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Review article

Education in Aquatic Medicine - A Need of the Hour for Sustainable Aquaculture in India

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ABSTRACT

Aquaculture, a fastest growing food production sector in the world including India, is facing an array of challenges as the intensification of culture activities spreads infectious diseases at all stages of production. In addition, zoonosis, non-communicable diseases related to water chemistry and nutrition and communicable diseases due to viruses, bacteria, fungi and parasites are taking heavy toll with significant economic loss in India. Hence, the management of diseases and aquatic animals' health is utmost important, and the knowledge on aquatic medicine is becoming a principal pre-requisite in the new era of aquaculture development. In this short review, we have highlighted the importance of education on aquatic medicine as a need of the hour for sustainability in Indian aquaculture.

INTRODUCTION

Fish culture has a long history of 4000 years, dating back in 2000 – 1000 BC, Chinese were considered earliest to begin aquaculture in the world. However, the practice of fish culture in Indian sub-continent might have started when the practice of building water reservoirs of varying sizes as a source of water, were initially used to hold fish and later on to culture them (Ling, 1977). Aquaculture (FAO, 2014) has evolved and expanded rapidly over the years, hence the 'Aquaculture' is now broadly defined as the breeding, rearing and husbandry of aquatic animals such as fishes, crustaceans and molluscs for food, ornamental and sports. Actually, it is a unique husbandry involving with special animals, especially cold blooded vertebrates and invertebrates, whose growth, metabolic activities and overall performance dependent heavily on ambient aquatic temperature. Therefore, their husbandry is different from that of the other land based warm blooded animals. Furthermore, the water the very medium which supports the animal influences the physiology, growth and other performances unlike the environment of land based animals (Lucu, 2014).

In the recent years, aquaculture has been one of the fastest growing food production sectors in the world including India. At present, India is the second largest producer of fish in the world contributing to 5.5 per cent of global fish production and also a major producer of fish through aquaculture and ranks second in the world after China (FAO, 2016). Though the plentiful, vast and varied inland and marine fisheries resources comprising rivers and canals, reservoirs, ponds and tanks, floodplain lakes and wetlands and brackish-waters available in India (Table 1) these resources have been exploited meagerly for aquaculture (Table 2).

Even then, the aquaculture sector has witnessed a rapid growth with annual rate of 7-8% significant contribution (above 50%) to total fish production in the last 15 years (Fig. 1). This impulsive growth in aquaculture could be attributed to the increase in the number of food fish and shellfish species being cultured in India including ornamentals. Three decades ago, a few species were cultured in India mainly in inland waters and then aquaculture was contributing less than 10% of total fish production in the country, but the number of species cultured today is close to 40 in India. In addition, the faster growth of aquaculture sector could also be ascribed to the immense scientific knowledge inputs gained at the various fisheries institutes in the country includes the development of intensive culture practices, polyculture, integrated fish culture practices, fish food organisms culture, various low-cost and efficient feed formulations to improve fish and shellfish growth and health (Msangi *et al.*, 2013).

Although the fisheries research in India begun during 1947, the formal fisheries education started in 1969 with the establishment of College of Fisheries at Mangaluru,Karnataka, as the first of its type in Southeast Asia [CIFRI, 2016 and COFM, 2016).However, the need of

fisheries knowledge and its potential has been given a prime importance in the country during the last three decades.As an evidence, today there are 25 fisheries colleges offering under- and post-graduate programmes, affiliated to various universities including several central fisheries research institutes in the country (Table 3). Definitely, these recent developments in the country would further increase the aquaculture production by exhaustive utilization of bountiful inland and marine resources. In addition, a good number of plant and animal fish food organisms cultured will also support the hatcheries and nurseries in aquaculture. Furthermore, the area under aquaculture is also increasing steadily in inland and coastal brackish water while marine water is also being added up for aquaculture slowly and steadily. Very interestingly, non-traditional environments such as manmade saline soils are also explored successfully for aquaculture. Intensification of culture activity with high stocking density, artificial feed and fertilizers is another dimension of aquaculture noteworthy.

