Sector during Covid 19, rising feed cost Post Covid-19 and gave the opinion of implementing better value chains, trainings, equipment, equipment's, and employee's safety. He briefed on the pivotal role played by CLFMA for the upliftment and sustainability of compound feed industry and animal farmers, present ongoing trends and how the Livestock Industry could be helpful in reviving the Animal Husbandry Sector in the Country.



*Dr Lipi Sairiwal, Assistant Commissioner, Department of Animal Husbandry & Dairying, GoI*

Dr Lipi Sairiwal, Assistant Commissioner, Department of Animal Husbandry & Dairying, Govt. of India explained AHIDF Guidelines and the entire process of application process in detail, which are available on the GOI. She has also guided on how to apply for the loan to all the participants.

**Website: dahd.nic.in & ahidf.udyamimitra.in**

Shri Udit Paliwal, Program Management Expert, Dr Lipi Sairiwal, Assistant Commissioner, Dr S.K. Dutta, Joint Commissioner, Shri Sadique Akhtar, Team Leader interacted very well in Q&A Session with the participants and tried to resolve every question and for any further queries, they requested to contact either CLFMA OF INDIA or directly on the website, where contact details are available, so that they can try to handhold and help the related stakeholders.

Closing Remark was made by Shri Suresh Deora, Hon. Secretary of CLFMA. He said the, AHIDF fund was a very good project for people in Industry whether they are Farmers, Section 8 companies, Proprietor, Partnership Firm, etc., as they can avail interest subvention of 3% on 90% of the Loan. He appreciated Dr Lipi Sairiwal for presenting the detailed guidelines of the scheme. He suggested the Government of India to consider the following requests to be included under the scheme:

1. Please expand the scope of the Scheme;
2. To add some more products like feed supplements and additives, by pass fat, breeder broiler and hatchery farms;
3. To link up this scheme with CGTME scheme. Where, there is a non-collateral loan up to Rs 2 Crores & he said that, if this scheme is combined with CGTME Scheme CLFMA will be very grateful to the whole Ministry.

# MANAGE, organizes Webinar on Entrepreneurship Opportunities in Aquaculture sector

**Hyderabad, August 23:**

National Webinar entitled Entrepreneurship Opportunities in Aquaculture Sector was organized by MANAGE, Hyderabad on 23 August 2021 on Webex platform and in this programme, Dr Manoj Sharma, shrimp farmer (owner of Mayank Aquaculture Private Limited) and aquaculture expert in India based at Surat, Gujarat spoke and gave a presentation on 'Entrepreneurship opportunities in the aquaculture industry'

Dr Manoj Sharma stated that Government of India is very much eager to develop aquaculture sector in the country with PMMSY to double aqua-food export, production and farmers' income. Rise in five aspects, viz., population, food demand (tackling food scarcity), malnutrition in developing / under-developed countries, fish demand and awareness about human health have led us to focus more on aquaculture.

Emphasizing on fish as cheapest source of animal protein available on earth, Dr Manoj Sharma spoke about different kinds of water resource available in India and percent of it utilized for aquaculture; India's annual inland and marine fish production, total value of annual exports in fisheries and shrimp from India and annual shrimp production; major species of aqua-product export; mode of aquaculture practices in India (water-based, land-based, recycling, integrated farming system); present aquaculture supply chain (export-oriented and domestic); aquaculture industry requirements (feed, seed, medicine, others) that creates opportunity for an aspiring entrepreneur; concepts driving seafood trade (traceability, sustainability, quality, certification);

resources and opportunities for the youth (freshwater and brackish water aquaculture, marine fish farming, ornamental fishery, biotechnological interventions, indoor farming, young fishery graduates as technical experts, nutritionists, research scientists, domestic market interventions).

According to Dr Sharma, a 1 hectare of land utilized for aquaculture provides employment to 10 individuals and indirectly to more than 15 individuals. He also discussed about new trends and focus in aquaculture industry, new farming systems and candidate species; financial outlay (farm area, water spread area, number of ponds or cages, production, project cost and gross income) of each of the different farming systems, viz., inland fish farming in cages in reservoirs and dams, freshwater finfish culture (major carps and Pangasius sp), ornamental fish farming, seaweed culture in bamboo raft, shrimp farming in biosecured ponds.

As recent focus on shrimp farming in Indian domestic market, Dr Sharma established 'Zhingalala Store' (farmed fresh shrimp to doorstep and plate), which is a vision for domestic shrimp market in India and that serves above 45 shrimp delicacies.

He highlighted six facets of shrimp farming development, namely wasteland converted into best productive land; self-employment opportunity for millions of coastal fishers; infrastructure development in coastal villages – reverse migration; labour intensive employment; support food and safety through aquaculture; foreign revenue earner through exports.

Dr Sharma encouraged participants and aqua-entrepreneurs online by speaking on funding organizations like NFDB, State Fisheries Departments; gave a comprehensive concept and overview on producing food through aquaculture by youths and ended his presentation with the comment: 'The power of aquaculture if handed over to the youth can definitely bring the wave of development and immense opportunities for the nation and its people'.

# Centre allows import of 12 lt GM soyameal

*Move will help the Covid-hit domestic Livestock industry.*

**New Delhi, August 24:** The government on August 24 relaxed norms to allow import of 12 lakh tonnes of de-oiled and crushed genetically-modified (GM) soyabean as poultry feed with the Environment Ministry (MoEF) clarifying there was no concern from the environmental angle as it does not contain any living organism, a statement issued by the Ministry of Commerce and Industry said. The relaxation of the import norms will benefit farmers, poultry farmers and fishermen, who have been affected badly after soyabean meal prices soared across the country. The imports will be allowed till October 31.

**Breather for livestock sector:**

The poultry industry has been leading the demand to allow import of GM soyameal, stating that

*The imports will be allowed till October 31*

soyabean meal prices have topped Rs 1 lakh a tonne. Prices of soyabean meal surged as soyabean prices increased in line with the global trend in view of soyabean crop in South America being affected. In addition, production of palm oil and sunflower have also been affected across the globe due to Covid pandemic and drought-like conditions.

Currently, soyabean is quoted at Rs 97,500 a tonne at Indore in Madhya Pradesh, the hub of soyabean industry, while soyabean meal at Rs 87,000. Prices of both have tended to ease of late on reports of the Centre allowing imports of GM soyameal, besides the pending arrival of the new soyabean crop. The relaxation by the Centre came after clarification and prior permission from MoEF that "since soya de-oiled and crushed cake does not contain any living modified organism, this Ministry has no concerns and no objection for import of soya cakes from an environmental angle".

Armed with the no-objection certificate from the Environment Ministry, the DAHD approached the Commerce Ministry requesting it for facilitating import of the soyabean meal through Nhava Sheva (sea port) and Petrapole border (land port). An official communication from the Director-General of Foreign Trade asked authorities at respective ports to do strict monitoring to ensure that the import quantity of 12 lakh tonnes is not breached, the statement said.

"Application of provision as in Condition 6 (b) of General Notes Regarding Import Policy Schedule — I (Imports) of the ITC (HS) 2017 is relaxed to allow imports of 12 lakh tonnes of crushed and de-oiled GM soya cake (only non-living organism) under ITC HS codes 23040020 and 23040030 from Nhava Sheva port and LCS Petrapole, till 31st October 2021 or until further orders, whichever is earlier," it said.

**Rising input costs:**

The surge in soyabean meal prices resulted in input costs rising for the poultry sector, which in turn passed it on to the poultry item consumers. This resulted in broiler chicken prices soaring to over Rs 250 a kg recently. On the other hand, anti-GMO (genetically modified organisms) activists have opposed the Centre's decision to allow the import of GM soyabean meal. "What the Union Ministry of Environment, Forest and Climate Change and Genetic Engineering Appraisal Committee have reportedly stated is highly objectionable and legally untenable," the coalition for a GM-Free India said in a statement on August 13, according to a report published in The Hindu Business Line.

# Short term strategies to maintain 'Business As Usual' status in Aquaculture amidst COVID-19

*Menaga Meenakshisundaram & S. Felix **
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## Highlight Points

The paper provides a summary of an indicative strategies in the supply and demand side of the business chains in aquaculture and fisheries sector. The objective is to provide a timely suggestion based on the scale of the impacts from the perspective of the stakeholders involved in the business, as well as collate suggestions for interventions that may inform and guide the development of mitigation measures.

**Abstract:**
The paper provides a summary of an indicative strategies in the supply and demand side of the business chains in aquaculture and fisheries sector. The objective is to provide a timely suggestion based on the scale of the impacts from the perspective of the stakeholders involved in the business, as well as collate suggestions for interventions that may inform and guide the development of mitigation measures.

**Introduction:**

Over the past 20 years the aquaculture sector has evolved from having a relatively minor role to playing a mainstream part in the global food system. The phenomenal growth reflects the increased attention to food system outcomes, with consumers, value chains, and sustainability criteria progressively shaping the direction of the industry. Continued growth in the sector has important implications for achieving the United Nation's Sustainable Development Goals.

The outbreak of the COVID-19 pandemic largely disrupted health, food and economic systems. Indian Aquaculture is not an exception where millions of people's lives got severely affected. Central and State Governments were confronted with difficult choices in management of services, supplies and populations around the world. Living through shocks and disruptions builds resilience. This resilience can come in the form of social capital (such as extended family networks) and traditional or normative practices (such as sharing resources) or in the form of preparedness systems in formalized institutions and processes. But the pandemic is different in its nature and its impacts have been the worst than any other experienced shocks. Although the pandemic impact has not been directly assessed in India, the Governments and regional institutions have responded by developing mitigation and adaptation measures.

