**A review on infectious diseases in Asian seabass (*Lates calcarifer*)**

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**Abstract:**

Asian seabass (*Lates calcarifer*) or barramundi, a catadromous fish cultured in freshwater, brackish water and marine closed or open aquaculture systems. During the culture, it is affected by various diseases that cause huge loss in production. The diseases are caused by bacteria, virus, fungi and parasites. These pathogens create many changes in Asian seabass externally and internally, so they must be diagnosed and treated. There are no treatment methods identified for few diseases, so it must be prevented from entering the culture systems. “Prevention is better than cure” as the line says there should be preventive measures that are most effective against diseases. Both wild and cultured fishes are affected by numerous diseases. Health management in fishes is the most important in culture systems. Among all the pathogens, parasites cause serious effects in fish. This article provides you with basic information regarding the diseases that occurred in Asian seabass, diagnostic methods, prevention and treatment.

Keywords: Disease, *Lates calcarifer*, Asian seabass,

**Introduction:**

Aquaculture is the farming of aquatic organisms, viz., fish and aquatic plants in various production systems like tanks, ponds, lakes, swamps, floodplains, wetlands, mangroves, canals, rivers, lagoons and reservoirs and one of the important food production sectors in the world. World fisheries and aquaculture production has attained around 178.5 million tonnes in 2018. In this, 96.4 million tonnes are contributed from inland and marine capture fisheries, and 82.1 million tonnes was produced by inland and marine aquaculture (FAO, 2020). Globally 67.1 million tonnes with the value of 164.1 USD billion fish were exported (FAO, 2020). Species diversification in aquaculture is influenced by consumer preference, technical innovations like economies of scale. Diversification in the species farmed is facilitated by the development of the farming and hatchery technologies for various fish species like tilapia, Asian seabass etc... However, the sustainability of the farming of various species is greatly determined by the species selected for farming and the intrinsic risk factors are an adaptation to the environmental characteristics, susceptibility resistance to various diseases. The first and foremost problem in the economic loss of aquaculture is the disease outbreak. Although hatchery production and commercial extension of the farming industry, there is a prevalent outbreak of various infectious diseases caused by viruses, bacteria, fungi and parasites. As in other farmed fishes, disease outbreaks both infectious and non-infectious remain as the major challenges in Asian seabass farming. Infectious diseases caused by bacterial, viral, parasites and non-infectious diseases caused by adverse environmental parameters and nutritional deficiencies are encountered at Asian Seabass farming. Good biosecurity measure is the effective method for the prevention of diseases. The following are the infections so far occured in seabass.

* **Viral diseases:**

The important virus families inflicted in Asian seabass culture is Nodaviridae and Iridoviridae. Viral infection in fishes provokes an immune response that eliminates the infecting virus. Incorporation of the vaccine also provokes an immune response which confers an artificially acquired immunity to that viral pathogen.

1. **Nodavirus:**

Viral nervous necrosis (VNN) or viral encephalopathy and retinopathy (VER) is caused by single-stranded RNA nodavirus. This is the most common viral disease infected in Asian seabass and it is very susceptible to VNN. The first piscine nodavirus designated was striped jack nervous necrosis virus (SJNNV). After that, piscine nodaviruses was also designated for VER outbreaks in Asian seabass (Comps *et al.,* 1994).

**Aetiology:** NNV belongs to the family Nodaviridae, which consist of small (25–35 nm), non-enveloped viruses with a very simple architecture. It is a single-stranded RNA segment with two positive-sense.

