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Review Article

A Short Review of Asian Seabass (*Lates calcarifer*) Cultivation

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ABSTRACT

Aquaculture is the most reliable sector to the providing world nutrias food. It is all depended on the cultivable species. Asian seabass is one of the candidate species for aquaculture because of the wide range of water quality tolerance, growth performance, and consumer preference. The Indian and Western Pacific Oceans are where Asian seabass is found in its natural habitat. It can be cultured in the earthen pond, floating or stationer cages, and recirculating system. Seed resources are available in rivers and lakes of fresh water, but aquaculture is the depending on the hatchery that produces seed because of the superior growth production. In the nursery phase, cannibalism is predominant in Asian seabass cultivation, which will improve via the grading of a shooter. Feeding is one of the important management for good growth performance and reducing cannibalism to give the optimum feed requirements. The growth rate of the Asian seabass is 400-600 g in 4 to 6 months. Asian seabass farmers are suffering from some infectious and non-infection diseases, it will improve via the good management practices of the culture promises. In this review paper, some key points of Asian seabass farming are covered for better understanding.

Keywords: *aquaculture, Asian seabass, culture, cannibalism, disease, feeding, grading.*

INTRODUCTION

Barramundi, also known as sea perch or giant sea perch, is a species of *Lates calcarifer* (Fig. 1). In the Indo-West Pacific region, Asian seabass and Australian seabass are both widely distributed in freshwater and along the shoreline (Aji, 2012). It may be farmed in cages, earthen ponds, tanks, or complete seawater and is a commercially significant species in Australia and Southeast Asia (Thassim et al., 2019).

Barramundi is a candidate species for aquaculture due to its popularity and high demand.

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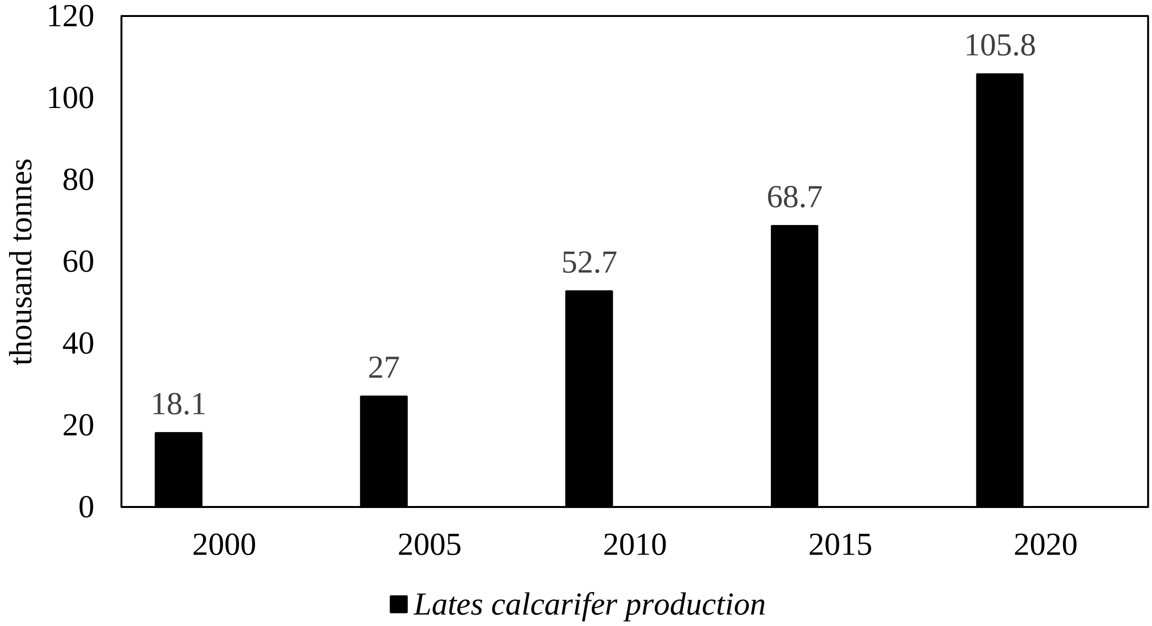
In addition to the qualities that make it popular with consumers, such as soft, mild-tasting, boneless fillets, the Fish is also rapidly growing and euryhaline (can be grown in salinities ranging from fresh to seawater). Scientific classification of the Asian seabass is motioned in Table 1 (Schipp et al., 2007).

Table1. Scientific classification of Asian seabass

Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Perciformes
Family	Latidae
Genus	*Latest*
Species	*L. calcarifer*

In Thailand's Songkhla Marine Laboratories in the early 1970s, methods for rearing Barramundi were initially established, and since then, the aquaculture of the species has advanced significantly. Aquaculture for Barramundi expanded in China, India, Indonesia, Malaysia, the Philippines, Singapore, Taiwan, Vietnam, and Australia in the 1980s and 1990s. Other recent adopters of barramundi farming include the United States, the Netherlands, the United Kingdom, and Israel. Many of these nations are actively investing in research into barramundi culture methods. In recent years, it has expanded across Asia and Europe. Since several of these nations are investing in active research into barramundi production techniques, barramundi farming is growing as a result of ongoing technological advancements. 20 years of the Asian seabass production data in Table 2 and Figure 2 indicated (Schipp et al., 2007).



20 years of graphical presentation of world seabass production Adapted from FAO, 2022

Barramundi is a hardy, prolific species that can tolerate a wide range of salinities and only needs basic hatchery and grow-out production procedures (SPC, 2014). In controlled circumstances, they can reproduce all year round and have a significant number of offspring. Barramundi is disease-resistant and can adopt an artificial diet (Carter et al., 2009). To maintain commercial growth rates, Barramundi must be raised in warm climates (tropical regions) (Boonyaratpalin & Williams, 2002). Barramundi is a perfect choice for aquaculture because of its qualities.

Since Asian seabass has a high nutritional content and a high market price, it is a widely consumed seafood. Today, the three most prevalent methods for growing seabass are pond, pan, and marine cage cultures. Cannibalism and size variations are the main challenges in seabass culture. This paper presented the Asian seabass according to cultivation which steps and information are the keep in mind before starting the cultivation of that highly preferable spices, and which type of obstacles are presented author described here.