In this article, we outline policy recommendations to mitigate and support recovery from the ongoing shock of COVID-19. These are divided into supply side and demand side recommendations and recommendations that are immediate (aimed at mitigating the ongoing shock) and for longer term (aimed at resilient recovery).

**A. i. Supply side recommendations – the immediate task**

Immediate supply side recommendations fall into two groups:

(i) Ensuring the smooth functioning of aquatic food value chains and

(ii) Providing emergency financial support to actors in them.

The first set of recommendations (to Global Standards) include the following aspects:

- Ensure that logistics (transport and storage), physical market places and "lateral" value chains delivering inputs are designated essential. They must also be exempt from movement restrictions and kept open and operating, with social distancing and sanitation provisions such as water and soap for hand washing and providing personal protective equipment to protect public health. This is the most fundamental condition for avoiding supply-side shocks (Liverpool-Tasie et al. 2020; BIFAD 2020).
- Designate workers throughout aquatic food value chains as essential workers. Special consideration should be given to mitigating the effects of containment policies on migrant workers, who make up a significant part of the workforce in many aquatic food value chains and can be particularly vulnerable to both lockdown measures and health risks (Marschke et al. 2020).
- Ensure that rules governing containment policies are clearly formulated and publicized widely to maximize compliance and minimize rent seeking opportunities.
- Establish regular processes of consultation between Government, Fisheries professionals and relevant Business associations at national and sub-national levels.

Expectations of the Stakeholders in Aquaculture sector

a. The following observations were made in discussion with the fish farmers of the different states:

- COVID-19 and associated containment measures severely disrupted aquatic food value chains, but effects on supply chain were relatively (surprisingly) short-lived.
- Demand for aquatic foods has yet to recover to pre-pandemic levels. Demand for production inputs and services also remains low, resulting in substantially lower incomes for businesses and workers throughout the value chain compared to 2019.
- Prices of aquatic foods have trended downward over the course of the pandemic, apart from a brief spike in retail prices during March–May 2020. This trend reflects depressed consumer demand.
- Prices of manufactured feeds have risen. This reflects increased costs of doing business and inflation, though prices of most raw materials for feed have remained relatively stable, in line with international agricultural commodity prices.
- Aquatic food value chain actors have adapted to challenges in multiple ways. These include reducing production costs, using alternative inputs, leveraging social capital via informal networks, borrowing, seeking alternative employment and reducing food consumption.
- Coping strategies allow smaller producers and other actors to persist in the short run. However, they seem likely to undermine well-being and longer-term resilience.
- Larger businesses appear to have greater capacity to adapt proactively. These advantages may deepen as the COVID-19 crisis continues, leading to concentration in some value chain segments.
- Formal assistance has been limited. In most of the states, not all the famers received financial or other support from Government and other agencies.
- COVID-19 has exacerbated pre-existing inequalities. Asset-poor actors and those in precarious occupations have proven most vulnerable to financial, food and nutrition insecurity and health risks, with highly gendered consequences. Needs to quickly identify emerging problems in aquatic food value chains and agree on and implement remedies.
- Avoid border closures and restrictions on imports or exports to help prices remain stable.

**A. ii. Supply side recommendations – the long term task**

The second set of recommendations is prefaced by the observation that emergency financial support to actors in aquatic food value chains has been very limited where such schemes are implemented, they should take into account the following:

- Accord value chain actors such as traders, transporters, input suppliers and processors the same priority as producers when allocating resources.
- Focus on small and medium enterprises, farms and fishers, as these are more labor-intensive (employing many more people) than large enterprises, and they account for the majority of food produced and traded (Reardon et al. 2020).
- Bailout programs that prioritize allocation of scarce resources to industry could exacerbate inequities rather than reduce them (Ahmed et al. 2020). To maximize impact, aid packages can be scaled progressively. For example, when providing financial aid to farms, payments can be made on a sliding scale weighted in favour of smaller farms, rather than allocating a flat fee per unit area.
- Financial support packages for business should be well advertised. They must have transparent and simple application criteria and be designed in recognition that most aquatic food value chain enterprises are informal and often unbanked, making it necessary to devise inclusive application and distribution mechanisms.
- Loan timing and duration should take into account seasonality, such as by scheduling disbursement around peak stocking season for farms, and repayment dates after final harvest.

**B.i. Demand side recommendations – the immediate task**

In most of the states of India, the reach of formal social safety nets appears to have been limited or patchy to date. Keeping value chains working is thus of paramount importance. Nevertheless, where implemented, safety nets play important roles in mitigating the impacts of shocks on the poor and vulnerable (Gilligan 2020).

- Unconditional cash transfers targeted particularly to vulnerable and poor groups, including women of reproductive age, can increase consumption of nutritious aquatic foods and stimulate demand for their production. Disbursement can be timed to coincide with the implementation of any forthcoming waves of lockdown measures, such as in Myanmar, or other periods of particularly acute stress, including cyclones and drought.
- Aquatic foods such as dried fish can be included in food aid packages as nutritious, culturally appropriate, convenient and low-cost foods, and used as an alternative to nutritional supplements that also stimulate demand for production.

Long term, supply side recommendations for the long term are aimed at revitalizing aquatic food value chains to protect livelihoods and human nutrition, contribute to post-pandemic recovery and promote resilience to other future shocks. These include the following:

- The physiology of widely consumed aquatic organisms means that there is little chance of transferring viral zoo noses to humans (Bondad-Reantaso et al. 2020). This is strong grounds for promoting aquatic foods as preferred animal-source foods, given the associations between

livestock rearing and bush meat consumption and the emergence of new infectious diseases (Tomley and Shirley 2009).

- Construct or upgrade critical infrastructure, such as roads, electricity and market places.
    - Establish systems for real-time monitoring of the quantities and prices of aquatic foods and inputs produced and traded to track changes and support speedy interventions where necessary.
    - Provide practical digital literacy training to actors throughout aquatic food value chains to support digitalization in aquaculture and fisheries to facilitate ease of advertising, marketing, input procurement, delivery of technical advice and payments.
- Invest in human capacity and skills development through training programs to support sectoral development in fisheries and aquaculture. This may include promoting production of nutrient-rich aquatic foods for household consumption to reduce food and nutrition insecurity in the face of shocks.
- Capture fisheries can play an important safety valve function during shocks such as COVID-19 but could be vulnerable to particularly heavy exploitation during such events (Fiorella et al. 2020; Stokes et al. 2020). Fisheries should be accorded higher priority in development planning processes because of their importance for livelihoods and food and nutrition security.

**B.ii. Demand side– the long term task**

On the demand side, revitalizing aquatic food value chains through the types of interventions described will boost employment and income. This will contribute to demand for aquatic foods and other goods and services through production, consumption and employment links (Filipski and Belton 2018). The COVID-19 pandemic has widened existing inequalities and underlined the weakness of existing forms of social protection in many countries (Gupta et al. 2020). Over the long term, better developed and more comprehensive systems of social protection and public health care will be key to pre-empting rapid, large-scale slides into extreme poverty and food and nutrition insecurity when shocks occur (Gerard et al. 2020).

**Conclusion**

The Global COVID-19 pandemic has already reversed years of progress on key human development indicators. The regions most affected are Sub-Saharan Africa and South Asia. Public health interventions continue to play an important role in saving lives, but the deepening economic crisis demands a renewed emphasis on protecting livelihoods and human nutritional status. Prior to the COVID-19 pandemic, the potential of aquatic food value chains to drive progress toward development goals made them important areas for investment and intervention. This potential makes renewed investments in aquatic food value chains and the livelihoods they support even more important in the context of post-COVID-19 recovery efforts. Revitalizing aquatic food value chains can play a critical role in protecting livelihoods and human nutrition. It will boost both employment and income and will contribute to demand for aquatic foods and other goods and services. Finally, future policies and programmes to promote aquaculture will require a food systems approach that examines nutrition, equity, justice, and environmental outcomes and trade-offs across land and sea.

# Four Less-familiar Gobiid fishes as 'Poor man's protein source'

*Subrato Ghosh*
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**Highlight Points**

Gobiid fishes found in village ponds and rivers are less-familiar to us, edible and are important component of 'Poor man's protein source' in West Bengal and other states. In February 2021, author observed and photographed four of them, viz., Glossogobius giuris, Boleopthalmus boddarti, Pseudapocryptes lanceolatus and Trypauchen vagina in small fish markets at Roydighi and Jumai Naskarhat in Indian Sundarbans region, Dist. South 24 Parganas, WB and collected information on these small indigenous fishes is presented in this communication.

**Introduction:**

**Small indigenous fishes (SIF)**

Fish can become a poor man's protein with consumption of those, whose market value and demand is lower than commercially-important cultivable major carps and catfishes.

***Boleophthalmus boddarti***

In Proceedings of Workshop on 'Small Indigenous Freshwater Fish Species: Their Role in Poverty Alleviation, Food Security and Conservation of Biodiversity' published by ICAR-CIFRI, Barrackpore in February 2010, it was mentioned that Indian people have traditionally depended on varieties of indigenous inland fish species as source of nutrition, which are easily available from nearby water bodies. Out of about 765 species of native freshwater (warmwater and coldwater) fishes found in India (ICAR-NBFGR document 2011-2012), a large number of them are familiar only to local population and out of it, 450 species are Small Indigenous Freshwater Fishes. SIF are better known to rural population due to importance they attach to these species as vital and affordable source of nutrition. Significant numbers of them are rich source of nutrition, i.e., protein and micronutrients for rural poor either on a seasonal basis or round the year. Dr. N. P. Srivastava, Former Principal Scientist, CIFRI in his poem has emphasized that small, native fish species, full of nutritional qualities, need to be recognized as life-giver for the poor and SIF can help meet nutritional needs of low-middle class and poor communities in villages.

