REVIEW ARTICLE

Impact of bacterial and fungal infections on edible crab *Paratelphusa jacquemontii* (Rathbun): A Review

Ghaware AU and Jadhao RG*

Department of Zoology, Shri Shivaji Science College, Amravati, 444603 Maharashtra. India.

*Correspondent author- Dr. Jadhao RG, Associate Professor, Department of Zoology, Shri. Shivaji Science College, Amravati, MS, India, Email: rajusingjadhao@gmail.com

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ABSTRACT

The edible crab *Paratelphusa jacquemontii* (Rathbun) support an important fishery in fresh waters sources in Maharashtra. However, the health management and diseases of fresh water crabs attracted less attention of researchers, and therefore, there is distinct lack of description of their pathogens and effect on other commercially important crustaceans and fish species. Diseases are a natural component of crustacean populations. Mortalities or other problems can arise when an outbreak occurs, and all too often the underlying causes of an outbreak are poorly understood. A variety of stressors can lead to outbreaks of disease or contribute to their severity. Pollution, poor water quality, hypoxia, temperature extremes, overexploitation have all been implicated in various outbreaks. This review focuses on impact of bacterial and fungal infections on edible crabs and histological and hematological changes in their body are discussed.

Keywords: Infections in crabs. *P. jacquemontii.* Fresh water crab.

INTRODUCTION

Water of good quality is required for living organisms. Dams are the most important water resource. Unfortunately, the fresh water sources are being polluted by indiscriminate disposal of sewage, industrial waste and human activities. The dams are always the victim of the negative impacts of urbanization. Most water bodies become contaminated due to incorporation of untreated solid and liquid waste. Large towns in India are situated near the dams, their runoff and those from agriculture lands find their way to the river and add in dam water which unfit for human use. Fresh water resource is becoming deteriorate day-by-day at the very faster rate. Now water quality is a global problem (Mahananda *et al.,* 2005)**.** Present day intensive farming for food and heavy industrialization for production of goods to meet the need of growing population has led to problem of pollution. Environmental pollutants are becoming toxicants due to their adverse effects on living beings. Ecological impacts of waste from agro industries are inevitable due to their wide composition (Thakur, 2006). Now a day, toxicity studies of such pollutants in environment are gaining immense importance.

Effect of pollution on aquatic life:

Human activities including defecation, washing, recreation (swimming/bathing and fishing) and waste disposal are prevalent especially where human settlements exist along the river banks. Similarly, several industries are located along the river banks. High levels of faecal indicator bacteria can be indicated by presence of pathogenic microorganisms present in water body. Higher the level of indicator bacteria is directly proportional to faecal contamination and greater the risk of water-borne diseases (Pipes, 1981)**.** Human faecal material is generally caused greater risk to human health because it contains human enteric pathogens (Scott *et al.,* 2003). Faecal coli and faecal streptococci are most widely used indicator bacteria (Kistemann *et al.,* 2002; Pathak and Gopal, 2001; Harwood *et al.,* 2001; Vaidya *et al.,* 2001).

The healthy aquatic ecosystem is depended on the biological diversity and Physico-chemical characteristics (Venkatesharaju *et al.,* 2010). Any chemical, biological or physical change in water quality that has a harmful effect on living organism or makes water unsuitable for desired use is water pollution. (Miller, 2002)**.** Microorganisms are widely distributed in nature and diversity of microorganisms may be used as an indicator for organic pollution (Okpokwasili and Akujobi, 1996). The micro-organisms are present everywhere on earth which includes biota, soil, water and atmosphere. They can easily enter in to the biosphere from environment. Aquatic animals have close contact with these microbes. Aquatic animals like fishes, crustaceans always taken large number of microbes in to their body parts from water, sediments and food. There are several research reports on microbial infection of crustaceans (Aravindan and Sheerja 2000; Rajendran *et al.,* 2008; Faghri *et al.,* 1984; Najiah *et al.,* 2010).