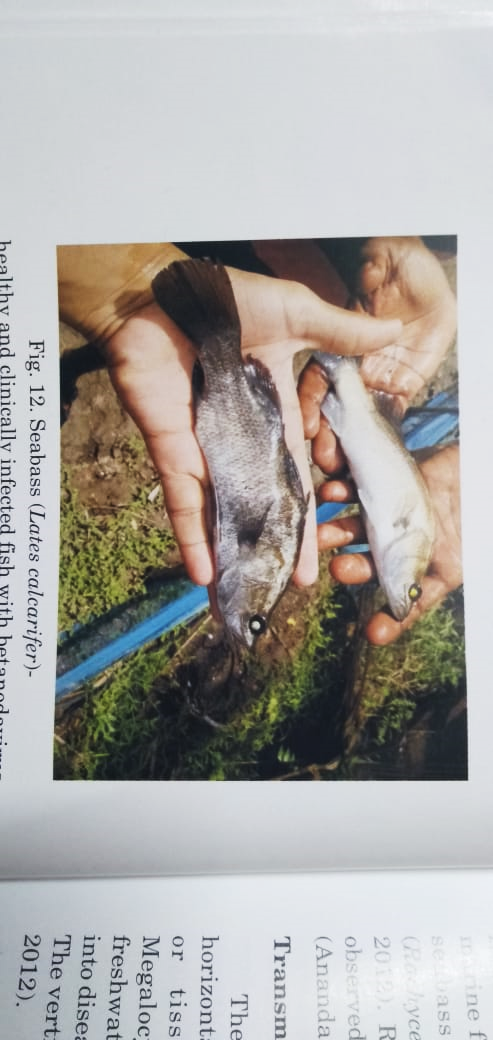
**Geographic distribution:** India, Indonesia, China, Israel, Malaysia, Australia, Singapore, Tahiti, Taiwan, Philippines and Thailand (Munday *et al.,* 2002). RGNNV genotype was reported in Asian seabass in India, Malaysia and Israel (Binesh and Greeshma, 2013).

**Symptoms:** fish becomes pale and dark colouration with redness around the head (Humphrey, 2006). The major infected part in fish is the Central Nervous System, including the brain, eyes and spinal cord resulting in cellular vacuolation and degeneration (Azad *et al.,* 2006a). Mostly affected in larvae and juveniles from intensive culture systems. Photoreceptor contains degenerated cones and clumping of melanin can be seen in retina. Temporary flexion of the body results due to tonic spasms of myotomal musculature can be observed. Abnormal swimming patterns with uncoordinated dashing, rolling and pitching, anorexia and change in pigmentation are frequently observed.

**Transmission:** It is transmitted by both vertical and horizontal transmission. Vertical transmission is by the virus in reproductive fluids in male and female brood stock and fertilised eggs infected with virus (Johansen *et al.,* 2002, Azad *et al.,* 2006), while the horizontal transmission is by water supply, feeding contaminated fish and cannibalism (Hick *et al.,* 2011; Manin and Ransangan, 2011). Brood stock not infected with the virus and maintaining good water quality prevents transmission.

**Diagnosis:** The virus is diagnosed by lesions in the brain/retina in light microscopy, detection of virions by electron microscopy, serological techniques and molecular techniques like ELISA, PCR (Munday *et al.,* 2002). VNN detection is an enzyme-linked apta-sorbent assay (ELASA) procedure, in which aptamers are used as substitutions of antibodies (Zhou *et al.,* 2017). Although identification of the subclinical infection is difficult due to the low quantity of viruses.

**Treatment:** There is no treatment for VNN, but now formalin deactivated betanodavirus gives protective immunity to seabass. Proadifen hydrochloride, a cytochrome P 450 inhibitor, showed strong anti-VNN activity (Bandin and Souto, 2020). Immunisation using recombinant viral coat protein expressed in Escherichia coli or virus-like particles expressed in a baculovirus expression system or formalin-inactivated virus may be effective in controlling the disease



1. **Iridovirus:**

Iridovirus, a member of the family Iridoviridae cause infection in freshwater and marine fishes known as Lymphocystivirus or Lymphocystis disease virus (LCDV). It is. Infection - pebble or wart-like nodules most commonly seen on the fins, skin, or gills.

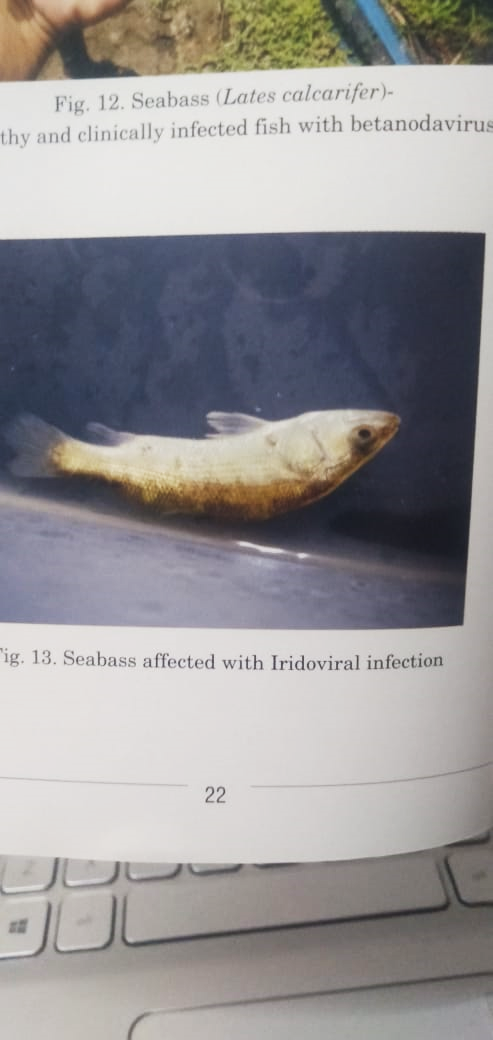
**Geographic distribution:** This infection was reported in Australia, Thailand and Singapore. 10% mortality has been reported in Thailand (Tonguthai and Chinabut, 1987) whereas 100% mortality in fry of Asian seabass in Singapore (Cheong *et al.,* 1983).

