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Use of Iraqi marshes for the aquaculture of fish and shrimp

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Abstract

Aquaculture activities in the southern part of Iraq faced many problems. Local people are not well aware that aquaculture could be a good activity to improve their socioeconomic status. There are very few hatcheries to supply enough fingerlings. The water quality is changing and becoming more saline, which have negative impact on the growth rate of the cultured fresh water species. To improve aquaculture in the southern part of Iraq, all these parameters should be considered to plan an effective management. Making use of the naturally-occurred water impoundments in the southern marshes and turning them into productive fish ponds is a practical approach. The present study suggests various rearing techniques which are suitable for such water bodies. These include introduction of peripheral and transaction dikes to create extensive fish ponds. Fish cages and net enclosures represent also a special profitable approaches. Rearing fish in fish rice fields can also be practiced in certain areas in the marshlands. Conducting steps, implementation techniques and advantages of various rearing methods have been discussed. Fry and fingerlings supply should be maintained through establishing local hatcheries, which produce fingerlings of all carp species (common, grass and silver carp) in addition to some native species such as Bunni (B. sharpey). Aquaculture activities in the marshes should include releasing fingerlings into the available open waters using big net enclosures. Few other developmental recommendations were also suggested, such as the introduction of new fish species that are more tolerable to the present water quality. The introduction of new types of culture methods such as cages and recirculation systems which are compatible with the freshwater shortage, quality and depths. There are big chances of success especially with the availability of sufficient amount of very productive water and cheap work power, but research for optimizing stocking and harvesting is essential.

Keywords: Unconventional waters, Aquaculture, Iraq

1. Introduction

The Southern marshes of Iraq contain immense of temporary or permanent shallow water bodies at the lower reaches of Tigris & Euphrates. They comprise a complex of inter-connected shallow freshwater water bodies which covers 20,000 km^2 of open water, and includes both permanent and seasonal marshes. The most important ones are those situated to the East of Tigris (Huaiza & Shuwaija Marshes, 3000 km^2), those laying between Tigris & Euphrates such as Damlag & Sanyah Marshes and those on both sides of Euphrates such as Al-Hammar Marsh (5000 km^2).

At the beginning of 2003 only seven percent of the original marshlands remained. Satellite photos indicate that by 2005 a percentage of 39% of the destroyed marshes had standing water (UNEP, 2006). Field studies concluded that water quantity and quality were sufficient to restore some area of the marshes (Richardson and Hussain, 2006). The values of the Marshes are numerous, including rich flora and fauna, livestock grazing fields, fish and other wildlife breeding places (Hussain and Ali, 2006). They are important for economic, social and biodiversity values as appeared in number of studies (Bedair, Al-Saad and PI Salman, 2006).

Fishing activities have adversely affected by the drainage disaster. Productions of fish in the marshes fall dramatically, due to negative changes in the environmental conditions. Refolding of the marshes refresh the hope of increasing fish production through restocking of fish fingerlings in extensive farms which can established with low coasts and serve as nursery and incubation grounds.

Inhabitants of the southern marshes of Iraq are primarily depending on water for their livelihood. The main livelihood activity is fishing. Fish production has declined during recent years due to overfishing, shortage of water, draining and salination. Accordingly a dramatic decrease in the family income of marsh inhabitants was noted. This has been pointed out by many United Nations reports. The result of a recent survey carried out by FAO–Iraq (2010), have pointed out that the economy of many people living in the region has been intimately involved with the marshes which provide important habitat for a wide range of fish species, many of which are of economic importance. Inhabitants of the marsh are currently suffering from several socio-economic problems. Traditional fishing and agricultural practices are not especially productive due to lack of scientific techniques, training and economical feasibility. In addition, dangerous fishing methods have been practiced in nearly all marshy areas such as the use of toxic pesticides and electric fishing

Fisheries development in the marshes may help the socio-economic status for people inhabiting the region (Marsh Arabs), because fishing is their main tool to cover their living expanses. Fish farming represents an additional activity which may increase fish production in the area along with fishing wild fish. Selected suitable farming practices might be suggested to help the people of the marshes economically and fighting unemployment. Most of these practices are easy to construct besides being very profitable.

