Edited by Min Kuanhong

MAJOR AQUACULTURE SPECIES AND CULTURE TECHNIQUES FOR AFRICA

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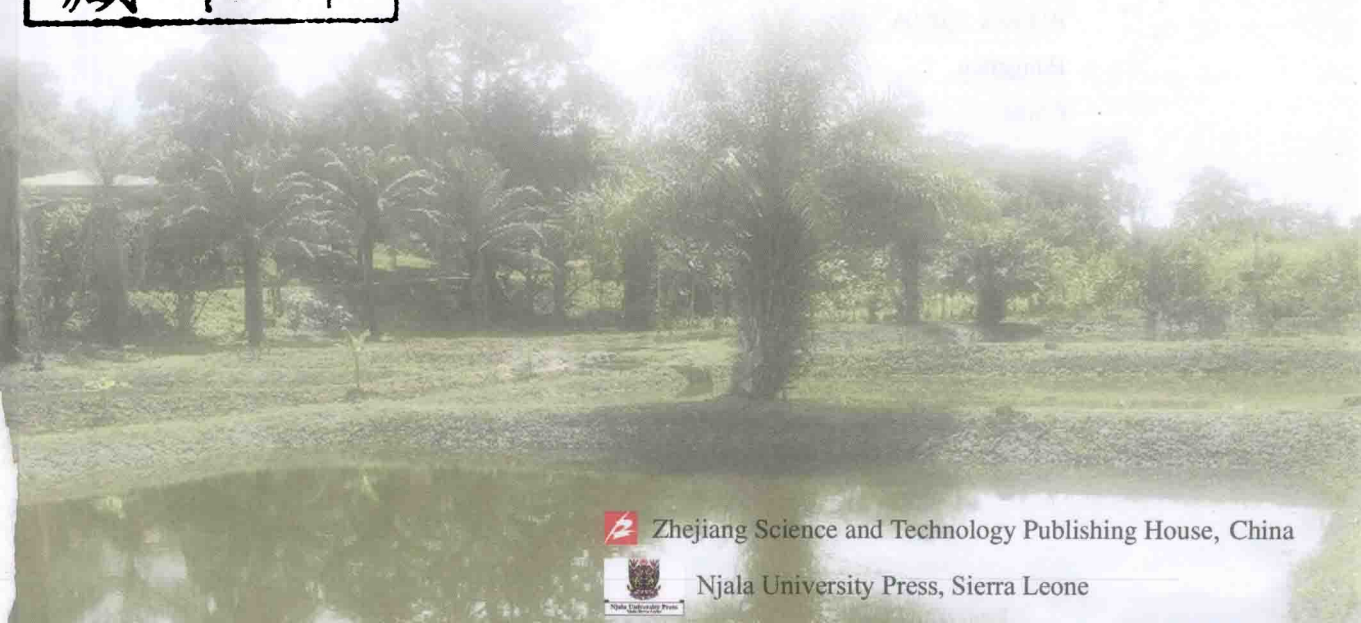

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Preface

With increase in global population, competition for resources becomes more acute and the need for food security is more critical. The pressure for food security is felt more in the tropical regions of the world where most of the developing nations lie. This pressure has led to increased demand for quality protein food especially fish. Fish are an important source of both food and income to many people in developing countries. However, with the decline in landing from capture fisheries the development of the aquaculture sector becomes a sine qua non.

Increased aquaculture production is clearly needed to meet the demand for quality protein. Increased demands for aquaculture production mean increasing pressure for development of more efficient production systems. Aquaculture has the capacity to contribute to increased economic and nutritional well-being of the poor especially in the third world ravaged by hunger and food insecurity. To meet this demand and ensure the success of aquaculture operations there is the need for a comprehensive source of aquaculture information. This source however, should be of practical value and should contain information which the fish farmer or extension agent can understand and apply. To this end a consortium of experienced and well informed professionals in the field of aquaculture and fisheries management have come up with this book *Major Aquaculture Species and Culture Techniques for Africa*.

This book, compiled in a concise and readable manner, is meant to serve as a practical guide to fish farming in the tropics. It covers the culture for common carp, tilapia, catfish and a few numbers of

conventional Chinese carps; fish processing is also included in the book. It furnishes ample information on the farming techniques for the fishes at different stages as well as health related management issues in the operation process.