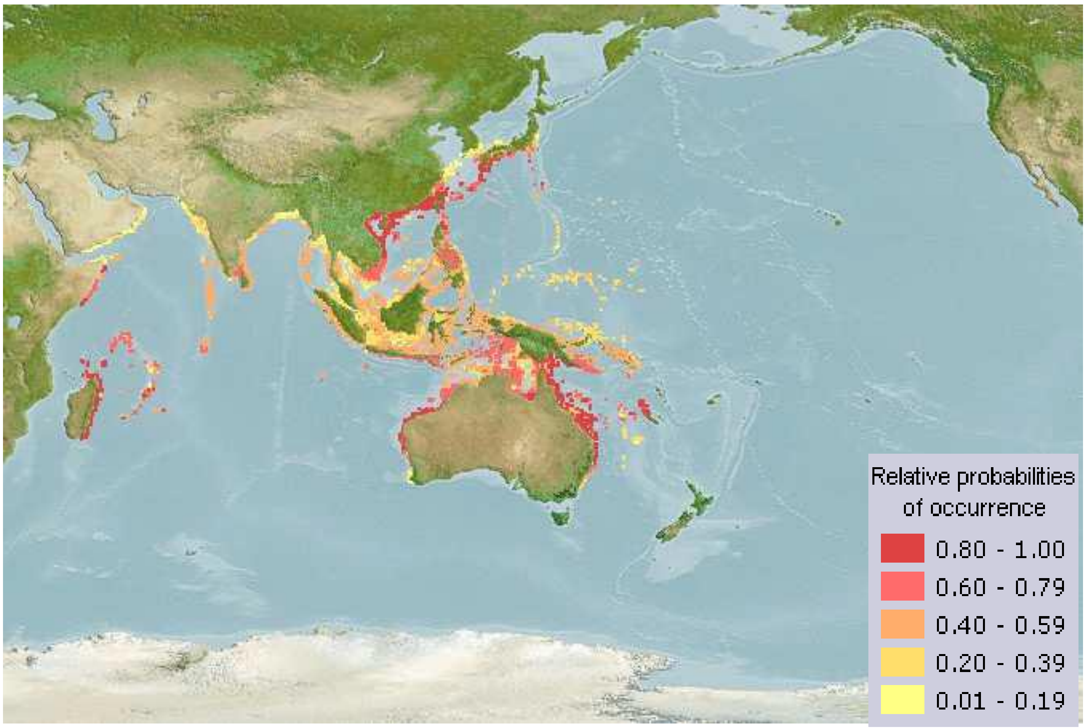


Fig. 1. A map of *L. calcarifer* distribution indicating its western, eastern, northern, and southern limits. Adapted from Vettorazzi, M. B. 2018

2. Distribution of Asian seabass

The Indian and Western Pacific Oceans are where Asian seabass is found in its natural habitat. Australia's coastline, Southeast and East Asia, and India are all included (Luna, 2008). Between latitudes 24°N to 25°S and longitudes 50°E to 160°W, seabass is widely dispersed in tropical and subtropical regions of the Western and Central Pacific and the Indian Ocean indicated in Figure 2 (Mathew, 2009).

L. calcarifer is found in coastal waters in the northern Indo-Pacific area, south to Australia, and west to East Africa. This species is abundantly found in India in the lower reaches of rivers that border estuaries and along the shore. Lagoons tend to be avoided by a portion of the population, especially very large, mature adults, who instead appear to occupy the smaller lagoons. occur in estuaries, less salinized intertidal zones, and other brackishwater areas (Day, 1958). The distribution of the Asian seabass is indicated in Figure 1.

3. Morphology and distinctive characters of Asian seabass

The body is compressed, and elongated and has a deep caudal peduncle. Large, elongate, strong body with a prominent snout and significant concave dorsal profile in the head; concave dorsal profile turns convex in front of a dorsal fin. The pectoral fin is short and rounded, with several short, sharp serrations above its base. The dorsal and anal fins both have a scaly sheath. The dorsal fin has seven to nine spines and ten to eleven soft rays. Round caudal fin; anal fin with three spines and 7-8 soft rays. large ctenoid scale (rough to touch). Colour: two phases, either golden brown in freshwater or olive brown top with silver sides and belly in a marine environment. In an adult, it is typically silver below and blue-green or greyish above. Fins are dark brown or almost black. Juveniles have a brown spotted pattern on their head and nape with three white stripes, as well as irregularly spaced white spots on their back. Bright pink eyes that sparkle at night (Mathew, 2009).

4. Life history of Asian seabass

Asian seabass (2–3 years) growth cycle is running in freshwater areas like rivers and lakes that are connected to the sea. It grows quickly, frequently reaching a size of 3–5 kg in just 2–3 years. To mature their gonads and breed, adult fish (3–4 years old) move from interior waters into the sea near the river's mouth, where the salinity is between 30-32 ppt. The Fish spawns by the lunar cycle in the late evening, typically at the beginning of the new moon or the full moon. As a result, estuaries can be reached by the eggs and hatchlings. Larvae grow here before migrating further upstream to continue growing (Mathew, 2009).

Pelagic eggs hatch in just 24 hours, and the larvae quickly develop as they travel into mangrove habitats, mudflats, and lagoons in floodplains. After a year, juveniles travel into coastal waters before migrating upstream, where adults stay for three to four years. By dams, populations that are landlocked go to the dam face but do not reproduce. Aquaculture raises it extensively for use as food or in-game fish stocking plans. During the wet season, catadromous migration is seen, where the Fish move downstream to shallow mudflats in estuaries (Roberts et al., 2021).

5. Culture protocol of Asian seabass

5.1 Seed resources

In Asia, *Lates calcarifer* is widely cultivated. However, the availability of fingerlings from the wild is unreliable. Therefore, this species' aquaculture is reliant primarily on hatchery-produced fry (Jerry, 2013). Thailand has produced the most progress when it comes to producing seabass seed from spawners that have been captured in the wild and induced to reproduce since 1973. Currently, Thailand produces more than 100 million seeds yearly. As a result, Thailand's seabass culture sector is now provided with a substantial and reliable supply of seed (Nammalwar & Marichamy, 1998).

The Central Institute of Brackishwater Aquaculture (CIBA) has standardized the technological package for seabass seed production under controlled conditions, which may be scaled up to any desired level. The technology package covers the development, maturation, and controlled spawning of captive land-based broodstock, egg collection and incubation, live feed culture, larval rearing, and the creation of formulated feed for fry, fingerlings, and the grow-out period. Young seabass can be caught in the wild (E.g. April to June in West Bengal, May to August in Andhra Pradesh, Sept to Nov. in Tamil Nadu, May to July in Kerala, and June to July in Maharashtra) (Arasu et al., 2008).