The same FAO-Iraq (2010) survey, which has been done on Al-Huweza Marsh showed that the current fish stocks, fishing activities and production of fish in the marshes fell dramatically. Accordingly, a development programme is needed to improve the living standards of such communities through restocking fish fingerlings in extensive farms and rearing fish in intensive ponds or cages.

Aquaculture systems suitable for extensive and semi-intensive fish farming in the marsh were previously suggested by Salman (1993).

The main aims of the present study are:

1. Making use of neglected water bodies & turning them into profitable fish & prawn farming sites.
2. Improving the socio-economic status of people living near water sources.
3. Creating employment opportunities.
4. Maintaining cheap food supply to the local people.

To turn parts of the marshes in to extensive or semi-intensive fish and shrimp farms, the following methods are suggested:

2. Partial Transect & Peripheral Dikes and Ditches

2.1 Ponds with small partial transect dikes

This design maintains adequate water supply for ponds with larger depth. The transect dikes improve water depth in shallow area, so that it can be used as fish ponds. Such dikes need to be controlled by water gates to maintain certain water levels. Width of the primary (main) dikes reached 2 m while secondary dikes are 1m wide only. The design is suitable for permanent marshes where semi-intensive cultivation can be practiced.

2.2 Ponds with peripheral dikes and ditches

Dikes used for protection of rural areas from flood can also be used as peripheral dikes for ponds and lakes suitable for extensive (large area & low coast) fish culture, by increasing water depth than the surrounding water body. These ponds may serve the surrounding agriculture farm through being water storage tanks, providing water rich in organic manure (fish feces). Peripheral dikes are suitable for temporary marshes which are subjected to flood and dry seasons. The design includes digging fish canals (ditches) parallel to the peripheral dikes to allow fish to live and grow during draining time (fish refuge). When flooding season comes, fish will be distributed around the neighboring protected areas or even mixed with wild fish. Mixing during flood season must be taken in consideration when building peripheral dikes. Ponds surrounded by peripheral dikes may also be used for growing field crops during dry season into a appropriate production cycle between fish and crops. Field crops must be harvested before flood, leaving a fertile soil to fish ponds. Fish are allowed to leave ditches to the wider ponds to continue their growing till reaching marketable size.

3. Fish cages & Net Enclosures

3.1 Preface

Cage culture of fish is a method of raising fish in containers enclosed on all sides and bottom by materials that hold the fish inside while permitting water exchange and waste removal into the surrounding water. Cages are constructed in a variety of shapes using materials such as reed, bamboo or wooden slats and wire, nylon and other synthetic meshes. Support structures can hold cages on the water surface or suspended above the bottom of a body of water (Alex & Swingle,1996).

Cage culture is an aquaculture production system where fish are held in floating net pens. Cages are widely used in commercial aquaculture overseas and individual cage units come in all shapes and sizes and can be tailored to suit individual farmer's needs. Cage units can be made from locally available construction materials such as PVC pipes, wood or/and steel. Cages can be used in both freshwater and marine environments.

Cage farming in Asia is practiced in fresh, brackish and inshore coastal waters. It currently occurs in all freshwater habitats and is extremely diverse in nature, varying in cage design, intensity of practice, husbandry methods and the species farmed (LKIM, 1984). In general, freshwater cage farming is practiced on a small scale, but in some instances clustering of cage operations can contribute a significant level of production (AFS, 2005). In 2004, FIMA (Aquaculture Management and Conservation Service) convened an expert workshop on cage culture in Africa. This activity was given a high priority considering the rapidly-growing interest in cage culture in the region.

The Philippine Bureau of Fish and Aquatic Resources (BFAR) INCA has access to the various technologies and experiences in developing and operating cage fish culture systems for various species of fish production. According to Pillai and Sollows (1980), work carried out on the culture of fish in cages in Nepal, the introduction of the practice to private fishermen by the project and its technical and economic aspects are described in their report. With plastic circular or rectangular fish cage system, various high value fish can be produced intensively to standard marketable sizes. Depending on loading densities of fish fingerlings, production capacities of these fish cages can be up to 10 to 20 Metric tons of fish harvest every grow-out cycle of 4 months. There are times when existing bodies of water do not lend themselves to open pond culture and cage culture may be the best alternative (http://www.inca.com.ph).