A total 574 species of finfishes found in West Bengal (WB), 239 are freshwater and Gobiid fishes are SIF, belong to both freshwaters and brackishwaters, are important component and contributor as 'Poor man's protein source'. It is important to document local names of these fishes, their market prices, demand, their proper identification and the indigenous knowledge wealth of local elderly villagers about time of availability of fishes in the year, availability status, habit, medicinal values, etc. As SIF in inland waters, species which come to our mind are Labeo bata, Ompok pabda, Nandus nandus, Mystus gulio, M. vittatus, M. cavasius, Chela bacaila, Puntius sarana, P. ticto, P. sophore, Amblypharyngodon mola, Chanda nama, C. ranga, Anabas testudineus, Heteropneustes fossilis, Scatophagus argus. Artificial propagation and conservation strategies of some of them have been standardized.

**Distinguishing features**

In fishes belonging to Family Gobiidae (Order Perciformes : Sub-order Gobioidei), body is elongated, small eyes covered with skin, 2nd dorsal fin longer than 1st one, body without lateral line canal, scales often partly or totally absent, spinous dorsal fin (with 2-17 flexible spines) separated from 1st one, teeth on both jaws generally small and conical. These are naturally-occurring fishes, not farmed in WB, yet to become commercially-important, do not reach city markets normally. They are found in Hooghly-Matlah estuary and mangrove waters of Indian Sundarbans. Boleopthalmus boddarti (Pallas), Pseudapocryptes lanceolatus (Bloch & Schneider) and Trypauchen vagina (Bloch & Schneider) are found in brackishwater (tidal) rivers and creeks (tidal channels) of Indian Sundarbans region and muddy bottoms of estuarine areas; Glossogobius giuris (Hamilton-Buchanan) found in both freshwater and brackishwater environments, grows to much larger size in latter condition. These Gobiid fishes are caught and sold (marketed) locally in live or just-dead state.

**Glossogobius giuris**

G. giuris is also a component of SIF, termed 'beley' and 'bhutkuri' in Bengali, caught from nearby rivers and streams, also get naturally recruited to beels, freshwater swamps and homestead/common freshwater village ponds (clear and turbid), which are harvested using 'Khyapla jaal' (cast net) and in good numbers using scoop nets or hand picking from pond bottom mud when lentic water bodies are dewatered. G. giuris of rivers attains larger size, found in upper surface of big and small rivers. Author studied and observed its gill rakers to be moderately stout, like fine bristles and widely positioned, 10-11nos in one arch. Lengths of intestine in three specimens 35gm, 50gm and 75gm varied between 9.2-11.6cm and RLG 0.53:1 – 0.56:1 total length. A pond-dwelling 12.6cm specimen had intestine length 5.5cm. It is seldom found in Kolkata fish markets, price Rs 300-400/-/kg (12-14cm size, 10-14gm); has become less available in village ponds, captured mainly from beels and rivers. Riverine G. giuris (40-50gm, sometimes 90-150gm) tastes better than those of ponds.

*Pseudapocryptes lanceolatus*

**Pseudapocryptes lanceolatus**

P. lanceolatus is an amphibious air-breathing fish, termed 'guley', 'chewa', 'kalo chewa', 'chengo', 'sada chengo' and 'bego chengo' in Bengali. According to WB State University publication, both G. giuris and P. lanceolatus inhabit deep water near mud surface and during high tide, they come out at upper surface of river. It is found from saline to freshwater zone of Hooghly estuary, caught in good numbers in pre-monsoon, monsoon and post-monsoon months, also found in mudflats of estuaries. Bengali people cook different delicious dishes of this fish (head not eaten), only seldom found in Kolkata markets, 12-18gm size. It is found in Piyali river and nearby rivers of Roydighi town, brackishwater rivers is their natural habitat, sold in local markets at Rs 250-370/-/kg (15-17cm size; sometimes Rs 400/-/kg), local demand is high. Traditional fisherfolk of Indian Sundarbans and general inhabitants consume it. At Jumai Naskarhat near Kakdwip town, it is captured from Kalnagini, Gondogata, Kalobeney creeks/river channels, sold locally at Rs 350/-/kg. The species Taenioides buchanani is quite similar to P. lanceolatus.

**Boleophthalmus boddarti**

B. boddarti is termed 'dahuk', 'dakuria' and 'menua' in Bengali, 1st dorsal fin is grayish having blue spots, is found sheltering in mud holes and mud bottom of tidal rivers and creeks, estuaries and coastal beaches; an intertidal dweller, amphibious and air-breather, walks on lands and mudflats during low tide with caudal and pectoral fins, cannot remain under water for prolonged time, can see clearly when outside water, males with colourful wings jump upto 1.5 feet height. Author saw it in pictures but never as specimen till February 2021. It is very less available in local fish markets in South 24 Pgs, sold at Rs 200/-/kg and above (8-12cm size). People catch them only in low quantity, mostly for household consumption, kept in freshwater before cooking to remove mud. This fascinating fish arouses considerable interest and enthralls tourists at Sundarbans.

**Trypauchen vagina**

T. vagina is termed 'lal chengo', 'lal guley', 'lal chewa' and 'lal ghagra' in Bengali, has remarkable unique pink/pinky-white body colour, ventral (pelvic) fins typically united forming adhesive disc-like structure. It is fairly common in coastal waters, estuaries and tidal rivers along Bay of Bengal. Author never saw it, neither in picture nor as specimen, till February 2021. Like P. lanceolatus, it is found in nearby rivers of Roydighi town, brackishwater rivers is their natural habitat, sold in local markets at Rs 80-150/-/kg (12.5-15cm size), local demand is moderate, not as high as P. lanceolatus. At Jumai Naskarhat, it is captured from Kalnagini, Gondogata, Kalobeney river channels, sold locally at Rs 150/-/kg. The species Odontamblyopus rubicundus is also termed 'lal chewa' in Bengali, similar to T. vagina but does not have pinky-white colour; only anterior body part is reddish.

*Trypauchen vagina*

**End note**

Village ponds and freshwater beels in general in WB and estuarine wetlands and tidal rivers in Indian Sundarbans region harbour a rich variety of inland species of fishes (including afore-mentioned four Gobiids), many are region-specific, exploited by traditional local fishermen using conventional fishing gears. Fish is desperately needed to feed the world's poorest people. In two photos in front cover of CBFM Booklet-3 published by World Fish Center and Dept of Fisheries, Bangladesh, two village women seen going for fishing and one of them holding adult G. giuris on palm – as if such fishes sustain them. These four species of Gobiids are among

the fish resource diversity sustaining lives of local fishing vcommunities in Indian Sundarbans, who live close to the resource. Often fish sellers themselves are the fishers – author noticed that they are poor. Lives of poor fishers depend on such resource, often those are caught in indigenous fishing trap 'Mughri' or 'Aatol'; which holds potential in improving nutritional security, income and social fabric of village communities. Sri Panchanan Halder at Roydighi, Sri Nandikanta Naiya at Jumai Naskarhat, Sri Mithun Mandal at Sagar islands while giving some information about four fishes to author stated that they have been eating P. lanceolatus and T. vagina since childhood, tasty but now observed at Canning town, Taldi, Nischindipur (T. vagina and P. lanceolatus sold at Rs 100-150/- and Rs 250-300/-/kg respectively), Namkhana wholesale fish markets and other places in Indian Sundarbans in very less quantity. Sri Halder noticed that in recent years, these two species are under the threat of extinction and their availability is decreasing very fast. But still in this part of the coastal WB (in Roydighi and nearby markets), those are somehow visible in regular basis, though amounts are negligible. Mainly some local people manage to buy before it goes out of stock very quickly – that is the main reason for being not found in Kolkata city markets. These fishes are less-regarded and need conservation measures, for being a treasured resource in terms of biodiversity values, their utility as food by the rural mass, specially the poor (forming a part of their regular diet) and as materials for scientific studies in ichthyology.

*Glossogobius giuris*

# Gassen Plus

## Bon Ammonia and obnoxious Gasses

Shrimp / Fish performs all their body functions and growth in water. Good quality water and proper D.O. levels determines the success or failure. Good quality water, optimum D.O. level is of prime importance for health and growth of Shrimp / Fish.

Irregular water exchange, excess and leftout feed, dead algae, fecal matter, increases the organic load at the pond bottom. Accumulation of such waste absorbs available oxygen, creating anaerobic condition which leads to pollution of pond bottom. Polluted pond bottom and unhealthy environmental conditions triggers the release of toxic gasses like Ammonia, $H_2S$, Methane, etc, The toxicity of Ammonia, Hydrogen Sulphide, Methane attributed mainly due to unionized form. As the concentration in water increases, ammonia excretion by aquatic organism diminishes and the level of ammonia in blood and in other tissues increases. Ammonia increases oxygen consumption by tissues, damage gills and reduces the ability of blood to transport oxygen, and increases the disease susceptibility. To eliminate / overcome the above problems 'GASSEN PLUS' Yucca Schidigera, it contains Steroidal"Saponin" which help to reduce ammonia and other noxious gasses such as $H_2S$, Methane, etc., Microbial enzyme "Urease' Production inhibited by Saponin which leads to an increases D.O. and reduction of BODand COD levels.

