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Effect of temperature variation on disease proliferation of common fishes in perspective of climate change

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Abstract

Meteorological variations and global warming frequently produce serious losses in fishing stocks and fish production. The rate of fish production depends on climatic variation and demand more prudent management of natural sources, attention to technological action and more specific knowledge of the fish and the emergent pathogens. Temperature affects the development of parasites and pathogenic bacteria and may also have effects on the resistance of fish to disease. Certain environmental conditions are considered door openers to opportunistic pathogens and important initiators of stress. Global warming and worsening of other environmental parameters causes an alteration of the immune-response, with a reduction in the resistance of fish and increases the occurrence of various diseases of fish. Climate change cans increase pathogen development and survival rates, disease transmission, and host susceptibility. Disease in fishes is caused by the infection of various types of bacteria, viruses and fungi. This type of disease has been noticed in many states of India.

Keywords: Climate change, diseases, fish, global warming, pathogen.

Introduction

The effect of climate change due to temperature variation on biological world is now a global concern. Recent climate change has been recorded worldwide, which is affecting the fishery sectors (Cochrane et al., 2009; Williams and Rota, 2011; Winfield et al., 2016; Golam et al., 2017; Adhikari et al., 2018). Changes in climate are predicted to affect fishes at all levels of biological organization like cellular, individual, population, species, community and ecosystem, influencing physiological and ecological processes in a number of direct, indirect and complex ways. The distribution of parasites and pathogens will be directly affected by variation of temperature but also indirectly, through effects on host range and abundance. Numerous disease outbreaks have been associated with environmental and climatic events. The transmission rates of fish parasites and pathogens are expected to increase with increasing temperature. The fish immune system is optimal at normal summer temperatures for each species (Manning and Nakanishi, 1996). Water temperatures above or below the physiological optimum may cause stress, increase susceptibility to infection and the likelihood of disease and mortality. The effects of climate change on parasites and pathogens will be superimposed onto the effects of other anthropogenic stressors in ecosystems. Climatic effects on parasites and diseases of key species may cascade through food webs, with consequences for entire ecosystems. Change in temperature will affect on aquaculture by increasing risk of disease outbreak through alteration of the immune response, with a reduction in the resistance of fish, increased occurrence of parasite and pathogenic organisms which cause the overall economic loss. Impaired aerobic performances and thermal tolerance in infected fish may potentially result in decreased host survival in the wild, especially in relation with predicted higher average summer temperatures and increased frequency of extreme events in the context of global climate change (Bruneaux et al., 2017)

Effect of climatic condition on disease proliferation

The impacts of climate change on aquaculture are more complex than those on terrestrial agriculture owing to the much wider variety of species produced but different to fisheries because various control conditions can be applied in the production process (Brander, 2007). Climate change in particular, rising temperatures can have both direct and indirect effects on global fish production. It has been implicated in mass mortalities of many aquatic species, including plants, fish, corals, and mammals (Harvell et al., 1999; Battin et al., 2007). Climate change is predicted to have important effects on parasitism and disease in freshwater and marine ecosystems (Marcogliese, 2008). All aquatic ecosystems, including freshwater lakes and rivers, coastal estuarine habitats and marine waters, are influenced by climate change (Parry et al., 2007; Scavia et al., 2002; Schindler, 2001). Aquaculture has developed from an extensively low capital practice to large intensive culture with a wide range of cultured species. However, one deterrent to successful aquaculture is the occurrence of infectious diseases among cultured fish species, which lead to poor economic viability of the aquaculture industry (Snieszko, 1974). In India, aquaculture has grown considerably in the past few decades with culture of Indian common carps as the important component species. Fish diseases are the major constraints for aquaculture loss in India (Otta et al., 2003). Tough fishes are poikilothermic, thus their physiology, including the immune response, is directly affected by the ambient temperature (Bowden et al., 2007). Proliferative kidney disease (PKD) is a widespread parasitic disease affecting salmonid fish species in North America and Europe which can result in very high mortality rates in farmed populations (Hedrick et al., 1984; Burkhardt-Holm et al., 2005; Sterud et al., 2007). Increased temperature can affect host–parasite interactions both directly and indirectly through increased number of spores released to the water, stimulation of parasite proliferation and exacerbates the fish immune response and results in more severe lesions in the renal tissues due to the inflammatory response (Clifton-Hadley et al., 1987; Bettge et al., 2009[a,b]; Bettge et al., 2009b; Tops et al., 2006; Gay et al., 2001; Bettge et al., 2009[a,b]).

The anthropogenic activities, eutrophication and global warming are considered as emerging cause of fish disease proliferation (Okamura et al., 2011). The Global climate change, host–parasite relationships are expected to be affected by multiple factors such as parasite range extension, increased virulence, modified temporal dynamics, decreased host condition and increased frequency of disease outbreaks (Marcogliese, 2008; Gallana et al., 2013; Paull and Johnson, 2014).

