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Nursing technique and growth environment of Rabbit fish (Siganus guttatus) in the area of Tam Giang lagoon, Thua Thien Hue

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1. Summary

In the area to the east of Hue city, in Vietnam, lays Tam Giang lagoon, one of Asia's largest lagoons, with an area of 22,000 hectares. This lagoon is suitable for aquaculture. One reason for this is because the salinity differs from sweet to salty in different parts of the lagoon. The Vietnamese Government advocates an increase in environmentally-friendly aquaculture and the fish *Siganus guttatus* (Rabbit fish) is a candidate for this. This fish eats mainly algae and can be cultivated in a polyculture. The purpose of this master thesis was to investigate how the fish *S. guttatus* are cultivated in nurseries. Focus was set on a farm located near the town of Tuan An, which cultivated the fish in cement tanks. What would be examined was growth in length and weight and various parameters of water quality where the fish were held. These results would then be compared to farms where fish were reared in earthen ponds on the shores of the Tam Giang lagoon. Only water quality and interviews with the farmers were made on the farms rearing *S. guttatus* in earthen ponds. Also an economic evaluation would be performed for the different farms.

One nursery (farm 1) rearing *S. guttatus* in cements tanks was visited during an 8 week period. During these 8 weeks the fish grew 3.1 cm and 1.7 g. The mean water parameters were: temperature: 28.4 ° C, salinity: 20.6 ‰, alkalinity: 140 ppm, pH: 7.7, DO 4.5 mg / L, TAN: 0.4 ppm. Three other farms (farm 2, 3 and 4) were visited for interviewing the farmer cultivating Rabbit fish in earthen ponds. At 2 of those farms (farm 2 and 3) also the water quality was analysed according to the same parameters as farm 1. The results from farm 2; temperature: 30 °C, salinity: 13 ‰, alkalinity: 60 ppm, pH: 8, DO: 3 mg/L, TAN: 0.2 ppm. The results from farm 3; temperature: 32 °C, salinity: 16 ‰, alkalinity: 120 ppm, pH: 7.5, DO: 4 mg/L, TAN: 0.2 ppm.

The management on the farms differed on some points. Farm 1 produced its own concentrate feed during the first month, consisting of fish meal, rice bran, cassava root meal, vitamins and probiotic (*Bacillus subtilis*). After the first month the fish got fed the same as on the other farms; industrially produced pelleted concentrate feed. In Addition, the fish were fed seaweed from the family of *Gracilaria*. None of the farms added chemicals to the ponds during cultivation of the Rabbit fish. One farm added saponins to the water between different cultivation batches. This to eradicate the fish that had swam in to the pond when the pond was refilled with new water. Two of the farms changed the pond water regularly, while a third added water from the lagoon to the pond after heavy rain. The fourth farm changed nothing in the pond during the rearing period.

Profits did not differ significantly between the farms that were reared in earthen ponds. However, the farm with cement tanks produced much higher profits per square meter. It was difficult to draw conclusions about differences between the different farming methods because of too few data.

2. Sammanfattning

I området öster om staden Hue i Viet Nam ligger lagunen Tam Giang lagoon, vilken är en av Asiens största laguner med en area på 22 000 ha. Denna lagun lämpar sig väl för vattenbruk då salthalten skiljer sig från söt till salt beroende på var i den man befinner sig. Den Vietnamesiska regeringen förespråkar en ökning av miljövänligt vattenbruk och fisken *Siganus guttatus* är en kandidat för detta. Denna fisk äter främst alger och gynnas av att födas upp polykultur. Syftet med detta arbete var att undersöka hur denna fisk odlas, från fångst i det vilda vid 1 månads ålder och upp till ca 4 månaders ålder. Fokuseringen kom att ligga

speciellt på en gård (gård 1) som odlade fisken i cement tankar och var belägen nära staden Tuan An. Det som skulle undersökas var tillväxt i längd och vikt samt olika parametrar på vattenkvaliteten i de cement tankar där fisken hölls. Detta hållningssätt skulle sedan jämföras med 3 gårdar där fiskar föddes upp i grävda jord-dammar invid stranden till Tam Giang lagoon. Där undersöktes vattenkvalitet (gård 2 och 3) samt skötsel (alla 3 gårdar). Även en ekonomisk beräkning skulle utföras för de 4 olika gårdarna.

Gård 1 besöktes under 8 veckor och tillväxten i längd och vikt på fiskarna var som följer; 3.1 cm samt 1.7 g. Medelvärdet för vatten parametrarna var; temperatur: 28.4 °C, salinitet: 20.6 ‰, alkalinitet: 140 ppm, pH: 7.7, löst syre (DO): 4.5 mg/L, totala ammoniak kvävet (TAN): 0.4 ppm. Resultat från mätning av vattenkvaliteten på gård 2; temperatur: 30 °C, salthalt: 13 ‰, alkalinitet: 60 ppm, pH: 8, DO: 3 mg/L, TAN: 0.2 ppm.
Resultat från mätning av vattenkvaliteten på gård 3; temperatur: 32 °C, salthalt: 16 ‰, alkalinitet: 120 ppm, pH: 7.5, DO: 4 mg/L, TAN: 0.2 ppm.

Skötseln mellan gårdarna skiljde sig på några punkter. Gård 1 tillverkade sitt eget koncentrat-foder innehållande fiskmjöl, riskli, cassavarots-mjöl, vitaminer och probiotika under den första månaden. Därefter utfodrades fiskarna likadant som på de andra gårdarna; med industriellt producerat, pelleterat, koncentrat-foder. Utöver detta utfodrades fiskarna med vattenväxter från familjen *Gracilaria*. Under odlingsperioden tillsatte inga av gårdarna några kemikalier till vattnet. En av gårdarna tillsatte däremot saponiner mellan fiskodlings-omgångarna. Två av gårdarna bytte vatten regelbundet, medan en tredje tillsatte vatten från lagunen efter kraftiga regn. Den 4:e gården förändrade ingenting i dammen under uppfödningsperioden.
Ekonomin skiljde sig inte mycket mellan de gårdar som hade uppfödning i dammar. Däremot hade gården med uppfödning i cement tankar en mycket högre vinst per kvadrat meter vid jämförelse med de andra gårdarna. Det var dock svårt att dra slutsatser om skillnader mellan de olika uppfödningssätten på grund av för få data.

3. Introduction

The Tam Giang lagoon is situated in the province of Thua Thien Hue. It runs along the coast and stretches for more than 70 km (Tuyen & Brzeski, 2000). The Tam Giang lagoon is one of the biggest lagoons in Asia and has an area of 22 000 ha. It is unique in its landscape and biological resources (Phap & Thuan, 2002). The water in the lagoon is brackish and gives many opportunities for different aquaculture production. The Tam Giang lagoon is well suited for aquaculture and can, according to the Vietnamese government, help the population living in the province of Thua Thien Hue with an increased income (Phap & Thuan, 2002). This can be done by helping villagers to begin working with aquaculture in the Tam Giang lagoon, which would lessen the exploitation pressure and lack in aquatic resources.

The Rabbit fish (*Siganus guttatus*) is cultivated in brackish waters and is very well adapted for aquaculture in the tropics (Duray, 1998). Some of the reasons are; they can maintain high reproduction in captivity, they have a low trophic level in the food chain (principally herbivore but can also eat feed of various origin, i.e. opportunistic omnivore) and the market acceptability for *S. guttatus* is wide. *S. guttatus* has also been shown to be a popular food fish for humans (Lam, 1974). Rabbit fish can be cultivated in many different systems such as net cage, floating cage, pond and tank (Duray, 1998). This gives farmers many different opportunities to cultivate the fish and earn a living. One problem with cultivating *S. guttatus* is the availability of fry for farmers. This is because of the difficulty of rearing the *S. guttatus* fry and the decrease in catches of fry in the wild. Artificial reproduction has not been successful with low survival rate of Rabbit fish fry (Juario et. al., 1985).

Problems have been addressed by the Vietnamese government with the conducted aquaculture in the county (Kongkeo et al., 2010). Issues as pollution of waters, diseases, and trash fish used as direct feed to fish (which will lead to a depletion of natural fish population) are becoming big problems. Especially the shrimp culture in the country has become a big environmentally problem regarding increasing pollution and spreading of diseases. Due to this, the government recommends polyculture of fish and culturing of herbivorous fish. *S. guttatus* is therefore a good candidate to culture.

The objective for this project was to study the rearing of *Siganus guttatus* with main focus on one farm located close to Tam Giang lagoon in Thua Thien Hue. The management, water quality, growth of the fish and how that influences the profit was studied on this farm. To compare with different culturing models other farms located in Tam Giang lagoon with a cultivation of *S. guttatus* in earthen ponds was also visited to question the farmers and measure the water quality.

