AQUACULTURE PRACTICES IN AFRICA

SYSTEMS IN USE AND SPECIES CULTIVATED

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1. Introduction

The status of aquaculture development in Africa has been the subject of considerable debate in recent years for despite a nutritional need to increase fish production, fish farming has far from achieved predicted goals. Perhaps the first quantified report of fish farming activities in Africa is that by Meschkat (1967) presented during the 1966 'FAO World Symposium on Warmwater Pond Fish Culture'. This was followed in 1975 by the first Regional Workshop on aquaculture planning in Africa (FAO 1975) and Symposium on Aquaculture in in Africa (FAO 1976) both held in Ghana. These were followed by other meetings (CIFA 1980, Coche 1983), FAO Technical Conference on Aquaculture, Kyoto (Pillay and Dill, 1976) and World Conference on Aquaculture, Venice (Pillay 1981). Balarin and Hatton (1979) reviewed the situation but with special reference to the tilapia while (CIFA, 1974) list other species of importance in Africa and FAO (1982a) describe research centres and Chakroff (1982) reviews extension services.

More recently the situation has been discussed at the 'FAO World Fisheries Conference, Rome' and during 'Aquacoltura '84, Verona'. Although the proceedings have yet to be published, Anon (1984) makes reference to the latter. The material from these meetings was not available to include in this study. Presented here therefore is a review of those reports already mentioned as well as available major country status reports published since 1980. These include works on Zambia (FAO, 1980); Ivory Coast (Vincke, 1982); Mozambique (FAO, 1982b); Rwanda (Schmidt and Vincke, 1981); Central African Republique (Blessich *et al*, 1983); Malawi (Cross *et al*, 1983); Tunisia (FAO, 1983); Congo (Balarin, 1983); Egypt (Sodek, 1984) and a current FAO 12 country review by Balarin (1984a-g) and Balarin (1985, h-l).

2. History of Fish Culture in Africa

Although carp culture, first initiated in China, is believed to be the forerunner of modern day aquaculture, tilapia keeping in ponds in Egypt around 2500 BC, nearly 1000 years before, heralded the start of the concept of fish farming. The only remnant of an ancient traditional fish farming technique is the Howash farms in the Nile Delta in Egypt which by virtue of their extensive area (=30 450ha, Sadek, 1984 and 48 845ha, Ardill, 1982) suggest a long standing practice. Other apparently indigenous traditional fish culture practices which have evolved in Africa include the brush-parks or 'acadja' system of Benin (Welcomme, 1971), Ghana and Madagascar (Ardill, 1982) the fish holes of 'Whedos' of Benin and Cameroon (Welcomme, 1976); and the 'Barachois' of Mauritius (Ardill, 1982). These systems are unique to Africa. No documented evidence however is available of their early development history but reports acknowledge the existence of such fish culture systems over the last two centuries.

Fish culture proper was therefore reintroduced into Africa during the colonial period with perhaps one of the first developments taking place over one hundred years ago (Safriel and Bruton, 1984). For reasons of familiarity and preference, the Europeans favoured exotic fish (e.g. trout, carp and black bass). Initially therefore between 1910 - 1960 large numbers of exotic fish were introduced into African waters. The main emphasis however was rearing and stocking of sport fisheries. It was soon apparent that there was scope to increase fish production through reservoir stocking as a ration fishery and later through classical pond culture. Perhaps the first scientifically orientated approach to farming fish for food was initiated in tilapia culture in Kenya in 1924. Balarin and Hatton (1979) describe this early progress, but it was not until after the Second World War that fish farming was extensively introduced into rural communities with the establishment of demonstration experimental farms and an active extension agency. By 1960, Anon (1984) describes over 300,000 ponds operational in 20 African countries, most were rearing tilapia. From then on interest would appear to have rapidly deteriorated except where considerable Government support was provided. Farmers possibly became discouraged by the effort required for little return due to stunting in ponds of the favoured tilapia. An absence of technical understanding to curb this as well as biological problems in breeding of a suitable alternative such as Clarias, Carps or any other indigenous species led to an abandonment of ponds.

Recent innovations in warmwater fish farming technology and realisation of the importance of fish production in rural communities had seen renewed efforts on the part of Governments and foreign aid agencies such that 20-30% of the original pond developments have now been reactivated.

3. The Status of Aquaculture in Africa

For the purposes of this study 54 countries and outlying islands of Africa were considered. Available data on statistics from published and unpublished works generally indicate that the information was scant and no reports were available for Cape Verde, Comoros, Equatorial Guinea, Guinea Bissau, Namibia, Sao Tome, Zaire and Western Sahara.