**Symptoms:** Appearance of small to moderate-sized, irregular, nodular, wart-like growths on the fins, skin, or gills. Lesions occurs mostly at the periphery of the vascular system. Development of single or multiple nodular lesions in the fins, skin and internal organs (Pearce *et al.,* 1990). These lesions resemble cauliflower, so it is called cauliflower disease. Lesions inhibit physiological processes and lead to secondary bacterial infection that kills the fish.

**Diagnosis:** PCR and nucleic acid hybridisation technique (Cano *et al.,* 2007). Cell lines established have a susceptibility to LCDV include SF cells from Asian seabass (Chang *et al.,* 2001). SB cell line was also derived from Asian seabass.

**Transmission:** The virus can be transmitted only through horizontal transmission.

**Treatment:** No known method of therapy or immunization.Avoidance is the universal control measures. Preventive measures are culling of infected fish and stocking of disease-free certified fishes. Stocking density should be decreased because transmission is through direct contact.

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* **Bacterial diseases:**

The common bacterial pathogen affecting Asian seabass are Streptococcus, Flexibacter, Vibrio, Aeromonas, *Cytophaga johnsonae* and Epitheliocystis. They are of wide range of shapes, ranging from rods to spheres. Most of the bacteria are harmless. Among them few are beneficial. A few harmful bacteria cause infectious diseases in fishes that may be transmitted to humans (Austin, 2010).

1. **Streptococcus:**

**Aetiology:** Streptococcosis is caused by gram-positive bacterium *Streptococcus iniae.*

**Geographic distribution:** It was once reported in Australian marine cages that caused 70% loss in production (Bromage *et al.,* 1999). Outbreaks of *S.iniae* in northern Australia are typically associated with mud and silt entering fish cages following heavy rains during the hot summer wet season (JH Creeper and NB Buller, 2006).

**Symptoms:** There are two clinical forms of the disease namely, sub-acute and acute. The sub-acute clinical signs are protrusion of eyeball, darkened colouration and erratic swimming (Perera et al, 1998). Indication of being mild corneal opacity in some cases is the only acute sign in Asian seabass. Infection in internal organ is haemorrhage, hyperhaemia, cellular degeneration and inflammatory cells infiltration (Kayansamruaj *et al.,* 2017). There is heavy loss in acute infection whereas in sub-acute only 1% loss (Bromage and Owens, 2002). Wild fish cultured in sea cages serves as an important reservoir of *S.iniae*. This is a zoonotic agent that affect the individuals handling infected fish which causes development of cellulitis in hands and endocarditis (Agnew and Barnes, 2007).

**Diagnosis:** Conventional and rapid identification system Polymerase chain reaction (PCR) was used to determine *S. iniae* (Suanyuk *et al.,* 2010).

**Treatment:** Vaccination in fishes showed only limited success up to six months. Infection fish can be protected by administration of oral or injection of antibiotics (Agnew and Barnes, 2007). Reduction in stocking densities, removal of moribund fish and effective barrier netting may control the disease in cages. In closed recirculatory culture systems, restocking of disease-free certified fish, disinfection and reduce stocking density will eliminate the disease. Primary immunization with oil-based formalin-killed vaccines (FKVs) prepared S. iniae and secondary booster was used (Lan *et al.,* 2021). A single vaccine containing combination on *Streptococcus iniae* and *Streptococcus agalactiae* showed better results (Lan *et al.,* 2021). *Sargassum* sp. extract can be used as an immunostimulant in Asian sea bass against *S.iniae* (Yangthong *et al.,* 2016).