5.2 Asian seabass an ideal candidate for aquaculture

It is a species with broad physiological tolerances and a known for being relatively hardy. The high fertility of female Fish offers an abundance of resources for seed generation in hatcheries. Production of seed in a hatchery is comparatively easy. Pelletized meals work well for seabass, and young Fish can be easily weaned to them. Grow quickly, taking six months to two years to reach a harvestable size (350 g to 3 kg) (Shingare et al., 2020).

5.3 Problems associated with Asian seabass culture

Throughout the early stages, cannibalism predominated (1-20 g). The primary diet of the underprivileged in developing nations depends on either a high protein content or trash fish. Unpredictable supply of wild Fish, with a greater abundance of Fish on India's east coast than on its west coast (Comps et al., 1991).

5.4 Pond and cage preparation

Successful fish culture in ponds requires careful design consideration. Appropriate soil type. Water must be able to remain in the soil. If not, a synthetic liner or compacted clay liner may need to be used to line the pond. These two raise the price of construction. The pond needs to be close to a fresh, brackish, or marine water source. Water needs to be easily accessible and shouldn't need to be pumped over long distances or very high. Water inlet size and location. Each pond needs its water entry point. Having one pond's intake water serve as another's wastewater is bad management. The water inflow must have enough capacity to swap the pond's water quickly if necessary. The place and dimensions of the water exit. Every pond needs its water outlet, ideally on the side that isn't the water inlet. The outlet ought to be big enough to swiftly drain the pond if necessary. The watergate or "monk" design is one kind of pond outflow.

The pond's design must make it simple to remove the Fish. The typical approach is incorporating a drainage channel and collection sump in the pond base or right outside the pond wall. The pond walls must be constructed to reduce the likelihood of erosion or collapse when exposed to tidal wash or intense monsoonal rains. To completely drain the pond and concentrate the Fish in the harvest sump, the pond bottom needs to be appropriately sloped. The pond must be close to an electrical source to run aerators, pumps, and other equipment. A source of fresh water that can be used to regulate salinity or treat the Fish therapeutically should be accessible if the pond is marine, even if this is rarely practical. It could be necessary to defend the pond from predators like birds (Schipp et al., 2007).

Floating Cages

The net cages are suspended on bamboo, wood, or GI pipe frames. Bamboo, plastic buoy, or styrofoam drums are used to keep the cage afloat. The cage's most practical size is rectangular, with a volume of 50 m^3 (5 m x 5 m x 2 m). Concrete weights are placed in each of the cage's four bottom corners to stabilize it. The cage component needs to be secured to the ground. Strong winds and currents could cause the cages to tremble a little. Floating cages can be placed on tidally fluctuating coastal waterways (Philipose, 2013).

Stationary Cages

This kind is attached to four wooden poles that have been put at its corners. Typically, stationary cages are placed in shallow harbours with little tidal fluctuation. Similar to the floating cages in size (Tookwinas, 1989).

5.5 Acclimatization of seed

The acclimatizing tanks are filled with high-quality filtered and moderately aerated saltwater that has the same salinity, temperature, and other characteristics as the transported medium once the Fish have been delivered to the hatchery or holding facility. The Fish should be kept in these tanks for one to two hours with a flow-through water setup because they will be stressed out from transit. To prevent infection caused by small injuries, if any, the Fish are treated with Acriflavine (1 ppm) for 10 minutes after normalization and then with 100 ppm formalin for an hour. Before moving the Fish to the brood stock holding facility for additional upkeep, they should be carefully monitored for 3 to 5 days (Arasu et al., 2008).

5.6 Stocking rate

Each size group's stocking is completed independently. Cannibalism losses would be reduced as a result (Tookwinas, 1989). Depending on the size of the fry, different stocking densities are used: 5,000/m^3 for those under 1 cm, 4,000/m^3 for those between 1.0 and 1.5 cm, and 2,000/m^3 for those between 1.5 and 2.5 cm (Nammalwar & Marichamy, 1998).

5.7 Size grading

As a cannibalistic fish, seabass impacts the culture's survival and sustainability if due care is not taken with their feeding, cleaning, and maintenance. In light of this, seed grading is a crucial stage in seabass nursery raising. To lower cannibalism and increase the percentage of survivability throughout nursery rearing, this is necessary. Every 4-5 days, size grading is carried out. All the seed from each hapa is extracted for grading, and it is placed in grading containers. Shooters are then separated from the small seed group and stored in distinct hapa according to their sizes as smaller, medium, and larger ones (shooters) (Patil et al., 2020).

For Fish reared in ponds, grading can be a challenging process. To collect and grade the Fish, the pond is often either completely drained or if only some of the Fish are to be graded, dragged using an appropriate net. One of the reasons some pond farmers decide to raise their Fish in cages inside the ponds is this. The right pond design can greatly simplify the grading process if the Fish are permitted to move freely throughout the pond. The addition of a capture zone or sump can make it easier to catch Fish and return them to the pond. If necessary, Fish raised in cages can be easily graded. To concentrate the Fish, the cage netting is partially pulled out of the water, or in the case of steel cage netting, an inner capture net is utilized. The Fish can then be scooped or pumped from the water into a motorized grader once they have been confined to a small space. Each farm's management techniques determine whether and when grading is necessary (Philipose et al., 2010).

6. Culture of Asian seabass

Due to its ability to adapt to even freshwater, seabass can be raised in ponds and cages in both coastal and inland settings. The fry or early fingerlings that are either caught in the wild or purchased from hatcheries must be further raised to stackable size in the nurseries for improved survival. Hatcheries with external tanks or on-site ponds and cages are both options for nursery-rearing young animals (Barlow et al., 1996).

Although this species' net cage culture techniques have been developed in Thailand, Malaysia, Singapore, Hong Kong, and Singapore. Since 1976, numerous Southeast Asian nations, including Malaysia, Indonesia, and Thailand, have built pilot-size seabass cultures in floating net cages under FAO. Seabass can be successfully raised in ponds, net cages, and pens in India. Ponds are where the majority of traditional cultural practices are located in the nation. There is not much data on the survival or production rates of this species available for study. Improved growth and production outcomes have been observed in the seabass culture in West Bengal's paddy fields. The production was reportedly between 2000 to 2760 kg/ha/yr. The CMFRI's experimentation with seabass culture in a coastal pond at Tuticorin (Nammalwar & Marichamy, 1998).