This book will be an invaluable text for undergraduate students in universities, polytechnics, schools of fisheries and agriculture, for students studying for degrees or diplomas in fisheries with the intention of becoming fisheries extension and development officers.

Finally, the book is meant for the general reader who is neither a fisheries student, fisheries professional or scientist nor a biologist but a layman interested in investing in the aquaculture sector.

I therefore strongly recommend this book to all who seek knowledge about profitable fish farming in the tropics.

Professor Abu Sesay
Vice Chancellor & Principal
Njala University,
Sierra Leone

Introduction

Aquaculture has been developed in Egypt since 2000 BC, however, aquaculture can be dated back to 2,500 BC in China. Depending on advanced technology and practical farmers' experience, the production of aquaculture all around the world has already reached 63 million tons which is accounted for 41% of the total fish production. Aquaculture production has provided 34% of the protein supplies for the human consumption (while mutton 24%, pork 22% and beef 15% respectively). Due to constantly growing production presently, the supply of basically required animal protein is much higher. It is estimated that the population will be 9.3 billion in 2050, 2.4 billion more than that of nowadays. The net growth will account for 35% of the present population. Meanwhile, the food production in 2050 should be increased by 70% in addition to 200 million tons of meat food so as to meet the demand of whole population. However, grain production has been heavily restricted by the land expansion while animal production has been constrained by food competitions, fish meal requirements in the diet and increasingly severe environmental pollutions. Therefore, aquaculture becomes essential in meeting the demand of animal protein food so as to maintain the world food security. It is estimated that an additional 44 million tons of fish is required in 2050, based on the present rate fish production and consumption.

This book aims at offering practical aquaculture skills based on aquaculture both in China and some countries in Africa. It covers various aquatic species such as common carp, tilapia, catfish and a few numbers of conventional Chinese carps. It covers the processing of fish production as well. It provides ample information on the aquaculture techniques at different stages as

well as fish health management in the operation process. Fishes covered in this book are highly characterized by good growth rate, strong resistance against diseases, easy operation and well-accepted markets. Writers for this book have well presented their personal knowledge and field experiences in aquaculture, providing their first-hand information collected from the field. They are working as researchers undertaking many national and international projects for fish farming techniques, feeds and nutrition, farming systems, health management and economics. They are also working as professors teaching national students and international participants. They have extensive knowledge and experiences for international programs and are good at working with farmers. The information provided in this book is comprehensive and can be practically used as field guide for fish farmers.

Certainly the book can be improved better in both the idea presentation and the language applications. Due to different culture contexts, the terms used may not be appropriate for readers from different countries. It is hoped that the culture differences will not be obstacles in understanding the text, as well as in following the operation procedures.

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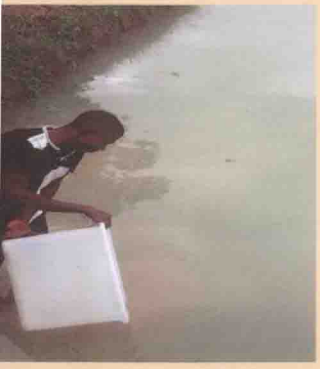
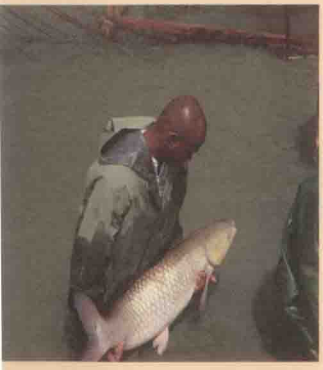


CONTENTS



Chapter 1 Tilapia Aquaculture

Tilapia is one of tropical fish species which originated from Africa. Due to its high growth rate, wide range of food sources, short reproduction cycle and culture period, high disease resistance and strong environmental adaptability, it is highly recommended by FAO (Food and Agriculture Organization) for worldwide farming. It is one of the most popularly cultured fish species in the world. It has been one of the dominant species for freshwater aquaculture because of its promising market potential.