Diseases in crabs:

The crustaceans are highly sensitive to water pollution (Guerra-Garcia and Garcia-Gomez, 2004) and their distributions are greatly affected by the physico-chemical parameters. Nutrients in coastal waters have caused many environmental problems, such as death of benthic fauna, decapod crabs' occurrence of algal blooms (Lapointe *et al.*, 2004; IMA, 2006). The gills of prawns and crabs are easily infected as they lie in the base of the thoracic limb or even their appendix, and are in direct contact with the pathogen-bearing water. Prawns and crabs need good water quality. They like to live in a place where there is clean water and plant life (Yang and Huang, 2003).

Scientists at the Cefas Weymouth Laboratory have described several pathogens of *Cancer pagurus* collected from the English Channel fishery. These have included the causative agent of pink crab disease (the dino flagellate parasite *Hematodinium sp.*; Stentiford *et al.*, 2008; 2002), the type species of a new genus of intranuclear microsporidian infecting the hepato- pancreas of *Enterosporacanceri* (Stentiford *et al.*, 2007), a systemic infection caused by a new species of *Paramarteilia*, a systemic yeast-like pathogen (Stentiford *et al.,* 2003), and most recently, a non-occluded bacilliform virus infecting the hepatopancreas of juvenile crabs *C. pagurus* bacilliform virus (CpBV); Bateman and Stentiford (2008).

Vogan *et al.* (2001) have shown that crabs with more severe levels of shell disease also display histopathological alterations to several organ and tissue systems, including systemic melanised haemocyte nodules, with a significant proportion of haemolymph-derived isolated bacteria exhibiting chitinolytic activity. Despite this bacteraemia and a decrease in haemolymph protein concomitant with symptoms of shell-disease syndrome, no dramatic alteration in various immune parameters were observed (Vogan and Rowley, 2002). Pathogenic microbes have been identified from different part of various crustaceans and factor causing damage to crustaceans and factor causing damage were also analysed. Presence of bacteria in mud crab *Scylla serrate* from Malaysia was also reported (Najiah *et al.*,2010). Krishnika and Ramasamy (2012) have demonstrated that *Artemia sp.*Cyst carry pathogenic and bacteria like *vibrio spp.*

Bacterial infection:

Crustaceans are a native of aquatic ecosystem and so inhabiting the harmful effect of microbial growth. Crustaceans comprise 15% of the total fishery catch. Among them crabs from the main item which occupy the second position in food pyramid as an economic importance fishery resource. They are edible and have high nutritive value. They are highly nutritious and excellent means of obtaining essential live protein, lipid, minerals and vitamins. The fresh water crab *Paratelphusajacquemontii* (Rathbun) is an important nominee and cultivable for aquaculture in India. The micro-organisms are present everywhere on earth which includes biota, soil, water and atmosphere. Aquatic crustaceans always take large number of microbes in to their body parts from water, sediments and food. When any aquatic animal is exposed to polluted medium, a sudden stress is developed for which the animals should meet more energy demand to overcome the toxic stress. Inorganic and organic contaminants entering coastal waters may be concentrated by edible marine organisms to varying degrees from either water, their food or sediments (Fowler, 1982).

A microbial infection has been the major concern of aquaculturists worldwide. Various bacteria in marine and estuarine environment such as *Vibrio parahaemolyticus*, *V.cholerae* and *Vibrio* species are potential human pathogens (Broza *et al.,* 2008; Senderovich *et al.,* 2010). According to Lalitha and Thampuran (2012) farmed crabs carry significant no. of motile *aeromonas*. *Vibrio* sp. was predominant bacteria isolated from haemolymph and external carapace of blue crabs. (Davis and Sizemore, 1982) The marine crabs contain high level of bacteria which were collected from region of human habitation. V*ibrio* sp, *pseudomonas* sp. *Acinetobacter* sp., *bacillus* sp. isolated bacteria from the haemolymph of normal blue crabs, Sizemore *et al.,* (1975). Prayitho and Latchford (1995) observed experimental infection of crustaceans with luminous bacteria related to photobacterium and *vibrio*. A total 91 bacterial isolates consisting of 12 bacterial sp. were isolated from *Scylla serrata* (Najiah *et al.,* 2010). In relation to the health and food safety for human consumption, it was crucial to understand the bacterial flora of fresh water crab.