Currently, Seabass is cultivated in cage farms throughout the coasts of most of its range, with Southeast Asia producing the majority of the species. These farms frequently cultivate a variety of species, such as groupers (Family Serranidae, Subfamily Epinephelinae), seabass, and snapper (Family Lutjanidae). Large-scale seabass farms are emerging in Australia, where the Fish are raised outside of tropical climates, and recirculating production systems are frequently employed (e.g. in southern Australia and the north-eastern United States of America). Iran, Guam, French Polynesia, the United States (Hawaii, Massachusetts), and Israel have all used seabass for aquaculture (Mathew, 2009).

6.1 Nursery rearing

In South-East Asia, young Barramundi (1.0-2.5 cm TL) may be introduced into nursery ponds with fresh or brackish water, nursery cages, or both. The sizes of nursery cages range from 1.8 m^3 (about 2 x 1 x 0.9 m) to 10 m^3, and they can be either floating or fixed (ca. 5 x 2 x 1 m). Because the net mesh used in nursery cages is so thin (1 to 2 mm), powerful currents can easily damage it and it fouls up quickly. Barramundi juveniles are stocked at densities of 80–300 fish per m^3 in nursery cages and 20–50 fish per m^2 in nursery ponds. For the first week, Barramundi is fed minced trash fish (4-6 mm^3) twice daily at a rate of 100% of the biomass, which is then reduced to 60% and 40% of biomass for the following two weeks. The minced Fish may have 2% vitamin premix added to it. The Fish are "taught" to eat at the same location every day at the same time. Once the fingerlings have grown to 5-10 cm TL during this 30-45 day nursery phase, they are moved to grow-out ponds or cages (Kungvankij et al., 1986)

Juvenile Barramundi was taken from intense culture tanks or rearing ponds in Australia and then moved to nursery facilities. The majority of nurseries employ small cages made of insect screen mesh in above-ground or concrete tanks. Several barramundi farms have freshwater nursery facilities and employ freshwater ponds for grow-out. Barramundi juveniles (> 10 mm TL) can be moved from seawater to freshwater in as little as 6 hours without suffering any appreciable mortality (Rimmer, 2003).

Weaning Barramundi into synthetic feeds is possible. even at sizes as small as 10 mm TL however, delaying weaning until the Fish are at least 15-20 mm TL results in improved survival and quicker acceptance of artificial meals. Within a few hours of being harvested, these small barramundis may start eating inert diets, and most Fish start eating within a few days. High-quality weaning meals are sold commercially and, while costly, are preferred to the lower grades of typical grower foods since they seem to appeal to Fish more (Barlow et al., 1996).

The weaning phase is when most deaths occur during the nursery phase. These deaths have a variety of causes, but the majority are due to illnesses brought on by stress related to harvesting, salinity conversion, and high stocking densities in nursery tanks. At the nursery stage and the early stages of growth, cannibalism may cause an important number of fatalities. Fish up to 60–67% of a barramundi's length will be consumed (Parazo et al., 1998). Cannibalism is most pronounced in Fish less than 150 mm TL and may begin in the latter stages of larval development. It causes comparatively minimal losses in larger Fish. Grading the Fish at regular intervals (often at least every 7–10 days) to make sure that the Fish in each cage are comparable in size reduces cannibalism (Lucas & Southgate, 2003). Indonesia, Philippines, and Thailand nursery culture practices are described in table 3.

Table3. Nursery culture practices of Asian seabass in three Southeast Asian countries

	Indonesia	Philippines	Thailand
Culture System	Tanks	Tanks or in hapa nets in ponds	Tanks, ponds, cages set inside ponds
Tanks, ponds, cages set inside ponds	Straight run	Modular	Straight run
Stocking density	1000–2000 fish/m^3 in tanks	Phase 1: 1000–2000 fish/ m^3 in tanks Phase 2: 500–1000/m3 in tanks	50–62 fish/ m^3 in ponds
Size at stocking	1.2–2.4 cm	Phase 1: 0.3–0. 5 cm Phase 2: 2.5–5 cm	1–2 cm
Size at harvest	5–8 cm	Phase 1: 2.5–5 cm Phase 2: 10–12 cm	10–15 cm
Feeding management	3–4 times daily using formulated pellets	Mixed feeding with live food (rotifers, copepods, *Artemia*, mysids, minced fish and formulated pellets)	Formulated pellets two times a day in ponds, trash fish two times a day in net cages
Water management	Flow through exchange	Flow through exchange in tanks, tidal flow in ponds (sometimes pumped)	Flow through exchange in tanks, tidal exchange in ponds
Stock management	Size grading every: 10 days	Phase 1: 2–3 times a week Phase 2: 1–2 times a week	Size grading every 5 days

Adapted from Biology and Culture of Asian Seabass Lates calcarifer (Jerry, 2013)

6.2 Grow-out culture

The mostly Asian seabass culture is practiced in Asia, employing cages that are fixed or float in coastal locations. These cages are 2-3 m deep and range in size from 3 m^2 to 10 m^2. The range of mesh sizes is 2 cm to 8 cm. Raising Seabass fingerlings or juveniles to marketable size is known as "grow-out culture." Furthermore, varying from 4-6 months to 8-12 months is the culture period (Cheong, 1990).

Asian seabass culture in ponds

Seabass have primarily been cultured in ponds in Thailand, Australia, and India using an intensive approach. Two culture systems—monoculture and polyculture are used in the pond culture of seabass. Nonetheless, the pond's architecture and site design are crucial to the culture's success (Aldon et al., 1997).

Criteria for selection of a site for Asian seabass culture

The site should always have a sufficient supply of high-quality water. The following are some of the fundamental standards for water quality. The culture site should experience modest tidal variations, ranging from 1.5 to 3 m. Avoid going in areas with acid-sulfate soil (Prema, 1997). Asian seabass requires some basic physico-chemical water parameters for good growth performance this all-water parameter are mentioned in Table 4.

Table4. Optimum levels of physicochemical parameters of pond water for nursery and grow-out culture of Asian seabass

Water Parameters	Nursery Culture	Grow-out Culture
Salinity (ppt)	20–32	10–30
Temperature (^{o}C)	25–32	26–32
Dissolved oxygen (ppm)	4–8	4–8
pH	7.0–8.5	7.5–8.5
Nitrite-nitrogen (ppm)	0.05	< 1
Unionized ammonia (ppm)	0.02	< 1
Transparency (cm)	30–50	30–50

Adapted from Madrones-Ladja et al. 2012, Jamerlan and Coloso 2010

Pond design and construction

The majority of seabass grow-out ponds have a rectangular shape, range in size from 0.5 to 2.0 hectares, and have a water depth of 1.2 to 1.5 m. Each pond has its inlet and outflow facilities, and the bottom should slope in the direction of the drainage side. Ponds are prepared before stocking using the methods used for nursery pond preparation (Kritsanapuntu et al., 2005).

