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INTRODUCTION OF EXTENSIVE CAGE CULTURE SYSTEMS FOR BREEDING OF CATFISH (*CLARIUS GARIEPINUS*) AND COMMON CARP (*CYPRIN CARPIONUS)* AT THE AQUACULTURE TECHNOLOGY DEMONSTRATION CENTRE, XHARIEP DISTRICT: AN AGRICULTURAL EXTENSION PERSPECTIVE

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ABSTRACT

The Aquaculture Technology Demonstration Centre is aided by the Chinese government to enhance the development of aquaculture in South Africa, and thus provide agricultural extension services to farmers and fisheries. The approval of activities and site selection was endorsed by Chinese and South African representatives. The project is based at the Gariep dam in the Xhariep District. The centre primarily focuses on training, demonstration, and research. It is currently being operated by the Free State Department of Agriculture with support from the Department of Agriculture, Forestry and Fisheries. At present, research is being conducted on the culturing of the following fish species, catfish, carp, goldfish, and koi. Tilapia will be introduced in the near future. The purpose of the research is to improve the livelihoods of poor communities, to commercialise small-scale farmers, and to exhilarate economic growth. In addition, the centre aims to support and encourage the use of affordable and natural resources, and to address several challenges including a lack of land, skill, sufficient production, as well as market and quality inputs. Therefore, the practice of fish breeding at the centre aims to deliver extension and advisory services to South African farmers and fisheries. Furthermore, the centre will aim to assist with the production of quality fish stock, to remedy breeding difficulties, and to address fish production shortfalls.

Keywords: Cage culture, catfish, common carp, agricultural extension

1. INTRODUCTION

The China - South Africa Agricultural Technology Demonstration Centre (ATDC) is the first project of the Chinese government to assist South Africa within the agricultural sector. The basic purposes of the centre include teaching and training, experimental research, as well as demonstration and promotion of the existing level of skills and developmental needs within the fresh water aquaculture of South Africa. Alongside relevant parties in South Africa, the centre strives to become the main research base for fresh water aquaculture training and research within South Africa and even extending towards the whole of southern Africa.

Under the support of the Chinese Ministry of Commerce and the Chinese Embassy in South Africa, the staff members of the centre worked in close co-operation with various corporations from China in the planning and implementation of the project to achieve the guidelines and standards set out by the South African Ministry of Agriculture, Forestry and

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Fisheries, as well as the Free State Department of Agriculture. Over the past three years, the achievements of the centre have laid a significant milestone in China's technology and skills cooperation with South Africa. In accordance with the relevant requirements of the Ministry of Commerce and the Ministry of Agriculture, the centre has achieved remarkable results.

Many of these achievements are derived from the experimental research that takes place at the centre. Experimental research is considered an important stepping stone of the Demonstration Centre for China's Technology. Under the participation of the centre's specialists and management team, the specialists have successfully carried out the research for the artificial breeding of catfish, goldfish, koi, carp, and the local yellow croaker. Through their research, the centre has been able to successfully acquire fish eggs as well as to hatch them, thereby producing high-quality fish fry. Different methods were used in this process, such as selected indoor tanks and outdoor ponds. The results gained were significant; thereby demonstrating that China's advanced aquaculture technology could successfully be used in South Africa, and could help to improve the skills level of South Africa's aquaculture technology.

The experimental study also included the promotion of a variety of adult cultivation methods, namely, net cage culturing; pond culturing of catfish; fish and plant symbiosis; as well as culturing of fish in paddy-fields. All of the attained results were found to be successful and significant. These technologies have a wide application prospect in South Africa, and will play an active role in the promotion and improvement of aquatic products as well as enriching the aquatic farmers (HLPE, 2014). As noted by the University of Rhodes (2010), the practice of aquaculture has only been around for about 2500 years, as compared to agriculture which is thought to have started about 10 000 years ago. The first records of aquaculture are from China, where carp (*Cyprinus carpio*) were cultured.