Fungal infection:

Fungi which may form potential pathogens stressed or immunodeficient crustaceans is groups of *Lagenidiumsp., Sirolpidiumsp.* and *Fusariumsp.* The main fungal diseases are larval mycosis and *Fusarium*disease. Larval mycosis caused by *legenidiumsp,* and *Sirolpidiumsp,* which are typical fungi attaching shrimp larvae result in fungal spore in gills and appendages, and high shrimp larvae mortality (90%) in 2-3 days. Fusarium disease is a common disease that affects all developmental stages of *penaeid*shrimp in aquaculture. This disease generated from *Fusariumsolani, F.oxysporum* and other *Fusarium sp.* causes gill fouling (Black gill), tissue lesion with melanisation of appendages, fungal spores in gills and high mortality (Gabriel and Felipe, 2000). Sixteen species of fungal flora and five species of bacteria from *Charybdis feriata*have been isolated (Rajendran *et al.,* 2008).

The occurrence of fungi and fungus-like organisms in water reservoirs is of great importance for sanitary and epidemiological reasons, as some of the fungi are pathogenic to humans. Man lives in a close contact with fungi throughout life. Fungi and fungus-like organisms regarded as important etiological factors of mycotic infections are identified in fresh and salt waters. The most commonly encountered fungi in various ecosystems include such pathogenic species as *Aspergillus candidus, Candida albicans, Penicillium mycetomagenum,* and *Trichosporon cutaneum. Candida albicans* and *Trichosporo ncutaneum* induce mycotic infections of skin, circulation systems, and organs (Dynowska 1997; Ulfig 1996; Rózga *et al.,* 1999; Kiziewicz and Czeczuga 2001).

The infected prawn showed black gills, but the other apparently looked healthy. Duc *et al.,* (2010a) demonstrated the pathogenicity of both the fungi isolated from mantis shrimp to *kuruma* prawn *Penaeusjaponicus* by intramuscular injection of conidial suspensions. These fungi caused mortality in the injected *kuruma* prawn. Especially cumulative mortality in *kuruma* prawn injected with 0.1 mL of a conidial suspension with 5×10^6 conidial/mL of *Acremonium sp.* reached 100%. The results indicated that the both fungi were also pathogenic to *kuruma* prawn. The prawn is important cultured crustacean in Japan, and lives in the same environmental conditions.

Water parameters favor infections:

The environmental parameters play an important, because the variations in the water parameters, such as temperature, salinity, pH, dissolved oxygen and nutrients influence on the crustaceans abundance and life cycles. Various source of water pollution causes untold hazards to several non-target organisms such as prawns, fishes, frogs, mussels and crab.

Temperature is very important parameter because it influences the biota of water body by affecting activities such as behaviour, respiration and metabolism. Many researchers taking interest in the effect of global climate change on diseases in both wild and cultured organisms (Harvell *et al.,* 1999, 2002). Aquatic animals are highly sensitive to temperature change and it is widely accepted that increase temperatures can lead to reduced oxygen tension in the water, higher microbial growth and immunosuppression, resulting in higher prevalence of disease (Le-Moullac and Haffner, 2000).

pH is defined as the intensity of the acidic or basic character of a solution at a given temperature. Generally, natural waters have a pH of between 5 and 9 and most aquatic organisms survive in waters within this range. With the exception of some bacteria and microbes, if pH goes higher or lower than this range, aquatic life is likely to die. Water with low pH increases the solubility of nutrients like phosphates and nitrates. These makes these nutrients more readily available to aquatic plants and increase the harmful growth called "algal blooms." As these blooms die, bacteria numbers increase in response to the greater food supply. They in turn, consume more dissolved oxygen from the water, often stressing or killing fish and aquatic macro invertebrate's like insects, crustaceans, molluscs and annelids.