1. **Vibrio:**

**Aetiology:** Vibriosis, a deadly haemorrhagic septicaemia disease is caused by vibrio. Vibrio may be *V.cholera, V.parahyemolyticus, V.anguilaarum* and *V.ordalii.* They are gram - negative, motile, curved or straight rods (0.5 × 1.5 – 2.5 μm).

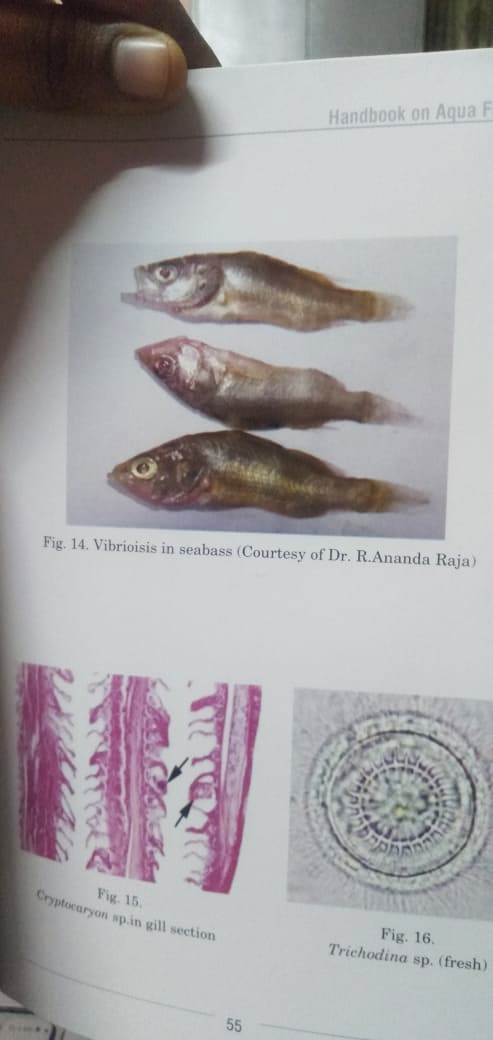
**Geographic distribution:** It was reported in phillippines with 2-3% daily mortality (Tendencia, 2002).

**Symptoms:** Infection was characterised by extensive cutaneous, systemic haemorrhage and localised cutaneous ulceration (Krupesha Sharma *et al.,* 2013). Clinical signs are abnormal swimming behaviour, opaque eyes, exophthalmia externally and necrosis and haemorrhage in kidney, liver and spleen internally. This caused huge mortality, so research has been undertaken to elucidate virulence of the pathogen and to develop detection techniques (Frans *et al.,* 2011).

**Diagnosis:** Culture on selective medium- thiosulphate citrate bile salt agar (TCBS)

**Transmission:** Transmission is horizontal through oral route.

**Treatment:** Administration of antibiotics like oxytetracycline.Vaccination with a dose of DNA plasmid encodes the major outer membrane protein showing protection (Kumar *et al.,* 2007).



1. **Aeromonas:**

**Aetiology:** Motile aeromonads of *Aeromonas hydrophila* cause haemorrhagic septicaemia in fish. It is opportunistic gram negative, motile bacterium.

**Symptoms:** External signs include dark colouration, swollen abdomen, reddened body, necrotic fins and extensive ulcers over flanks or dorsum. Initially, the ulcers are shallow and then the surface progress to brown as it necrotizes or decays. Dropsy, hyperemia and congestion of internal organs are found as internal signs.

**Diagnosis:** Agar like TSA, nutrient agar and MacConkey agar (Moyer, 1996), gel-diffusion technique, ELISA, PCR and DNA fingerprinting AFLP (Huys *et al.,* 1996).

**Transmission:** This is transmitted horizontally by discharge from intestinal tract, external lesions on the skin and water.

**Treatment:** Antibiotic like oxytetracycline, sulfamerazine. Formalin-killed vaccine of *V. harveyi, S. agalactiae*, and *A. hydrophila* strains were mixed with feed pellet and palm oil as an adjuvant was added to improve their antigenicity (Mohamad *et al.,* 2021).

1. **Flexibacter (Gliding bacterial disease / Tail rot disease):**

**Aetiology:** Columnaris disease is caused by gram-positive, filamentous *Flexibacter columnaris.*

**Symptoms:** The bacteria first gain entry through damaged caudal fin, where the tissues are gradually eroded away by the bacteria. The bacteria then invade the muscular region by disintegrate and causing typical tail rot. Internal organs show no pathological changes.