Each day, a portion of the water in the pond needs to be changed by opening the water inlet gate to permit water to enter the pond at high tide. The water outlet gate is opened to let water out of the bottom as the tide goes out. To keep the water's high quality, do this. Doing so reduces organic waste build-up and fish illnesses (Arasu et al., 2008).

Monoculture of Asian seabass

This method involves only stocking the pond with juvenile seabass. 5–10 cm seeds are stocked at a rate of 5,000–10,000 per ha in a well-maintained pond. Following stocking, regular water exchange and feeding take place. The main obstacle to seabass cultivation is feeding. Currently, feeding is done primarily using trash fish in the chopped and crushed form twice or thrice daily in several countries worldwide, including India. Initially feeding at a rate of 40–50%, it eventually drops to 5%. 10% of the biomass is maintained as the overall feeding rate. However, by gradually introducing the feed during the initial stages of raising, Seabass can be easily weaned to an artificial pelleted diet. Seabass grows to 400–600g in size after 4–6 months of culture, producing 2–3 tonnes per hectare. The size will increase to 800 to 1200 g, and the production will range from 3 to 5 tonnes/ha if the culture time is extended to 8 to 12 months (Aldon, 1997).

Polyculture of Asian seabass

Along with other forage fishes like tilapia, seabass is cultivated using the extensive pond culture method. As tilapia does not sell well on the market, this fresh Fish is fed to seabass. Using fertilizers, lime, etc., this procedure gets the pond ready for a culture so that natural food growth can occur. Tilapia Fish are introduced into the pond at a rate of 10,000–15,000 per ha when an abundance of natural feed is seen in the pond. The male-to-female tilapia pond introductions have a sex ratio of one to three. Being a prolific breeder, Tilapia fingerlings and fry will be in great supply in the pond within one to two months of being reared. These juveniles will be the feed for the stocked Seabass seed.

The pond is stocked with seabass seeds (5 to 10 cm in size) from a nursery pond or cages. Typically, 3000 to 5000 seabass are stocked per hectare. In this method, additional feed is typically not needed. Once every three or four days, a 30 to 50% exchange of water is made. In other instances, supplemental feeding using less expensive feed materials like groundnut cake and rice bran is offered as feed for the tilapia to consume and grow into a healthy size as it is consumed by seabass. Southeast Asian nations are more accustomed to using this vast cultural method. Polyculture is used to produce seabass up to 2-3 tonnes per year (Aldon, 1997).

Cage culture of Asian seabass

In Thailand, Malaysia, Singapore, and Hongkong, seabass culture is extremely advanced. It is a very effective and financially viable culture method that can be employed to any degree, depending on the farmer's capabilities.

Net cages that are stationary or float can be used as cages. In places with more than 4 or 5 m of water depth, floating net cages are constructed, whereas stationary cages are used in areas with less than 3 to 4 m of water depth. The following factors should be considered when choosing a location for cage culture (Philipose et al., 2013).

Criteria for the site selection for cage culture

Protection from high winds and waves is necessary. Sites for this cage culture should ideally be in protected bays, lagoons, or inland seas. The area's water circulation should be adequate. Tidal fluctuation should be between one and five m. Strong water currents shouldn't be present where cages are being installed. Biofouler tends to stick to the cage structures, which causes clogging and less water movement. So, the site should ideally be far from the area of the sea where foulers are more prevalent. The chosen site's water quality needs to be free of sources of domestic, industrial, and agricultural pollution as well as other environmental dangers (Rao, 2012).

Floating net cages

To provide stability, the net webbing is constructed in the desired size and shape and then safely fastened to wooden, GI pipe, or bamboo structures. The ideal cage size should fall between 50 m^3 (5 m x 5 m x 2 m) to 100 m^3 (10 m x 5 m x 2 m). Sinkers of the proper weight are fastened to the bottom corners of the cages to keep them floating. Floating materials like plastic, styrofoam drums, or bamboo are used to keep the cages afloat (Philipose et al., 2013).

Stationary net cages

The bamboo or wooden poles that are inserted at the corners of these cages are secured. As a result, the cage becomes stationary and cannot be moved from that location. An inner and outer net mesh size of the cage is motioned in Table 5.

Table5. The mesh size of cage net

TL (cm)	Cage mesh size (mm)	
	Inner net	Outer net
7	10	18
15	18	36
20	28	36
25	36	50

Adapted from Biology and Culture of Asian Seabass Lates calcarifer (Jerry, 2013)

Management of cages

Following acclimatization, seeds from hatcheries are stocked at a density of 20 no./m^3 with a uniform size of 7 cm (5 g). The cage net is then changed to one with a larger mesh size, as seen below in Table 5. It is important to take precautions to prevent debris or fouler from adhering to and clogging the cage. Cleaning should be done daily, and any potential crab damage should be examined.

Grading frequently is preferred. Bigger Fish should be eliminated so that the Fish in the cages are of the same size.

Recirculating systems for Asian seabass culture

Intense production in a regulated indoor environment is the second method of on-growing Barramundi. Growout systems with recirculating tanks often employ fresh or brackish underground (bore) water and an amount of recirculation through filters (Rimmer & Russell, 1998). The main benefit of these systems is that provided water is readily available; they may be placed close to marketplaces. These systems' high levels of temperature and feeding control enable year-round production and quick development. However, compared to outdoor cage systems, construction and operating expenditures are typically higher (Hyde, 1998).

Stocking densities in recirculating systems are typically kept between 15 and 40 kg/m^3, depending on the technology and procedures employed. Barramundi can grow to market size (500 g) in 6 to 12 months at ideal temperatures. Also, it prevents environmental issues brought on by pond or cage culture operations from releasing nutrients into open rivers (Schipp, 1996).

Growth rate

After 4-6 months, seabass raised in cages reaches a weight of between 400 and 600 g. When the Fish are given more time to grow up to 8 to 12 months, their weight increases to 800-1200 g. In cage cultivation, production rates of 6 kg to 14.4 kg/m^3 are attained (Lucas & Southgate, 2003). Three countries, Indonesia, the Philippines, and Thailand, grow-out cultural practices are motioned in Table 6.