This paper focuses specifically on extensive net cage culture systems, which are effective methods of intensive aqua culturing. The catfish (Clarius gariepinus) and common carp (Cyprin Carpionus) are two of the major freshwater species in South Africa (HLPE, 2014). It is therefore necessary to conduct studies on the effects that this type of culture system may have on the growth and survival of catfish and common carp, and to provide farmers and fisheries with the relevant knowledge and skills. Thus, the aim of the experimental study was to determine if extensive cage culture techniques would have an influence on the growth and survival of fish (catfish and common carp). Flowing from the aim of the study, the following objectives were investigated:

1. The effect of temperature on the growth and survival of catfish and common carp in cage culture systems.
2. The effect of feeding techniques on the growth and survival of common carp and catfish.

2. CAGE CULTURE

Whilst demand for aquatic food products increases, production from capture fisheries at a global scale is levelling off, and most of the main fishing areas have reached their maximum yield. If further pressure is placed on global fisheries, the damage could become severe to a point at which the ocean's biodiversity will deteriorate and crucial ecosystems' services will be lost (The World Bank, 2007). Global aquaculture has been growing rapidly in the past two decades. Several techniques and new species have contributed to the increase in world aquaculture production from less than 10 million tons in 1989 to more than 24 million tons in

2001 (excluding aquatic plants) (FAO, 2002). Cage culture, the practice of farming of aquatics in cages and nets, is one of the new culture techniques and has become widespread around the world (Huguenin, 1997).

Cages are widely used around the world to culture fish in natural or artificial water bodies. The use of cages in aquaculture has several advantages. Firstly, cages do not require land-ownership and can be moved to the most suitable area (University of Rhodes, 2010). Secondly, cages protect fish from predators and theft. In addition, they can be kept in groups which facilitates the size-sorting of fish and prevents unwanted reproduction of some species. Cage culturing is, however, not without disadvantages. For instance, they do not allow the fish access to the substratum from which they can feed or seek refuge, with the ever-present risk of losing the entire stock within a cage should the fish be able to escape. Cages also suffer from fouling of the mesh in certain waterbodies. This prevents water free-flow through the cage, resulting in poor water quality at times. Cages may also pollute some waterbodies due to the accumulation of uneaten feed and fish waste below the cage (Pearson & Black, 2000; University of Rhodes, 2010).

Many species of fish are suitable for cage culturing. Species which have been previously researched and successfully reared in cages in the south-eastern region of the United States of America include catfish, trout, tilapia, striped bass, red drum, bluegill sunfish, crappie, and carp (SRAC, 1997). The strengths of the species need to be weighed against their weaknesses in order to decide if the species is suitable for achieving the desired outcome of a fish-farm. Furthermore, if the species has previously been cultured in the region, then the culture techniques are likely to be well developed and cultivation will be relatively simple (Appleford, Lucas, & Southgate. 2012).

The materials used in constructing a cage may vary depending on what is available. According to Cakaloz (2011), the common materials for cage construction are wood, steel, and plastic. In more underdeveloped areas, materials such as bamboo have successfully been used. The material selection for cages should be durable, nontoxic, rust proof, and elastic. Flotation may be accomplished with the use of plastic jugs or barrels. The wire used for constructing the cages does not have to be plastic coated, however, corrosion may destroy a cage within three months if there is no protective coating. Furthermore, an opaque cover is necessary for most species of fish, especially if the water is highly transparent (Huguenin, 1997).

Netting: The netting has three major functions namely, keeping the fish stock together, protecting the stocks against harmful external influences, and allowing free water exchange between the inside and outside water. The most commonly used netting material is flexible nylon since it is relatively inexpensive, and it can be treated with chemicals against anti-fouling. Rigid netting material such as rigid plastic, galvanised or plastic-coated steel are also used in some cases. In addition, the mesh size should be as large as possible, taking into account the fish size. The larger the mesh size the better the oxygen supply of the stocks.