4. Literature review

4.1 Water characteristics

4.1.1 pH

The acid balance of a solution is measured with pH. The hydrogen ion concentration of a solution is the negative logarithm to the base 10 and the scale runs from 0 to 14. pH is a factor that is very important when describing water quality (Chapman & Kimstach, 1996). pH has a big influence on a body of water regarding many biological and chemical processes. The hydrogen ion activity is at a given temperature indicating a solutions acidic or alkaline character. This processes are controlled by the solutions dissolved chemical compounds and the biochemical processes. The pH is mostly influenced by the concentration of CO_2, HCO_3^- and CO_3^{2-} and the balance between them. If there is a change in pH this can be due to effluents being present. Most natural waters have a pH of 6.0 to 8.5. If waters contain a lot of organic matter the pH can be lower. Salt lakes and eutrophicated waters can have higher values than 8.5.

4.1.2 Salinity

The salinity refers to the quantity of solids per gram, dissolved per kilogram of water (Day, 1999). Salinity ranges from 0 ‰ in fresh water to 40 ‰ and over in tidal pools and tropical lagoons. The average salinity in the open ocean is 35 ‰ and brackish waters have salinities between 0.5 ‰ and 30 ‰. The salinity in a water body has a big influence of what organisms that live in that specific environment.

4.1.3 Temperature

The temperature in a body of water undergoes changes according to the climatic fluctuations (Chapman & Kimstach, 1996). Surface waters temperature are affected by many different factors; season, altitude, latitude, time of day, cloud cover, air circulation and depth and flow of the body of water. The waters temperature in turn affects many processes in the water; physical, chemical and biological. The number of chemical reactions rises as the temperature increases as does the volatilisation and evaporation of substances from the water. A rise of temperature also leads to a decrease of solubility of gases in the water. In warm waters the metabolic and growth rate of living organism's increases and also the oxygen consumption and organic matter decomposition.

4.1.4 Dissolved oxygen (DO)

Oxygen is part of nearly all chemical and biological processes in a body of water. The content of dissolved oxygen (DO) is therefore essential when making a water quality assessment (Chapman & Kimstach, 1996). The DO is always changing in natural waters because of variations in temperature, salinity, turbulence, algae and plants photosynthetic activity and atmospheric pressure. The changes can occur seasonally and even on a 24-hour basis. DO concentrations decreases when biological respiration (ex decomposing processes) increases. Values of 5 mg/L and under may cause a lower functioning and survival of biological communities. If the DO reaches values under 2 mg/L most fish in the waters die.

4.1.5 Total ammonia nitrogen

One way to measure the nitrogen concentration in a body of water is to measure the total ammonia nitrogen (TAN) concentration which includes the un-ionized and the ionized forms of ammonia; NH_3-N+NH_4^+-N (Ehrlich & Cantin, 1995). Ammonia is produced by fish and other animals as a way to get rid of nitrogenous wastes, ammonia is excreted from the gills of the fish. The un-ionized form of ammonia is toxic. In a body of water there is equilibrium between NH_3 and NH_4^+ . When the temperature and pH rise, the concentration of NH_3 increases and thus the toxicity.

4.1.6 Alkalinity

When measuring water quality parameters it is common to determine also alkalinity apart from pH (Chapman & Kimstach, 1996). This is because alkalinity and acidity are reflecting the waters base and acid neutralising capacity. Acidity and alkalinity are inter-related with pH when the water has no capacity to buffer. The alkalinity is determined by the amount of titrated bases. The compounds are predominantly carbonate, bicarbonate and hydroxide. If a body of water has a low alkalinity (concentration of basic compounds) i.e. a low buffering capacity, the pH in the water body is easily changed from for example atmospheric, acidic deposition.

4.2 Tam Giang lagoon

Tam Giang lagoon is situated in Thua Thien-Hue province in Viet Nam, covers 22 000 ha and runs 70 km along the coast. This makes it one of the biggest lagoons in the whole of Asia (Juario et. al., 1985). The lagoon has two openings to the South Asian Sea and many rivers from the west connect with it (Figure 1). The North opening is called the Thuan An opening and the South, the Tu Hien opening. Here, the salinity is at its highest concentration in the lagoon. The two openings result in a mixture of fresh and salt water in the lagoon, with the salinity fluctuating depending on the season (wet and dry) and the flow distance from freshwater rivers and openings to the sea. In the dry season, the salinity changes between 25 and 30 ‰, while in the rainy season it changes between 0 and 5 ‰ (Ton, 2000).

This semi-closed system has fluctuations in the tides with up to 50 cm in the rainy season, which causes low lying areas to be flooded (Le Van et. al., 2000). During the dry season, however, the water flow is very weak. Because of the increasing aquaculture with nets and cages that disrupt the water flow in the lagoon, tidal currents have changed and thus the water quality is poor further into the lagoon and aquaculture can not be conducted in these areas.

Catching of fry in Tam Giang lagoon is mostly done with help of bottom nets which are set up in the opening to the sea (predominantly in the Tuan An opening) (Brzeski & Newkirk, 2000).

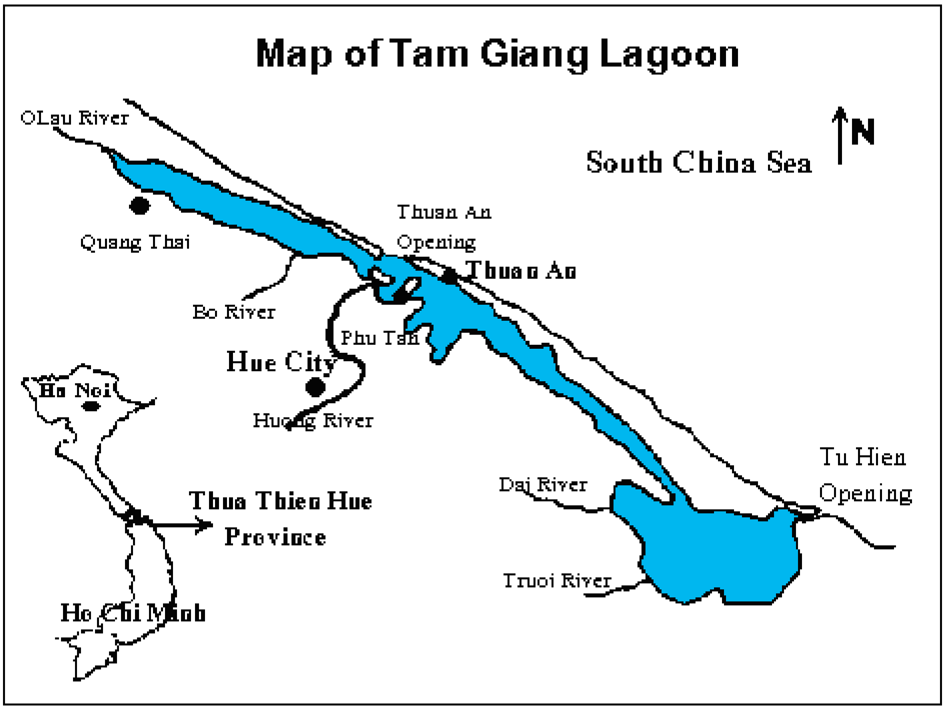

Figure 1. *Tam Giang lagoon (Phap & Tuan, 2002)*

4.3 Water quality management

Examination of the water quality is a very important step in fish culturing (Meybeck et. al., 1996). The water environment needs to be verified so that the intended culture needs matches with the actual quality of the water. An on going water quality assessment during the culture period helps to detect changes that may not be visible to the eye. Monitoring can also help to detect trends on the measured water quality parameters.

4.4 *Siganus guttatus*

Siganus guttatus belong to the group Rabbit fishes or siganids and the family name is *Siganidae* (Lam, 1974). This group of fish is common in the indo pacific region. *S. guttatus* are schooling fish. This makes it easy to cultivate in large densities. The Rabbit fish has become more and more popular to cultivate in Southeast Asia, primarily because the fish have a low trophic level, meaning, they can be fed seaweed. This is better for the environment as no trash fish are required as feed. Another reason for this growth in popularity is the increasing demand from consumers (Hara et. al., 1986a). Their natural habitats are according to Lam (1974) coastal areas, and they leave and enter rivers with the tide. One problem for farmers wanting to cultivate *S. guttatus* is the lack of supply of fry for stocking all year round (Hara et. al., 1986b). Farmers need to be careful when handling Rabbit fish, this because their fin spines contains venom that irritates the skin if they get in contact (Lam, 1974).

4.4.1 Spawning

The male Rabbit fish become sexually mature at an age of 10 months while the female mature later, at around 12 months of age (Juario et. al., 1985). According to studies by Rachmansyah et. al. (2007), Rabbit fish spawn at night (between 23.00-03.00) just before full moon. Other studies show that *S. guttatus* spawn between the new moon and the first quarter moon

(Rahman et. al., 2000; Susilo et. al., 2009). The Rabbit fish can spawn all year round (Hara et. al., 1986a). Rabbit fish that are ready to spawn show a swollen abdomen and changed behaviour, such as loss of appetite and frequent schooling movement (Rachmansyah et. al., 2007). At spawning the Rabbit fish produces between 250 000 and 500 000 eggs, the quantity is dependent on the size of the fish. A net is used as a substrate for the eggs to attach to so that they can be moved from the hatching tank to the nursing tank. The eggs that are not fertilized either float to the surface or sink to the bottom. During spawning the Rabbit fish change colour, the female turn darker while the male turn lighter with white spots on his flank (Hara et. al., 1986a). *S. guttatus* have shown no difficulties to spawn in captivity. Fish that are subjected to stress (such as handling) have been shown to spawn and thus without any need for hormonal treatment (Ayson, 1989). Rabbit fish that where not subject to any form of stress did not spawn. However, when fed with a lipid enriched feed, the fish have been shown to spawn without external stress (Hara et. al., 1986b). It is also possible to induce spawning in *S. guttatus* by injection of human chorionic gonadotropin (HCG) (Juario et. al., 1985).