**Diagnosis:** Wet mount preparation of infected tissues, microscopic examination of lesions.

**Transmission:** This disease easily affects the stressed fish. It enters the fish through gills, mouth or any wound on the skin. It is highly contagious as it spreads easily.

**Treatment:** Feed medicated with oxytetracycline or a bath in sodium nifurstyrinatecan be used as a standard treatment. To reduce mortality in affected seabass, a combination of freshwater treatment and reduction of stocking density (Sobhana, 2009).

1. ***Photobacterium damselae* subsp. *damselae:***

*Photobacterium damselae* subsp. *damselae* is a bacterial pathogen present in seawater.

**Symptoms:** abdominal swelling, exophthalmia, darkening of the skin and yellowish discolouration around the anus externally and cloudy yellow abdominal cavity and gelatinous fluid with liver haemorrhage.

**Diagnosis:** This disease is diagnosed by PCR.

**Treatment:** Use of antibiotics is only means to prevent the disease.

1. ***Cytophaga johnsonae:***

**Aetiology:** *Cytophagaa johnsonae* is a filamentous rod shaped, gram-negative bacterium.

**Symptoms:** erosion of the skin, lower jaw and pectoral fins are affected. At the end of lesions, scales became elevated. It was reported initially in Queensland with 2-5% mortality (Carson *et al.,* 1993).

1. **Epitheliocystis:**

Epitheliocystis or gill chlamydia is caused by chlamydia or rickettsia-like microorganism. The disease caused by this bacterium is named epitheliocystis which is evidenced by formation of cyst on the gills and skin as in barramundi (Meijer *et al.,* 2006). They do not function outside the host because they are obligate intracellular bacteria. Research says that it is chronic and opportunistic pathogen within Asian seabass (Anderson and Prior, 1992).

**Transmission:** Mode of transmission is still unknown, but horizontal transmission has occurred in some host species.

**Diagnosis:** Preliminary diagnosis is observation of white to yellow cyst on the gills or skin. Histology and electron microscopy is used (Nowak and LaPatra, 2006).

**Treatment:** There is no treatment for epitheliocystis.

* **Fungal diseases:**

The fungal infection caused in Asian seabass is EUS. Fungi are filamentous, microscopic organism that produce spores.

1. ***Aphanomyces invadens*:**

**Aetiology:** Epizootic Ulcerative Syndrome is caused by *Aphanomyces invadens*. The motile spores invade the skin. It is reported only in freshwater and estuarine waters.

**Symptoms:** It is called as red spot disease because the infection begins as a small area of reddening over a single scale. In Asian seabass, development of cloudiness of cornea with or without lesions in the skin. It causes huge losses in Asian seabass juveniles (Humphrey and Pearce 2004). Since it appears on skin, marketability problems occur.

**Diagnosis:** PCR (Afzali *et al.,* 2016).

**Treatment:** Antiseptic iodophore solution or increase in salinity is the control measure (Humphrey and Pearce 2004).

* **Protozoan parasites:**

Protozoans are unicellular eukaryotic organisms. They are most important parasites affecting fish. They cause harm to fish mainly by mechanical damage, secretion of toxic substance, occlusion of blood vessels and rendering host to secondary infection. The various protozoan parasites are flagellates like Trypanosoma, Oodium and Henneguya sp. Ciliates like Trichodina, Chilodenella, *Cryptocaryon irritans* and Epistylia.

1. **Flagellates:**
2. **Trypanosoma:**

**Transmission:** Parasite directly transfer from one fish to another (Buchmann and Bresciani, 2009). Leeches are intermediate host.

**Symptoms:** Affected seabass shows anorexia, lethargy, scale loss, splenomegaly and exophthalmia (Humphrey *et al.,* 2010). Trypanosoma infect the vascular system (blood) of fishes that cause anaemia and lethargy.

**Diagnosis:** Under light microscopy with stained blood smear. It was diagnosed as primary cause of death in Australian marine cages.

**Treatment:** There is no treatment but eradication of leeches helps in protection from trypanosomes.

1. **Oodinium sp:**

**Aetiology:** Velvet disease is caused by Oodinium species. They are dinoflagellates. In marine, *Amyloodinium ocellatum* and in freshwater, *Piscinoodinium pillulare*. It has 2 flagella for locomotion and infect skin, fins and gills.