Table6. Grow-out culture practices for Asian seabass in Indonesia, Philippines and Thailand

	Indonesia	Philippines	Thailand
Culture System	Cages	Ponds or cages	Ponds, cages, pens, rice and fish culture
Stocking density	80–100/m^3 later 10–15/m^3	0.5–2/m^2 in ponds 30–50/m^3 in cages later reduced to 10–15/m^3	1–2/m^2 in rice fields 80-100/m^3 later 10–15/ m^3 in cages
Size at stocking	5–8 cm	10–12 cm	10–15 cm in ponds 5–10 cm in rice fields
Size at harvest	400–500	400–500	400–700 in ponds
Feeding management	Commercial Pellets 3–4 times daily	Trash fish, pelleted feeds 3–4 times daily	Trash fish, pelleted feeds 3–4 times daily
Water management	Tidal flow	Tidal exchange in ponds, pumps	Tidal exchange in ponds, pumps

Adapted from Biology and Culture of Asian Seabass Lates calcarifer (Jerry, 2013)

7. Feeding habits and management

Adult seabass or Barramundi eat primarily Fish and crabs since they are opportunistic predators. Although the seabass is thought to be a ravenous carnivore as an adult, juvenile seabass are omnivorous. The Fish is adept at ambushing or stalking prey. A study of the stomach contents of wild individuals (1–10 cm) revealed that small shrimp, Fish, and other invertebrates make up the majority of the remaining 20% of the stomach contents. More than 20 cm long Fish have a stomach that is entirely made up of animal prey, 70% of which are crustaceans (like shrimp and small crabs) and 30% of which are smaller Fish. At this stage, the majority of the fish species discovered in the guts are mullets and slip mouths or ponyfish (Leiognatus sp). (Mugil sp.) (Mathew, 2009).

Broodstock Diet

A high-quality diet comprising recently thawed whole mullet and squid is fed to broodstock barramundi. Typically, each piece of feed is between 10 and 20 cm in size. During the days that the Fish are not being fed, the tank is cleaned. The Fish are fed three times every week. A particular diet additive is added to the feed for the broodstock, and each serving of food is additionally infused with a vitamin combination (Schipp, 2007).

Larval Diet

At 28°C, seabass start eating 50 hours after hatching. The larval meal should be introduced early rather than later, though. After 60 hours without food, larvae will experience irreversible starvation, and at least 50% of them will perish. Each new food type should be introduced to larvae gradually. This is accomplished by progressively lowering the proportion of the previous food type while steadily raising the proportion of the new food type. Getting the Fish to recognize and accept the new meal particle is important. When Fish are weaned appropriately, feed loss and starvation-related fish mortality are reduced.

The utilization of live feeding species, such as rotifer (*Brachionus plicatilis*), Artemia (newly born nauplii, enriched nauplii, subadult or adult biomass), and the freshwater cladoceran Moina, is crucial for the successful development of seabass larvae.

As of the third day, the larvae are fed rotifers (*Brachionus plicatilis*). Up to the fifth day, algal water is introduced every day. The rearing tank's algal concentration is maintained at about 20,000 cells per millilitre. It is important to use high-quality algal water since there is a risk of contamination in open-air algal cultivation with flagellates, ciliates, and filamentous algae that are poisonous to fish larvae. The algae not only provide food for the rotifers but also aid in the transformation of toxic excretory products like ammonia and other metabolites in the rearing container into less toxic nutrients.

The rotifers in the larval rearing tanks are kept at a starting concentration of 20–30 nos/ml and increased to 40–50 nos/ml from the fourth to the eighth day. Fresh rotifers should be put into the tank each day to maintain the necessary concentration of food once the water has been exchanged. The larvae could not be ready to consume the large-sized rotifer in the early stages (3-5 days). The early larvae should therefore be fed small-size rotifers that are less than 120 after the rotifers have been removed from the tanks using appropriate mesh-size (100) cloth nets. Rotifers of various sizes can be fed starting on the sixth day.

From days 9 to 15, brine shrimp (Artemia) nauplii are fed alongside rotifers; from days 16 to 21, only Artemia nauplii are fed. As the raising days go on, the density of the nauplii in the medium is gradually increased to 6000 nos./l while being maintained at 2000 nos./l initially. By evaluating the unfed Artemia in the raising tank at the time of water exchange, the daily ratio is modified. By the 25th day, the larvae will be between one and five cm long, and the fry can be given Artemia subadult (biomass) in addition to prepared minced Fish or shrimp meat. The fry may also be gradually weaned onto artificial food (Arasu et al., 2008).

The nutritional content of such rotifers may be subpar in situations where they are unable to receive an adequate supply of marine microalgae. In these situations, the rotifers can be given an enrichment with specialized media by soaking them in cod liver oil or SELCO DHA for 12 to 18 hours. Through this procedure, the rotifers consume the enrichment medium, which is rich in the PUFAs necessary for larval growth. After being cleaned, the rotifers are fed to the larvae. Artemia nauplii/biomass can also be enhanced and fed in this way. At 25 days, seabass larvae can also be fed Moino sp. and other Cladocerans (Arasu et al., 2008).

Growout Feed

'Trash fish' or commercially available pellets made especially for this species are used to feed Barramundi. In Australia, only pellets are utilized; trash fish is frequently used in Asia. When fed trash fish, Barramundi are fed twice daily at a rate of 8–10% body weight for Fish under 100 g and 3–5% body weight for Fish above 600 g. To boost the weight of the feed at a low cost, rice bran or broken rice may be added, or vitamin premix may be put into the waste fish at a rate of 2%. Barramundi fed on trash fish typically has high food conversion ratios (FCRs), which typically range from 4:1 to 8:1 (Cheong, 1989).

Australian barramundi diets typically include 10% fat and 45% crude protein (CP). Extruded pellets that are semi-floating are typically chosen over sinking pellets because they are available to fish—which only feed at the surface or in the water column—for a longer period. In the summer, the Fish are fed twice daily, and in the winter, they are fed only once daily until they are satisfied. Farmers like to adjust feeding rates by observing the Fish's feeding behaviour. Hence automatic feeders are not being employed. Under experimental circumstances, pellet-fed Barramundi has attained FCRs of 1.0:1 to 1.2:1, although FCRs of 1.6 to 1.8:1 are typical in commercial farms. Seasonal variations in FCR (Barlow et al., 1986).