4.4.2 After fertilization

Eight hours after fertilization it is possible to observe the development of the embryo (Rachmansyah et. al., 2007). After 14 hours, the heartbeat can be observed and past 18 hours, it is possible to note the embryo moving and the yolk sac appearing. The eggs hatch after approximately 20 hours.

4.4.3 Larvae and fry

When Rabbit fish larvae are hatched, they are transparent with an approximate length of 1.7 mm (Hara et. al., 1986a; Rachmansyah et. al., 2007). Around 6 hours after hatching the Rabbit fish larvae develop neuromast cupulae which are present until around 39 hours after hatching (Hara et. al., 1986a). During this early period, the larvae show high sensitivity to external stress and handling, which results in a low survival rate. After one day their length reaches approximately 2 mm and the yolk sac is reduced in size. On the second day after hatching, the yolk sac disappears and the fry opens its mouth and eyes, their total length is now around 2.1 mm. The digestive tract is also developed, so is the tail, pectoral fins and gills. The mouth is approximately 125 μm at this stage (Juario et. al., 1985; Rachmansyah et. al., 2007). After 2 to 3 days the fry's feed source is of exogenous origin (Rachmansyah et. al., 2007). The biggest problem for the young fry is to ingest feed because of their small mouth and the lack of feed of suitable size. Natural feed for the fry is rotifers. During day 3 and 4, after hatching, larval rearing trials have shown a high mortality rate (Hara et. al., 1986b). In the trial ingested rotifers had a maximum length of 162, 178 and 203 μm in 2, 3 and 4 day old larvae, respectively (Hara et. al., 1986b). Of the rotifer culture fed to the *S. guttatus* fry during this trial only 17 % where smaller than 162 μm. The survival rate of fry aged 2 to 4 days increased when the rotifer were strained through mesh plankton nets (80 and 100 in size). Up to day 6 after the larvae has hatched, most rotifers are still too big for the mouth of the fry. This causes big problems for farmers rearing fry of Rabbit fish. At day 8 the fry are approximately 4.4 mm long and at day 13 they are 7.9 mm long according to Hara et. al. (1986a). The fry grows quickly in length and has elongated fin spines which could deter predators as well as enhance flotation. The Rabbit fish reaches juvenile stage at approximately 45 days and are then 22 mm in length (Duray, 1998).

It is very important that the larval of Rabbit fish have a feed that is small enough to be ingested (Hara et. al., 1986b; Ayson, 1989). This has a great impact on the growth and survival of the fry. Kohno et. al. (1988) showed that feeding of exogenous feed started when the *S. guttatus* mouth had a size of 200 μm which was 55.5 hours after hatching. The ingested rotifer had a width of 125 μm. The width of the rotifers ingested was examined to be 55-70 % of the width of the *S. guttatus* mouth.

One commonly used rotifer is *Brachionus plicatilis* which is fed to the larvae when the fry begin to feed on exogenous feed (Watanabe & Kiron, 1994). This species is approximately 50 to 200 μm and is therefore suitable feed to *S. guttatus*. When the fry grow bigger, another species that is suitable as a natural feed is artemia (200-500 μm).

Kohno et. al. (1988) showed that high mortality of *S. guttatus* fry occurred at different growth stages and when changing from endogenous to exogenous feed. Thus, the feeding of the larvae plays a very important role for the survival.

The Rabbit fish are tolerant to a range of salinities (Hara et. al., 1986a). In a study by Hara et. al., (1986b) it was shown that salinities ranging between 20 to 32 ‰ did not effect incubation and hatching of the fry. Young & Duenas (1993) recommend that the salinity should be 32 ‰ for spawning and fertilization of *S. guttatus* eggs. To attain a survival rate over 50 % it is also recommended that the eggs are kept in a salinity range of 14 to 37 ‰. For the highest survival rate of the eggs and larvae, the salinity should gradually be changed to 16 ‰.

Hara et. al. (1986b) argued that the biggest problem to cultivate *S. guttatus* is the survival rate of the fry which has been shown to be very unpredictable. The reasons are believed to be the condition of the broodstock and the feed to larvae. If the broodstock are not in a good condition they can not produce viable progenies. In a study by Juario et. al. (1985) the most critical period was between days 3 and 5. At day 4 the yolk and oil globule were resorbed and the larvae was dependent on external feed. Without a proper feed source the larvae would die.

4.4.4 Feed to S. guttatus

S. guttatus, in its natural habitat, are primarily herbivores, but in captivity they can be fed a range of feedstuffs (Lam, 1974). When looking at siganids anatomy it is shown that they are well adapted to feed of plant origin, with features such as thick walled, very long and coiled intestines. It has also been shown, however, that Rabbit fish in their natural habitat consume feed originating from animals, for example fish larvae, amphipods and sponges. In cultures they receive both natural feed (algae) and pelleted, concentrate feed. If only given algae the Rabbit fish will not grow at an optimal rate. It was shown in a study by Parazo (1990) that *S. guttatus* had the best growth when fed a ration high in energy (3832 kcal/ kg feed), and that had a high content of crude protein (45 %) in addition to carbohydrates and fat. The higher energy content of the ration was in the study derived from increased percentage of dextrin and cod liver oil. The higher growth can be explained by that *S. guttatus* are able to utilize carbohydrates and fats as energy, allowing the protein to be used for growth. The fish which received the lowest amount of protein (25 % of total ration) gained the least in weight. Rabbit fish which received a ration high in energy (3832 kcal/kg) compared to a ration low in energy (3161 kcal/kg) had more fat in the carcass. This extra fat can serve as an energy reserve if the fish is moved to a pond with lower feed supply. According to Parazo (1990) the most economic ration contained 35 % protein and was high in energy (3832 kcal/kg).

The broodstock's feed have been shown to be very important with regard to survival of larvae (Hara et. al., 1986b). When fed a diet of 18 % lipids the survival rate was significantly higher compared to diets containing 15 or 12 %. The feed given to the broodstock influences the development of the yolk and oil globules, which the larvae are dependent on the first days after hatching (Ayson, 1989).

Farmers feed *S. guttatus* with seaweed and then usually from the group; *Gracilaria*. *Gracilaria* is a group of warm water seaweeds that is common to grow in South East Asia but is widely distributed in almost the whole world (FAO, 1990). The biochemical composition of one *Gracilaria* species (*Gracilaria changgi*) was examined by Norziah & Ching (2000); protein 6.9 %, total lipids 3.3 %, fiber 24.7 %, ash 22.7 %. Of the total lipids, 74 % was unsaturated fatty acids, which most of them were omega fatty acids. Of the protein, 16 amino acids were found, of which all of the essential amino acids for humans were present.

4.4.5 Cultivation of S. guttatus in Viet Nam

S. guttatus has in the Philippines been reported to grow to a length of 50 cm (Von Westernhagen & Rosenthal, 1976). When culturing Rabbit fish in Viet Nam fingerlings are caught from the wild and placed in a nursery pond, which can be an earthen pond or cement tank. This occurs in May when the *S. guttatus* fingerlings are around 1 month and can be found along river beds and in shallow waters (Le Van et. al., 2000). The Rabbit fish are cultivated in the nursing pond for approximately 3 months and are then sold and transferred to a grow-out pond (Nguyễn, 2011). The culture in the grow-out pond is most commonly a polyculture with crab and shrimp together with the fish. The culture in the nursery pond is a monoculture. The Rabbit fish are cultured in the grow-out pond for 4 to 6 months and are then harvested in spring and they have then a weight of 200-400 g / fish.

4.5 Different culturing systems

4.5.1 Pond

Pond culture is the most common system to grow fish in Southeast Asia (Rabanal, 1994). Ponds can be situated either inland or along the coast and this system is mainly land-based. Ponds are constructed at the shore-line of Tam Giang lagoon where it is shallow (2 metres) (Le Van et. al., 2000). When building ponds the ecosystem changes in the lagoon due to destruction of sea grass and freshwater macrophyte beds and also the nursing ground for many fry and juvenile aquatic species. The lagoon area is also diminished which has an impact on the distribution of species, both native and migratory from the sea.

Figure 2. A earth pond in front with cultivation of Rabbit fish. To get to the pond a "monkey bridge" needs to be crossed (photo, Cecilia Stattin).

4.5.2 Cage and net

The second most used aquaculture system in Southeast Asia is the use of cages or nets (Rabanal, 1994). This way to culture fish is very cost effective due to use of common area to cultivate the fish and a low price for the cage and net. Cages and nets can be used in many different water resources, such as; reservoirs, lakes, rivers, coastal coves and bays. This method is not vulnerable to floodings (Gonzales et. al., 2006). Nets and cages allow the water to naturally exchange and maintain the natural environment in the enclosure (Le Van et. al., 2000). However, it also hinders the natural water currents and the migration of fry in the lagoon. With a lack of nursing grounds due to pond construction and the use of these kinds of culturing systems, the natural occurring fish in Tam Giang lagoon will decrease rapidly. The use of nets and cages in Tam Giang lagoon is increasing at a high rate and the public area used for mobile fishing is decreasing fast.