3.2 The Advantages

Advantages of the cages and net enclosures are:

1. They can serve as a fish cultivation tools for a single family or small groups in the marshes community.
2. They use limited water resources.
3. The method needs little training on construction and management compared with other practices.
4. It can be established with limited financial support.
5. It can be operated using locally-available, low cost raw materials and cheap work power. .
6. Cages and net enclosures are considered as new fish farming technology in the southern marshes of Iraq.

The advantages of cages compared with other culture systems, as pointed out by Chue (1982) include:

1. Use existing water bodies and provides private ownership in public waters
2. Technical simplicity with which farms can be established or expanded
3. Lower capital and initial expenditure cost compared with land-based farms
4. Easier stock management and monitoring of fish health and growth.
5. Fish cages and enclosures are easy to build, require minimal maintenance
6. Offer protection from predators and competitor species of fishes
7. Provide controlled feeding.
8. Provide simplify harvesting of stock
9. Cages are a convenient approach to raising fish for personal consumption and for marketing
10. High yield of fish and good economic return.
11. A method to develop fish husbandry skills before considering more expensive production systems.

3.3 Types & Implementation of fish cages

Fish cages can be constructed from a variety of materials. Generally, the longer a material can last in contact with water, the more expensive it is to use. Some consideration should be given to the expected "life" of the fish cage. There are a few basic principles to consider when planning building a fish cage:

1. All materials used for the cage should be durable, nontoxic, and rustproof. Plastic netting is often used. Sunlight can also damage the plastic mesh, so leaving the cages in the water year-round may be better.

2. The netting material used for the body of the cage must allow maximum water circulation through the cage without permitting fish escapes. Mesh sizes less than 1⁄2 in. often clog with algae. Netting material of 1⁄2 in. and 3⁄4 in. mesh size are most commonly used.
3. Some type of flotation is needed to suspend the cage at the water's surface — small inner tubes, plastic jugs, or pieces of styrofoam.
4. Sunlight stresses fish; therefore, a lid should be included to block some of the light.

There are two types of fish cages to be used depending on the depth of water:

a) Floating (convenient for water bodies where depth of water is more than 5m).

b) Fixed (convenient for water bodies where depth of water is less than 5m).

They can be built in different shapes such as the most convenient rectangular shape or the square and round (circular) shape.

These simple yet ingenious cages made of reed or bamboo and netting, enable poor people to breed fish, providing families with a protein-rich diet and a way to generate vital income. In contrast to natural fishing, where fishermen have to depend on chance, raising fish in cages enables a predictable and more assured source of income. Fish cage culture is one of the fastest growing business opportunities right now. Cage culture can be integrated into almost any standing water, provided that the water quality is suitable and there is adequate water depth beneath the cages to allow water movement. Adequate depth depends on the depth of the net and intensity of production. The depth should be sufficient to keep the nets clear of the sediment and allow water exchange beneath the net.

One of the most important considerations affecting cage culture is the placement of the cage. Weather and shelter are important considerations in determining the suitability of a site for cage culture as they can impact on both the cage structure and enclosed fish. The cage units should be built to withstand prevailing wind and wave conditions at the selected site. Good water exchange is also important in cage culture to replenish oxygen and flush away wastes. Therefore, the fish cage should be placed in an area where there is at least ½ m of water between the bottom of the cage and the lake bottom. The fish cage should also be placed where the water can move freely through and around the cage. Since wind action is the primary contributor to water movement, the cage should be placed in open water where the prevailing winds can create water movement. Water quality factors such as temperature, salinity, pH, suspended solids and the presence of algal blooms can potentially influence the growth and survival of your fish. In addition, sources of pollution and the tendency of the water body to stratify during the summer can also negatively impact on water quality. Disturbances near the cage, such as swimming, boating, and fishing activities are not desirable.

Fig. (1): Two types of locally made floating fish cages (Fisheries Department, Basrah University, 2010)

3.4 Stocking & Production

The minimum recommended stocking density for common carp is 80 fish/m^3. A recommended maximum stock density for beginning farmers is the number of fish that will collectively weigh 150 kg/m3 when the fish reach a predetermined harvest size (Schmittou, 1991). The smallest recommended fingerling size for stocking is 15 g. A 15-g fish will be retained by a 13-mm bar mesh net. Larger fish can also be stocked into cages. Survival rates in well-placed and well-managed cages are typically 98 to 100 %. Unless greater mortality is expected, no adjustment is needed to calculate stocking density.