Bacterial strains such as Bacillus Subtilis, Nitrobactor, Nitrasomonas, rapidly converts ammonia into Nitrates, Nitrites and finally non-toxic Nitrogen. Hydrogen Sulphide converts into Sulphates, Sulphites and finally non-toxic Sulphur, Methane into Non-toxic carbon. This conversion reduces the obnoxious gasses in the pond bottom. Reduction of this gasses improve the D.O. level in the water and bottom.

**COMPOSITION:**
YUCCA SCHIDIGERA
ALOEVERA
BACILLUS SUBTILIS
BACILLUS POLYMIXA
BACILLUS LICHENIFORMIS
NITRASOMONAS
NITROBACTOR
STABILIZERS

**DOSAGE :** 1 Kg per Acre or consult your Aqua Technician For Specific Usage & Dosage

**PRESENTATION:** 500 gms &1 kg


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# Introducing the Predators (BALOs) of the Challengers (Vibrios) to Shrimp Farming

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**Highlight Points**

- BALOs are small obligate gram-negative predatory bacteria that feed on other gram negative bacteria.
- As shrimp farming is seriously hampered by Vibrios, these BALOs, owing to their unique lifestyle and natural ability to eliminate Gram-negative microbes, have a great potential as a bio-control agents in shrimp farming and other aquaculture practices.

**Introduction:**

Aquaculture, most likely the quickest developing food-producing sector, presently represents almost 50% of the world's food fish and is seen as having the best potential to satisfy the developing need for aquatic food. Shrimp culture has been encountering a gigantic increment without outskirts everywhere in the world since 1970. It is regularly considered as living dollar as it contributes an enormous amount by value to the entire aquaculture production. Notwithstanding this sprout and spread, their escalation has not left them liberated from infection assaults by microbes. Vibriosis has been distinguished as a serious illness issue in shrimp culture ponds everywhere in the world. Mass mortalities of shrimp ascribed to flare-ups of vibriosis have been recorded from hatcheries and grow-out ponds of numerous locales. For instance, diseases brought about by Vibrio parahaemolyticus, Vibrio cholerae, and Vibrio vulnificus have brought about huge monetary misfortunes in shrimp farming regions. These infections and anti-microbial resistance faced by the aquaculture industry presented the probiotic idea and the utilization of Bdellovibrio and like organisms (BALOs) as a probiotic / biological agent to control pathogens or potential microbes in sustainable aquaculture.

**BALOs**

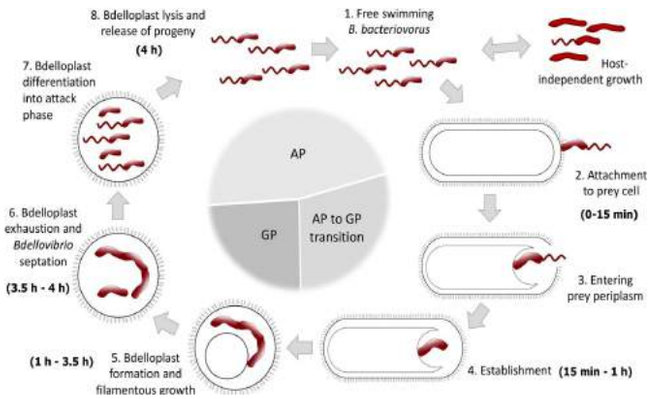
Bdellovibrio and like organisms (BALOs) are a group of small, obligate, Gram-negative bacteria that selectively prey on a broad range of gram-negative bacteria, including vibrios. These kind of obligatory predatory lifestyle is restricted to alpha-proteobacteria (genus Micavibrio) and delta-proteobacteria (families: Bdellovibrionaceae, Bacteriovoraceae, Peredibacteraceae, Halobacteriovoraceae and Pseudobacteriovoracaceae) all commonly gathered under the term BALOs. They are diverse both phylogenetically and environmentally. One among the best-contemplated BALOs is Bdellovibriobacteriovorus which serves as a model organism for bacterial predation. While the term was coined by Robert E. Buzzzchanan it was discovered unintentionally by Stolp and Petzold in 1962 during the confinement of bacteriophages of the phytopathogen Pseudomonas syringaepv Phaseolicola from soil suspension. They were named portraying their morphology and the alleged lifestyle; as they bend and appear to adhere to their prey and assimilate the prey cell content, suggestive of a leech which means "bdella" in Greek. These Bdellovibrio are exceptionally motile, flagellated and are tiny estimating about 0.25 × 1.0 µm. Among them, there are three types, namely B. bacteriovorus, B. stolpii and B. starrii.

BALOs are ubiquitous in nature and are found in a variety of natural and manmade environments. They can be seen in soil and different aquatic habitats such as ocean, rivers, lakes, sewage and wastewater treatment plants. The genus Bacteriovorax is one among them that was predominantly isolated from both water and sediment samples. BALOs can attack the periplasm and duplicate inside many prey microorganisms, lysing them and further assaulting different microbes. This makes BALOs possibly amazing inhibitors of environmentally and clinically unwanted microorganisms. As an extraordinary gathering of predatory prokaryotic microbes, BALOs are progressively being viewed as an alternative bio-control agent in the field of aquaculture, in China specifically.

**Life cycle**

BALOs Hhave convoluted life cycles consisting of both host-dependent and host-free replication. In host-dependent replication (periplasmic life cycle), susceptible Gram-negative host bacterium is encountered by attack phase BALOs(0.2 to 0.4 µm in diameter with single polar flagella).They enter the cell by enzymatically digesting a hole in the host membrane. The invader then forms a bdelloplast (encystment), within the host's periplasmic

space. Containing a replicative structure, the bdelloplast looks like an extending worm that gets supplements for development from the host. The bdelloplast, upon maturation septates into multiple immature cells usually of 3 to 9. These small immature cells are released from the host and grow into mature, attack phase cells. Alternative to the above one, BALOs can also duplicate external to any prey (epi-biotic life cycle) or in the absence of prey through host independent pathway. In the absence of prey, BALOs can frame variable length chains in the extracellular milieu. These chains septate subsequently to shape individual BALOs that is capable of reinitiating the replication process. In the epi-biotic life cycle (Eg. Bdellovibrioexovorus), the predators join to the prey surface and perform parallel parting on the external surface of the prey cell while prey cytoplasmic substance decline. The same is seen in Micavibrioaeruginosavorus which is another type of predatory bacterium of Vibrio which resembles the size and shape of the attack phase BALOs but parasitizes and kills the cells of the host without entering the host. They are significant in killing bacteria in biofilms.




***Life cycle of B. bacteriovorus (Source: Bratanis et al., 2020)***

***AP - Attack Phase; GP-Growth Phase***

**Importance**

Natural microbes frequently exist as organized single or multi-species networks connected to surfaces, with a front of extracellular polymeric substances – also called biofilms. While shrimp grows by moulting, this process of shedding the exoskeleton by shrimps during culture causes an accumulation of bacterial biofilms at the pond bottom. This paves way for V. parahaemolyticus to form biofilms on shrimp surfaces. It has been reported that BALOs could focus on their prey both in water and in biofilm. These predatory bacteria like most bacteria, shares the ability to form biofilms. Although they have the ability to form self-biofilm, these BALOs have the potential to inhibit the formation, as well as to reduce the preformed biofilms of other bacteria, which has gained due interest. With this evidence, Kongruenget al. (2017) demonstrated the potential of BALOs to control AHPND in shrimp farms.

Bdellovibrio, by flagellar motility and chemotactic responses directs itself towards its prey. In a study by Richards et al. (2012), the counts of V. Parahaemolyticus diminished from 3 log units to non-detectable levels whereas the vibrio predatory bacteria (VPB) increased 3 log units within 48 h. They have proposed a new paradigm that VPB are important modulators of pathogenic vibrios in seawater. Also, provided evidence that these VPB play a direct and perhaps a significant role in stifling vibrios in shellfish. The above studies and experiments opened doors for the use of these BALOs commercially in various fields and disciplines. The Hebei Weierli Animal Pharmaceutical Group, one of the renowned Chinese companies, produces B. bacteriovorusas a probiotic for aquatic animals, poultry, and different farm animals.

**Conclusion**

Despite the fact that the obligate predatory bacteria were first portrayed almost 60 years ago, many of the molecular mechanisms remain limited and rather tricky. Nonetheless, these predatory bacteria are currently acquiring increased consideration, much owed to the alarming reports on the ascent in antimicrobial resistance and an overall rise in environmental awareness. The potential use of predatory bacteria as live antibiotics, water cleaner, bio-control agents and as hotspots for the disclosure of novel biotechnological tools for research have been proposed and demonstrated through several reports. BALOs have a wide prey range, however the manner in which they select their prey is quite unknown. As of now, the principle impediment to incorporate this thought is the absence of adequate information about the ecology of predatory bacteria. Finally, it is concluded that BALOs do have solid antibacterial activities against various bacteria, including vibrios, and have an extremely strong application potential in aquaculture practices.