Figure 3. To the left a picture of a cage for fish cultivation, to the right a picture of a net used for catching fish in Tam Giang lagoon (photo, Cecilia Stattin).

4.5.3 Cement tank

Cement tanks are occasionally used to cultivate Rabbit fish, although they are not the main fish species grown in this system (Nguyễn, 2011). It is most often shrimp which are cultivated in cement tanks and when not being used for this cultivation, Rabbit fish may be utilized to avoid losing money on empty tanks.

Figure 4. A picture showing cement tanks indoor which at the time were used for cultivating Rabbit fish (photo, Cecilia Stattin).

4.5.4 Cultivation period

Agriculture and aquaculture practises in Viet Nam follow the lunar calendar which is a lunisolar calendar (Brzeski & Newkirk, 2000). The year consists of 12 months with 29.5 days per month which means that each year is 355 days long. To keep it in synchrony with the solar year an extra month is added every third year. The end and beginning of the months are indicated by the new moon. The eleventh month begins on a new moon, the day before or the day of winter solstice (Ho, 2012). This means that the beginning of the New Year (month 1) starts between mid January and mid February every year. The lunisolar calendar is more accurate when it comes to following the seasons (start and end of rainy season) than the solar calendar which is used in most western countries.

Most of the aquaculture in Tam Giang lagoon is conducted during the dry season (Brzeski & Newkirk, 2000). During the rainy season temperature and salinity fluctuations in the water can cause the fish to die. Another big problem during the rainy season is the floodings. Harvests from earth ponds are completed before the floods come in. During the rainy season many fishers stop their operation due to low catches (Ton, 2000).

The *S. guttatus* normally breed in March and April. Therefore, the fingerlings are caught by fishermen in May and cultivated in either earth- or cement ponds. The factor that is most limiting to increase Rabbit fish production is the supply of seed (Juario et. al., 1985)

4.6 Sustainability

There are different aspects of sustainability that are important in aquaculture. Kutty (1995) described production technology, economical, social and environmental aspects as being most important to aquaculture in Southeast Asia. The main goal in conducting aquaculture may not be to have a maximum output, but to have a sustainable production that will provide the farmer with a stable income. It is also important that production is conducted according to the farmer's specific conditions. When environmentally friendly aquaculture is carried out the probability is much higher that the business will be economically sustainable.

One problem with raising *S. guttatus* is the lack of fry. This is because larvae mortality is very high when hatched in tanks and out of their natural habitat. This poses a big problem for the farmers rearing fry of *S. guttatus* because they are then dependent on wildly caught fish (Gonzales et. al., 2006). The catches of fry have lately declined, due to over-fishing, and if continued, will lead to a degradation of the ecosystem. In order to cultivate *S. guttatus* in a sustainable way it is important to develop methods for high survival rate of the larvae and fry from broodstock.

Most of the people living around Tam Giang lagoon are very poor (Le Van et. al., 2000). They live off mobile fishing in the lagoon, as other forms of aquaculture require investments which they can not afford. Their way of earning a living with mobile fishing gear is hindered by the nets, cages and ponds that are increasing in the lagoon. When the lagoon area is converted to aquaculture, it changes from being public to only benefiting a few people and the poor who operate this mobile fishing must travel further to find suitable grounds to catch fish. Though the aquaculture conducted with nets, cages and ponds can be more sustainable regarding over-fishing, the poor fishers have a harder time earning a living.

4.7 Economic efficiency

The economic efficiency is very dependent on which system that is in use and the degree of intensity that is used at the specific farm (Rabanal, 1994). An intensive production with a lot of input can make the business vulnerable, for example to flooding and disease. An extensive culture that is adapted to the conditions of its surroundings and that is conducted environmentally friendly is much more likely to become economically sustainable.

5. Field study

5.1 Material and Methods

The objective for this project was to study the rearing of *Siganus guttatus* with main focus on one farm located close to Tam Giang lagoon in Thua Thien Hue. The management, water quality, growth of the fish and how that influences the profit for the different culturing models was studied on this farm. The management and profit was studied through interviews with the respective farmer. The question asked to the farmer can be seen in appendix 1. The measured water quality parameters and growth of Rabbit fish was tested according to Table 1. Other farms located in Tam Giang lagoon with a cultivation of *S. guttatus* in earthen ponds were also visited to question the farmers and measure the water quality, the methods were the same as for farm 1 described above.

The study was carried out by measuring water environment and growth of *S. guttatus* once every week, for a total of 7 weeks, at a farm (referred in this paper as farm 1) near Tuan An city, see Table 1 for measurement and parameters. The fry were cultivated in cement tanks and caught from the wild (Tuan An inlet). Visits to earthen ponds around Tam Giang lagoon were made to investigate the water environment, feed and management of *Siganus guttatus*, by measure water quality parameters and through interviewing the farmers. A total of 4 farms were visited.

Table 1. *Measurements in the cement tank water on the farm near Tuan An (farm 1)*

Parameters	Type of test	Unit
Salinity	Gravitational test. Whole numbers from 0 to 30	Parts per thousands (‰)
pH	Titrating of chemical reagent, colour result from titrating compared with colour scheme. Test values from 6.7 to 9.1 (with 0.3 leaps) Testkit: Cong ty co phan chan nuoi C.P. Viet Nam	
Total ammonia nitrogen (TAN)	Titrating of chemical reagent, colour result from titrating compared with colour scheme. Test values: 0; 0.2; 0.5; 1; 2; 5. Testkit: Aqua am; Advaned Pharma CO. LTD.	Parts per million (ppm)
Alkalinity	Titrating of chemical reagent, number of drops until change in colour were counted and compared with scheme. Testkit: Aqua base; Cong ty co phan chan nuoi C.P. Viet Nam	ppm
Dissolved oxygen (DO)	Titrating of chemical reagent, colour result from titrating compared with colour scheme. Testkit: aqua DO; Cong ty co phan chan nuoi C.P. Viet Nam	mg/l. (measured from 11/9)

Temperature	Analogue thermometer	Celsius (°C)
Length of fry	Measured by picking up the fish to a paper that was mm marked, 15 fry where every time measured and mean length was calculated.	Millimeter (mm)
Weight of fry	Measured on a household scale where 30 fish were collected from the cement tank, placed in a bucket with water and weighed on the scale. (On 2011-09-11 it was only possible to catch 22 *S. guttatus* for measuring the weight)	Milligram (mg)

Other information about the cultivation at the different farms where collected through interviewing the farmer in charge (see appendix 1).

5.2 Presentation of farms

5.2.1 Farm 1

Farm 1 was the main farm for this project work, where most of the work was conducted. Visits were made once every week for 7 weeks. The farm had cement tanks located both indoor and outdoor (see Figure 5). Outdoors the tanks were covered by a roof to keep the water in the shade. The farm was located near Tuan An city close to the shoreline of South Asian sea. When the study was conducted shrimp and Rabbit fish was cultivated in different tanks on the farm. Rabbit fish length and body weight was measured, the water was tested on several different quality parameters (see table 1 for details). During the first month the Rabbit fish received on farm-made concentrate feed high in protein, that can be seen in Figure 5 to the right on the net. Month 2 and 3 the Rabbit fish got fed pelleted industrial feed. During the whole nursing period also seaweed (*Gracilaria*) were fed to the fish.

Figure 5. *Picture to the left shows one cement tank on farm 1 located outdoor, picture to the right shows a cement tank located indoor with concentrate feed on the net by the wall and gracilaria hanging on a string into the water (photo, Cecilia Stattin).*

5.2.2 Farm 2

Farm 2 was visited 2011-09-16. The Rabbit fish were cultivated in an earthen pond with a size of 1500 m² (see Figure 6). The pond was stocked with 10 000 Rabbit fish caught in Tuan An sea door. Farm 2 was located on the eastern shore of Tam Giang lagoon approximately 10 km south of Tuan An city. The Rabbit fish were cultivated in the same pond for 3 months and then moved to a grow-out pond. The fish were fed both industrially-made, pelleted, concentrate feed and seaweed (*Gracilaria*). The farmer was interviewed and the water parameters described in table 1 was tested.


Figure 6. *The picture to the left shows the interview with the farmer owning farm 2, the picture to the right shows the earthen pond that in this project was called farm 2 (photo, Cecilia Stattin).*

5.2.3 Farm 3

Farm 3 was visited 2011-09-18. The earthen pond that was used for the Rabbit fish culture (see Figure 7) was 2500 m², 23 000 fry were bought in and cultivated for 3 months. The farm was located on the eastern shore of Tam Giang lagoon, close to Tuan An city. The ration consisted of both seaweed and industrially-made, pelleted, concentrate feed. An interview was made with the farmer as well as measurements of the water quality according to table 1.