Floats: The floats should keep all the floating devices (netting with frame, feeder, walkway, etc.) safely on the water surface. Empty barrels, plastic containers or styrofoam bodies can be used for that purpose. Specially designed air or foam filled plastic floats are also readily available.

Frame: The frame can be made of galvanised steel, aluminium, timber, and different plastic materials. The frame should be mechanically strong, resistant against corrosion, and easily repairable or replaceable. For fixing the different frame elements together, special joints have to be used. Rubber and hemp hose ensure flexible connection between the adjoining cages. Furthermore, although the feeder is not a real part of the frame structure, one has to provide for the mounting and easy operation of a feeder during the design (Cakaloz, 2011).

2.1. Fish stocking densities in cage culture

The weight of the total production in cage culture depends on many factors such as fish species, stocking density, fish size, culture period, cage size, water quality parameters, and the amount of feed provided. The minimum recommended stocking density for common carp and catfish is 80 fish/m^3, while the recommended maximum stocking density for beginner farmers is the number of fish that will collectively weigh 150 kg/m^3. The smallest recommended fingerling size for stocking is 15g for any fish. Cages can result in up to 98% survival rate when they are well placed and well managed (Huguenin, 1997; Schmittou, 1991).

2.2 Feeding fish in cages

As stated by Hancz (2011), the purpose of cage fish culture is to economically produce crops of fish. Economic feasibility is obtained through a balance of maintaining a productive ecosystem and adding sufficient nutritional inputs to achieve optimal crop yields. The objective of feeding fish in cages is to economically provide proper nutrition for fish growth and good health while minimising metabolic waste and ecosystem pollution (Mente, Pierce, Santos, & Neofitou, 2006).

As each species eats a different diet, each species of fish has its own nutritional requirements. Fish and other animals require food to supply energy for movement and other activities as well as for growth. As fish are 'cold-blooded', their body temperature is the same as the water in which they are living. Thus, they do not have to use energy to maintain a stable body temperature and therefore tend to be more efficient users of food than other animals. The optimum temperature for growth varies for each species. Within a species' preferred range of temperature, the metabolic rate, and the need for food, increases until the optimum temperature is reached (Pearson & Black, 2000). This explains why, in areas where there is a wide temperature range during the year, the fish eat much more food during the summer than in winter (University of Rhodes, 2010).

During cage culture techniques, the fish must be fed daily to ensure adequate supply of good quality feed (Mente *et al.*, 2006). The fish that are confined in cages have limited access to natural food from the pond, however, they still need a nutritionally complete diet. Feeding equipment such as automatic feeders may be installed to make feeding easier. Common feeding problems that occur in cage culture include poor quality feed, incomplete feed, inadequate feeding or underfeeding, overfeeding, and feeding at the wrong time of the day. Many of these problems have no simple solution and some degree of stress will occur (Masser, 1997; Mente *et al.*, 2006).

3. METHODOLOGY

3.1 Study area and climate

The study was conducted at the Agricultural Technology Demonstration Centre (ATDC) which is located at Gariep Dam in the Free State Province. ATDC is situated at 30.6º west longitude, and 25.5º south latitude of South Africa, on the south of Free State Province. The area belongs to a tropical highland climate zone, where the sun is very tough with large temperature changes between day and night. In winter (June-August), the average temperature is 10-12ºC; the maximum temperature during the day can reach as high as 30ºC, while at night, under the influence of the Atlantic sea breeze, the lowest temperature reaches a minimum of -4ºC. Temperature changes during winter are around 20ºC between day and night (Tshetlo, 2014).