In general, the concentration of dissolved oxygen will be the result of biological activity. Photosynthesis of aquatic plants will increase the DO during day light hours and the DO levels will fall during the night time hours. The physical factors that influence DO are temperature altitude, salinity, and stream structure. As this microbial activity increases, oxygen will be consumed out of the water by the organisms to facilitate their digestion process.

Dissolve oxygen is one of the most important abiotic factors influencing young stages, such as zoea and megalopa in aquatic ecosystem (Das, 2000). Pollution is results in the low dissolved oxygen levels and in high nutrient levels in these waters, which can lead to an imbalance of crustacean's communities through the food web. Dissolve Oxygen concentrations clearly affect the behaviour of decapods (Riedel et *al*., 2008; Haselmair *et al.,* 2010). The respiration rates influence the metabolism in crustaceans. Bridges and Brand, 1980; Henry, 1994; and anaerobic metabolism (Johnson, 1985) will reduce growth and moulting frequency Allan and Maguire, (1991) and cause mortality Madenjian *et al.* (1987) reduction of metabolic rate Hill, (1991) and change in osmotic pressure of the haemolymph (En-Charmantier *et al*., 1994).

Turbidity measures the "cloudiness" of water; more accurately, it measures the range to which light is scattered and absorbed by suspended sediment, dissolved organic matter, and, to a lesser extent, plankton and other microscopic organisms (Clesceri, *et al.,* 1994). Turbid water is undesirable from aesthetic point of view in drinking water supplies. Increased turbidity levels are generally correlated with changes in other water quality parameters. Suspended sediment upstream that results in increased turbidity which can directly affect invertebrate populations like crustaceans and fish health and population through egg smothering and lower dissolved oxygen (Waters, 1995). Suspended sediments that increase turbidity levels can also be important transporters of nutrients, bacteria and toxic compounds (Sorensen *et al.,* 1977).While knowing of these relationships, increased levels of turbidity reduce the amount of light that can penetrate into the water column, which can adversely affect the health of aquatic life.

There must be adequate supply of nutrients for synthesis of new cells and generation of energy in any aquatic environment that sustains bacteria growth. Nitrogen, sulphur, and phosphorus are essential complements for carbon, hydrogen, and oxygen in cell metabolism, with many bacteria obtaining their nitrogen and sulphur requirement from nitrates and sulphates respectively (EPA, 1992).

Effect on aquatic life:

Physico-chemical variations induce changes in immune status of crustaceans. These physico-chemical variations are often stressing crustacean, resulting in a reduction of immune vigour. Water quality monitoring has one of the highest priorities in environmental protection policy. The main objective is to control and minimize the incidence of pollutant oriented problems, and to provide water of appropriate quality to serve various environmental purposes (Bockstael *et al*., 1987; Sargaonkar and Deshpande, 2003).

Crustaceans are highly valuable in the seafood industry of the world. Many of the crabs are commercially important as a food source for people. They have developed a successful relationship between the environment and the biological mechanisms involved in evolutionary process. Out of about 640 species of marine crabs so far recorded from Indian waters only 15 species are edible, which inhabit the coastal waters and adjoining brackish water environments, support commercial fisheries (Radhakrishnan, 1979; Varadharajan *et al.,* 2009; Varadharajan, 2012). Due to microbial pollution in the aquatic ecosystem the reproductive process get decelerates and on the other hand long term contact to the microbes cause a considerable damage to the tissue of reproductive organs, decelerating the reproductive cycle and restricting the development of eggs, hatching of eggs and newly hatch young one are also affected by close contact with microbes and ultimately reduced their yield during long term exposure of micro-organism get accumulated in the tissue of animals and thus it becomes unfit for human consumption. In aquatic ecosystem a number of animals such as fish, crab, prawn etc. have their niches and all are economically important and useful as a food. When the aquatic environment are being threatened by a number of pollutants the aquatic organism including crabs can also have deleterious effect on gonads of male and female crabs.

