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THE POTENTIAL CONTRIBUTION OF SOME AQUACULTURE PRACTICES TO THE ARABIAN FISHERIES INDUSTRY UTILIZING MARINE WATERS

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ABSTRACT

Two successful aquaculture practices experimentally and commercially of the White Indian Prawn *Penaeus indicus* and the Rabbitfish *Siganus rivulatus* have been demonstrated along the coastal lines of Saudi Arabia; The first practice incorporated on shore pond culture of *P. indicus* which took place on both coastal lines of the Red Sea and the Arabian Gulf. The second practice was the off shore floating finfish cage culture of *S. rivulatus* which took place on the coastal lagoons of the Red Sea. Shrimp pond production of *P. indicus* was up to 10 tons per ha per year. Finfish (*S. rivulatus*) production was 20 kg/m³. Both practices have two production cycles per year.

If only 10% of the total on shore and off shore coastal lines of the Arabian countries (23441 km), were subjected to aquaculture investments; the hypothetical production contribution will exceed 1600 tons of *P. indicus* and 400.000 tons of *S. rivulatus* per year respectively.

The above species are examples, other species have potential for production on a large scale, such as Tilapia, Grouper and Seabass.

Results of an additional practice concluded a commercial potentiality of polyculture as a mean of increasing production is promising for *Penaeid* shrimp and *S. rivulatus*, since an experiment has proven the possibility of rearing both species together in the same facility utilizing Red Sea water for the same culture period.

INTRODUCTION

In Saudi Arabia yearly fish production from the Red Sea and the Arabian Gulf reached 63.9 thousand tones in 2002 (Saudi Arabian Fishery statistics bulletin 2004) at the same time imports exceeded 90.9 thousand tones with a value of 500 million SR for the same year (Saudi Arabian Fishery statistics bulletin 2004).

Aquaculture was considered to close the gap between production and importation. The governmental aim was to apply and adapt the existing worldwide technologies and production systems suitable to local environmental conditions.

Commercial aquaculture may be defined as a mean to promote or improve the growth, and enhance production of finfish and shellfish up to marketable size in fresh, brackish, and marine waters.

The selection of a site for aquaculture depends on:

(1) Species chosen for culture.
(2) Legal and socio-culture aspects.
(3) Infrastructure requirements.
(4) Biophysical requirements.
(5) Culture system employed.

The first practice
On shore culture of the Indian White Prawn (*Penaeus indicus*) in ponds

Site selection and pond design:

A pond is an earthen or concrete container that holds water. Water is added only to fill the pond or to replace water lost by seepage and evaporation. Water exchange does not exceed one complete change in 24 hours. Ponds are constructed by both excavation and levee construction. The excavation soil is used to form pond banks. Water is supplied from coastal wells or by pumping from nearby coastal areas. Draining is by gravity. The size, shape and depth of ponds also can be controlled during construction.

Beach ponds are constructed on shore in sandy areas where seepage may be a major problem. To avoid seepage problems, a polyethylene or a plastic-like liner could be used for that matter. The design aspects of an aquaculture farm depend on the species. For finfish it is necessary to herd the stock in tanks, ponds, enclosures or cages, where as for shrimp; ponds are typically the traditional culture facility. Ponds are often classified by use; for example: rearing ponds are stocked with fry to rear fingerlings; Grow-out ponds are stocked with fingerlings that will be grown out to eating size. Ponds may have a special designation depending on the species cultured such as shrimp ponds. Marine shrimp have been cultured in earthen ponds for many centuries; the Romans practiced brackish water pond culture, and they learned the techniques from earlier civilizations. Egyptian artwork also depicts pond culture, but Asia has the oldest history of pond culture (Ling, 1977; Atkinson, 1983).

Shrimp farming systems can be divided into three categories which are based on management intensity: extensive, semi-intensive and intensive. The main characteristics of the extensive method of shrimp culture is that production depends entirely on natural conditions. The semi-intensive farming method; a nursery phase, carefully laid out ponds, feeding and water pumping. The intensive culture system introduces smaller ponds, high stocking densities and continuous management of feeding, waste removal and aeration (Rosenberry, 1990).

Commercial shrimp ponds in Saudi Arabia are constructed along the coastal line of the Red Sea in large sizes of more than 1 ha. in area; incorporating the semi-intensive system.

Initially, the tiger prawn *Penaeus monodon* was imported to start penaeid culture in the Kingdom of Saudi Arabia. However *P. monodon* presented some technical problems for commercial culture (Bukhari *et al*., 1989). Poor adaptation to local high salinity conditions was associated with low survival and slow growth; which made the culture period too long and yield too low. In addition, seed supply was limited due to poor maturation of cultured specimens and unavailability of local wild seed.