Types of fish diseases and causing organisms

Temperature is a key determinant for many fish diseases like Ichthyophthiriasis, Furunculosis, Lernaeosis, Columnaris, Spring viraemia of carp, etc. (table 1). Bacterial diseases are also considered to be major cause of mortality in fish (Grisez and Ollevier, 1995). There are different reported diseases of Indian major carps include Ulcer (Manohar et al., 1976), Dropsy (Kumar et al., 1986a), Bacterial gill disease (Swain et al., 2003), Hemorrhagic septicemia (Sahoo et al., 1998), Columnaris (Kumar et al., 1986b) etc. Ulcerative syndrome is one kind of disease that is generally found in fishes is caused by the infection of various types of bacteria, viruses and fungi. This type of disease has been noticed in many states of India such as West Bengal, Orissa, Bihar, Utter Pradesh, Sikkim and Kerala (Pal and Pradhan, 1990; Pradhan et al., 1991, Harris et al., 1992). Also a wide range of bacteria belonging to the genus such as *Aeromonas, Pseudomonas, Flavobacterium, Enterobacter, Staphylococcus, Streptococcus, Edwardsiella, Moraxella, Myxobacter* and *Escherichia* have been found to be isolated from different fish disease conditions. Among them *Aeromonas, Flavobacterium* and *Edwardsiella* are found to cause severe morbidity and mortality (Swain and Nayak, 2003). In aquaculture, the etiology of any disease condition is very complex. A single bacterium is often reported to cause different types of infection and lesions. *Aeromonas hydrophila*, a freshwater fish pathogen, is found to be primarily associated with or is a secondary invader of various disease conditions such as hemorrhagic septicemia, dropsy, ulcers and ulcerative syndrome, etc (Aoki, 1974; Egusa, 1978). Moreover, the infection by a particular organism may be affected by so many factors including water quality parameters. Incidentally when water temperature begins to climb, many parasites and microbes capable of grow at a fast rate and causing fish diseases. In such a condition the whole immune systems of fishes have got stressed by warmed-up water, low oxygen availability and become more susceptible to infections and diseases. Fish with only cutaneous infections may have several types of concealed lesions including increased amount of lipofuscin and haemosiderin in the liver and spleen; however, most visceral organs were not necrotic (Ventura and Grizzle, 1988). The bacterium *Aeromonas hydrophilia* has been reported to cause the death of large number of fish and alligators in lake Apopka, Florida (Shoots et al., 1972). Natural and experimental *Aeromonas* infections in fish, amphibia and reptiles are associated with haematological (Roberts, 1978) and histopathological changes (Huizinga et al., 1979). The bacteria *Aeromonas salmonicida*, which causes a disease called furunculosis in salmon and trout. There are two species of Aeromonas which cause disease in warm water fishes are *Aeromonas hydrophila* and *Aeromonas sobria*. Aeromonas infections are probably the most common bacterial disease diagnosed in cultured warm water fish. *Aeromonas hydrophila* and other motile aeromonads are among the most common bacteria in freshwater habitats throughout the world (McGarey et al., 1991).

Losses of more than 70 million rupees due to disease-induced mortality and impaired growth are incurred annually in Andhra Pradesh. Ectoparasitic diseases account for 70% of the problems, while bacterial and fungal diseases account for 27.5% and 2.5% problems, respectively (Rao et al., 1992). Considering the fish and prawn health management in Andhra Pradesh the losses have been found high due to disease than due to environmental factors (Viswanatha et al., 2014). In case of low aquatic environmental temperature fish reduces metabolic activities, which in turn makes the fish more susceptible during the winter period towards parasitic infection (Hossain et al., 2013). Variations in physico-chemical parameters, such as water temperature, pH, dissolved oxygen, alkalinity, hardness and chloride are favorable conditions for outbreak of the fish disease (Mastan and Ahmed, 2013).

La Patra et al., (1993) showed that 2g weight fry farmed in 15°C water found antibodies 3–4 weeks post-infection with IHNV and 16g trout produced neutralized antibodies after 2 weeks. The antibody titre increased until the 6th week at 15°C. However, at 10°C, instead, 14 weeks were necessary before anti-IHNV antibodies could be observed (Hattenberger-Baudouy et al., 1995). The effect of increasing water temperature on aquatic disease dynamics emphasizes the importance of the biology of each disease (Karvonen et al., 2010).

Management and remedial measures

As climatic change increases temperature and environmental variation, there are needs to be more emphasized on fisheries management to adopt or overcome such stress conditions. Serious loss of fish due to infection will only take place where pathogen and host are available in an environment that favors disease. The climate changes create an additional imperative to implement the ecosystem approach to fisheries, a holistic, integrated, and participatory approach to obtain sustainable fisheries (FAO, 2006). The management strategies of fisheries should be improved and may focus on building adaptive capacity and resilience. Weather warning facilities should be available to every fisheries and aquaculture sectors for remedial measures.