1.1 Habitat Adaptations

1.1.1 Morphological Characteristics

Tilapia belongs to the order Perciformes, family Cichlidae, genus *Tilapia*. This genus comprises more than 100 species including subspecies. At present, 15 of them are cultured all over the world. *Tilapia mossambica*, *T. nilotica*, *T. galilaea*, *Oreochromisco aureus* and *T. zillii* etc. (*Oreochromis*) are major species introduced to China. There are some hybrid tilapia, such as *Nile mouthbreeder* (*T. nilotica* ♂× *T. mossambica*♀), AuNi tilapia (*T. nilotica*♀× *T. aurea* ♂) and red tilapia (mutated hybrid from *T. nilotica* × *T. mossambica*), among which AuNi tilapia is an all-male species which is widely cultured in China.

AuNi tilapia

Red tilapia

1.1.2 Physiological and Ecological Characteristics

1.1.2.1 Temperature

Tilapia can grow in water with a temperature range from 16 to 38℃. The proper temperature for growth is 22 to 35℃ and the optimal temperature for growth is 30℃. The majority of tilapia species can survive with a temperature range from 10 to 12℃, but AuNi tilapia can survive within 8 to 10℃. Tilapia with different size has different resistance to low temperature. Generally, the bigger the size is, the higher the resistance will be.

1.1.2.2 Dissolved Oxygen (DO)

For tilapia, the need for DO is lower. This species can survive in fertile water with lower DO. The amount of aerators required is small in intensive farming compared with other species aquaculture. Normally, tilapia will not gasp for oxygen until the DO is lower than 2 mg/L. However, the growth rate will get lower if DO is below 3 mg/L.

1.1.2.3 pH

Tilapia has a strong adaptability for pH fluctuation in pond water. It can survive within the range of 5 to 10. The pH value of 7.5 to 8.5 in pond water helps the accumulation of Nitrite, which helps increase the survival rate and fast growth of fingerlings. So the optimal pH value for tilapia growth is 7.5 to 8.5.

1.1.2.4 Salinity

Tilapia is a euryhaline species. It can survive in freshwater as well as in brackish water. The optimal salinity of water for tilapia growth is about 8‰. Tilapia farmed in brackish water has a good taste and is welcomed in markets. However, the reproduction of tilapia is hindered in sea water with salinity of above 21.5‰.

1.1.2.5 Growth

Tilapia has a high growth rate. Male tilapia grows faster than the female. The body weight of male tilapia is 40% higher than that of female one. Compared with other species, AuNi tilapia grows faster. For example, AuNi tilapia can reach above 650 g in the first year if the fingerlings hatched in early spring (early April) are stocked in May for intensive culture. The weight of AuNi tilapia can be over 1,100 g in the first year if bigger-size overwintering fingerlings are stocked in May. For the model of one-crop farming, the yield per hectare can reach 16,500 kg after 4 to 5 months culture. For double

crop farming model in southern China, the production can reach above 2,000 kg/ha.

1.1.2.6 Feeding Habit

Tilapia is omnivorous fish, with a tendency to be herbivorous. Tilapia feed mainly on zooplankton at larval stage. The scope of food expands with the growing size of the fish. The usual common foods are all kinds of planktonic, benthic and epiphytic algae, tender higher aquatic plants, all organic detritus and a little animal feeds such as earthworms, small shrimps and aquatic insects.

Market size tilapia

Under culture conditions they can utilize all kinds of vegetable leaves, tender grass, brans, seed cake and pelleted feeds if applied. At a proper temperature, the ability and intensity of their food intake are much higher.

1.1.2.7 Habitat

Tilapia is a benthos species, but the water layer of their activities vary with water temperature. In the morning, they prefer to inhabit the middle and upper water layers as the temperature rises gradually in the pond. They search for food at the upper layer at noon and immediately sink to the pond bottom if disturbed. In the evening, tilapia prefers to inhabit the middle and lower water layers as the temperature drops. From night to dawn of next day, they are less active and stay at water bottom. At fry stage (with a body length of 1 to 1.5 cm), they swim in groups in shallow water close to the pond dike. They scatter over the pond as they grow.