The weight of fish produced in cages depends on many factors including the fish species, stocking density, fish size at stocking, culture period, cage size, water quality, and feeds used. Reported yields can be misleading unless production details are provided. Numerous studies have been done with cages (Eng *et al*., 2006). According to Pillai and Sollow (1980), there is relatively less accumulation of metabolic wastes, and constant renewal of oxygenated water within the cage since there is constant circulation of water through the meshes of the cages. This enables higher stocking rates and consequently, higher production per unit volume than in ponds.

3.5 The use of fish cages in the marshes (Case Study)

Fish cages and enclosures are known to be one of the intensive fish rearing methods which utilize small water area and provide high fish production. They are recommended for areas of low productivity, limited water resources and risk of pollution such as the southern marshes of Iraq. The limited use of such technique has always been related to high cost of construction and maintenance. The need of this technology in the poor areas of the marshes led to the proposal of simple technological designs that use locally available materials and satisfy the critical criteria of fish rearing systems. Use of such system as a family fish farm would enable local inhabitants to increase fish production in their areas, increase family income and improve livelihood conditions through better socio-economic status.

Semi-intensive rearing of fish can be practiced in the marshy area with wide net enclosures. The local fishing nets and reeds are used to build such low cost enclosures which serve both nursing and growing purposes. Small nursing enclosures (400 m^2) are usually built within large one. Fish are allowed to transfer from nursing to growing enclosures easily. Production of such rearing method with semi-intensive practices may reach 1000 kg per Donum (2500 m^2) which is 10 times the production of the surrounded areas. Proposing such projects came for the following reasons:

1. Because of water shortage in Iraq and the need to use it for crop irrigation, it would be much better to use readily available natural marsh land for fish culturing activities.
2. The costs for culturing fish in cages and net enclosures are lower than that of earthen pond; moreover the net production in this system is better.
3. Decline of carrying capacity of Marshland for commercial fish species, so these kinds of projects will enhance the fishery resources.
4. The socio-economic status of people living in the Iraqi marshes, impose the urgent need for new technological development of fish production.

USAID (Business Models for Aquaculture in Iraq, 2006) reported that in a country like Iraq with a limited supply of animal feed, the development of aquaculture makes considerable sense because the most common varieties of farmed fish have a much more favorable feed conversion rate than either cattle or poultry. In previous trial, silver pomfret was successfully raised in coastal cages and enclosures by Salman et al. (1991). In the 1980s there were reportedly some 2,000 fish farms in Iraq. Now, apparently, there are only some 500 or so, all of them using earthen ponds, and averaging around 8,000 m^2 of water surface; whereas there is no attempt to used cages right now. The expected benefits of such rearing system to people inhabiting the marshes are:

The main beneficiaries of this project are the poor fishermen and farmers inhabiting the southern marshes of Iraq on family and community levels.

The project will introduce an additional and profitable source of income for them unlike before that they depend on farming only under unfavorable conditions.

Producing fish in floating cages require a small fraction of the farmer-beneficiaries time. It is estimated that they only spent at most one hour a day to tend to the fish. The rest is devoted to their farm or other activities.

The success of this project may attract private or governmental investment in the area. That will help in creating more employment opportunities for local people.

The economic uses of the marsh resources by the farmers will help in sustainable development and environmental protection from water pollutants.

The sustenance of the indigenous species thriving in the marshes is ensured since the community can produce their fish requirement instead of catching these species with pesticides and electric fishing.

3.6 Conducting step for a fish cages project

The conducting steps for a fish cages project in the marshes with their respective time intervals (Table, 1) are as follows:

1. **Site selection**

Survey for the most suitable sites would be conducted in the marshes area to select sites that maintain the essential criteria. Those include water depth, shelter, weather, water exchange and circulation, water quality, pollution hazard and fishing activities. Besides these criteria, site selection survey would take the presence of poor communities in the selected area into consideration.