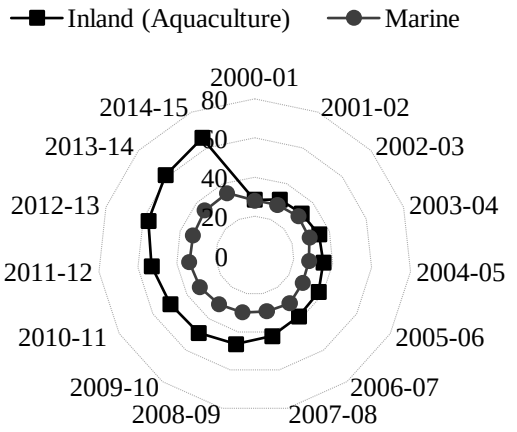

Fig.1: Fish production from Inland (Aquaculture) and Marine sectors during last 15 years in India

However, there are several challenges that could halt the growth of aquaculture sector in the country, including the large scale and unregulated movement of aquatic animals and their raw or processed products across national and international borders is most important from aquaculture production, export and health point of view. Additionally, a general aquaculture package of practices alters the very water in terms of its chemistry and microbial load and has significant negative impact on the health of fish in culture system. Furthermore, zoonosis due to aquaculture activity is another important aspect needs to be given greater attention. Due to the increase in aquaculture activities, incidences of diseases are increasing. Non-communicable diseases related to water chemistry and nutrition are one part of it. Communicable diseases due to viruses, bacteria, fungi and parasites are taking heavy toll with significant economic loss. In India, it is estimated that annual loss due to one viral disease, the white spot virus disease in shrimp is more than Rs. 1000 crores (Kalaimani*et al.,* 2013).

Scope for Aquatic Medicine

The emergence of a disease is the most important and imbalanced interaction between the pathogen (infectious or abiotic agent), host and environment (Fig. 2) (Salama and Rabe 2013). Hence, the management of aquatic animals' health with medicine knowledge is becoming a principal pre-requisite in the new era of aquaculture development. Besides the positive impact of medicines on the aquatic animal health, the practice of aquatic medicine has also a negative impact on aquatic life, environment and fish consumers at the end. Over the years, there is significant increase in gathering of information particularly on the immunology of fish, crustaceans and molluscs. In view of poor immune system of aquatic animals, it is better to prevent the diseases by avoidance (biosecurity) and at the best, manage the diseases with judicial application of drugs and chemicals (Walker and Mohan, 2009).

Table 1: Inland and marine fisheries resources of India

Marine	
Length of Coast Line	8,118 km
Exclusive Economic Zone (EEZ)	2.02 million km^2
Continental Shelf	530 thousand km^2
Number of Fish Landing Centres	1537
Number of Fishing Villages	3432
Number of Fishermen Families	874749
Fisher-Folk Population	4056213
Inland	
Total Inland Water Bodies	73.59 lakh ha
Rivers & Canals	195210 km
Reservoirs	29.07 lakh ha
Tanks & Ponds	24.14 lakh ha
Flood Plain Lakes / Derelict Waters	7.98 lakh ha
Brackish Water	12.40 lakh ha

Against this background, health managers in aquaculture should ideally be fishery professionnel with adequate knowledge and training in fish biology, environment and aquaculture package of practices. In the Western world, aquatic medicine is practiced by veterinarians who study fish, which is covered under wild life and aquaculture hardly contributes 10% to their total fish production. However, in the Asian countries, which constitute 80% of world aquaculture activities, aquatic medicine should be handled by fisheries professional with adequate training and knowledge in pharmacology, chemotherapy and toxicology.

Table 2: Area under Aquaculture in India.

Resource	**Area available (million ha)**	**Under cultivation (million ha)**
Freshwater	2.36	0.944 (40%)
Brackish water	1.23	0.123 (10%)