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# Endocrine disrupting compounds/ chemicals in aquatic environment: Effects and possible consequences on fish

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**Highlight Points**

1. Endocrine disrupting compounds/ chemicals (EDCs) include synthetic and natural hormones, plant metabolites, phthalates, pesticides and aromatic compounds.
2. EDCs are mainly absorbed into the body of aquatic organisms through various ways like respiration, maternal transfer in the lipid reserves of eggs, osmoregulation etc.
3. EDCs have the ability to interrupt the normal functioning of the endocrine system, as they can copy actual hormones, alter the expressions of specific receptors, and disrupt their form of synthesis and metabolism.

## Introduction

The presence of environmental pollutants in aquatic ecosystem is a major concern worldwide. Effluents from surface runoff, agriculture, industrial and domestic sewerage sources are usually released into aquatic ecosystem. Besides, there are certain chemicals which have been banned, yet few of them are still in use and persist in the environment. These contaminants released from different sources get deposited on sediment and biota and remain there for quite a very long period that causes serious environmental changes threatening the organisms living in it. While these environmental contaminants can affect various biological systems, many of them interfere with hormonal regulation in aquatic species and are, therefore, known as endocrine disruptors. Substantial scientific evidence gathered over the years suggest that numerous chemicals/compounds/substances used in industries, agriculture activities and/or naturally occurring compounds have the potency to affect the endocrine systems and hormonal activities of aquatic animals. These contaminants pose a risk and act as endocrine modulators and endocrine disruptors affecting proper functioning of the endocrine system. The clinical symptoms observed through endocrine modulators are milder and reversible, whereas effects by endocrine disruptors are more serious and not always reversible, and may lead to death.

The endocrine disrupting compounds/chemicals (EDCs) include a range of chemicals/contaminants, including synthetic and natural hormones, plant metabolites, phthalates, pesticides, PCBs as well as many aromatic compounds found in aquatic environment. These endocrine disruptors or EDCs are characterized as micropollutants, which can disrupt the normal functioning of the endocrine system of fish even at low levels. EDCs have been reported to adversely affect the developmental and reproductive disorders of several aquatic species, including fish. In fact, among all the vertebrates, fish live in close proximity to the discharge released in water, and therefore, have the highest exposure as compared to those far off. Further, many of these EDCs, because of lipophilic and persistent nature, have the ability to bioaccumulate and/or biomagnify in organisms and have the characteristic of affecting the animals' endocrine system due to their characteristic deleterious effects. Further, some EDCs are slow to break-down in the environment and become potentially hazardous over time. With so many contaminants with characteristic deleterious effects released to aquatic environment, exposure of organisms to EDCs is ubiquitous and inevitable contributing to adverse health effects. The human exposure typically occurs due to occupational exposure and with consumption of contaminated fish, affecting their health and well-being. This article highlights the deleterious effects of the compounds/chemicals that are released into the aquatic environment which in turn has the ability to affect the endocrine system of fish.

## Endocrine disrupting compounds/chemicals (EDCs)

The endocrine disruptors are exogenous substances or mixtures of compounds/chemicals that change the functions of the endocrine system adversely affecting the health of an intact organism, or its progeny, or (sub) populations. Fish are considered as one of the primary risk organisms for EDCs, as the aquatic systems are the sink of pollutants of various forms from different sources. Fish, being an aquatic organism, lives in close contact with water and is constantly bathed and gets exposed to a solution containing pollutants/contaminants. So compared to terrestrial animals, fish are more vulnerable to these chemicals as they uptake chemical contaminants through

multiple routes including directly from the water via the gills, skin and drinking (gut), through the diet (in case of cultured species) and/or via sediment contact and get exposed. As gills possess thin epithelial membranes with large surface area coupled with the relatively high ventilation rates, it also facilitates the uptake of compounds from the water and their transfer into the blood stream as well. As most of the EDCs are lipophilic, they are accumulated in the fat of the organism. Further, the rate of bioaccumulation of EDCs is higher in fish compared to other organisms at lower trophic levels in the food web.

The recent population growth coupled with increased anthropogenic, industrial and agricultural activities has increased the load of chemicals in the aquatic environment. These are natural, produced by animals and plants (phytochemicals and phytoestrogens), fungi (mycoestrogens) and cyanobacteria or man-made synthetic substances that are discharged into the water bodies. The plant hormones and chemicals (phytoestrogens) suspected to act as endocrine disruptors are daidzein, a soy-derived isoflavone that originates from plants and herbs, genistin from lupins, soybean or fava beans, kaempferol from tea, broccoli and others. The synthetic compounds (xenobiotics) are a highly heterogeneous group and include dichlorodiphenyltrichloroethane (DDT) and its metabolites; industrial products or its compounds such as dioxins, bisphenol A (BPA), and polychlorinated biphenyls (PCBs); pesticides such as chlorinated insecticides, imidazoles, and triazoles; chemical substances used in cosmetics, such as phthalates and parabens; several heavy metals including copper, nickel and cadmium. Some of these compounds are resistant to environmental degradation through biological, chemical, and/or photolytic processes and for that reason is considered to be Persistent Organic Pollutants (POPs). The use of hormones such as food supplements in livestock and aquaculture are also considered as important pathways of EDCs contamination in the aquatic environment. Sewage effluents and wastewaters, which often receive domestic, industrial and/or agricultural wastes following their partial or complete biodegradation during the treatment process, also release a complex (and ill-defined) mixture of natural and synthetic chemicals into the aquatic environment.

It is estimated that near about 60,000 man-made chemicals are in routine use worldwide and most of these enter the aquatic environment. These natural and synthetic pharmaceuticals, pesticides and other chemicals with endocrine disrupting activity are entering the aquatic environment via disposed wastewater, agricultural run-off, and groundwater discharge, and can accumulate both in sediments and in biota, including fish. As per National Academy Panel on Hormonally Active Agents in the Environment, more than 46 hormonally active agents from agricultural, pharmaceutical, and industrial chemicals (NRC, NAS 1999) can potentially disrupt/affect the endocrine systems of several terrestrial as well as aquatic species. A list of common natural and man-made chemicals found in the aquatic environment is presented in Table 1.

| Type | Specific Examples of EDCs | Use/Source |
|---|---|---|
| Persistent organic pollutants, including pesticides, fungicides and insecticides | Dichlorodiphenyltrichloroethane, lindane, chlordecone, carbaryl, malathion, mancozeb, vinclozolin, toxaphene, procloraz, procymidone, chlorpyrifos, endosulfan, methoxychlor, methyl sulphones, polychlorinated biphenyls (PCB's) | Organochlorine insecticides, pesticides mostly in agricultural activities |
| Non-halogenated phenolic chemicals, plasticizers and other additives | Octylphenol, dibutyl phthalate, nonylphenol, bentylphenol, resorcinol, butylbenzyl phthalate, bisphenol A, bisphenol F, bisphenol S, phthalate esters, triphenyl phosphate, n-Butylbenzene, triclocarban, butylated hydroxyanisole | Cosmetics, toys, medical products and food wraps, plastics and polycarbonate, food industry |
| Pharmaceuticals, growth promoters, personal care products, xenobiotics and phytoestrogens (natural and synthetic) | Mycotoxins, 17β-estradiol, estrone, genistein, coumestrol, diethylstilbesterol, ethinyl estradiol, isoflavones, prenylflavonoids, flutamide, parabens | Preservatives in cosmetics, toiletries, and pharmaceuticals, pulses including soya bean |
| Halogenated phenolic and organic compounds | Polybrominated diphenyl ethers (PBDE's), Hydroxy-PBDEs, 4-Dichlorophenol, pentachlorophenol, Hydroxy-PCBs, polychlorinated dibenzodioxin, dioxin | Flame retardants, plastic cases in electronic items, foam cushions in automobile industry and other textiles. Production of some pesticides and the bleaching of paper pulp |
| Metals and organometallic chemicals | Arsenic, cadmium, lead, methyl mercury, tributyltin, triphenyltin | Industrial use |

***Table 1: Common reported natural and man-made pollutants/EDCs in various aquatic environment***

**Overview of the Piscine Endocrine System**

The internal secretion system or endocrine system is complex with many organs contributing to a multi-faceted regulatory system that governs the normal growth, development and reproduction of an organism. The endocrine system is a set of organs and tissues that are located throughout the body in fish and secrets hormones, the signaling molecules. Out of sixteen organs and tissues in teleosts that secrete hormones, the pituitary gland or hypophysis, thyroid gland, corpuscles of stannius, adrenal gland and pineal gland are important. The glands of endocrine system synthesize and secrete hormones and along with the central nervous system control and regulate many biological processes. The functions of the endocrine system, also known as the hormonal system, is to mediate and control kinetic, metabolic, morphometric and behavioral effects that include energy metabolism, growth and development, reproduction, homeostasis, pigment migration and osmoregulation. For example, the thyroid gland secretes thyroxine (T4) and triiodothyronine (T3), adapting the fish to changes in temperature and to osmotic stress. Likewise, the pituitary gland in fish secretes a number of hormones which affect growth, osmoregulation, lipid metabolism and reproductive development and behavior, as well as controlling other endocrine glands.

**Effect of Endocrine Disrupting Chemicals on Fish**

Most of the EDCs are easily absorbed into the body of aquatic organisms through various ways like respiration, maternal transfer in the lipid reserves of eggs, osmoregulation etc. They act via mimicking or blocking natural hormone functions within an organism and interfere with the biological process. In fact, EDCs have the ability to interrupt the endocrine system, as they can copy actual hormones, alter the expressions of specific receptors, and disrupt their form of synthesis and metabolism. Interestingly, man-made compounds or natural chemicals, such as phytoestrogens have the potential to imitate natural compounds despite the fact that their chemical structure is different. Different kinds of hormones could be targets of environmental chemicals: reproductive hormones such as estrogens and androgens, thyroidal hormones, corticosteroids, growth hormone etc.