Even though sinking pellets are also well-accepted by the Fish, seabass appear to prefer a slow-sinking pellet diet. The Fish would readily adapt to the floating feed pellets if they were fed to them from the start. The cost and necessary feed management skills are two interrelated elements that should be taken into account when comparing sinking and floating pellet diets (Ali et al., 2012).

Although they are manufactured in less expensive Ring-die pellet mills, the sinking pellet feeds used in the field have produced the needed growth, production, and good FCR. However, it has been noted that feed management plays a crucial role. There is concern that an excessively sinking particle will harm the pond's soil and water quality by settling at the bottom. To track consumption and feeding rates, it is desirable to use slow-sinking and floating types of feeds, but there is a good chance that the pellets may settle at the sides and bottom of the pond, contaminating the soil and water (Ali et al., 2012). According to the body weight of the Asian seabass feeding rate, feeding times and which type of feed used is described in Table 7.

Table7. Suggested feeding schedule for Asian seabass during grow-out culture

Average body weight (ABW, g)	Feeding rate (% ABW)	Type of feed	Feeding frequency (times daily)
20-50	7	Starter	3
50-100	6	Starter	3
100-200	5	Grower	2-3
200-300	4	Grower	2-3
300-400	3	Finisher	2-3
400-500	2.5	Finisher	2-3

Adapted from Jamerlan and Coloso 2010

Live Tilapia

The seabass is raised alongside other Fish, like tilapia. Tilapia fry is consumed by seabass. Two months before seabass stocking, tilapia broodstock is introduced at a density of 2,000 fish/ha and a sex ratio of 1:1. 3,000–6000 fish/ha of seabass between the sizes of 10 and 15 cm are stocked. In certain instances, tilapia is raised in separate ponds, and the fry is harvested to feed seabass (Arasu et al., 2008).

Supplementary Feed

Small enough to fit in the Fish's mouth, chunks of fresh garbage fish are diced up. The size of the Fish affects how much is fed. For Fish with an average weight of less than 100 gm and more than 100 gm, the feeding rate is 8 to 10% of body weight and 3 to 5%, respectively (Arasu et al., 2008).

The main obstacle to seabass culture right now is the lack of floating extruded pellet feed. Fish are typically fed rubbish or feed with little market value when there isn't any good pelleted feed available. In the first two months of culture, the feed should be administered twice daily at a rate of 8–10% of the total biomass, at 6-7 A.M. and 6-7 P.M. After two months; feeding is only performed once per day in the late evening, at a rate of 2% to 5% of the total biomass. When utilizing extruded pellet feed, the recommended FCR for seabass is 1:1.2, whereas the observed FCR when using trash fish or farm-made feed is 1:5-7 (Biswas et al., 2010).

8. Sampling protocol

A. In cage

Fish samples were taken periodically to evaluate growth performance and separate the shooters weekly. Three random samples of 10 fish each from each net cage were used to measure the weekly mean length and weight changes. Initially, shooters were included in the samples to calculate the average body weight of the Fish that were growing. The shooters that were removed without replacement had a minimum size differential from the remainder of the stock of about 33% (Parazo et al., 1991).

Finally, using the sampling data, the average body weight of the Fish in each cage, excluding the shooters, was calculated, and the weekly diet was adjusted as necessary. Additionally, the weekly values and the value at harvest were used to calculate the cumulative number of shooters separated, while the mean final length, weight, and survival of Fish were recorded at the time of harvest. Weekly separated shooters were separated, kept in a net cage until the experiment's conclusion, and fed the same feed. During harvest, shooters from the isolated net cage had their final individual weights recorded, and the mean weight was determined. After sampling, fresh cages were put in place right after. After properly brushing away algae and silt that had clogged the mesh on used cages, they were dried in the sun (Biswas et al., 2010).

B. In pond

Step 1: After 30 DOC First one pond six cast net sampling was conducted.

Step 2: Calculate the cast net covering the total area and net opening efficiency.

- Cast net covering area A = πr^2, Unit - m^2 (π = 3.14)

Most of the cast net 12 (3.66 m) feet in diameter r = 6 feet (1.83 m)

- Cast net opening efficiency 70% may be.

A = πr^2 x opening efficiency of cast net 70%

= 3.14 x (1.83 x 1.83) x 0.7

= 7.36 m^2

Step 3: Calculate the average of six cast net numbers of seabass and the total weight of one cast net converted help of average.

- **Population Density =** Total No. Fish in Cast Nets / Total Area of Cast Net (m^2)
  = 176 / 7
  = 25 No. / m^2
- **Survival Rate %**

= Population Density x Total Area of Pond x 100 / Total Stocking Density

= 25 x 10,000 m^2 x 100 / 3,00,000

= 83%

- **Average Body Weight (ABW) / Mean Weight =** Total Weight (g) / No. of Fish

= 550 / 176

= 3 g (DOC 30)

- **Average Daily Weight (ADW) = ABW / DOC**

= 3 / 30

= 0.1 g

- **Biomass =** Population Density x ABW x Total Area of Pond x Survival Rate / 1000

= 25 x 3 x 10000 x 0.83 / 1000

= 622.5 kg/ha (DOC 30)

- **FCR** = $\frac{\text{Weight of feed given (kg)}}{\text{Weight of seabass (kg)}}$
- **FCE** = $\frac{\text{Weight of seabass (kg)}}{\text{Weight of food given (kg)}}$

9. Dieses management in Asian seabass culture

It is recognized that Barramundi is susceptible to a variety of illnesses, viruses, and parasites, some of which have significant biological and economic significance for the production of farmed Fish and others which are incidental (Schipp et al., 2007).

Non-infectious diseases

A. Deformities

Barramundi has a variety of abnormalities that have been identified. They include jaw deformities, missing opercula, and dorsal fin absence. Fast-growing Fish may have nutritional deficits or imbalances, including those in critical fatty acids, minerals, and vitamins, although the reason is unknown (Yue et al., 2022).

B. Cannibalism

Cannibalism is a behavioural feature that can result in the targeted Fish being eaten to death, or it can result in skin injury with secondary bacterial infection and death in the case of a fish that is too large to be eaten. Cannibalism, particularly at the fry or fingerling stage, may be a significant factor in losses in farmed Barramundi. Regular fish grading can prevent cannibalism by putting similar-sized Fish in each tank (Liu et al., 2017).