Table 3: Professional fisheries colleges of India

Sl No	Name of the Colleges	Location	Established Year	Degree Programmes offered
1	College of Fisheries http://cofmangalore.org/	Mangaluru, Karnataka	1969	UG/PG/PhD
2	Fisheries College and Research Institute http://tnfu.ac.in/pages/view/fc_ri_thoothukudi	Thoothukudi, Tamil Nadu	1977	UG/PG/PhD
3	College of Fisheries http://www.kufos.ac.in/	Panangad, Kerala	1979	UG/PG/PhD
4	College of Fisheries http://www.ouat.ac.in/CollegeFisheries.aspx?id=7	Rangailunda, Orissa	1981	UG/PG/PhD
5	College of Fisheries http://www.dbskkv.org/f-Fishereis.html	Ratnagiri, Maharashtra	1981	UG/PG
6	College of Fisheries http://gbpuat.ac.in/acads/cfsc/index.htm	Pantnagar, Uttarakhand	1985	UG/PG/PhD
7	College of Fisheries http://www.pusavarsity.org.in/?page_id=574	Dholi, Bihar	1986	UG
8	College of Fishery Science http://www.aau.ac.in/	Raha, Nagaon, Assam	1988	UG/PG/PhD
9	College of Fisheries http://www.jau.in/cof/	Veraval, Gujarat	1991	UG/PG/PhD
10	College of Fishery Science http://svvu.edu.in/CfscMuthukur.html	Muthukur, Andhra Pradesh	1991	UG/PG/PhD
11	College of Fishery Sciences http://www.wbuafscl.ac.in/	Kolkata, West Bengal	1995	UG/PG/PhD
12	College of Fisheries http://cofcau.nic.in/	Lembucherra, Tripura	1998	UG/PG/PhD
13	College of Fisheries http://www.cofudaipur.ac.in/	Udaipur, Rajasthan	2003	UG/PG/PhD
14	Faculty of Fisheries http://www.skuastkashmir.ac.in	Srinagar, Kashmir	2005	UG/PG/PhD
15	College of Fishery Science http://cofsngp.org/	Nagpur, Maharashtra	2006	UG
16	College of Fisheries http://www.nduat.in	Faizabad, Uttar Pradesh	2006	UG
17	College of Fisheries http://cofsu.in/	Udgir, Maharashtra	2006	UG
18	College of Fisheries http://www.gadvasu.in/college-home.asp	Ludhiana, Punjab	2008	UG/PG/PhD
19	College of Fisheries http://cgkv.ac.in/fisheries.aspx	Kawardha, Chhattisgarh	2010	UG
20	College of Fishery Science http://www.mppcvv.org/Fisheries%20College.html	Jabalpur, Madhya Pradesh	2012	UG
21	Fisheries College and Research Institute http://tnfu.ac.in/pages/view/fc_ri_ponneri	Ponneri, Tamil Nadu	2013	UG
22	College of Fisheries http://www.csauk.ac.in/college-fisheries.html	Etawah, Uttar Pradesh	2015	UG
23	College of Fisheries Science http://www.nau.in/home.php?unit=123	Navsari, Gujarat	2015	UG
24	College of Fisheries http://www.ku-guj.org/about.aspx	Gandhinagar, Gujarat	2015	PG
25	College of Fisheries	Chidambaram, Tamil Nadu	2015	UG

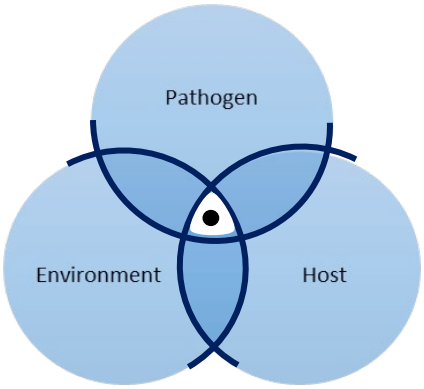

Fig. 2: The disease triangle

Development of Aquatic Medicine

First and foremost, the development of therapy and drug evaluation in aquatic animals should be on time and temperature basis. The study of aquatic medicine that is pharmacokinetics - time / temperature, effective dose, mode of action of drugs in different species of fishes, crustaceans and molluscs should be initiated on a war-foot basis. It is a herculean and time requiring task, yet very crucial for the growing aquaculture. Information on the chemicals or drugs used in fish farming, run-off of chemicals from agriculture and allied activities, kinetics of chemicals, residues and their effect on fishes and ultimate consumers - the humans is very important.

While considering the above basic facts in pharmacology and toxicology for aquaculture, the scope of aquatic medicine should be explored keeping in view the following facts of aquaculture

- Aquaculture is practiced in fresh, brackish and marine environment. Aquatic medicine should be developed suiting water chemistry of these environments and associated changes due to aquaculture activities.
- Similarly, chemistry of soils in fresh and brackish/salt water has greater influence on water and further on the drugs and chemicals applied. In simple, aquatic medicine should be viewed with soil chemistry.
- Physiology and immunology of aquatic species is highly variable. Therefore, aquatic medicine should be custom made to species - fishes, crustaceans, molluscs from fresh, brackish and marine water.
- Aquatic medicine should be viewed from different package of practices – feed-based aquaculture and fertilizer-based aquaculture.
- Physiology, enzyme and immune profile of aquaculture species at different life stages is highly variable. Therefore, aquatic medicine should be fine-tuned to different life stage of fishes and crustaceans - larvae, fry, fingerlings, sub-adults and adults.
- Aquatic medicine should be viewed from medicine application point of view - to water, to feed, and to soil.

CONCLUSION

Overall, it is important to design and develop aquatic medicine considering immune system (prophylaxes) vs benefits and hazards of drugs and chemicals vs avoidance of pathogens through bio-security measures.

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