As stated earlier, EDCs act as hormone agonists or antagonists, affecting hormonal signaling of organism at multiple potential sites. The most well-known and common mode of action among EDCs is the imitation of endogenous hormones. Such effects can be agonistic (i.e. a chemical binds and activates the natural hormone receptor) or antagonistic (i.e. a chemical blocks the receptor action). In general, EDCs not only impair reproductive performances like decrease fertility, hermaphroditism and sex reversal, altered sex ratios, hatching success but also causes metabolic defects such as thyroid dysfunction, and even alters the immunological and behavioural functions in various animals, including fish. Effects of EDCs on fish physiology suggest that these can affect the endocrine system of fish in several ways; they can disrupt the hypothalamic and pituitary function, growth, development and reproduction, liver function and thyroid and inter-renal function. Further, they can interfere with endogenous endocrine pathways and cause sex steroid disruption in fish. This disruption is associated with many different mechanisms, one of which involves binding xenobiotics to the androgen and estrogen receptors, evoking physiological responses within the fish. Even though the binding affinity of most these substances to the estrogen or androgen receptors is low compared to endogenous steroid hormones, exposure to even low concentrations of xenoestrogens / xenoandrogens can disrupt normal developmental and reproductive processes.

A major route of exposure of fish to EDCs is from contaminants that have accumulated in lipid reserves within the egg of the mother. During early life stages of development, adipocytes get differentiated, and organs start developing. The exposure of fish at this stage to a mixture of such compounds is a cause of concern, as it is the most critical or vulnerable period in their development that can induce and manifest later. The variation in hormones synthesis levels result in reduced plasma sex steroid and pituitary gonadotrophin concentrations, disturbance of genes expression, alteration of gonads structure, disruption of liver functions, and altered fish behaviors. This in turn affect courtship and mating behaviors, absence of secondary sexual characteristics in males, induced vitellogenesis in juveniles and males, affecting egg/ sperm quality, fecundity (reproductive capacity), growth, immunity and morphogenesis (body pattern formation). Most worrisome are emerging threats from epigenetic changes, since problems persist or pass on to future generations who were never directly exposed.

As far as reproductive physiology is concerned, these EDCs differently affect male and female fish species, depending upon their ability to mimic endogenous hormones. The chemicals present in the environment that can disrupt reproductive system in fish are classified into four categories: estrogenic, anti-estrogenic, androgenic and anti-androgenic compounds. As estrogens and androgens play an important role in sex determination, sexual differentiation, and sexual development, many of the effects of EDCs are associated with the reproductive health of fish. In the case of male fish, alterations of sperm density and motility occurs resulting in reduced fertility whereas Inhibition of gametogenesis, development of intersex gonads, alteration of the gonadosomatic index, and decreased fertility is noticed in case of female fish. Although, matured female fishes induce vitellogenesis by excreting enough estrogen, but this process can be manipulated by exposing male and juvenile fishes to EDCs in the external environment resulting in elevated levels of a female egg protein vitellogenin in male fish and degeneration of gonadal tissue.

Fish behaviors can also be affected by EDCs exerting far wide implications at individual and population level. However, the efficacy of EDCs depends on their type, persistence level, lipophilicity etc. Besides, other factors that govern its effect include the rate of bioaccumulation, targeted species and its stage of growth, concentration, time and duration of exposure, role of other stressors, including environmental factors like temperature, salinity etc. Some of the effects of EDCs on the dynamics of endogenous hormones in fish are presented in Table 2.

| Source | Endocrine disrupting chemical/ compound | Action | Effect on endogenous hormones | Reference |
|---|---|---|---|---|
| Pharmaceuticals/ nonsteroidal anti-inflammatory drug | Ibuprofen | Increases estradiol-17β (E2) and decrease testosterone production | Changes dynamics of reproductive hormones in fish | Han et al. (2010) |
| Synthetic estrogen | 17α-Ethinylestradiol (EE2) | Reduces both E and 11-ketotestosterone in males | Changes dynamics of reproductive hormones in fish | Salierno and Kane (2009) |
| Polybrominated diphenyl ether (flame retardant) and prochloraz (imidazone fungicide) | 17α-ethynylestradiol (EE2) | Alters expression of gonadotropin-releasing hormone and its receptors | Disrupts neuronal systems | Zhang et al. (2008a, b); Han et al. (2011) |
| Heavy metal | Cadmium | Alters expression of gonadotropin-releasing hormone (GnRH) in the brain | Affects the neuroendocrine system | Martyniuk et al. (2009) |
| Synthetic organochloride insecticide | Methoxychlor | Increased 'stress' in Platyfish (Xiphophorus maculatus), Swordtail (X. helleri) | Behavioural effect | Magliulo et al. (2002) |
| Alkylphenolic compounds | Octyphenol, 17b-oestradiol | Decreased or impaired male courtship | Reproductive effect | Gray et al. (1999) |
| Organometallic compound | Mercury | Increased vulnerability to predation | Behavioural effect | Kania and O'Hara (1974) |
| Persistent organic pollutants (exposure of female fish) | Polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs) and dichlorodiphenyl trichloroethane (DDTs) metabolites | Suppressive effect on ovarian follicle development, decreased viability of eggs produced. | Changes dynamics of reproductive hormones in fish | Lyche et al. (2013) |

***Table 2: Effect of EDCs on the dynamics of endogenous hormones in fish***

**Fish as a Model to Study EDCs**

Endocrine-disrupting compounds/chemicals (EDCs), the most common and widespread contaminants in the aquatic environment can cause alterations in the growth, development, physiological homeostasis and overall health status of vertebrates. Therefore, it is necessary to evaluate the adverse effects of EDCs particularly those that affect the hypothalamic-pituitary-gonadal (HPG) axis of vertebrates. Looking into the fact that the endocrine system of fish is fundamentally similar to that of higher vertebrates, including mammals and there exists a significant degree of conservation of basic aspects of the HPG axis across vertebrates. Fish, with highest species diversity, are believed to be appropriate models for testing EDCs and to study the impacts of these chemicals. Several fish species especially small fish like fathead minnow, Japanese medaka, and zebrafish, are suitable model species which can provide a technically robust basis to predict the modes/mechanisms of action of various types of EDCs in other vertebrates.

Additionally, fish models offer a number of technical advantages, including ease and economical maintenance, high optical transparency and rapid development of embryos. Further, the advantages of using fish as a model for such type of studies include easy assessment and monitoring of the fecundity, hatchability rates and developmental abnormalities or subsequent reproductive problems of the resultant offsprings. Further, fish, irrespective of sexes, can produce large numbers of gametes which is very useful to examine the malformations, if any. The glandular system in fish species like zebrafish have similarities with higher

vertebrates, including those in humans and therefore, considered as a model suitable to study alterations on the endocrine system. The fish reproduction may, therefore, be a relevant indicator and could be explored as an excellent model to understand or shed light on the underlying basis or mechanism of endocrine disruption caused by various EDCs. However, before selection of an ideal species as a model and designing of test protocols, a good knowledge of the biological traits of that species is a pre-requisite.

**Conclusion**

The aquatic life is under threat as a result of rapid urbanization, industrialization in which the massive production of chemicals and their subsequent introduction into the environment has been greatly increased. Although there are nearly 85,000 man-made chemicals in the world and 1,000 or more of these may be EDCs based on their probable endocrine-interfering properties, a few of them have been studied for safety. Some of these chemicals can unbalance the endocrine system of an organism, which can lead to adverse effects on its physiology and development. Exposure of organisms to endocrine active compounds remains poorly characterized, particularly in developing countries. Now days, various methods viz. physical, chemical and biological (absorption, adsorption, chemical degradation, biological degradation, transformation and volatilization) are used for removal of EDCs from waste waters. Based on the physicochemical characteristics and only after a thorough understanding of wastewater constituents, different processes viz. biofiltration, ozonation, activated sludge, reverse osmosis (RO), activated carbon adsorption (ACA) or advanced oxidation processes (AOPs) are employed for removal of EDCs. Although efficiency of recent chemical and physical methods employing advanced technologies (AOPs, RO, ACA) for removal of EDCs is good, they are expensive and in that case, biofilms might be the better opportunity.

As a large number of compounds are responsible for endocrine-disrupting activity in diverse fish species, convenient but relevant assay methods are therefore, desired. Biomarkers have been developed for the interaction of EDCs with the estrogen receptor in a range of teleost species. For example, the induction of vitellogenin is used as a biomarker in cyprinids or salmonids. Likewise, the glue protein spiggin is used as a biomarker of exposure to (anti)-androgenic compounds in the three-spined stickleback, Gasterosteus aculeatus. In case of industries releasing high quantities of chemicals contributing to endocrine disruption in fish, government should bring some policy to regulate the discharge or suggest switching to alternative greener chemicals that do not impact the endocrine system.

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***More references can be provided on request**

# Fish Transcriptomics: Workflow and its Applications

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**Highlight Points**

- Transcriptomics is a highly performed experimental technique recently used in fishes to identify the differential expression of important genes at various developmental stages and time points.
- The workflow of transcriptomics from RNA isolation to Bioinformatics analysis to understand the physiology of fish at molecular level.
- Several applications of transcriptomics in aquaculture.
- Transcriptomics is a recent state of the art technique to develop molecular markers in huge numbers for important commercial fish species.
- Transcriptomics helps in enriching the genetic resources of candidate and novel fish species to make better fruitful breeding strategies of fishes.