**Symptoms:** Pyriform trophonts (<160 µm) attach to the epidermis with rod like rhizocysts which penetrates epithelial cells and finally destroy by causing hyperplasia, fusion of lamellae and petechial haemorrhage (Humphrey *et al.,* 2006). External velvet-like layer occurs on surface.

**Diagnosis:** Infection diagnosed by microscope.

**Treatment:** Bath treatment with copper sulphate (<2ppm) or benzalkonium chloride (0.5ppm).

1. ***Henneguya sp*:**

**Aetiology:** *Henneguya setiuensis*, *Henneguya voronini* and *Henneguya calcarifer* were reported in Lates calcarifer in Malaysia (Borkhanuddin *et al.,* 2019).

**Symptoms:** *Henneguya sp* infects the gills and when heavy infection found on skin. Gross signs are hyperplasia, bronchitis and necrosis. It has 2 flagellae that attaches to the host and transforms to sac-like trophont. They encyst and produce dinospores.

**Diagnosis:** Presumptive diagnosis of the disease is based on clinical signs, gross lesions and microscopic examination of wet mounts from gill biopsy.

**Treatment:** Bath treatment with copper sulphate (less than 2 ppm) or benzalkonium chloride (up to 0.5 ppm) for up to 3 days may be effective (Buchmann and Bresciani, 2009).

1. **Ciliates:**
2. **Tricodina:**

Trichodina is a genus of ciliate protists that have a ring of interlocking cytoskeletal denticles, which provide support for the cell and allow for adhesion to surfaces of Asian seabass. They affect the gills and inner operculum of barramundi (Rückert *et al.,* 2008). They reproduce by binary fission and feed on organic matter by filtration. Dense populations inhibit normal physiological function like osmoregulation.

**Symptoms:** Clinical signs are excessive mucous production, anorexia, hyperventilation and lethargy.

**Diagnosis:** Diagnosis can be made through microscopic detection in gill or skin scrapings.

**Treatment:** Bath Treatment of formalin, copper sulphate, sodium chloride and sodium percarbonate (Buchmann and Bresciani, 2009).

1. **Chilodenella:**

Chilodonella are single cell organisms that affects the gills and skin of freshwater Asian seabass. This parasite was documented in large Asian seabass in freshwater pond systems in northern Queensland (Anonymous, 2007).

**Symptoms:** morbidity, mortality, lethargy and anorexia. Dense populations on the host epithelium inhibit normal physiological function, including osmoregulation, gas exchange and excretion.

**Diagnosis:** Diagnosis can be made through microscopic detection in skin or gill scraping.

**Treatment:** Bath treatment with formalin, copper sulphate, malachite green and methylene blue are effective (Buchmann and Bresciani, 2009).

1. ***Cryptocaryon irritans*:**

**Aetiology:** White spot disease is caused by infection of a ciliated protozoan parasite that occurs in marine (*Cryptocaryon irritans*; saltwater ‘Ich’) or freshwater (*Ichthyophthirius multifiliis*; freshwater ‘Ich’) environments.

**Symptoms:** White spots (0.4–0.8 mm) on external fish surfaces are encysted trophonts, which feed on host epidermis. Tomonts encyst to form tomocyst that undergoes numerous cell divisions. One tomocyst produce 1000 free-swimming theronts that escape to attach a host. Increase in temperature may cause infection (Karvonen *et al.,* 2010). *C.irritans* is a major parasitic disease that affect Asian seabass kept in tanks for breeding (Humphrey 1996). Once the organism establishes in a large fish culture facility, it is difficult to manage due to its rapid life cycle and there can be 100% mortality if left untreated. Trophonts are horse-shoe-shaped macronucleus with numerous moving cilia. Heavy infections reduce the osmoregulatory ability causing hyperplasia leading to mortality.

**Diagnosis:** Diagnosis is by making skin scrapings and examining for trophonts under microscope.

**Treatment:** Malachite green (0.2 ppm) is effective bath treatment. Treatment with formalin, copper sulphate, sodium per-carbonate, sodium chloride, hydrogen peroxide, or other disinfectants will kill infective theronts and trophonts leaving the fish skin and increase or decrease in salinity can be done.

1. **Eimeria:**

Eimeria is a significant pathogen of Asian seabass that affects the intestine in nurseries in Vietnam (Gibson-Kueh *et al.,* 2011). Genetic sequences for piscine-derived eimeria are not yet found.