1.2 Brooders Management and Breeding Technologies

Tilapia breeding can be characterized by:

- Early sexual maturation. Taking Nile tilapia for example, they reach sexual maturation in 2 to 4 months after being hatched out (with a body length of above 10 cm).
- Short spawning period. In general, they spawn once every 30 to 50 days. In southern China, such as

Guangdong Province, Guangxi Zhuang Autonomous Region and other regions, tilapia can spawn 5 to 6 times a year.

- Lower requirements for breeding conditions. The female can reach maturation and spawn in small size (100 g) in static water environemnt.
- Eggs incubation in the mouth of female brooder and larvae cared by brooders. The eggs incubation and fry nursery are processed in the mouth of brooder. At this stage, brooder does not take food. Eggs will turn over from interior side to exterior side and from upside to downside of the mouth with the respiratory movements to ensure enough oxygen when incubating. When the yolk sacs become smaller, the larvae enter the so-called mixotrophism period. Brooder releases the larvae from the mouth in shallow water and starts feeding. At this stage, larvae have lower swimming ability. They often gather around the brooder and search for food when swimming. Usually, larvae tend to cluster in the upper layer and brooder stay below the water layer the larvae stay.

Indoor incubation facility of tilapia

The fecundity is low for each spawning, for example, about 300 eggs for the first spawning. The fecundity will become higher as the brooder grows. The fecundity of brooder with a body length of 18 to 23 cm is 1,100 to 1,600 eggs each spawning and 1,600 to 1,700 eggs each spawning for brooder with a body length of 25 to 27 cm. However, the accumulated fecundity of tilapia is higher due to breeding features mentioned above.

1.2.1 Pond Condition for Spawning

1.2.1.1 Site Selection

Ponds for tilapia spawning should be located near water sources. It is convenient for water irrigation and drainage with quiet environment and convenient transportation. In China, those near

overwintering brooders of ponds are commonly selected for spawning because the incidence of injury on brooders can be decreased during pond shift.

1.2.1.2 Pond Area and Water Depth

Generally, the pond area of tilapia spawning is about 1,400 to 4,000 m^2. Either too big or too small is not convenient for management. For the former, it's difficult for fry or fingerling harvest. For the latter, it's hard for water quality management and easy to cause a bigger fluctuation of water temperature. It's better to maintain the water depth within 1.4 to 1.5 m short after brooders stocking. The water depth should be decreased to 0.8 to 1.2 m during spawning. But it's good to increase the water depth to 1.2 to 1.4 m during high-temperature days in summer.

1.2.1.3 Pond Shape and Soil Texture

The pond shape should be rectangular with longer west-east dike than north-south dike. Pond slope close to dike in shallow water should be available for brooders to make nests and spawn. The pond bottom should be flat and concave. The sediment should be loam and sandy loam. It's inconvenient for fry or fingerling harvests if there are some wild grasses in shallow water of pond slope close to dike.

1.2.2 Pond Clearing and Disinfection

Pond clearing and disinfection should be done before stocking of brooders. Wild fish, wild grasses and other things, especially the wild grasses in the area from pond center to the place 1.6 m away from pond dike should be removed after draining the pond. Strict inspection of pond dike should be done and make sure that filtering nets cover for the inlet and outlet are firmly installed. Pond bottom should be exposed to sun until the soil cracks. Water about 10 to 20 cm deep should be introduced 10 to 15 days before brooders stocking and then chemicals

Pond cleaning practice

are applied for pond disinfection. The chemicals used for pond disinfection include teaseed, bleaching powder and quicklime, among which tea seed and quicklime are more effective for pond disinfection. The amount of tea seed for disinfection is 600 to 750 kg/ha. For quicklime, it is 2,250 to 3,000 kg /ha, while bleaching powder 225 to 300 kg/ha (available chlorine content: 30%).

1.2.3 Water Quality Management

Netting with small mesh size net should be done to remove wild fish, wild grasses and other things a few days after disinfection. Then water can be introduced. The water inlet should be covered with small mesh size cloth to filter the water. The cloth cover on the inlet should be cleaned frequently. After water introduction, base fertilizer should be applied over the pond. The amount of fermented manure is 4,500 to 9,000 kg per hectare. For green manure, it is 7,500 to 12,000 kg per hectare. It's better to keep the water color in tea green or yellow green. If the green manure is used for fertilizing, it should be turned over often until it's rotten and then the residue of grasses should be removed. Stocking of brooders can be done after water test about 7 to 10 days after disinfection.