Fig. (2): Sites selection (FAO-Iraq, 2010)
Sites suitable for fish cages Sites suitable for net enclosures

2. Preparation of raw materials

Materials used for cage construction should be inexpensive and readily available. They should be durable and strong, but lightweight and allow complete exchange of water volume every 30 to 60 seconds by using a minimum of 13-mm square mesh size. The materials must allow free passage of fish wastes and be resistant to fouling but not stress or injure fish.

Row materials for cage construction consist of main and auxiliary materials. The main materials are frame and plastic mesh. The auxiliary materials represent floats, anchors, feeding box, cage cover and walkway. Frame materials would be selected from local plant materials such as reed and wooden sticks. Fixing materials are mainly from plant origin. PVC pipes and joints may also be used to support the cage walls. The empty drums would be used as floats for the cages. The cages will be bound to a wooden platform or walkway floated by oil drums.

3. Cage and enclosures construction

The cages and net enclosures would be constructed according to the planned designs using locally available reed and wooden sticks of cheap price. PVC pipe may also be used when needed in the construction. Square and rectangular cages of selected sizes (2x2 and 2x3 m2) can be constructed from readily available reeds and nylon ropes. Inside the reed frame a well stitched inner nylon cloth of suitable mesh size and a closable lid is tied. Floats, anchors and walkways needed are to be fixed according to field trials. Detailed figures of the design and construction procedures of the cages and net enclosures are available upon approval of the project.

4. Positioning of the cages and net enclosures

The cages and enclosures are planned to be positioned in relatively open areas with good water circulation, away from still or stagnant water where poor water quality may stress or kill fish. Water depth of 1.5 – 2.0 m is necessary to ensure that the cage bottom is at least 0.2 m (0.5 m preferred) above the bottom sediments. Net enclosures might be fixed in shallower area. With rows of cages spaced at least 1 m apart in easily accessible areas to facilitate routine maintenance and feeding.

5. Release and feeding of selected fish species

Stocking densities is to be decided according to the cage sizes, aiming at harvesting 100 kg/m^3. A planned density of 80 – 100 fish of 15-30 g weight would be cultivated for the monoculture. Balanced combination of stocking densities for the polyculture is under consideration. Balanced feeding ration would be formulated and prepared as pellets using local feeding staff. Cages shall be supplied with feeding trays for feeding the fish at certain feeding level (5-8 % of body weight).

6. Continuous monitoring of growth, feed conversion and health of fish

Samples of fish are taken at biweekly intervals to measure length and weight and therefore growth rates. Feed conversion efficiency is to be determined by calculating the amount of supplemented feed and increase in fish weight, During the cultivation period fish health monitoring would be conducted and any sign of parasites or disease infection would be diagnosed and isolated.

7. **Monitoring of water quality criteria**

Temperature, salinity, pH, dissolved oxygen, nutrient concentration and water productivity would be monitored biweekly to ensure suitable water quality.

8. **Harvesting of fish at the end of the experimental period**

Upon harvesting fish after the 9 months period, fish will be weighed to estimate the production levels for the benefit of the poor local people.

9. **Conducting a production analysis (Economic Feasibility)**

Lists of fixed running expenditures along with profits of fish production would be analyzed to calculate economic feasibility.

Table (1): Time Intervals for the conducting steps

Task	**Months**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Site selection	■											
Cage Construction	■	■										
Fish Farming			■	■	■	■	■	■	■	■		
Harvesting & Data Analysis											■	
Reporting												■

3.8 Fish Species

Farming of three fish species (Common, Silver and Grass carp) in mono- and poly-culture style can be performed. Six different combinations can be suggested to be tried and tested aiming at maximum growth and production. The suggested trials are:

Polyculture	Monoculture
Common carp + Grass carp + Silver carp	Common carp
Common carp + Grass carp	Grass carp
Common carp + Silver carp	Silver carp
Grass carp + Silver carp	

4. Fish cum Rice Culture

In practice the area was famous for both rice plantation and fisheries activities in the past (i.e. before drainage). It has currently been exploited for both agronomy and fish farming although on small scale due to shortage of water. As the process of refolding continues, the need to make use of those naturally prepared ground for agriculture and fisheries practices is essential, beside conserving their biodiversity richness.