Figure 7. *The picture to the left shows the owner of farm 3 feeding the Rabbit fish with the industrially-made concentrate feed, the picture to the right shows the earthen pond that in this project was called farm 3 (photo, Cecilia Stattin).*

5.2.4 Farm 4

Farm 4 was visited 2011-08-28. The Rabbit fish were cultivated on an island in an earthen pond in Tam Giang lagoon close to Tuan An city (see Figure 8). The Pond was 800 m² with 20 000 fish fry that were cultivated for 3 months. The pond was owned by the same man that was running farm 1. The Rabbit fish was given the same feed as farm 1 and also the same *Gracilaria* that was cultivated in a pond on the same island as farm 4 was located. An interview was made with the farmer owning farm 4.

Figure 8. *The picture to the left shows the earthen pond that in this project was called farm 4, the picture to the right shows the earthen pond were the farmer owning farm 4 grew gracilaria (photo, Cecilia Stattin).*

6. Results

6.1 Water environment

The water environment was tested 8 times during a period of 7 weeks on farm 1. The numbers from the testing are shown in Table 2. For a more schematic view see Figure 10. All parameters changed during the project period. pH and TAN were the parameters that changed the least with a standard deviation of 0.2 and 0.3 respectively. Salinity showed the largest change, with a standard deviation of 3.3.

The water environment was analysed at 2 other farms (farm 2 and farm 3) which cultivated the Rabbit fish in earth ponds on the shoreline of Tam Giang lagoon. Both were situated on the eastern shore but on different latitudes**.** Results from farm 2 and 3 environment measurements are shown in Table 3. A fourth farm (farm 4) was also visited. On this farm the farmer was only interviewed and no water parameters were analysed.

Table 2. *Results from water measurements on farm 1, from 8 different dates during a 7 week period, rearing S. guttatus in cement tanks near Tam Giang lagoon*

Farm 1	Max	Min	Mean	Standard deviation
Temperature (°C)	30	25.5	28.4	1.4
Salinity (‰)	27	16	20.6	3.3
Alkalinity (ppm)	190	110	140	24.5
pH	7.9	7.5	7.7	0.2
DO (mg/L)	6.0	3.0	4.5	1.5
TAN (ppm)	1.0	0.2	0.4	0.3

Table 3. *Results from water environment measurements on farm 2 and 3, from two different dates rearing S. guttatus in earthen ponds on the shoreline to Tam Giang lagoon*

	Farm 2 2011-09-16	**Farm 3** 2011-09-18
Temperature (°C)	30	32
Salinity (‰)	13	16
Alkalinity (ppm)	60	120
pH	8.0	7.5
DO (mg/l)	3.0	4.0
TAN (ppm)	0.2	0.2

Farm 3 shows a higher temperature than both farm 2 and especially farm 1, where the mean temperature was 28.4 °C. The salinity for farm 2 shows a very low value (13 ppm) compared to farm 1 and 2, 20.6 ppm and 16 ppm respectively. Farm 2 also shows a low value for alkalinity (60 ppm) compared with the other two farms.

6.2 Growth of *S. guttatus*

The result of the measurement of growth, length and weight of the *S. guttatus* fry at farm 1 can be seen in Figure 9. At the first occasion the fry had been at the farm for 10 days (approximately 40 days old), they then weighed 0.5 g/ fish and had a length of 2.7 cm. During the last occasion for measurement, the weight per fish was 2.2 g and length per fish had increased to 6 cm. A more schematic view of the fish growth from farm 1 can be seen in Figure 10. Note that the scale on the x-axis (10 day leaps) does not follow the dates when the farm was visited (7 day leaps with 1 extra visit the first week).

The growth rate changed during the period of the project, from being positive (increasing weight and length) to some periods of negative growth rate (weight loss and decreasing in length). In Figure 9 negative growth (weight and length) can be seen. This is most likely an error and is due to too few individuals being tested, that does not display the true values of the Rabbit fish population.

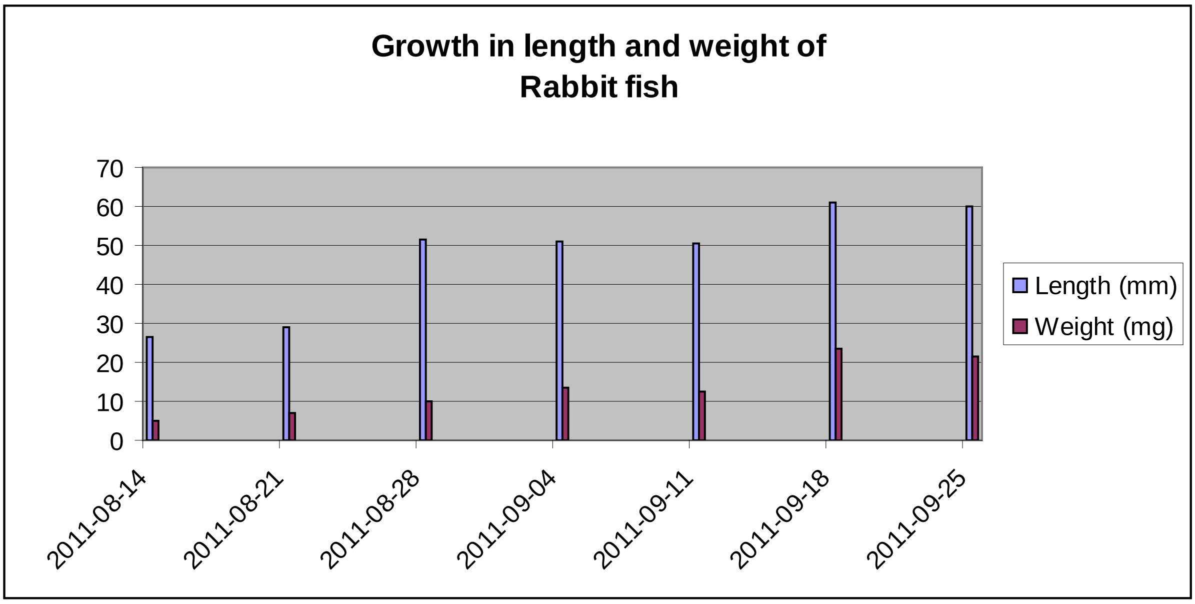

Figure 9. *Results from 7 different measurements of length and weight of S. guttatus on farm 1.*

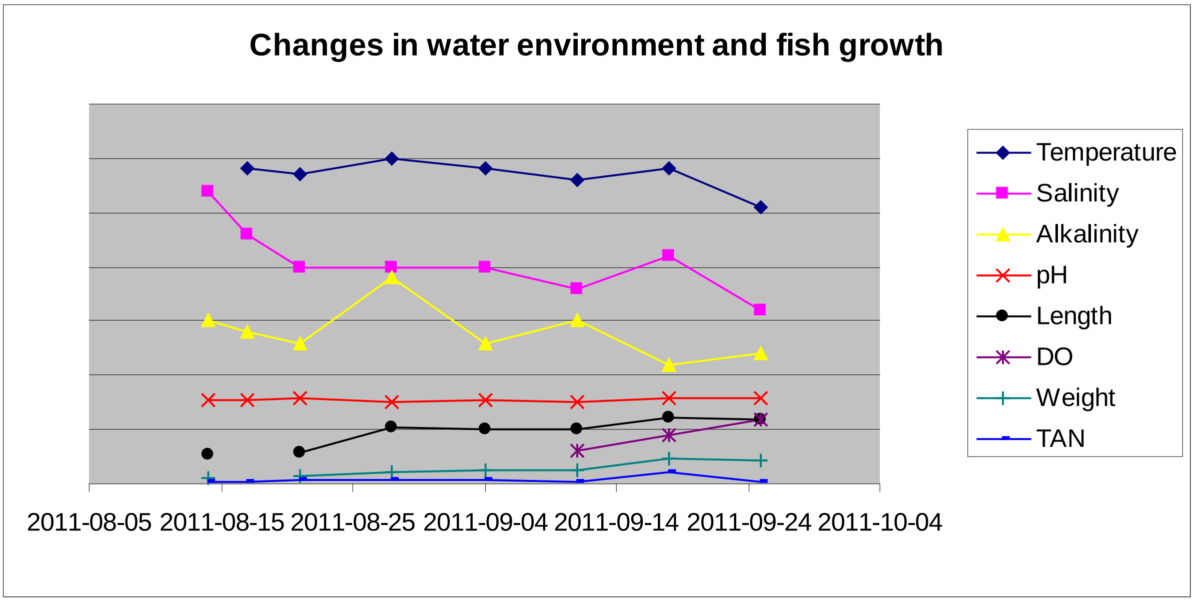

Figure 10. *All collected data from farm 1 on water environment and S. guttatus growth that gives an overlook on the relations between the different parameters.*

6.3 Management

6.3.1 Farm 1

The *S. guttatus* fry at this farm were only reared in cement tanks. When caught from the wild (with the age of approximately 30 days) in Tuan An sea door, the fry were first placed in cement tanks, indoors, measuring 4m² with room for 2000 fry in each. There were 5 similar cement tanks. After 2 weeks the Rabbit fish were moved to a cement tank outdoor that was 20 m² with 10 000 fish with a stocking density of 500 fish/ m². The *S. guttatus* received concentrate feed 3 times per day, after approximately 1 week they were also fed seaweed (*Gracilaria*). The seaweed was given to the Rabbit fish during the whole nursing period (2 to 3 months). The fish received around 20 % concentrate feed in relation to their body weight. This meant that the ration changed, mostly every second week. The first month the Rabbit fish received an on farm-made concentrate feed. Month 2 and 3, the fish would receive industrial-made, pelleted, concentrate feed. The amount of the different ingredients of the on farm-made feed would change between the ages and weights of the fish. One example of how the concentrate was mixed together;

1. 50% Fish meal (38-40% CP)
2. 30% rice bran
3. 15% cassava root meal
4. 2.5% vitamin (B1-B12)
5. 2.5% probiotic (*Bacillus subtilis*)

The amount fed to the fish was 20% of body weight.