Pollution and its effect on crab:

Crustacean's life patterns are strongly related to environmental factors (Macpherson, 2002; Hiddink and Hofstede, 2008). Physical and chemical factors are highly affected by crustacean's inhabitants. This study is agreement with earlier studies (Collins, 1983; Mukhtar and Deeni, 1998). In general, the organic waste dump caused environmental stress in coastal waters, which resulted to low landing of important crustacean fisheries, and affect the diversity of decapod crabs (Wyatt and Yolarda, 1992; Lemly, 1996). The pollution is due to many pathogens, as well as toxic chemicals can exert harmful effect on crustaceans, and also the health of consumers

(Philips *et al*., 2002). The contaminated food, sediment, suspended particles as well as water (Abrams and Roth, 1994; Berard *et al.,* 1999) contributes to the bioaccumulation of these compounds in crustaceans. Crustaceans have been unlocking vascular systems, in which many haemocytes generously flow in haemolymph (Soderhall and Smith, 1983), Destoumieux *et al.,* 1997). Circulating haemocytes of the immune, functions against parasites and microbes (Bauchau, 1981). Since, the moult cycle influences the status of a number of physiological processes, and since, an animal's physiology influences its behaviour and its interaction with its environment also the affected haemocyte antibacterial activity of decreased immune mechanism of decapods (Chisholm *et al*., 1992; Haug *et al*., 2002). The physic-chemical parameters are vital ecological factors, as it directly affects oxygen consumption, metabolism, growth, moulting, hormones and survival of crustaceans (Chen *et al*., 1995; Medesani *et al*., 2001). It is often in low diversity areas that productivity is highest and human exploit of these systems for food and other uses.

2.11 Effect on crustaceans:

Botkin and Keller (2003) state that sewage pollution that have been observed in all aquatic ecosystems, affecting water resources if not properly treated before discharge. Due to sewage pollution has an important effect on benthos; crustaceans are mostly known as bio-indicators in various aquatic ecosystems, especially for polluted waters (Rinderhagen *et al.,* 2000). These temporary changes are mostly observed in organic matter and sensitive species such as crustaceans soon leave the polluted area (Bat *et al.,* 2001). Crustaceans are the most sensitive group among benthic assemblages affected by sewage pollution (Del Valls *et al.,* 1998; Bat *et al.,* 2001; Guerra-García and García-Gómez, 2004). Many studies were carried out as regards the effects of sewage pollution on crustaceans found in various localities of the Mediterranean.

Del Valls *et al.,* 1998 and Guerra-García and García-Gómez (2004) carried out the studies on the effects of sewage pollution on crustaceans of soft bottoms, respectively. Water quality is the important parameters that determine the life of crab species and also due to the plant ecosystems are important for fishery production (Tiwari, 2011; Zhang *et al.*, 2011; Srinivasamoorthy *et al.,* 2012; Wu and Zhang, 2012). Distribution and existence of crabs depend on specific environmental parameters such as pH and DO (Diaz and Conde, 1989). Brachyuran crabs inhabiting tropical waters usually breed throughout year whereas those found in temperate aquatics breed only in certain months of year (Warner, 1977). Environmental factors like temperature, salinity etc. have also been held responsible to affect the size at maturity in crabs (Fisher, 1999) and are also responsible for variations in moult increment and in the number of moults as well (Hines, 1989).