Few questions have been raised, which need to be addressed. The conclusion that such kind of fish farming is not suitable for the marshes is not absolutely right, since both activities have already been practiced in the area. Few notes, however has to be explained. The following scientific discussion aims at clearing the situation whether the method should be implemented or not. Answer for the raised questions such as: Does it request too much work and technical knowledge? Is it too expensive? Is it too far from Maadan culture? is no for all. This means that the method can possibly introduce to the area. The following proposal would explain the ways that can be followed for introducing this special culture method. Advantages and disadvantages would also be discussed as far as the area is concerned.

4.1 Advantages

In appropriate region the raising of fish in rice fields is considered one of the best and most rational means of using agriculture land. The method is old and has been practiced in the Far East for centuries and reached high

degree of technical perfection. The advantage of rearing fish in rice paddies are many and can be considered of great importance to the rural economy:
It contributes, at low coast, to the production of animal protein.
If practiced in vast areas, it can extensively used..
Rice & fish can be raised simultaneously.
Fish can control weeds, mollusks (Bilharzias hosts), destroying culicids beds such as *Anopheles* (Malaria transformer) and *Stegomya* (Yellow fever).
It has been noted that the presence of fish increases rice production by between 5 – 15 %. This can be explained by indirect fertilization mineralization of rice by fish excrements, unutilized artificial diet and algal control.
Techniques
The different techniques used in the cultivation of fish in rice fields differ considerably from region to region depending upon local conditions such as climate, fish species, varieties of rice, manuring and artificial feeding. Capturing of wild fish populated rice field when in flood is different from stocking and rearing desirable fish species. It is necessary also to differentiate between simultaneous (rice & fish are grown together) and alternate (fish and rice harvested alternately) production when referring to harvesting rice and fish (once per year each for instance), or triple harvest (2 for rice and 1 for fish). Another complicated method can give five harvests of fish and rice over 2-years period.
Another very important factor is the size of fish produced which may be the key limiting factor if consumers prefer large sized fish for eating. This again depends upon the size of fish used for restocking and supply of water. It is possible, however, to produce fingerlings starting with fry or to produce fish for eating starting with fingerlings. Sometimes rice fields can be used as spawning pond. But whichever kind of production is chosen the cultivation period is generally short and limited to a few weeks. There should be some arrangement to hold the fish in ponds or ditches while doing weeding or draining to the rice field. In all cases, rice is considered the principal product and fish cultivation is complementary and secondary.

4.2 Rearing system design
Rice fields used for the production of fish must be arranged in the same way as ponds except that the water must be shallow because of the presence of the rice.
Water supply and evacuation should be controlled by surrounding the field by low earthen dikes built from the ditches soil and water gates supplied with screens to prevent fish escape (reeds or bamboo).
Principle (1m deep) and secondary ditches (50cm wide & 30 cm deep) should be dug around and across the swamp to facilitate draining and fish refuge.
Level of water con be adjusted according to the requirements of both products, if reared together or alternately. Water flow should be adequate (1-2 liters per second per hectare for instance).

4.3 Criteria for choosing fish species & rice variety
In tropical region, at low altitudes and marshy countries, temperature is high and the dissolved oxygen content can fall quite steeply and acidity can increase. Under these circumstances, the choice of fish species for rearing is limited to those able to support such difficult conditions. In those areas Carp is the right choice. If fish and rice are produced at the same time, a variety of rice must be chosen which support being in fairly deep water and at the same time can resist the fish (as carp) digging on the bottom of the swamp in search for food.

4.4 Production levels of fish in rice fields
Production of fish in rice fields varies considerably and depends on the method of exploitation, cultivated species, depth of water, soil fertility and the amount of care given. Methods based on captured fish generally give very small production (40 kg/ha/years) but widespread areas are used. When rearing methods are used, much higher production can be harvested (100-200 kg/ha/year)..However, with feeding, production can exceed 200 kg/ha/year as in the case of Japan where production reached 1000-1800 kg/ha/year.