6.3.2 Farm 2

The fry cultivated on farm 2 were caught in Tuan An sea door. The Rabbit fish were cultivated in an earthen pond with a size of 1500 m² and a stocking density at the start of the culturing period of 6.7 fish/ m². Prior to stocking the pond was emptied from water and let to sun dry. After this the pond was filled with water from Tam Giang lagoon and fish from the surrounding waters sometimes got in to the pond trough the pond let in. To kill off the unwanted fish saponins were added to the water, as saponins are toxic to fish (Francis et. al., 2002).

The first 15 days after stocking, the fish fed from natural resources in the pond, after this time they received industrial produced, pelleted, concentrate feed and *Gracilaria*, probiotic was also supplemented. The concentrate was fed 2 times per day (total 2.5 kg feed/day). Survival rate from the nursery pond was 60 %. No actions were taken if disease occurred in the pond. Nothing was changed in the pond during the culture period of the fish, no cleaning of the pond or addition/removal of water. Feed was the only thing added to the pond from stocking. The most difficult part of culturing Rabbit fish, according to the farmer, was the weather and disease that lead to death of the fish. Especially difficult was a special weather phenomenon occurring in the summer (May, June). The phenomenon often happens during the afternoon and includes thunderstorm, rain, very muggy and warm air temperature. If there then is a lot of organic material in the pond, this will decompose and toxic gases will be produced; ammoniac, nitrite, hydrogen sulphide and methane (Patin, 2012). This will then cause death of fish in the pond. This weather occurs a few times per year and is very problematic for the farmers.

6.3.3 Farm 3

The Rabbit fish were cultivated for 3 months in an earthen pond with a size of 2500 m². 23 000 fry from Tuan An sea door were stocked in the pond, with a stocking density of 9.2 fish/ m². The Rabbit fish culture had a survival rate of 50 %. The fish were fed *gracilaria* (1 ton/ 10 days) and 1.5 kg industrially produced, pelleted, concentrate feed (per day). The pond was only cleaned between batches of fish, but if it was flooded new water from the lagoon was added (usually in the morning). The greatest difficulty with culturing Rabbit fish is the dependency to the weather conditions. When the sun shines the fish have a good growth rate, but when it is raining the fish grows poor and easily die.

6.3.4 Farm 4

This farm had an earthen pond with a size of 800 m². The pond was stocked with 20 000 fry, with a stocking density of 25 fish/ m², that were caught in Binh Dinh province. The Rabbit fish had the same age as the stock cultivated in farm 1. The Rabbit fish were fed concentrate feed (same as farm 1) 3 times per day and the farmer also placed wound balls of *Gracilaria* in the pond from early morning until 11 am each day (see Figure 5, right picture). Every second day the water was changed, 1/3 of the water were let out to a dike next to the pond and new water from the lagoon were pumped in. No actions had to be made to prevent disease because no diseases were prevalent. All fish in the pond was harvested at the same time.

6.4 Economy

The calculations on the economy for the 4 different Rabbit fish cultures can be seen in Table 4. Farm 1 and 2 show similar cost but farm 2 has higher income than farm 1. Farm 4 has a slightly lower cost and higher income than farm 3 which result in a higher profit, both per batch and square meter. Farm 3 and 4 has the highest income and also the highest costs, compared with farm 1 and 2. Farm 1 has the highest profit per square meter compared with all farms, but the lowest profit per batch. Farm 4 has the highest profit of all farms per batch. The calculations can be seen in appendix 2.

Table 4. *Results from the economical calculations on the 4 different farms culturing Rabbit fish near and in Tam Giang lagoon*

	Farm 1	**Farm 2**	**Farm 3**	**Farm 4**
Cost	2 650 000 VND	2 440 000 VND	10 945 000 VND	10 000 000 VND
Income	10 400 000 VND	15 600 000 VND	23 000 000 VND	24 700 000 VND
Profit/batch	4 750 000 VND (2 205 SEK)	11 860 000VND (5 506 SEK)	12 055 000 VND (5 597 SEK)	14 700 000 VND (6 824 SEK)
Profit/m²	237 500 VND (110 SEK)	7 907 VND (4 SEK)	4 822 VND (2 SEK)	18 375 VND (9 SEK)

7. Discussion

7.1 Water environment

Water quality parameters were measured at farm 1, 2 and 3. A small difference in water temperature and salinity could be detected between farm 1 and farm 2 and 3. Farm 2 and 3 had a more natural water environment than farm 1. This would be because the cultivation was conducted in earth ponds and the water was not changed. The water environment on farm 2 and 3 were only tested once and are therefore only indications and no definite conclusions can be made. The water on these farms were also allowed to better follow the natural environment changes because the production was in earth ponds and more close to the natural conditions (for the fish) compared with the conditions on farm 1. The temperature on farm 1 followed the air temperature to a great extent even though the cultivation was in cement tanks and under roof. The temperature on the other farms (in earth ponds) was also dependent on the cloud cover since they did not have any roof or cover over the pond water. It is therefore possible that the temperature fluctuated more in the ponds at farm 2 and 3.

The alkalinity showed big fluctuations on farm 1. The carbonate and bicarbonate content was in every measurement equal to each other but the total amount differed throughout all measurement opportunities. Farm 1 showed slightly higher values on alkalinity. One reason for this could be the cement that the tanks were constructed of. Cement contains carbonate and it is possible to think that the carbonate could be transferred to the water in the tank. Farm 2 and 3 had very different values on the alkalinity as well. One factor that can affect the values on the alkalinity is the test itself. The test bottles were difficult to handle which affected the size of the drops that was titrated. This could be true for all the titration tests which mean that the accuracy of the tests was not so high.

The pH did not differ despite changes in alkalinity. It was not possible to observe any relationship between pH and the water temperature. The water had a good buffering capacity which made the pH to stay stable. The pH value for farm 2 and 3 were in the same range as for farm 1. The pH for farm 2 was slightly higher than farm 2 and 3. This could possibly have a relationship with the alkalinity on farm 2 that had a value of 60 ppm, this value was lower than both farm 1 and 3. The low alkalinity (low buffering capacity) could then give rise to a slightly higher pH.

DO was only measured at farm 1 at the 3 last test occasions. The test kit was not available before that. According to Chapman & Kimstach (1996) values under 5 mg/L can be harmful to biological communities. DO on farm 1 had values of 3 and 4.5 mg/L which would then be harmful. According to Nguyễn (2011) values down to 3 are acceptable and under that value starting to be harmful. The DO content from the water quality measurements was at an acceptable level on all farms according to Nguyễn (2011). *S. guttatus* survive on low DO values, down to 0.7 ppm (Duray, 1998). The adaptability to different DO levels is influenced by the metabolic rate in different species of fish.

The salinity in the cement tank at farm 1 started at 27 ‰ and was down to 16 ‰ at the last recording. Young & Duenas (1993) showed that the highest survival rate was obtained if the salinity was gradually changed to 16 ‰. The survival rate on farm 1 had been shown to be 60 % in previous year which is a rather high number compared with other farms cultivating *S. guttatus* where the most common survival rate is 50 % (Nguyễn, 2011). The higher survival rate on farm 1 can be because the water quality was controlled and the water was changed when needed according to the fish needs. Recent results from farm 1 show that this year's survival rate was 40 % (Nguyễn, 2012). This was said to be explained by an unusually cold weather which caused an increase in fish death compared with last year.

The Rabbit fish does not tolerate low salinity and high temperature well (Duray, 1998). *S. guttatus* that were placed in freshwater had a total mortality of 28 % after 2 days. Wang et. al. (2011) showed that Rabbit fish can tolerate freshwater up to day 9, when they started dying from not eating. All fish in the study by Wang et. al. (2011) died after day 27. Different salinity concentrations have been shown to affect the activity in the antioxidant defence system. The activities of superoxide dismutas (antioxidative enzyme) and superoxide anion radical increased in the gills of Rabbit fish that were kept in salinity 5 ‰ compared to salinity 10, 20 and control group (reared in the local sea water). This shows that fish cultivated in salinity levels of 5 ‰ display a physical stress (Wang et. al., 2011).

The values for TAN were at a stable level throughout the test period at farm 1. The values were never close to toxic values. One explanation for this can be that the cement tanks were cleaned of debris and feed leftovers every second day. Farm 2 and 3 also showed a good level of TAN in the ponds. The natural environment in the earthen ponds therefore seems to be in balance regarding number of fish in contrast to feed and size of the pond, i.e. not too much feed leftovers and too much debris in the ponds, which would lead to high values of TAN.