1. **Epistylis:**

Epistylis is a protozoan parasite found in seabass especially in freshwater environment. This belongs to the sub-class Peritrichia. It occasionally turns pathogenic. It attaches to the fish by using stalks. They are large in number enough to cause a grey mat on the epithelial surface at different temperature.

* **Metazoan parasites:**

Metazoan parasites are multi-celled organisms that live on and within the body of their host. Common metazoan parasites are monogeneans (haptor-worms), digeneans (flukes), cestodes (tapeworms), nematodes (roundworms), acanthocephalans (spiny-headed worms), leeches and crustaceans.

1. **Helminthes:**
2. **Monogenean trematodes (haptor worms):**

Monogeneans are the most serious of all the parasitic diseases in Asian seabass and if left untreated fish develop secondary infections (Leong, 1997; Anonymous, 2011). The monogeneans *Neobenedenia melleni* and *Benedenia epinepheli* reported to infect Asian seabass are prevalent in tropical and subtropical fishes worldwide. They lay eggs into the water which hatch into ciliated larvae that directly infect fish.

**Symptoms:** Clinical signs are darkened body, pale gills, lethargy, loss of appetite and excess mucus production. High infection on fish lead to secondary infections by bacteria, ultimately resulting in emaciation and death. Large losses and mortality rates of 30–40% are commonly reported in Indonesia and Australia (Deveney *et al.,* 2001, Ruckert *et al.,* 2008; Anonymous, 2011). They irritate the eyes, causing opacity, exophthalmia and caudal and pectoral fins become frayed. They attach to the skin of their host and erode on mucous and epidermis.

**Treatment:** Acute bathing of infected fishes with formalin or freshwater solutions is effective method (Thoney and Hargis, 1991; Fajer-Avila *et al.,* 2008). Natural treatment methods are used instead of chemicals (Hutson *et al.,* 2012, Militz *et al.,* 2013).

1. **Digenean trematodes (flukes):**

Digenean occurs in wild and captive Asian seabass. They are usually found as **immature metacercariae in fishes**. The blood flukes (Family Aporocotylidae) are serious pathogens of hosts in mariculture. Although these species have no known pathology, other fish blood fluke are considered a major threat to fish production.Thin shelled eggs can be diagnosed in microscopy or histology.

**Geographic distribution:** *Cruoricola lates* was reported in Malaysia, Thailand and Australia in cultured Asian seabass (Herbert *et al.,* 1994). *Parasanguinicola vastispina* infects cultured fish in Malaysia (Herbert and Harrison, 1995).

**Symptoms:** Adult parasites release eggs into the vascular system. They cause inflammation in the gill, heart, kidney, liver, spleen, pancreas or other organs and decrease the physiological performance of these organs. They cause problem in open or semi-closed aquaculture systems because their intermediate invertebrate host may inhabit areas close to farmed fish, such as on cage structures or in sediment (Cribb *et al.,* 2011). Adult flukes found in the blood vessels. *Lecithochirium sp*. affects the intestine of seabass especially in wild fish. Incidence of infection was 86% and average parasite burden was 5.5%. Another digenetic trematode *Pseudometadena celebesensis* commonly found in the intestine of wild seabass. Its incidence of infection and parasite burden were 100% and 9.3% respectively.

**Treatment:** Oral administration of praziquantel may be the most effective treatment against blood fluke infections (Hardy-Smith *et al.,* 2012, Shirakashi *et al.,* 2012).

1. **Nematodes (roundworms):**

Nematodes are long, slender and cylindrical un-segmented worm that tapers at each end. In wild and farmed Asian seabass, several larval nematodes have been documented. Larval nematodes must complete their life cycle in a specific bird, fish or mammal species, but their larval stages may be able to survive in a large variety of intermediate hosts. Members of Anisakidae have been reported from farmed Asian seabass, if raw or undercooked seafood is consumed it may cause health issues in humans (Sabater, 2000).

**Treatment:** Nematodes may be excluded from farmed fishes by maintaining clean feed sources, such as an extruded pellet diet is a preventive measure.

1. **Cestodes (tapeworms):**

**Aetiology:** In farmed Asian seabass, two species of cestodes were found namely, *Scolex pleuronectis* and *Nybelinia indica* (Ruckert *et al.,* 2008) while other species are found in wild fishes.

**Symptoms:** Cestodes infect intestine, stomach, mesenteries and pyloric caeca of Asian seabass. Larvae of cestode (plerocercoids) are found in Asian seabass.