## Introduction

In molecular biology, transcripts expression is one of the most frequently performed experimental techniques in identifying a cell or an organism at the molecular level and to study of physiology before and after some stimulation. Transcriptomics is defined as the complete set of complementary mRNA produced in a cell or an organism. Transcript sequencing is done by RNA-sequencing in which the RNA from different tissues at different time points are first isolated and then analysed on their expression level. The development of the RNA-Sequencing (RNA-Seq) method allows an unprecedented opportunity to analyse the expression of protein-coding, noncoding RNA and also de novo transcript assembly of a new species or organism (Chatterjee et al., 2018).Comprehensive transcriptome analysis is believed to provide a resource for genome annotation, candidate gene identification and molecular marker development. Recent advancement in next-generation sequencing technologies like high-throughput mRNA sequencing (RNA-seq) facilitates in deciphering the functional complexity of the whole transcriptome of an organism. RNA-Seq generates a huge volume of data and accurate analysis of this huge data is always challenging and involves different steps and several bioinformatics tools. In the recent era, we are blessed with some advanced technologies and supercomputers. By using these supercomputers and advanced bioinformatics tools, the data generated from NGS platforms can reveal several hidden and significant information regarding the physiology and biology of the fish at the micro level.

## The workflow of Transcriptomics through Illumina Sequencing

The RNA sequencing starts from sample collection which is a vital step in transcriptome analysis. As the RNA produced inside is cell is going to be sequenced, so the proper care is required during sample collection. Samples should be stored in RNA later and properly preserved in liquid nitrogen. To decrease the number of samples, the tissues from different fishes of the same experiment are pooled in equimolar concentration before the sequencing. The sample collection is followed by total RNA isolation. The RNA is isolated through the Trizol method (Sambrook et al). Here the important point to take careof is to maintain and check the integrity of purified RNA using Bioanalyser. The samples having RIN (RNA Integrity Number) ≥8 are considered for library preparation. Figure 1 showed the Electropherogram of two different samples with different RIN.

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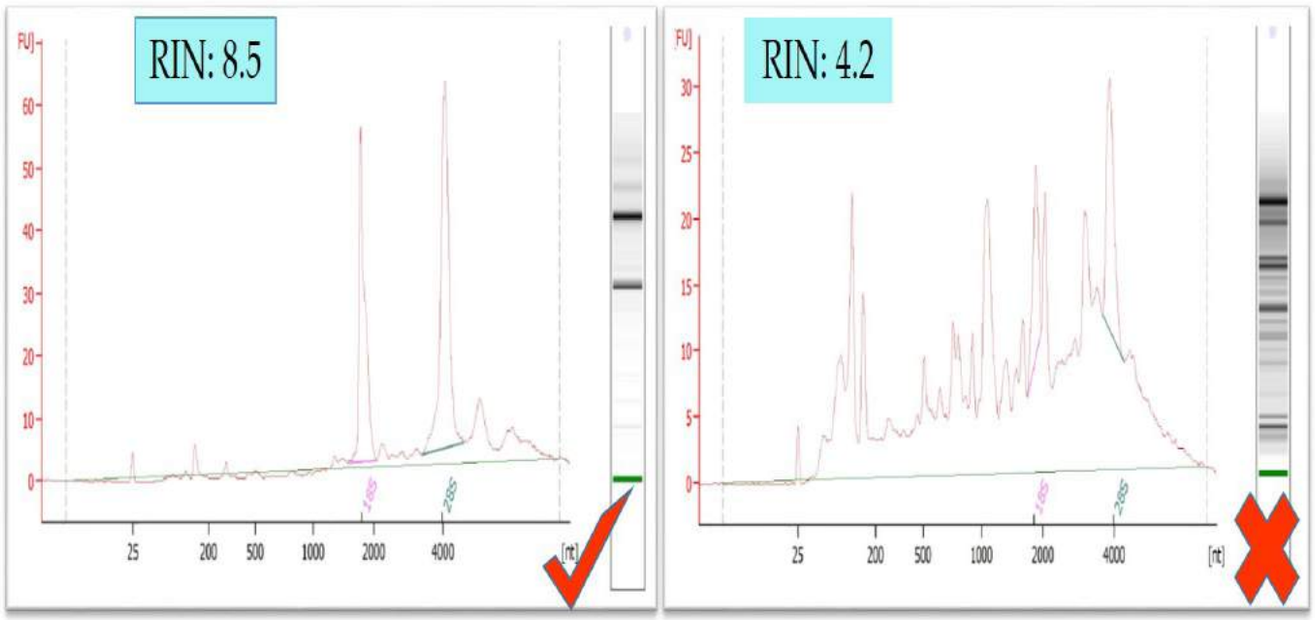


*Figure 1. Electropherogram of samples with RNA Integrity Number*

RNA samples are stored at -80°C until further use. After purification and fragmentation, the mRNA is converted into cDNA using random hexamers. Following the remaining steps of Transcriptomics as described in figure 2, the library is prepared finally and validated using the same Bioanalyser instrument. The library can be sequenced on any high throughput sequencer, but for Transcriptomics study, Illumina is most preferred and recommended.

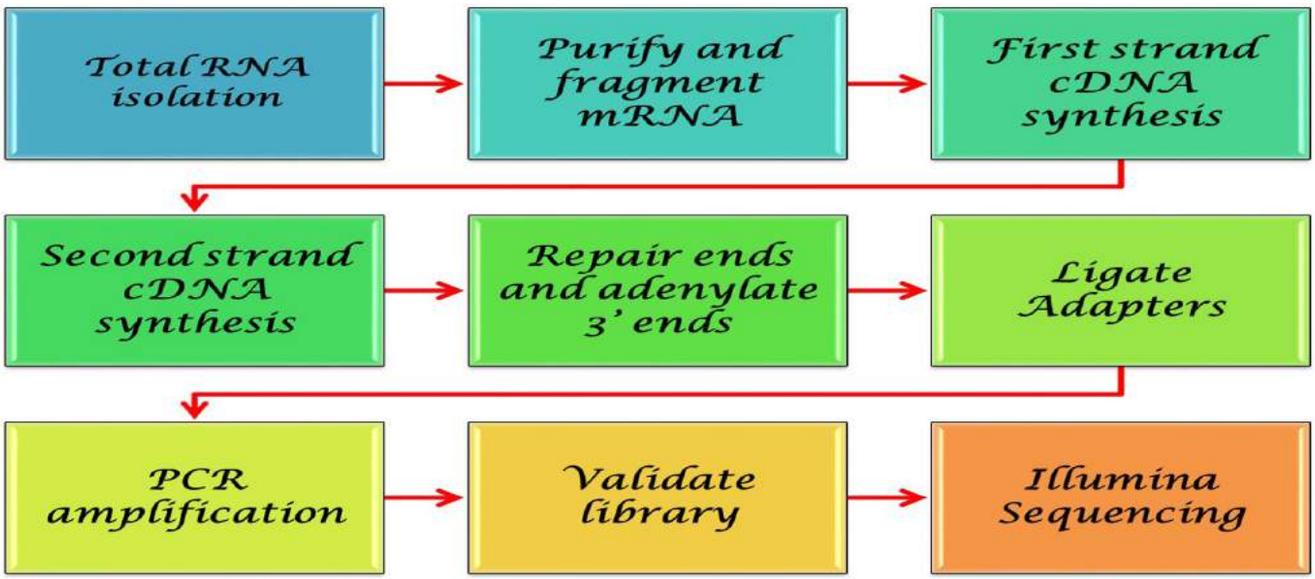


*Figure 2. Flow chart of Illumina RNA-Seq*

**Bioinformatics Analysis**

After sequencing, a huge data is receivedin raw form which needs accurate and reliable scanning. Numerous bioinformatics tools are available in the public domain to analyse the data. Some of the tools are freely available and some of the tools need subscription charges. In this section, the primary tools required for transcriptome data analysis are discussed. The raw reads generated in the FASTQ file format are checked using Fast QC software which determines the quality of reads like quality score, per base sequence content, per base GC content, sequence length distribution and duplicate sequences. Then raw reads are subjected to a quality filter to trim and remove unwanted or low-quality sequences using different software such as PRINSEQ and Kraken. The short quality reads are then assembled into a reference transcriptome (Contigs). Two approaches can be followed depending on the availability of reference genome availability.Reference-guided assembly if a reference genome sequence is available otherwise, de novo RNA-Seq assembly in the absence of a reference genome sequence. Different software and packages are available for both the approaches like Trinity, Velvet and CLC genomics workbench, etc. for the de novo assembly whereas Top Hat-Cufflinks, etc. for the Reference-guided assembly. Once the assembly is completed the next task is to find out the homology to

determine putative gene descriptions of all the de novo assembled contigs. Often, local BLAST is used to perform the homology search which provides all needed details of the contigs such as, gene id, protein id, coordinates of genes, hit numbers, expectation (E)-value, etc. For local blast, it is best to download the database first from the NCBI and then using the Linux operating system, BLASTX of the query sequences is done against the local nr (non-redundant) database.All contigs are also essential to be annotated functionally.GO (Gene Ontology) assignments were used to classify the predicted coding sequences based on their functions: Biological process, Molecular function and Cellular component. Usually, Blast2GO is the most common and popular tool for the functional annotation. Several other tools have been developed for GO analysis like GOstat, EasyGO, Gorilla, etc. For the prediction of gene pathways, the assembled annotated contigs are also compared to the Kyoto Encyclopedia of Genes and Genomes (KEGG) database using the Blast2GO program. As in transcriptome data, all the contigs are expressed genes, their EC (Enzyme commission) number is often given with the help of several EC prediction tools such as E-zyme, ECOH, ECPred, etc. Figure 3 is showing the Schematic representation of a transcriptomics evaluation approach. the predicted coding sequences based on their functions: Biological process, Molecular function and Cellular component. Usually, Blast2GO is the most common and popular tool for the functional annotation. Several other tools have been developed for GO analysis like GOstat, EasyGO, Gorilla, etc. For the prediction of gene pathways, the assembled annotated contigs are also compared to the Kyoto Encyclopedia of Genes and Genomes (KEGG) database using the Blast2GO program. As in transcriptome data, all the contigs are expressed genes, their EC (Enzyme commission) number is often given with the help of several EC prediction tools such as E-zyme, ECOH, ECPred, etc. Figure 3 is showing the Schematic representation of a transcriptomics evaluation approach.