Penaeid shrimp have been known to inhabit the Red Sea since the last century (De Man, 1882). *Penaeus indicus* an Indian White Prawn species originating from the Indian Ocean (Lee and Wickins, 1992). *P. indicus* has been found among other penaeid shrimp in the Gizan area (Red Sea coast southwest of Saudi Arabia) by Ghamrwi (1978) when a survey took place to study the shrimp fishery and spawning grounds in the Red Sea. Badawi and Cas (1989) collected *P. indicus* juveniles which are found abundantly on the southwestern coast of the Gizan area. These were brought to the Fish Farming Center to conduct various studies on growth, survival and spawning in captivity.

Experimental ponds along both the Red Sea and the Gulf costal lines were used for *P. indicus* density trails ranging from (20-80/m²), witch resulted in growth and survival rates ranged between (15-25) g and (60-90%) respectively (Bukhari *et al*., 1991a, 1993, Bukhari and Al-Thobaiti 1992 and Bukhari, 2000) (Table 1).

P. indicus post larvae were produced from ablated and unablated females (Primavera *et* *al*., 1982). Completing *P. indicus* life cycle without the need to collect new brood stock from the sea was also achievable in Saudi Arabia (Bukhari *et al*., 1991b).

Table (1): Different stocking densities, final weight (g), survival Rate (%) and production (tones $ha.^{-1}yr.^{-1}$) of Indian White Prawn *Penaeus indicus* in ponds.

Stocking densities m^{-2}	Initial weight (g)	Final weight (g)	Survival Rate (%)	Production (tones $ha.^{-1}yr.^{-1}$)
20-80	0.94-1.16	15-25	60-90	7-10

Commercial shrimp farms in Saudi Arabia have adapted the technique of shrimp post larval production in hatcheries. Ponds were stocking moderately with densities ranging from 15-30 postlarvae/m². Sizes of more than 20 g. with productions of 10 tones per ha. were obtainable.

The second practice:
Off shore culture of the Rabbitfish (*Siganus rivulatus*) in floating cage

Site selection and cage design:

Cage culture originated two centuries ago and commercially valuable fish are cultured in cages through out the world (Coche 1979 and Tacon *et al*., 1989). Cages differ in design, size, shape and location (floating or submersible), Although the majority consist of floating units (Beveridge 1996).

Large size cages (100-200 m³) each, with flexible framework and enclosed net floating free from the bottom are normally grouped in facilities of 10-12 cages, (Anon., 1979).

(1) The site must be in a sheltered area protected from waves and very strong water current.

(2) The water depth of the site must be at least 3.5 meter but not more than 30 meters.

(3) The sea bottom of the area should be flat, sandy or muddy and should not be rocky or over coral as the net may become torn.

(4) The site must not obstruct navigational, routes and must be at a suitable distance away from established navigational right of way.

(5) The sea site area must be near and accessible to a suitable land site which has access to market, and must have a jetty or pier for the servicing of the cages by boat.

(6) The site should be far from industrial and domestic pollution sources.

(7) Stocks of fry or fingerlings should be available close to the culture site.

(8) Local manpower and materials should be available close to the site.

Cages come in shapes (square, rectangular and circular), their floats and walkways are fabricated from PVC or rubber pipe. Cages also differ in sizes and locations (floating or submersible). The cage where the stocks will be placed is made from netting. Netting is usually made of flexible nylon or polyethylene. The size of cage and mesh depends on the age and species to be cultured. The mesh size of the net should be as large as possible to encourage good flow of water through the culture unit but be small enough not to allow the smaller individuals to escape. The main stock nets are normally suspended from within the cage frame. Typical dimensions range from 3 to 20 m across, 3 to 10m deep. Most commercial mariculture operations use nets of 250 to 1000 m³ in volume, corresponding to about 200 to 500 m² of netting. This is usually assembled in several panels, with suitable mounting rope, loops, and other fixings or attachments. As the nets must be handled regularly, and most cases frequently changed, they should be relatively light and manageable, yet durable. They should not cause damage to the stock, whether through trapping or abrasion. It is common also to use antifouling for net treatment such as organic copper, or organic tin compounds.

Floats are used to give buoyancy to the plastic containers, PVC poles, Styrofoam and air or foam filled plastic floats. Moorings to hold cages in position, particularly during rough seas and strong winds. The type and size of anchor used will depend on the nature of the sea bed and cage size.

Shock absorbers (tires) are commonly used as protection between the various floating components, and are simply tied or chained onto cage frames, etc. Car tires are used approximately a double for every 1.5-2m of joining frame length with particular taken at the corners of the cage. Breakwaters as an additional shelter during heavy storms, plastic drums or scrap tires are also used light connected with chain and moored to absorb a considerable amount of wave energy.

Rabbitfish (*Siganus* spp.) are widely distributed in the Indo-Pacific region (Herre & Montalban 1928). They have favorable aquaculture characteristics that make them a desirable culture species. *Siganus rivulatus* is one of several important species selected as part of the national mariculture development program in Saudi Arabia based on its good market value, in addition to augment fish protein supply in the Kingdom (Lichatowich *et al.*, 1984a and 1984b). The trials conducted in the Aqaba showed that the species is suited for commercial culture (Ben-Tuvia *et al.*, 1973).