7.2 Growth of *S. guttatus*

When *S. guttatus* are collected from the wild they are approximately 10 mm and are found on reef flats and sea grass communities (Duray, 1998). The first measurement occasion of the Rabbit fish at farm 1, showed a length of 2.7 cm. In a breeding trial by Juario et. al. (1985) fish with an age of 35 days had a length of 1.6 to 2 cm. It can therefore be imagined that the fish at farm 1 were older than 1 month when caught than was previously expected. According to Duray (1998) the Rabbit fish reaches juvenile stage at approximately 45 days with a length of 22 mm. The Rabbit fish must therefore have been older than 45 days.

It was not possible to compare growth between different culturing models (cement tank vs. earthen pond) because no growth parameters were measured on the farms rearing Rabbit fish in the earthen ponds. This was because the difficulty to catch the Rabbit fish, especially when they were kept in a big pond.

The growth of Rabbit fish is shown to be allometric (Djamali, 1978). An indication of this can be seen in Figure 9, for the length of Rabbit fish. No statistical comparisons have been made due to too few measurements. At the start 2 outdoor cements tanks were included in the measurements but after 3 weeks all fish had died in one of the tanks due to a parasite infection spread from the *Gracilaria*.

Growth of fish is depending on the feed given to the fish (Parazo, 1990). With an increasing level of protein the fish will have a higher growth rate. If producers only have a focus on high growth rate this will lead to more protein (with animal origin) will be fed to the Rabbit fish (Von Westernhagen & Rosenthal, 1976). Then the benefits of culturing the Rabbit fish will decrease. Examples of benefits are; no trash fish needs to be used as feed, Rabbit fish are primarily herbivores and can be fed algae, when feeding Rabbit fish algae the fish will ingest omega fatty acids that in turn the humans will ingest and benefit from when consuming this fish (Ogata et. al., 2004).

To be able to cultivate *S. guttatus* in a sustainable way it is very important to develop breeding in captivity so fry don't need to be caught from the wild which in time would lead to disturbances in the ecosystem. The lack of fry for farmers to cultivate is the most limiting factor for increasing of cultivation of *S. guttatus* (Gonzales et. al., 2006).

7.3 Management

All different farms had a different stocking density. Farm 1 had a very much higher stocking density than the other farms that kept their Rabbit fish in earthen ponds. It is though not possible to draw any conclusions on growth and water quality due to too limited data.

The feed on the different farms were quite similar. All farms gave the Rabbit fish *Gracilaria* together with a protein enriched concentrate feed. The farms that cultivated the *S. guttatus* in earthen ponds all gave them industrial concentrate feed while farm 1 produced their own concentrate feed. Farm 1 was the only farm that altered the ingredient ratio of the feed during the cultivation of the Rabbit fish to better suit the growth stage of the fish. Farm 1 included rice bran in the diet for the Rabbit fish. According to Duray (1998) Rabbit fish grow faster on rice bran but also have a lower survival rate.

Farm 1 and 4 were the only farms that changed the water in the ponds. Farm 3 added water from Tam Giang lagoon to the pond if there had been a flooding. Farm 2 said not taking actions at all if there were any problems with the pond. No farms treated the fish if any diseases would occur. The reason was said to be too difficult to diagnose the fish that were ill. The only chemical that was added to any of the ponds was to farm 2 which treated the pond between batches with saponins. The production of Rabbit fish seemed to be a low intensity system, not to much input. This can with a sustainable way of thinking be more profitable (Kutty, 1995).

7.4 Economy

The economic results showed different figures. Farm 1 showed to be the most profitable farm per square meter. This can be explained by that the farm had the highest stocking density. The profit when rearing Rabbit fish in earthen ponds compared to a cement tank gave indications to be much profitable per square meter for the latter. This was the biggest difference in profit per square meter that could be seen between different management strategies. It is difficult to give a definite answer on the economic situation on either of the farms due to a lack of information.

For the Rabbit fish to grow faster animal originated protein needs to be included in the diet. But if this is done at a high degree, much of the benefits of this primarily herbivorous fish are lost. *S. guttatus* has a potential to be produced in large quantities (Parazo, 1990). One reason why the culture and production has not increased is said to be because of a lack of commercial feed. According to Duray & Juario (1988) the major reason for hindering increased production is the lack of seed for farmers wanting to cultivate *S. guttatus*.

It was difficult to find good articles and sources to base the literature review on. The greater part of the articles dealt with fish fry from hatching to metamorphosis. No articles were found on economics on *S. guttatus* cultivation. The economy of Rabbit fish farming has not been investigated enough, not many reports is available in this area. This is something that should be further investigated.

8. Conclusion

S. guttatus have good possibilities to be cultivated in bigger scale for human consumption. It is a healthy fish to consume and is better for the environment to cultivate than other aquaculture species in Viet Nam today. One reason is because the Rabbit fish is mainly an herbivore and, when fed algae, will ingest omega fatty acids that in turn will benefit humans that consume the Rabbit fish.

All farms showed a positive economical value for their culture of *S. guttatus*. It is difficult to draw any conclusions on what management system that would be more profitable. But it was a bigger difference in profit per square meter between the farm with the cement tank (showed highest profit) and the earthen pond cultures than any other management difference.

The water environment differed between the farms. Farm 1 had 7 measurement occasions while farm 2 and 3 only had 1. It was therefore difficult to draw any conclusions for the differences that were shown. The growth parameters were not measured at all at the farms rearing their Rabbit fish in earthen ponds.

To continue the culturing of *S. guttatus* it is important to develop a higher survival rate of fry hatched in captivity. The fry at this time is only collected from the wild and the catches are now beginning to decrease. More studies need to be made in this area and also studies on *S. guttatus* growth from metamorphosis to harvest. No articles at all were found on economy for *S. guttatus*.

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10. References

Ayson, F. G. 1989. The Effect of Stress on Spawning of Brood Fish and Survival of Larvae of the Rabbitfish, *Siganus guttatus* (Bloch). Aquaculture. 80: 241-246.

Brzeski, V. J., Newkirk, G. F. 2000. Research towards community based coastal resources management in Tam Giang Lagoon, Viet Nam. Canadian cataloguing in publication data. Nova scotia. Appendix A: 213-217.

Chapman, D., Kimstach, V. 1996. Selection of water quality variables. In: water quality assessments – a guide to the use of biota, sediments and water in environmental monitoring. E&FN Spon, Chapman & Hall. London, UK. 59-126

Day, T. 1999. Chemistry of the oceans. In: Oceans. Fitzroy Dearborn publishers. London, England. 44-61.

Djamali, A. 1978. Some biological aspects of Rabbitfish, Siganidae, around Kongsi Island, Seribu Islands. Oseanologi de Indonesia. 9: 43-49.

Duray, M. N. Biology and culture of sigands. 1998. Aquaculture Department Southeast Asian Fisheries Development Center (SEAFDEC), Philippines.

Duray, M. N., Juario, J. V. 1988. Broodstock management and seed production of the Rabbitfish Siganus guttatus (Bloch) and the sea bass Lates calcarifer (Bloch). In: Perspectives in Aquaculture Development in Southeast Asia and Japan. Contributions of the SEAFDEC Aquaculture Department. Aquaculture Department Southeast Asian Fisheries Development Center Tigbauan, Iloilo, Philippines. Eds: Juario, J.V., Benitez, L.V. 195–201

Francis, G., Kerem, Z., Makkar, H. P. S., Becker, K. 2002. The biological action of saponins in animal systems: a review. British Journal of Nutrition. 88; 587–605.

Gonzales, E., Maung Soe, K., Mukherjee, R., Nguyen, S.H., Suspita, A., Wattoo, J.M., Bulcock, P. 2006. Regional review on livelihood opportunities related to mariculture development. Bangkok, Thailand, Support to Regional Aquatic Resources Management (STREAM).

Hara, S., Kohno, H., Taki, Y. 1986a. Spawning behavior and early life history of the Rabbitfish, *Siganus guttatus*, in the Laboratory. Aquaculture. 59: 273-285.

Hara, S., Duray, M. N., Parazo, M., Taki, Y. 1986b. Year-round spawning and seed production of the Rabbitfish, Siganus guttatus. 59: 259-272.

Juario, J.V., Duray, M.N., Dwray, V.M., Nacario, J.F., Almendras, J.M.E. 1985. Breeding and larval rearing of the Rabbitfish, *Siganus guttatus* (Bloch). Aquaculture. 44: 91-101.

Kohno, H., Hara, S., Duray, S., Gallego, A. 1988. Transition from endogenous to exogenous nutrition sources in larval Rabbitfish Siganus guttatus. Nippon Suisan Gakkaishi. 54 (7): 1083.

Kongkeo, H., Wayne, C., Murdjani, M., Bunliptanon, P., Chien, T. 2010. Current practices of marine finfish cage culture in China, Indonesia, Thailand and Viet Nam. Aquaculture Asia magazine. 15 (2): 32-40.