4.5 The use of fish cum rice method in Iraqi Marshes
The method can be used in Iraqi southern marshes to produce small-sized fish starting from fingerlings. These fish can be used for restocking either in fattening or extensive ponds or into the natural habitats for rehabilitation of the marshes. Both can increase the fisheries potential of the area.
Production of fish in rice fields to the marketable size (Table fish) is not possible due to the short rearing period and the preference of large-sized fish for eating by consumers in Iraq. In the case of carp, we need at least 9-

months period to reach nearly 500g fish. Alternate ponds for fattening must be used beside rice fields to reach such size.

Carp (common or golden) might be suggested for rearing due to its fast growth rate compared with other local freshwater species. Tilapia, if introduced to Iraqi marshes as an exotic species, might be the second choice.

5. Current aquaculture status in Basrah Province

Status of aquaculture in Basrah province had been previously discussed by Al-Mukhtar *et al.* (2005). Between 1982 to 2003 only 15 farms were registered with only 6.6% of them were actively producing fish. The authors pointed out the problems facing fish farming activities compared with other parts in Iraq. The total used area comprises only 4.77% of the total available area for fish farming in Iraq. Primitive practices in pond construction and various management steps were noticed. Economic feasibility study was conducted for the acting farms and found that the total profit approaches 5.78 million ID/donum (1/4 hectare) New rearing and management techniques were suggested to address the aquaculture potential in this province.

Results of a recent limited survey carried out by Ghazi (2010) (*personal communication*) in three regions of Basrah province showed the following statistics:

1. In Fao, 4 fish farms of a total area of 22.5 donum have been established. Tidal ponds of 1-5 donum in size were constructed by digging and stocked with common carp (main species), Shanak and Biah in a polyculture rearing. Salinity of water supply ranged between 15-20 ppt. They depend on natural supply to get fry and fingerlings. Remains of human food were used for feeding the fish.
2. In Abu Al-Khasib, 6 fish farms were found with a total area of 146 donum. Water supply depends on tidal current and pumping to earthen ponds which ranged between 1-10 donum in size. Fry and fingerlings are supplied by the university hatchery. Wheat, barley, grass and poultry by-products are used for feeding. Monoculture of common carp (66%) and polyculture (with grass and silver carp 34%) were practiced. Water salinity ranged between 15-20 ppt.
3. In Tannuma, 8 fish ponds with a total area of 158 donum were recorded. Three type of ponds (digged 62.5%, half-digged 25% and dikes 12.5% ponds) were found in the area. Polyculture of the previous three carp species was practiced in all ponds. Water salinity averaged 5 ppt depending on the pond position.

In addition to the previous fish ponds, other areas are planned to be surveyed in the near future aiming to establish a data-base for the aquaculture in the Basrah Province.

6. Future Steps (problems and solutions)

Aquaculture activities in the southern part of Iraq faced many problems:

1. Local people are not well aware that aquaculture could be a good activity to improve their socioeconomic status.
2. There are very few hatcheries to supply enough fingerlings.
3. The water quality is changing and becoming more saline, which have negative impact on the growth rate of the cultured fresh water species.

To improve aquaculture in the southern part of Iraq, all these parameters should be considered to plan an effective management.

Solutions can be summarized as follows:

1. Making use of the naturally-occurred water impoundments in the southern marshes and turning them into productive fish ponds is a practical approach.
2. The present study suggests various rearing techniques which are suitable for such water bodies. These include introduction of peripheral and transaction dikes to create extensive fish ponds.
3. Fish cages and net enclosures represent also a special profitable approaches. Rearing fish in fish rice fields can also be practiced in certain areas in the marshlands.
4. Fry and fingerlings supply should be maintained through establishing local hatcheries, which produce fingerlings of all carp species (common, grass and silver carp) in addition to some native species such as Bunni (B. sharpey) and Gattan (*Barbus xanthopterus*).
5. Aquaculture activities in the marshes should include releasing fingerlings into the available open waters using big net enclosures.
6. The introduction of new fish species that are more tolerable to the present water quality such as euryhaline species (Shanak *Acanthopagrus latus* and Biah *Liza subviridis*) or some commercial shrimp (Penaed) species.

7. The introduction of new types of culture methods such as cages and recirculation systems which are compatible with the freshwater shortage, quality and depths.

There are big chances of success especially with the availability of sufficient amount of very productive water and cheap work power, but research for optimizing stocking and harvesting is essential.

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