3.1 Aquaculture Statistics

Coche (1983) considers that statistics are both contradictory and often lacking such that no accurate estimate was possible. Production in 1981 was considered not to exceed 10,000t/yr contributing less than 0.1% to World aquaculture given as 8.7 million tonnes. CIFA (1980) refers to 1975 statistics, an estimated 107, 400t/yr about 1.8% of World production, while FAO (1975) lists over 30,000t/yr from only nine African states. Statistics remain confused because of the diverse nature of rural pond farming, absence of an organised aquaculture census and an uncertainty of the definition between fisheries management, semi-aquaculture activities and capture fisheries. For the purposes of this text the following definition is considered.

Aquaculture is defined as any increase in production from a man-made or modified area through some form of human intervention beyond that of merely harvesting the fish.

A composite picture of reported statistics is therefore presented in Table 1. The gaps and shortcomings of such a statistic emphasise the need for the enstatement of an enumeration system as established for fisheries, a feature likely to be vital in future fish farm development planning. The data presented suggests over 321,000 ponds as having been established, representing between 23,000-79,000 ha. The yield falls between 6950-144,400t/yr but is more than likely more closely approximated by the lower value.

3.2 Development Status

Aquaculture development in Africa falls into two broad categories varying according to organisational patterns, level of sophistication and intensity of operation. There are however a number of intermediate levels but the definitions adopted here are after Pillay (1975):

(a) *Small Scale Rural Aquaculture* characteristic of rural developments either by individual subsistence farmers, artisanal, village or community groups employing relatively unsophisticated techniques for the purpose of additional food production often integrated with other farming systems. Practised as a sole or part-time occupation, often dependent upon public sector involvement either for funding or support services, production units are small and yields low.

(b) *Large Scale Aquaculture Industry* generally developed as private sector investment or government corporate activity, involving large capital outlay, centralised management and a certain degree of vertical integration, the dominant objective is return on investment i.e. commercial activity. Development involves intricate feasibility study for correct system, species and site choice and is dependent upon inputs to maximise yields efficiency, often on a large scale.

The first type applies to the theme of this paper but the second is considered in the light of Balarin (1984h) and in terms of its future role in food production.

Initial emphasis in aquaculture in Africa was perhaps commercial enterprises for up-market fish such as trout or the rearing of black bass for sale to farmers for dam stocking, but the biggest development was into rural aquaculture. Over 37 of the countries considered list small scale developments. Of these by far the most extensive activities are in Zaire, Madagascar, Kenya, Central African Republic, Egypt, Cameroon and the Congo where over 85.6% of ponds were recorded (Table 1), 38% in Zaire alone. No statistics however are known for Nigeria which records up to 75,000t/yr production (CIFA, 1980) although conflicting reports suggest a low 127t/yr. (Bell and Canterberry, 1976). Rural aquaculture currently accounts for most of the aquaculture production in Africa generally concerning subsistence farmers using small 100-500m2 ponds utilising domestic wastes, composts, manures or occasional cottage agro-industry wastes as supplements.

Large scale industrial aquaculture does not appear to have developed to any large extent perhaps for economic reasons due to a past history of fish as the lowest priced animal protein. In addition to projects listed by Coche (1983) there are about 10-15 examples of public or private commercial enterprises, 13-20 pilot projects not yet demonstrated as economically viable and a number of development projects still at the planning stage. In all, 23 countries report large scale activities. Of these few are actually producing. These are notably the tilapia farms in Ivory Coast, Kenya, Malawi, Nigeria and Egypt, trout farms in Kenya and Zimbabwe, macrobrachium projects in Mauritius and Zimbabwe and oyster farms in Senegal. Perhaps some of the largest scale projects are planned for Egypt (three farms of 1000ha), Angola (500t), Lesotho (350ha), Upper Volta (450t), Libya (700t), Madagascar (200ha) and Kenya (various).

Most of the countries in Africa report freshwater culture practices. Mariculture activities have only a relatively recent history and there is a trend toward making use of brackish waters. Despite over 30 million hectares of potential coastal region suitable for cultivation (Bell and Canterberry, 1976), Africa has probably not ventured into marine farming until recently for lack of an understanding of the biology of indigenous marine species and precedence in planning priority to first exploit the fishery resource. Coastal aquaculture, mainly in lagoons, is now being considered although brackish water Howash, Acadjas and Barachois systems have a long history of use (Ardill, 1982).

3.3 Aquaculture Strategy Objectives

The development of aquaculture has generally been for the purpose of enhancing food production as discussed above, but there are a number of other applications which have found use in Africa. Briefly the objectives of aquaculture can be classified as:

(a) Production of fish for human consumption either local or for export.