1.2.4 Brooders Stocking

1.2.4.1 Brooders Selection

Tilapia as parent fish must be purely bred. The individuals with higher growth rate and bigger size should be selected as brooders. The body weight of fish through overwintering which are used as brooders should be above 250 g. Normally, male fish has a little bigger size than female one. The fish used as brooders should have following features:

- High dorsal side and thick flesh layer;
- Intact scales and fins;
- Bright color and clear spots;
- No sign of disease and without injury;
- Uniform body shape which is in

Checking the maturation of brooder

accordance with taxonomy standards.

1.2.4.2 Stocking Time

After stocking of brooders, the water temperature of spawning pond should be maintained above 20℃. In Guangdong Province, brooders are paired for spawning in late March. In some regions, such operation can be done earlier if greenhouse and temperature-control equipment are available. Stocking of paired brooders in full amount should be done in sunny days. Before stocking, brooders should be disinfected and dipped in 3‰ to 3.5‰ salt solution for 5 to 10 min.

The transportation of brooders should be carefully operated to minimize injury incidence and shorten the time of their recovery after stocking. Then chlorine dioxide solution with a concentration of 0.3 ppm should be used for prevention of wound infection and saprolegniasis.

1.2.4.3 Stocking Density and Sex Ratio

Stocking density of brooders depend on dissolved oxygen, pond conditions, and expected yield etc. Stocking density can reach up to 22,500 to 30,000 individuals per hectare in the condition that the brooder size is 250 to 300 g and pond with normal water temperature is equipped with an aerator (capacity:1.5 to 2.2 kW) per 2,000 m^3. For pond without aerators, 1,200 to 9,000 individuals (size: 300 to 500 g) per hectare can be stocked. For ponds covered with plastic film and equipped with aerators, the stocking density of brooders with size of 250 to 300 g can be 15,000 to 18,000 individuals per hectare.

Sex ratio is very important for brooders stocking. According to farming practices and experience in China, sex ratio of female to male at 2.5:1 to 4:1 is optimal to obtain high seed production. If more male tilapia is stocked in ponds, they will eat the fry if there are no adequate feeds provided, which will cause the decrease of seed production.

1.2.5 Nursery and Management

Brooders need intensive nursery because of their weak body condition, poor gonad development after a long overwintering period. Intensive nursery can be achieved through fertilizing and feeding. According to farmers' experience, the feed rate is about 3% to 4% of body weight of brooders. In order to stimulate the gonadal development of brooders, fine feeds and forage feeds should be supplied together to enrich their diets and meet their demands of nutrition. Generally, the protein content of fine feeds should be above 35%. The common feeds for brooders nursery include soybean cake, fish meal, corn powder and peanut cake, etc.

Feeding practice

Pond inspections should be done in the morning, at noon and in the evening after brooders' stocking. Frog eggs and predating organisms to tilapia should be removed or be eradicated. Water quality management should be paid close attention to. Some effective measures should be taken if the water is too fertile or black brown, such as changing water or spraying quicklime to avoid water deterioration which can cause brooders to gasp for air due to the oxygen depletion. Disinfection and water quality improvement should be done regularly. Quicklime should be applied once every half a month. The amount of quicklime is about 150 to 225 kg per hectare. Regular application of microbial agents is necessary to improve microbial communities and water environment.

1.2.6 Spawning and Hatching

1.2.6.1 Water Temperature

When the water temperature rises to 22℃ after stocking, brooders will soon reach estrus and ready to spawn. Eggs incubation and fry nursery are processed in the mouth of female tilapia. The time needed for eggs incubation varies with water temperature. It will take about 5 to 6 days for fry to hatch out when water temperature is 25℃ and 4 to 5 days for fry to hatch out when water temperature is 28 to 30℃. About 10 to 15 days are needed from spawning to fry

Tilapia eggs