Viral diseases

A. Nodavirus

Nodaviruses cause viral encephalopathy and retinopathy (VER), also known as viral neurological necrosis, when they infect Fish's central nervous system, causing vacuolation and degeneration (VNN). Even though the precise cause of nodavirus infection is unknown, it looks likely that the virus is shed in the reproductive fluids of both male and female Fish and is present in or on fertilized eggs. Vertical transmission is the process by which an infection spreads from broodstock to progeny through reproductive fluids or eggs. Although it appears that vertical transmission from carrier broodstock is a key method of disease transmission (Parameswaran et al., 2008).

Although Fish as old as 7 weeks have been observed with the disease, evidence of nodavirus infection is often most prominent in larval Barramundi between the ages of 15 and 24 days. Fish that are infected typically have a pale appearance or have generalized dark colouring along with head-region inflammation. Fish that are affected typically swim erratically in spiral motions. Then comes death after these symptoms. Losses can be devastating and jarring. Polymerase Chain Reaction (PCR) or other molecular diagnostic methods may be used to determine the presence of a virus in the Fish, but this does not necessarily indicate that there will be any symptoms or that the Fish will die (Parameswaran et al., 2008).

B. Lymphocystis

Lymphocystis is a skin condition that affects Fish all over the world and is caused by a virus called iridovirus. Few reports of lymphocytes in Barramundi exist. Single or numerous nodular lesions in the skin, especially on the fins, are a hallmark of the condition. Lymphocystis illness has no recognized cure as of right now. Fish have a decent chance of recovering if they are kept in a clean environment. It is also thought that lowering the number of sick Fish kept in cages might help them recover (Schipp et al., 2007).

Bacterial diseases

A. Streptococcosis

The gram-positive coccoid bacterium *Streptococcus iniae* is the source of the severe, widespread infection known as streptococcosis. Both freshwater and marine settings are susceptible to the disease, which has a high mortality rate. Although streptococcosis has been identified in Australian Barramundi for some time. The gills seem clogged up. Visceral organs may have numerous internal haemorrhages visible on their surface. The skeletal muscle frequently displays a pink-red colouration (Suanyuk et al., 2010).

B. Vibriosis

Members of the genus Vibrio and several closely related genera are responsible for the severe, economically significant bacterial infection known as vibriosis. Several marine and estuary fish species are susceptible to vibriosis, which is commonly secondary to other triggering factors such as poor water quality, stress, and malnutrition. Clinical symptoms in Barramundi include included aberrant swimming patterns, opaque eyes, and abdominal reddening. Internally, the kidney, liver, and spleen may have regions of necrosis and haemorrhage (Ransangan et al., 2012).

C. Bacterial Gill Disease

Fry/fingerlings frequently suffer from bacterial gill disease (BGD), especially those who are exposed to environmental stress. As the name suggests, bacteria, primarily from the Flexibacterial group, cover the gills, thus suffocating them. There could be a quick demise and significant mortalities. Fish with the infection may be discovered dead, and their gills usually protrude. Fresh gills examined under a microscope reveal an enormous number of elongated, massive bacterial rods covering the gill epithelium. In early cases, lowering salinity may lessen the severity of infection since BGD may be responsive to salinity variation. The Fish may be treated using surfactant agents or agents that drain the mucus from the gills. Benzalkonium chloride, a quaternary ammonium compound, may be used to treat, but careful attention to dosage is required because these compounds become more harmful at lower water temperatures and in water with lower salinity (Hutson et al., 2013).

D. Epitheliocystis

Chlamydial organisms infecting the gills result in the illness of epitheliocystis. Severe gill disease is caused by heavy infections in young Fish and may have a high mortality rate. Infectious Fish may not exhibit any overt symptoms. Fish may swim close to the water's surface, and their gills may seem reddish. Death rates could be high. Large numbers of cysts may be visible in the gill's epithelium under a microscope (Hutson et al., 2013).

Fungal diseases

Red spot, also known as Epizootic Ulcerative Syndrome (EUS), has occasionally been found to infect several wild fish species, including Barramundi. Affected Fish typically have deep red or hemorrhagic sores on their body's skin. The eyes may also be affected and affected by ulceration. Fish that lose their energy may become easily preyed upon by other species. Raising the salinity of freshwater ponds has been a successful method of treating red spot epidemics (Schipp et al., 2007).

Parasitic diseases

A. Cryptocaryonosis

Cryptocaryon irritans infection of the skin, and gills result in cryptocaryonosis, often known as Marine Ich. *C. irritans* is a ciliated protozoan parasite that can seriously afflict cultured marine Fish, particularly in the tropics. It is not host-specific. Fewer organisms will be found in most Fish. One of the main parasite conditions affecting Barramundi housed in tanks for breeding is this one. It is most likely to happen when Fish are under stress, which lowers their resistance to illness, particularly after being caught in the wild. The Fish start scratching or "flashing" on the tank bottom or walls when the sickness first manifests clinically. The Fish become listless and lose their appetite as the illness worsens. The Fish's eyes become opaque if untreated, and their scales may get white patches or tiny ulcers. The salinity must be reduced from its typical range of 30-35 ppt to at least 15 ppt or less to be treated. Changing the salinity can be done quickly if necessary, although a 24-hour transition period is advised (Khoo et al., 2012).

B. Trypanosomosis

The blood protozoan Trypanosoma sp. is the disease-causing agent in trypanosomosis. One case of trypanosomosis was identified in the Northern Territory (NT) in July 2005 in sea-caged Barramundi which had a high mortality rate. Fish with the condition exhibit lethargy, sluggishness, apparent blindness, and even death. Exophthalmos with intraocular bleeding is seen, along with massive hemorrhagic ulcers and minor skin erosions caused by haemorrhaging. Trypanosomosis has no effective treatments currently. Intakes of ponds should be monitored to avoid admission of potentially contaminated Fish because the infection may result from infected Fish (Luo et al., 2019).

C. Oodiniosis

Fish living in marine or estuary environments have experienced low-grade mortalities as a result of protozoan Oodinium sp. infection of the gills and skin. The Fish start to scratch or "flash" as symptoms of the illness, which is related to cryptocaryonosis. With severe infections, dead Fish with mucoid and clogged gills may be discovered. employing copper sulfate and/or reducing the salinity (Schipp et al., 2007).

CONCLUSION

The aquaculture of Barramundi is expanding quickly, and there is a substantial opportunity for the sector to expand further. Throughout the past few decades, several significant improvements have been made, leading to significant gains in both knowledge and manufacturing efficiency. For the past ten years or more, improvements in barramundi feeding, disease control, and larval culture have been made quickly. Work on selective breeding, aquaculture in non-traditional locations, including inland saline zones, and increased focus on product quality are new paths for the business as it begins to mature.

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