Kutty, M. N. Aquaculture development and sustainability in Southeast Asia. 1995. In: Towards Sustainable Aquaculture in Southeast Asia and Japan. SEAFDEC Aquaculture Department, lloilo, Philippines. Eds: Bagarinao, T. U., Flores, E. E. C. 91-108.

Lam, T. J. 1974. Siganids: their biology and mariculture potential. Aquaculture. 3: 325-354.

Le Van, M., Ton, T. P., Hoang, N. D. 2000. Aquaculture – its introduction and development, in Lessons from the lagoon: research towards community based coastal resources management in Tam Giang Lagoon, Viet Nam. Canadian cataloguing in publication data. Nova scotia. 115-134.

Norziah, M. N., Ching, C. Y. 2000. Nutritional composition of edible seaweed Gracilaria changgi. Food Chemistry. 68: 69-76.

Ogata, H. Y., Emata, A. C., Garibay, E. S., Furuita, H. 2004. Fatty acid composition of five candidate aquaculture species in Central Philippines. Aquaculture. 236: 361–375.

Parazo, H. H. 1990. Effect of dietary protein and energy level on growth, protein utilization and carcass composition of Rabbitfish, Sigunus guttatus. Aquaculture, 86: 41-49.

Phap, T. T., Thuan, L. T. N. 2002. Tam Giang Lagoon aquatic systems health assessment. In: Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development. FAO Fish. Tech. Pap. Eds: Arthur, J.R., Phillips, M.J., Subasinghe, R.P., Reantaso M.B., MacRae. I.H. 406: 225-234.

Rabanal, H. R. 1994. Overview of aquaculture development in Southeats Asia. In: Proceedings of the Seminar-Workshop on Aquaculture Development in Southeast Asia and Prospects for Seafarming and Searanching; 19-23 August 1991; Iloilo City, Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines. Eds: F Lacanilao, RM Coloso, GF Quinitio. 159.

Rachmansyah., Usman., Lante, S., Ahmad, T. 2007. Rabbitfish Siganus guttatus breeding and larval rearing trial. Aquaculture Asia, 3: 39-41.

Rahman, S., Takemura, A., Takano, K. 2000. Correlation between plasma steroid hormones and vitellogenin profiles and lunar periodicity in the female golden Rabbitfish, *Siganus guttatus* (Bloch). Comparative Biochemistry and Physiology Part B. 127: 113–122.

Susilo, E. S., Harnadi, L., Takemura, A. 2009. Tropical monsoon environments and the reproductive cycle of the orange-spotted spinefoot *Siganus guttatus*. Marine biology research. 5: 179-185.

Ton, T. P. 2000. Fishing in Sam – An Truyen – Tuan An area, in Lessons from the lagoon: research towards community based coastal resources management in Tam Giang Lagoon, Viet Nam. Canadian cataloguing in publication data. Nova scotia. 187-202.

Tuyen, T. V., Brzeski, V. K. 2000. Management of biological resources in Tam Giang Lagoon, in Lessons from the lagoon: research towards community based coastal resources management in Tam Giang Lagoon, Viet Nam. Canadian cataloguing in publication data. Nova scotia. 7-14.

Von Westernhagen, H., Rosenthal, H. 1976. Some aspects of the suitability of various Philippine siganid species (Siganidae) for mariculture. Aquaculture. 9: 297-311.

Wang, Y., Zhuang, P., Zhang, L. Z., Liu, J. Y., Zhao, F. 2011. Effects of salinity on survival, growth and antioxidant defence system of *Siganus guttatus*. Journal of Fisheries of China. 35: 66-73.

Watanabe, T., Kiron, V. 1994. Prospects in larval fish dietetics. Aquaculture. 124: 223-251.

Young, P. S., Duenas C. E. 1993. Salinity tolerance of fertilized eggs and yolk-sac larvae of the Rabbitfish Siganus guttatus (Bloch). Aquaculture. 112: 363-377.

10.1 Internet references

Convertworld. 2012. Convert currency, 1000 VND = 0.46 SEK. http://www.convertworld.com/sv/valuta/ 2012-01-31

Ehrlich, K. F., Cantin, M-C. 1995. Biological filtration and aquarium health management. http://davidcecere.pipidae.org/biocycle.htm. 2012-01-10.

FAO. 1990. Training Manual on Gracilaria Culture and Seaweed Processing in China. Fisheries and Aquaculture Department. http://www.fao.org/docrep/field/003/AB730E/AB730E00.htm. 2012-01-12

Ho, N. D. 2012. Vietnamese calendar. http://www.informatik.uni-leipzig.de/~duc/amlich/. 2012-01-05.

Patin, S. 2012. Gas impact on fish and other marine organisms. http://www.offshore-environment.com/gasimpact.html. 2012-01-24.

10.2 Personal messages

Nguyễn, D. Q. T. 2011. Personal message. 2011-09-26.

Nguyễn, D. Q. T. 2012. Personal message. 2012-01-30.

Appendix 1. Interview questions asked to the farmers at the 4 different farms rearing *S. guttatus* near and in Tam Giang lagoon

- What is the culturing period, month – month?
- How is the pond prepared before stocking?
- How many fish at the beginning of stocking?
- What is the pond area?
- What is the origin of the Rabbit fish?
- What was the price for the fish when bought?
- What type of feed do the fish receive during the culture?
- How many times and how much feed per day do the fish receive?
- What is the price for the feed?
- How often is the pond cleaned?
- How often do you change the water?
- Is pesticides used?
- Is diseases treated or in some way prevented?
- What is the weight per fish at harvest (how many fish/kg)?
- What is the survival rate?
- What is the price at harvest?
- Do you have any strategy to increase salinity if it rains much?
- What is the biggest challenge for you when rearing Rabbit fish?

Appendix 2. Economical calculations for the 4 farms rearing *S. guttatus* near and in Tam Giang lagoon

Farm 1

Cost
Buy fish: 10 000 pcs * 300 VND = 3 000 000 VND
Feed: 20 % bodyweight * 2 g (2 months old) = 0.4 g
0.4 g * 10 000 pcs = 4 000 g feed needed per day
4 kg feed * 59 days = 236 kg
236 kg / 25 kg feed bag = 9.44 bags → 10 bags needed
10 bags * 265 000 VND = 2 650 000 VND
Income
Survival rate: 0.4 * 10 000 = 4 000 fish
4 000 pcs * 2 600 VND = 10 400 000 VND
Income – cost → 10 400 000 – 5 650 000 = **4 750 000 VND**
Converted to SEK: 2 205 SEK (convertworld, 2012)

Profit per m²: 4 750 000 VND / 20 m² = **237 500 VND / m²**
Converted to SEK: 110 SEK (convertworld, 2012)
Things not included: price for land/cement tank construction (loan), price for sea weed, price for home made concentrate feed, salary

Farm 2

Cost
Buy fish: 10 000 pcs * 130 VND = 1 300 000 VND
Feed: 73.5 days * 2.5 kg = 184 kg
Buy in 25 kg bags → 184/25 = 8 bags needed
8 bags * 305 000 VND = 2 440 000 VND
Income
Survival rate: 0.6 * 10 000 fish = 6 000 fish
6000 fish * 2600 VND = 15 600 000 VND
Income – cost → 15 600 000 – 3 740 000 = **11 860 000 VND**
Converted to SEK: 5 506 SEK (convertworld, 2012)

Profit per m²: 11 860 000 VND / 1500 m² = **7 907 VND/ m²**
Converted to SEK: 4 SEK (convertworld, 2012)
Things not included: price for land/pond constructing (loan), price for sea weed, probiotic, salary

Farm 3

Cost
Buy fry: 23 000 pcs*200 VND = 4 600 000 VND
Feed: *Graciliria*: 88.5 days/10 days-1 ton = 8.85 ton grass cilia
8.85 ton * 500 000 VND = 4 425 000 VND
Concentrate feed: 1.5 kg -1 day * 88.5 days = 133 kg
Bags bought in 25 kg bags → 133/25 = 6 bags
6 bags * 320 000 VND = 1 920 000 VND
Total costs → 4 600 000 + 4 425 000 + 1 920 000 = 10 945 000 VND

Income
Survival rate: 0.5 * 23 000 = 11 500 fish
11 500 fish * 2000 VND = 23 000 000 VND
Income – cost → 23 000 000 – 10 945 000 = **12 055 000 VND**
Converted to SEK: 5 597 SEK (convertworld, 2012)

Profit per m²
12 055 000 VND/2500 m² = **4 822 VND/ m²**
Converted to SEK: 2 SEK (convertworld, 2012)
Things not included: price for land/pond construction (loan), salary

Farm 4

Cost
Buy fry: 2 000 000 VND
Industrial feed: 8 000 000 VND
Total cost: 10 000 000 VND
Income
9500 fish * 2600 VND = 24 700 000 VND
Income – cost → 24 700 000 – 10 000 000 = **14 700 000 VND**
Converted to SEK: 6 824 SEK (convertworld, 2012)

Profit per m²
14 700 000 VND/800 m² = **18 375 VND/ m²**
Converted to SEK: 9 SEK (convertworld, 2012)
Things not included: price for land/pond construction (loan), price for sea weed, salary

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