(b) Improvement of natural stocks or introduction of fish into new waters such as man-made reservoirs through artificial recruitment or transportation.

(c) Production of fish for fishery stocking.

(d) Production of a forage fish for rearing of a more valuable species.

(e) Production of bait for commercial or sport fishing.

(f) Production of ornamental or aquarium fish.

(g) Recycling of organic wastes, such as in sewage oxidation ponds.

(h) Rearing of select fish for stocking waterways for aquatic weed control as well as control of vectors of such diseases as malaria or bilharzia.

(i) Production of trash fish as a constituent of animal feeds.

Each of the above objectives could apply at village level but developments have decidedly been toward the production of food fish. Governments have concerned themselves with items b, g and h but whereas private enterprise has catered for c, d, f and to a limited extent, i, developments have been small. The limitations of this text will therefore be mainly toward food production but systems again can fall under one of two classifications:

- Seed production
- Table fish production

In rural enterprises there are very few specialised seed production farms generally this is a service provided by Government or from farmer to farmer. Government therefore by definition (Section 3.2a) provides most of the support services. Extensive research, either government or foreign aid assisted, has taken place in Egypt, Ivory Coast, Nigeria, Central African Republic and Zambia. Kenya and Zimbabwe register considerable research input from the private sector as well as having incountry commercial consulting firms to assist in technological transfer. The status of national extension programmes also indicates Cameroon and the Central African Republic as having a well developed service. In all 36 countries provide some form of extension training. There exists in Port Harcourt, Nigeria, a bilingual training institution for senior aquaculture staff at the 'African Regional Aquaculture Centre'. Other countries such as Central Africa, Congo, Ivory Coast, Madagascar and Kenya also provide training under an FAO/UNDP framework for small scale aquaculture development.

4. Aquaculture Systems in Africa

The fish farming techniques employed can be placed into two distinctive groups. These are:

(a) *Traditional Methods*: certain systems are believed to have an origin in Africa and are unique to the countries concerned having been practised for as long as anyone can remember. These are the Howash of Egypt, Acadjas and Whedos of Benin and Barachois of Mauritius (Table 2).

(b) *Conventional Methods*: reservoir or rice paddy stocking, ponds, cages, pens, tanks and raceways are all modern techniques, the concepts of which have been transferred from the developed nations and applied under African conditions. Introduction has been during the last 50 years and is now widespread (Table 3).

The distribution and level of application of each system type is summarised in Table 3. Detailed discussions of a technical nature are beyond the scope of this text but a brief description of each is provided emphasising the possible future application.

4.1 Degree of Intensification

The systems used in Africa fall into a number of categories of intensity of production which can be defined as :

(a) *Semi-aquaculture or 'ranching'*: fish are reared and either released into a natural water body or man-made reservoir with no further input other than harvesting. In addition certain structures such as 'brush-parks' may be employed to increase production but reproduction is uncontrolled, feeding negligible with perhaps occasional manuring. This operation approaches 'rangeland management' with yields generally low, up to 1.5t/ha/yr and applies to traditional systems, dams, ponds and rice paddy stocking.

(b) *Extensive Aquaculture*: analogous to 'pasture agriculture', the practice employs man-made units, generally rice fields or ponds, where production is dependent upon natural or enhanced natural productivity. Manure or fertiliser application or integration with livestock can be used to enhance primary production, but feeding if practised is supplemental. The limit to production is the level at which natural processes can provide food or oxygen needs and yields can attain a maximum of 5t/ha/yr. This specifically applies to pond systems.

(c) *Intensive Aquaculture or 'Feedlot'* is almost exclusively dependent on pond fertiliser or artificial feeding levels. Some form of aeration or flow is necessary for oxygen needs and system cleaning and careful attention is needed to system design. A certain infrastructure is required involving high capital investment, management is complex and the high energy requirement restrict such practices to commercial operations with possible yields as high as 2000t/ha/yr. Cages, tanks and raceways fall under this category.

The last category applies to system types where high density stocking necessitates feeding (Table 3) and represents a very recent development trend in African aquaculture. In the past, feedlot practices were limited to trout and then only on a small scale. Present day price increases of food fish due to limited fishery supply have meant that such intensive practices are now becoming more economically viable justifying the expensive feed costs. Although not strictly practised at the village level as are the other two categories, intensive systems hold potential in the future to develop as community investment projects. Feedlot practices are included here therefore as a means whereby levels of production could be increased at a rate likely to satisfy demand.

4.2 Traditional Aquaculture Systems

The systems listed in Table 2 each have a unique prerequisite set of site requirements and therefore are limited in their application but are to be considered as a possible alternative development for fishing villages who fish an already overexploited fishery.