In summer (December-February), the average temperature is 19-20ºC, with a maximum of 34ºC during the day, and a minimum of 4-5ºC at night. Temperature changes between day and night is around 25-30ºC. Every year from late July to early August, the water temperature drops to 7ºC and in mid-December to late February, the water temperature reaches a maximum of 27ºC. The annual water temperature change is around 20ºC. Water temperature reaches stability of above 18ºC during early November until March the following year, which is a total of 150 days. Water temperature reaches above 22ºC, which is more suitable for fish growth, for only 110 days. However, the water temperature still does not meet the temperature requirement of 28-31ºC, which is the most ideal for breeding. There are only seven months (mid-October to mid-May) in a year where the water temperature remains between 12-26ºC in the surrounding rivers and aquaculture waters (Tshetlo, 2014).

3.2. Cage culture setup

In March 2015, three submerged cages with dimensions of 4.2m x 3.9m x 2.5m and water depth of 2.5-2.7m were installed at the centre. They were used to stock 10 000 fish (5000 catfish and 5000 common carp fingerlings). The initial stocking size of both species was about 10g. The fish were fed twice daily with extruded pellet feed containing 36% crude protein content at 5% body weight for 90 days. The purpose of this cage culture was to study the growth rate of the fish under net cage culturing conditions, as well as the development of sexual organs and the pathogenesis of fish diseases. At the same time, it served as a demonstration base for the net cage culturing technology.

3.3 Data collection

In the implementation of the centre's operations, two breeding species were selected for observation, namely common carp and African catfish. The purpose of the experiment was to observe and record all essential data since the implementation stage. Two experiments were conducted, once in the summer period and another in the winter period. The first season of breeding was carried out in 2014 with 33 common carp (11 males and 22 females) and 11 African catfish (7 males and 4 females). The following year's experiment was conducted with the same quantity of common carp. The quantity of African catfish however increased to 79 (26 males and 53 females) catfish broods tocks.

4. RESULTS AND DISCUSSION

After two years of culture experiments, it was found that the growth rate of the local carp is faster than that of the catfish. Net cage culturing allows the carp and African catfish to reach sexual maturity. In addition, no deaths as a result of frostbite were found. Subsequently, the cultured products may be used as broodstock reserve to prevent fish disease developments. It is recommended to use fish of 100g or more in weight, and stock at medium-low densities.

Similar to results found by Pearson and Black (2000), the growth rate of fish has shown to be dependent on the environmental condition, nutritional level (quality of feeds) provided, the type of fish species, and the type of culture system used. Thus, the experiment indicates that, under complete feeding conditions, the greater the size of the species, the faster the growth rate. If the fish are stocked at an average weight of 400g and fed for 360 days per year, they grow to an average weight of 1800g, with a growth rate of 3.33g/d. Moreover, if the fish are stocked at an average weight of 120g and fed for 240 days per year, their average weight increases to 500g, with a growth rate of 1.58g/d. The rapid growth rate can be attributed to the flow of water, and fresh water quality which contains high levels of dissolved oxygen (5-6.5mg/ml).

However, little emphasis is placed on the production of affordable animal protein for the purpose of food security (HLPE, 2014). If there is no opportunity in the market place for a species, producing the fish will be of no value. It is therefore important that the market values the species at a high enough level to cover the production costs and still make a profit (Mahieu, 2015).

5. CONCLUSION

Aquaculture in South Africa is mainly focused on the production of high priced species (abalone, oyster, mussels, trout, and ornamental species) and is directed towards niche markets within southern Africa as well as the import markets of developed countries. This is mainly due to the fact that aquaculture development in South Africa is currently market-orientated and driven by both corporate and entrepreneurial participation, with an emphasis on economic earnings. The Agricultural Technology Demonstration Centre may proof to be an invaluable source of delivering extension and advisory services providing the introduction of valuable prospects ranging from training to experimental endeavours. The results of the centre's experimental research will subsequently aid emerging farmers to establish fish businesses and create employment. Therefore, by identifying ideal cage culture systems under extensive conditions, in a South African context, more effective extension and advisory services could be delivered to South African aquaculture farmers.

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