**Treatment:** Feeding of extruded pellets reduce the infection (Ogawa, 1996)

1. **Leeches:**

Leeches are segmented predatory worms and belong to subclass Hirudinea that occur in freshwater, brackish and marine environments. They get attach to their host using anterior and posterior suckers feed on the blood of the fishes (host) and leave the host. Until the last meal is digested it does not gets attached to another host (Kearn, 2004). It inhibits the host’s clotting enzyme, thrombin by injecting saliva while feeding to prevent clotting in fishes.

**Symptoms:** Anaemia, body discolouration, scale loss, frayed fins and restless swimming. To lay cocoons on a chosen substrate, including aquaculture structures such as moorings and nets, they detach from host. Cocoons have a ring-shaped compartment that seal them from the environment which protects the developing embryo. Heavy infestations of the leech, *Zeylanicobdella arugamensis* had caused mortality in Asian seabass fingerlings in sea cages in Malaysia (Kua *et al.,* 2010). Leeches can also serve as a vector for other parasites and pathogens like *Vibrio algniolyticus* (Kua *et al.,* 2010), viruses and protozoa (Burreson 1995). Severe infestations make fish unmarketable due to frayed fi ns, haemorrhages and swelling at attachment area and feeding sites (Cruz-Lacierda *et al.,* 2000, Kua *et al.,* 2010).

**Treatment:** 50ppm formalin bath treatment found effective for managing leeches (Cruz-Lacierda *et al.,* 2000)

1. **Acanthocephalans (spiny-headed worms):**

Acanthocephalid worms, despite their fearsome-looking proboscis with its rows of hooks, have not been observed as serious pathogens of fish. The great majority of acanthocephalans in seabass are found as adults in the gut.

1. **Crustacean parasites:**
2. **Copepods:**

Caligus adults are capable of swimming and can leave one host to become attached to another but other copepods cannot swim. Due to their broad distribution, direct life cycle and low host specificity, they are threat to aquaculture. This species was found in sea caged Asian seabass in Malaysia (Venmathi Maran *et al.,* 2009, Muhd-Faizul *et al.,* 2012).

**Aetiology:** Several harmful copepod species (sea-lice) are known from wild and farmed Asian seabass including *Caligus epidemicus, C.chiastos, C.orientalis, C.pagrosomi, C.rotundigenitalis* and *C.punctatus*.

**Symptoms:** The haematophagous copepod, *Lernanthropus latis* is found in brackish pond culture and sea cage culture of Asian seabass in Australia. Adult females attach to the primary gill filaments and smaller males attach to females in gills (Brazenor and Hutson 2013). Presence of *L.latis* is associated with poor fish health (Kuo and Humphrey 2008). Parasites cause irreparable damage to the gills by way of their mode of attachment and feeding activity (Small et al. 2002). They cause haemorrhages, hyperplasia and necrosis along the secondary lamellae of gill filaments (Kua et al. 2012).

**Treatment:** There are no known treatments, although bath treatment of hydrogen peroxide had been tried in the Australian mariculture industry. Emamectin benzoate (EMB) is found to be an effective oral treatment for controlling caligus (Raja, R.A et al, 2020).

1. **Isopods:**

Isopods that closely resemble *Aega* sp. have been found abundant in cage-cultured seabass.

**Symptoms:** Clinical signs are fish lose appetite, become anaemic, and grow very slowly. In heavily infected young fish, death occurs in 2-3 days. In wild fish, *Nerocila barramundaei* and *Rocinela latis* are only known but pathology is not known. Parasitic isopods are blood feeders that occur on the body, in the mouth or in the branchial cavity of the host fish. Infections of farmed hatchery seabass in the branchial and antero-dorsal regions by *Cymothoa indica* resulted in skin lesions caused low growth rates and mortality (Rajkumar *et al.,* 2005). The parasite always attaches to the gills.

**Treatment:** The preventive measure is to filter wild zooplankton.

**Conclusion:**

An area of continued research is the biodiversity of pathogens and parasites that may infect Asian seabass and appropriate mechanisms to treat infections. Management focuses on reducing stress, preventing introduction of pathogens and parasites and use of effective drugs and vaccines if available. Good health management is the best way for disease control. Continued reliance on wild conspecifics for stocking enables vertical and horizontal pathogen transmission. As our knowledge of Asian seabass disease increases, we understand more of the biology of the pathogens. The optimal rearing conditions, improved management strategies will be developed to help avoid diseases and increase productivity. Overall, the emphasis must be on prevention rather than treatment.

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