4.2.1 Lagoon Stocking/Barachois

As described by Ardill (1982) the system of Barachois is found only in Mauritius where the fringing coral barrier reef encloses a fairly sheltered and shallow lagoon. Coastal inlets in such lagoons are cut off by stone walls often fitted with screened gates for waterexchange. Fingerlings of mullet, *Siganus sp.* as well as any other fish fry caught by chance are collected from the lagoon and stocked in the Barachois at variable rates, generally approaching 1000/ha. Oyster farming may be included. Stocking and harvesting are an annual exercise and although low, yields are double the natural productivity of the lagoon.

The system is capital intensive but of long depreciation and low labour cost however as management has no control, production is low and tidal exchange precludes fertilising to increase yields. Predators and poaching account for heavy losses and legislation now prohibits any further such developments.

Whereas Barachois have found use in Mauritius, it is likely that they may have application in other coastal lagoons around Africa or in freshwater floodplains similar to the 'Modulas' in South America (Welcomme, 1976). Currently similar lagoons either artificially or naturally sealed are stocked and fished; practices common in Egypt, Ghana, Madagascar and Tunisia. Bell and Canterberry (1976) estimate Africa has 30 million hectares of suitable coastline for mariculture. Were 10% put to use and at a low 100kg/ha/yr, the potential is 300,000t/yr.

4.2.2 Fish Holes

Welcomme (1976) describes a series of artificial ponds or river channels which have been employed in Benin with similar systems found in Cameroon (Balarin 1984f) and Togo (Balarin, 1984d).

Generally termed 'Whedos' or 'Houedo' in Benin, production is proportionate to size of unit and yields of between 1.5-2.1t/ha/yr were recorded. Species composition however varied with size for excessive vegetation growth in small units created deoxygenated conditions favouring air breathing fish. *Clarias* are therefore common as are *Paraphiocephalus* spp in ponds below 500m^2. *Heterotis niloticus* was found in larger units and over 5000m "nits were characterised by Mormyrids and *Lates* sp.

A hybrid between 'Whedos' and 'Acadjas' (see section 4.2.4) termed 'Ahlos' is also described for Benin, where the trenches are filled with branches to increase production. The success of both methods depend upon a drain-in principle to concentrate fish as flood waters recede. The fishery represents a large scale infrastructure integrated into the traditional life of people living in the Oueme Valley, Benin. The technique is open to improvement by more effective management through artificial stocking and feeding and has a wide application elsewhere in swamp fisheries. Africa has over 12.0 million hectares of floodplain. Were it possible that only 1% of this area could develop a whedo system at yields of 1t/ha then 120,000t/yr could be produced.

4.2.3 Howash

This can be considered as a hybrid between the principle of 'Barachois' and 'Whedos'. Howash systems are unique to the Nile delta in Egypt where the flat topography permit the establishment of shallow ponds bounded by earthen dykes. Three types occur. (Tang, 1977):

(a) *Coastal*: distributed on the seaward slopes of the land between the Mediterranean sea and coastal lakes, such howash are filled by tidal action and have a salinity of 10 - 25ppt.

(b) *Lakeshore*: distributed around Lake Manzala and Burullous, of low salinity (0 - 5ppt) these howash are constructed on the lakeward slope and filled by the discharge of the irrigation drainage.

(c) *Lakewater*: actually built within the lakes to a depth of 2m but generally smaller than the other types and salinity of 0 - 10ppt.

The principle of howash systems is also employed in south-east Asia for milkfish farming but is not described elsewhere in Africa. Although present use of the howash in Egypt is currently controversial due to loss of potential irrigation water and interference with fisheries, the scope however for such developments in Africa is enormous for employment in low lying areas.

4.2.4 Brush-park (Acadja)

Recently reviewed in Balarin (1984e) there are eight different types of brush-parks as listed in Table 2 as described by Welcomme (1971) subdivided into two basic groups:

Akadjavi – round or circular in shape with hard wood outer ring and branch piles inside.

Ava - Generally larger, rectangular in shape.

Customarily 12 - 16 branches/m2 are used but production varies as a factor of density of branches:

$$\text{Log } P = 0.165d - 1.285$$

where: P = Yield in t/ha/yr

d = density of branches (n/m2)

About 30 - 60t/ha of dry wood is needed with an annual replacement rate of 30 - 75% requiring 75 m.d/ha which represents a large input and requirement for wood. Resultant deforestation has led to a decline in this practice such that new enclosure techniques are now being tested in Benin by an EDF funded project.