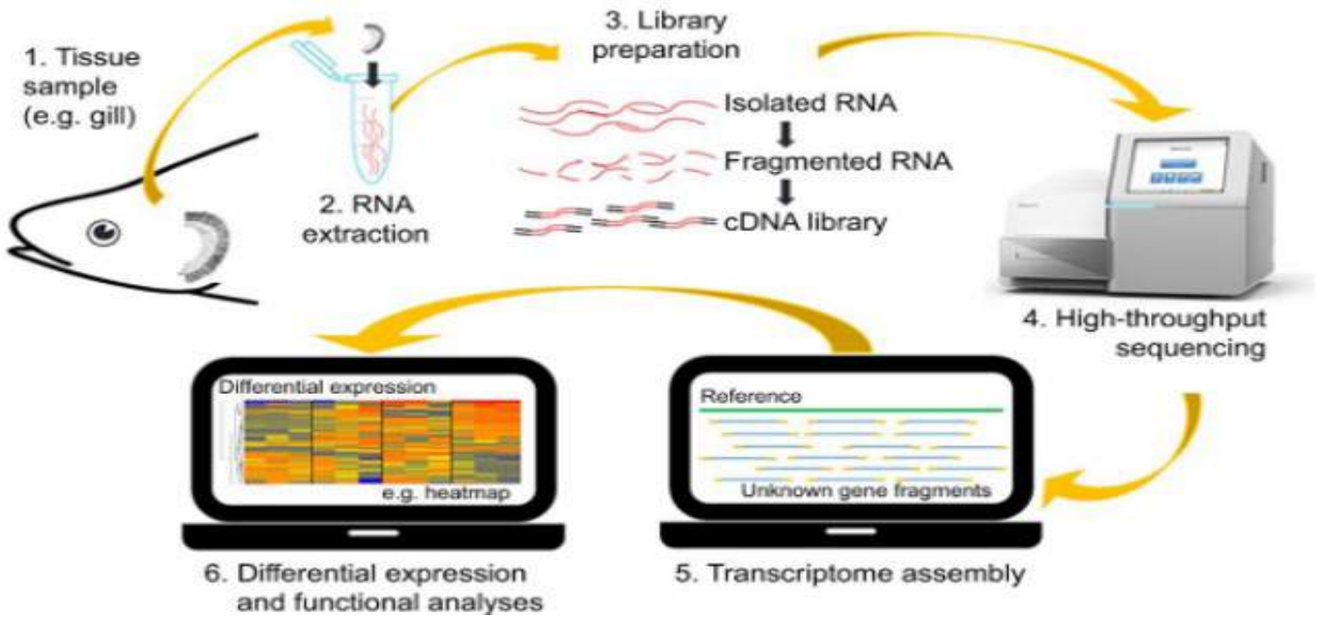


*Figure 3. Schematic representation of the flow of Fish Transcriptomics (Source: Connon et al., 2018)*

**Applications of Fish Transcriptomics**

Although the application of RNA-seq in fish Transcriptomics is at the nascent stage, the results of a Pubmed literature search (with keywords, "fish" and "RNA-seq") indicated that the number of publications in this field has increased considerably in the last 3 years. The transcriptome can be used in a wide range of applications such as identifying a collection of protein-encoding genes with alternative splicing and post-translation modifications, molecular markers, generation of genetic resources and importantly measure differential expression of thousands of genes within an individual at different environmental conditions or before and after the stimulation.

**Enrichment of Genetic Resources**

Transcriptomics helps in the identification of genes involved in growth, immune response, sex determination and gonad differentiation and genes associated with economic traits.Transcriptome data enrich genomic resources and therefore helps to expand the available database.In the fish with immune challenges, the entirefunctional genetic network associated with immunity and the specific immune pathways pre and post the challenges can be identified through transcriptomics (Aballai et al., 2017). Various researchers have been reported the genes and their pathways related to the growth of the fish through transcriptomics (Chatchaiphan et al., 2017). Transcriptome data have also been generated and utilised in the analysis of mechanism and genesinvolved in sex determination (Sun et al., 2013), sex differentiation (Lu et al., 2014), and overall reproduction in different fish species (Agarwal et al., 2020). Stress such as scarcity of food, varying temperature and salinity can trigger certain physiology responses in fishes. Through the transcriptomics mechanism of physical stress and death in fishes at the genome level and genes responsive to stress have been analysed by several

scientists. At different environmental conditions, pollutant sensitive and pollutant resistance fish species have been compared through the identification of pollutant responsive genes (Saaristo et al., 2017). Almost all the fish tissues have been used to generate transcriptome data through various researchers (Chandhini & Kumar, 2019).

**Identification of Novel Transcripts**

Transcriptome data can be leveraged to identify the novel transcripts in the non-model fish species genome. Several non-coding RNAs other than ribosomal and transfer RNA are of great interest due to their essential roles in many cellular processes, including translation, RNA splicing, gene regulation, and genome defence (Mattick and Makunin, 2006).The non-coding RNAs are grouped into two categories such as long ncRNAs (> 200 nucleotides) and small RNAs (< 200 nucleotides). Ulitsky et al.(2011) and Kure et al.(2013) have identified more than 550 distinct long intervening non-coding (lnc) RNAs in zebra fish embryos and 224 unique mature microRNAs in Atlantic salmon respectively. This novel discovery of transcripts will facilitate theannotation of newly sequenced genome and make the base for future omic studies.

**Expansion of Molecular Data**

The high-throughput RNA-seq technology is now used widely to expand the molecular data in the public domain to facilitate further functional studies. Through the de novo approach, the researchers are generating the de novo assembled and annotated genome references for many non-model species (Fraser et al., 2011). In the earlier time, characterization of one gene involved a lot of time and money but with the help of transcriptomics, thousands of full-length genes can be characterised at a time with the involvement of nominal money and time.

**Differential Gene Expression Analysis**

The best advantage of RNA-Seq is to identify dynamic changes in gene expression in response to the environment or to intrinsic programs that give reliable measurements of transcript levels within or between samples. The expression pattern changes from time to time depending on the environmental conditions. Through transcriptomics, the differential gene expression pattern of thousands of genes can be analysed to interrogate the fold changes in the expression of genes compare to controlled conditions. In the last few years, RNA-seq, with striking speed, has been widely used to detect differential gene expression in fish studies relating to immunology, toxicology, physiology, and diseases (Chandhini and Kumar, 2019).

**Analysis of Molecular Pathways**

Several genes are interacted each other to facilitate the function of the genes. The identification of regulated molecular pathways is an important finding of transcriptomics study. By comparing the annotated genes with the KEGG database, pathways are predicted and used to investigate the changes in physiology at the molecular level. Gene ontology studies during transcriptome analysis describe the molecular activities of a gene product. Through the cellular component, biological process and molecular function, thee genes and gene products are described under gene ontology. For example, steroid metabolism, lipid metabolism, immune-related and osmoregulation pathways were analysed in Nile tilapia in association with salinity adaptation (Xu et al. 2015b).

**Mining of Molecular Markers**

One important application of transcriptome data is the full-scale discovery of an important gene linked molecular markers with high accuracy. Through transcriptomics study, millions of SNPs and thousands of SSRs can be generated and after proper validation, these markers can be used in stock assessment, phylogenetic analysis, stock differential, marker-assisted selection, etc. (Lu et al., 2014). Several Online tools like MISA, SSR Locator, ESAP plus, etc. are available for the identification of SSRs from the transcriptome data while for the SNP discovery the tools are VarDict, GATK, VDAP-GUI, etc.

**Conclusion**

Transcriptomics provides a clear idea of differentially expressed genes in any control and test organisms. It also can be applied effectively for the development of molecular markers associated with many important aquaculture traits. Though, transcriptomics is a new technology and still in its infancy stage, however,it has better advantages over other gene expression approaches such as microarray. With the advent of modern NGS techniques and bioinformatics tools, Transcriptomics has been transformed into a powerful, cost-effective and user-friendly tool for deciphering many existing challenges in aquaculture related to growth, reproduction, nutrition and immunity. In the past few years, transcriptomics has made considerable contributions to the understanding of fish physiology and biology. As transcriptomics expand endlessly and its cost keeps decreasing, within the next few years transcriptomics will be exploited to a larger extent without a doubt and lead to many more exciting discoveries in the fisheries sector.

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