Identification of disease causing pathogens and its metabolism along with environmental condition is the prime factor for the management and remediation of fish diseases. Molecular biology can be a routine tool in the search for improved methods of diagnosis and control of fish pathogens and the epidemiology of infectious fish diseases (Kumar, et al., 2014). New molecular techniques, such as the 16S rDNA polymerase chain reaction (PCR) assay have recently been applied to bacteria screening. This assay relies on the amplification of the gene coding for ribosomal RNA (16S rRNA), which is present in almost all bacteria (Lee et al., 2002; Vernon et al., 2002). This assay has several advantages over traditional microbiological methods. It can detect infections by uncultivable pathogens where routine microbiological techniques have failed to detect the presence of bacteria in the clinical samples. In addition, when combined with DNA sequencing the assay provides a definite identification of the infectious agents. The 16S rRNA contains conserved and highly divergent regions. Nucleotide sequence of 16S rRNA has been widely used to understand phylogenetic relationships among prokaryotes (Barry et al., 1990 and Weisburg et al., 1991). Graham et al., (1991) applied phylogenetic relationships to species specific identification of bacteria and aligning the nucleotide sequences of 16S rRNA. Phylogenetic relationships of various bacterial pathogens have also been characterized in detail using the sequences of 16S rRNA (Dorsch et al., 1992 and Kita-Tsukamoto et al., 1993). A platform for remediation and management of fish disease due to effect of climate change should be developed for helping aquaculture sector and fish farmers.

Conclusion

The temperature variation due to Climate change will have significant impacts on fisheries and aquaculture. The climate change have negative impact on fisheries, damaging important ecosystems and causing reductions in fish stocks due to rising water temperatures and reduced plankton diversity. This could have significant effects on global food security and fisheries dependent employment in areas that are particularly vulnerable to the impacts of climate change. There should be provision of proper identification of fish diseases in different environmental conditions and its remedial measures in aquaculture sectors. Community level services like, insurance and weather warnings should be available to reduce risk. Sustainable

Table 1: Common diseases of cultivable fishes in India.

Disease	Causative Agent/Factor	Symptoms
Ichthyophthiriasis (White spot disease)	*Ichthyophthirius multifiliis*	White spots on fins, body surface then gills.
Whirling disease	*Myxosoma cerebralis*	Abnormal swimming, darkening of posterior part and skeletal deformation.
Lernaeosis	Anchor worm (*Lernae sp.)*	Small thread-like worm attaches to body surface (fin), anorexia (poor growth) and irritation
Columnaris	*Flexibacter columnaris*	Anorexia, whitish plaques eroding affected area (mouth, body surface, fin, gills), orange Lesions.
Furunculosis (Fin rot)	*Aeromonas salmonicida*	Inflammation(intestine and anus), lesions and bloody coloured fluid in muscle and skin, fin rot
General Septicemia	*Aeromonas hydrophila*	Ulceration of skin, distended abdomen, and inflamed fins and fin bases
Tail rot and Fin rot	*A.hydrophila, Pseudomonas spp. Cytophaga spp., Haemophilus*	Erosions, discoloration and disintegration of fins and tails.
Edwardsiellosis or Edwardsiella septicaemia	*Edwardsiella tarda*	Ulcerative abscesses in internal organs, haemorrahic ulcers on skin, fins and body, rectal protrusion
Eye disease	*Aeromonas liquefaciens, Staphylococcus aureus, various other bacteria*	Cataract of eyes, affect cornea, eyeball gets putrefied
Lymphocystis	Lymphocystis virus (*Iridovirus*)	Small, pearl-like tumefactions on skin, fins and tail, abnormal swimming or anorexia
Viral Nervous Necrosis (VNN)	Betanodavirus (*Nodaviridae*)	Vacuolating necrosis of neural cells of the brain, retina and spinal cord (up to 100% mortality in young fish)
Saprolegniasis	*Saprolegnia*	Grey-white patches on fish skin which have cotton wool-like appearance under water
Branchiomycosis (Gill rot disease)	*Branchiomyces demigrans*	Fungi usually grow on heavily deposited decaying organic matter of pond bottom. Fish become lethargic, redness of gills, which later become grayish-white, necrosis of gill filaments
Epzootic Ulcerative Syndrome (EUS)	*Aphanomyces invadans sp*. (Fungs), *Aeromonas hydrophila, A. sobria*	Fish become lethargic, redness of skin, ulcerative patches, high mortality

Source: Bowser and Buttner, 1993; Francis-Floyd, 2005; Ogunnoiki, 2009; AFCD, 2009: Crane and Hyatt, 2011; Pridgeon and Klesius, 2012, Mishra et al., 2017.

fishing operation and assistance in weather monitoring and post–harvest processing will minimize the losses in fisheries and aquaculture. A management plan will be established for disease control which will help the fishers for controlling different fish diseases not only in their ponds but also in co-operative sector, thus it will no doubt boost the socio economic condition of the fishers as well as entrepreneurs who are involved in different fishery communities.

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