Earlier studies conducted in the Red Sea on cage culture of *S. rivulatus* showed that the fish could reach harvest size (85-110g) in 150 days if fish densities of up to 60-120/m³ (Lichatowich *et al.*, 1984a).

Table (2): Stocking densities, final weight (g), survival rate (%) and production of the Rabbitfish *Siganus rivulatus* in flouting sea cages.

Stocking Densities m^{-3}	**Initial weight (g)**	**Final weight (g)**	**Survival rate (%)**	**Production (kg m^{-3} $^{-}$yr)**
80-120	2.0	85-110	90-95	16.4-20.4

Recently life cycle of *Siganus rivulatus* was also completed and seed supply became available for culture without the need to collect juveniles from the Red Sea. (Technical report of Fish Farming Center 2003). A commercial cage farm has already started producing *S. rivulatus* in Saudi Arabia.

The third practice

Polyculture of the tiger shrimp *Penaeus monodon* with the Rabbitfish *Siganus rivulatus* in Red Sea water

It has been reported that filamentous algal blooms could cause multiple problems in monoculture shrimp ponds; such as low dissolved oxygen levels and interfering with sampling, feeding and harvesting (Rouse *et al.* 1987). Polyculture is recognized as an effective means of increasing fish production plus solving the above problems (Swingle 1968, Hickling 1971, and Bukhari 1988). It has been proven that the introduction of the Rabbit fish *S. rivulatus* to shrimp ponds increased the total biomass production and decreased undesirable filamentous algal blooms (Bukhari, 1988 and 2002).

Table (3): Weight gain (g), SGR (g) and survival of the tiger shrimp*Penaeus monodon* in monoculture and in polyculture with the Rabbitfish *Siganus rivulatus*.

Culture system	Weight gain (g)	SGR (g)	Survival Rate (%)
Monoculture	6.7	1.3	77
Polyculture	9.4	1.8	80

CONCLUSIONS

From the first (on shore) practice of White Indian Prawn *P. indicus* in pond culture, production was 10 tons per ha. per year. If only 10% of the total on shore coastal lines of the Arabian countries (23441 km) were invested; total shrimp approximate yearly production for 1 m^2 of pond culture will be as follows:

2344.1(km) × 1 (m^2)(total farm area) × 1 (kg) yr^{-1}

= 2344.1 × 10^3 (m^2) × 70% (pond area) × 1 (kg) yr^{-1}

= 2,344,100 m^2 × 70% (pond area) × 1 (kg) yr^{-1} × 10^{-3} (tones)

= 1,600 tones yr^{-1}

From the second (off shore) practice of the Rabbitfish *S. rivulatus* in floating cage culture; production was 20 kg/m^3. Similarly, if only 10% of the total off shore coastal lines of the Arabian countries (23441 km) were invested; total Rabbitfish approximate yearly production for 1 m^{-3} of cage culture will be as follows:

2344.1 km × 20 kg m^{-3} × 10^{-3} tones $yr.^{-1}$

= 2,344,100 m × 20 kg m^{-3} × 10^{-3} tones $yr.^{-1}$

= 40,000 tones $yr.^{-1}$

From the third practice; it has been concluded that a commercial potentiality of polyculture *Penaeid* shrimp with *S. rivulatus*, is promising, since experiments have proven the possibility of rearing both species together in the same facility during the same culture period.

All of the above practices have two production cycles per year. The species discussed here are examples; other species have potential for production on a large scale, such as Tilapia, Grouper and Seabass.

When private sectors in Saudi Arabia took an interest in aquaculture, an estimated yearly net profit return of 20-30% was gained. In other words; the wholesale price for White Indian Prawn *P. indicus* is 25 ×10^3 SR $tone^{-1}$

The expected total gross profit:

(1,600) tones × (25 ×10^3) SR = 40 × 10^3 × 10^3 SR

Net profit is 20% of the gross profit. The expected net profit will be;

40 × 10^3 × 10^3 SR × 20% = 8 × 10^3 × 10^3 SR

or \$ 2 × 10^3 × 10^3 US yr^{-1} (approximately)

Similarly; **The wholesale price for the Rabbitfish *S. rivulatus*; is 15.000 SR $tone^{-1}$**

The expected total gross profit:

40,000 tones × 15,000 SR = 600 × 10^3 × 10^3 SR

Net profit is 20% of the gross profit. The expected net profit will be;

600 × 10^3 × 10^3 SR × 20% = 120 × 10^3 × 10^3 SR

or \$ 30 × 10^3 × 10^3 US yr^{-1} (approximately)

The Arab total increase in marine aquaculture production will be (1,600 + 40,000)= approximately 41,600 tones. Total expected net profit from the production increase will be around \$ 32 million US.

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