Histological effects of infections on organs:

Histological studies have a way for understanding the pathological conditions of the animal by helping in diagnosing the abnormalities or damages of the tissues of animals exposed to different stress. Reproduction is a physiological process and is an essential biological need of animals for the continuity of the generation which is known to dominate all other physiological processes. This main function of reproduction is to replace population losses due to death and migration (warren, 1971). Histopathological changes in the gonads in the freshwater crab, *Barytelphusacunicularis* observed when exposed to lethal and sub lethal concentration of pesticides (Chourpagar and Kulkarni, 2011). Sarojini (1990) studied the effect of heavy metal pollutant cadmium chloride on histopathology of the freshwater crab, *Barytelphusaguerini.*

The histopathological studies not only give an early indication of pollution hazard, but also provide useful data on nature and degree of damage to cells and tissues. It is a common tool for determining the deleterious effects of toxic substances in animals. Many workers have employed this tool in the study of aquatic pollution. Vernberg and Vernberg (1972) have observed changes in the gill tissue of crab after exposure to sub lethal concentration of mercury. Ghate and Mulherkar (1979) have studied the changes in the gill tissue of two freshwater prawns *Macrobrachiumlamerrii*and *Caridinaweberi* exposed to copper sulphate. Bodkhe (1983) reported the histopathalogical changes in the gills of freshwater crab, *Barytelphusacunicularis.*

Hematological alteration in infected crabs:

Crustacean haemocytes play important roles in a host's immune response; however, there is no a uniform classification scheme for crustacean haemocytes (Johansson *et al.,* 2000). Haemocyte classification in various crustaceans lacks consistency. Classification of the haemocyte types in decapod crustaceans is based mainly on the presence of cytoplasmic granules in hyaline cells, semi-granular cells and granular cells (Persson *et al.,* 1987; Persson, 1986). The same classification was given by Soderhall *et al.,* (1988) and Johansson and Soderhall (1989) for crayfish. Similarly, Jussila (1997) identified haemocytes in western rock lobsters, *Panuliruscygnus,* as hyalinocytes, semigranulocytes and granulocytes. The circulating haemocyte number is a stress indicator (Le Moullac *et al.,* 2000) and haemocyte counts may be a valuable tool in monitoring the health status of crustacean species (Mix *et al.,* 1980).

Many blue crab mortalities are attributed to systemic bacterial infections, especially when the animals are subjected to crowded, confined conditions. Mortalities in higher have been reported in crabs held in commercial shedding facilities (Krantz *et al.,* 1969). Gross signs of infection include lethargy, weakness, and possibly an enlarged chalky white area on a fifth pleiopod or the gills. Upon dissection, a pre-mortem plasma clot can often be seen in anterior-dorsal and frontal blood sinuses. Hemolymph from infected crabs may have reduced clotting abilities and diminution of haemocyte numbers. The formation of haemocyte aggregations can be seen histologically in arteries and haemal spaces of various tissues, including the heart; as the infection progresses, nodules can be seen in gills, heart, antennal gland, and other organs (Johnson 1976c). Apparently healthy crabs may exhibit a haemocytic response seen histologically which may be the result of recovery from a previous light bacterial infection (Messick and Kennedy 1990). Various species of bacteria have been isolated from the hemolymph of moribund and apparently healthy crabs, including *Vibrio parahaemolyticus,* a pathogen to both crabs and humans Krantz *et al.,* 1969; Davis and Sizemore 1982; Sizemore and Davis 1985)**,** also *Pseudomonas, Acinetobacter, Bacillus, Flavobacterium,* and a heterogeneous group of coliforms including *Escherichia coli* (Colwell *et al.,* 1975; Sizemore *et al.,* 1975).

Classification of crustacean haemocytes has been (and still is) one of the most debated point, mostly due to the lack of uniform classification criteria that enable to distinguish cell types. The THC of apparently healthy crabs decreased significantly upon development of milky disease. Classification schemes are different for each species and are based on haemocyte cytochemical properties, morphological aspect, biological functions or observation techniques. Therefore, resulting nomenclature is often controversial.

Hose *et al.* (1992) Gargioni and Barracco (1998) proposed to combine morphological, cytochemical and functional features of the crustacean haemocytes for a more convenient classification. In most of the Crustacean species, haemocyte classification is generally based on the presence/absence of cytoplasmic granules. Following this criterion, three types of circulating haemocytes are usually recognised in Crustacean: hyalinocytes (the smallest cells without evident granules), semi granulocytes (containing small granules) and granulocytes (with abundant cytoplasmic granules).

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