Generally *Sarotherodon melanotheron*, and *Chrysichthys* sp make up 60 - 96% of catches in Benin; fish are small 10 - 20cm and caught by net encirclement of the acadja and removal of branches. Production is calculated:

$$P = 0.957e\ 0.179t$$

where: P = Yield t/ha/yr

t = time in months since construction

4.3 Conventional Aquaculture System

Systems described in Table 3, although of a wider application than traditional methods, have not developed to the same extent perhaps due to an initial poor technological understanding.

4.3.1 Lake and River Fishery

Enhancement of natural production is possible by the introduction of fish species to fill a vacant niche. Successful examples are Nile Perch (*Lates niloticus*) stocked in Lake Kyoga and Lake Victoria and *Limnothrissa* sp in Lake Kariba. Although not strictly an aquaculture practice it is nevertheless a management tool also used in the control of aquatic weeds, malaria or bilharzia.

4.3.2 Retention Dams

Most parts of Africa are arid and dams have been constructed for water storage during the dry season for use as domestic or livestock water, by industry or mainly for irrigation. Such dams often lack a natural complement of fish and artificial stocking is necessary. Generally in order to create a balanced ecosystem a polyculture is preferred. Production is low but can be increased to 1.5t/ha/yr by regular stocking and manure application. Recently reviewed by Balarin (1984i), Africa has 6 million hectares under irrigation and potentially each hectare irrigated from a water reservoir or night storage dam could yield between 20 - 200kg/yr of fish. Assuming that only 25% of irrigated hectarage in Africa has a storage dam then a yield of 30 - 300 thousand tonnes per year is possible.

4.3.3 Rizipisciculture

Rice and fish production in the same paddy field has been tested in 28 countries but the greatest development success has been in Madagascar (Vincke, 1976). Rice paddies normally flooded to a depth of 10 - 24cm for 90 - 120 days are stocked with fry of 1 - 3cm one week after transplanting the rice. Tilapia and carps are preferred and either harvested with the rice or the fields reflooded and used as ponds yielding up to 2.25t/ha/yr with a potential 5 - 15% increase in rice. Integration provides weed, bilharzia and malaria control as well as reducing algal blooms and provides fertiliser through fish feaces and tillage due to the activity of the fish. Assuming 10% of irrigated land were rice, then at a low 300kg/ha/yr, Africa could realise an additional 180,000/yr fish production.

4.3.4 Pond Culture

Pond culture is perhaps the most widespread practice in Africa having been introduced into over 40 countries. Between 270 - 321 thousand ponds (Table 1) have been built of which possibly less than 25% are currently active. The greatest development has been subsistence small scale developments but some semi-commercial activities are recorded. There are four basic approaches to pond farming described in Table 3.

4.3.4.1 Subsistence Pond Culture

Ponds are either excavated, raised dykes or barrage type across streams or below larger reservoirs. Simple water inlet/outlet devices if present are either of bamboo, metal pipe or concrete monks. Pond size varies from 100 - 500m grouped around village or irrigation water sources. Community, family or individually built and owned, ponds are fished mainly for food. Design and layout can be poor, management variable and inputs consist of domestic wastes or composted weeds often placed in pens in the ponds. Yields are low, with production of 100 - 500kg/ha/yr common. With better manure or supplements, productions of 2.5t/ha/yr are reported but are rare generally due to competition between agriculture and livestock for such inputs.

The species most often used is the tilapia or mixed stocks but choice is generally dependent on availability from Government Seed Centres. Tilapia is a hardy species, ideal for these systems but its prolific breeding habits and the absence of any technical inputs to curb reproduction results in a harvest of small fish which has discouraged developments. In cooler areas, carps are now being introduced and other more frequently preferred species are *Clarias* and *Heterotis*, with the use of *Labeo, Lates, Micropterus* and *Hemichromis*, being tested.

The requirement for a supply of seed and some technological know-how necessitates Government support to such projects in the form of extension services. Funds and available trained manpower as well as the required infrastructure for training, research, seed production and transport are the main limiting factors. Although of high potential for integration with small holder irrigation schemes, the low yields often do not economically justify the national cost required to support such developments. However, limited success can provide animal protein production in rural areas where it might be needed. If the 23 - 79 thousand hectares of ponds in Africa were reactivated to give over 1t/ha/yr this would yield between 25,000 - 80,000t/yr.

4.3.4.2 Semi-intensive Pond Culture

This system attempts to make maximum use of natural productivity to provide food and oxygenation without the need for additional energy inputs for aeration. Fry of 5 - 25g are stocked at 10 - 30 thousand per ha in well constructed pond units. To enhance production, fertiliser or manures can be added. These include the following applications in kg/ha/week. Lime (40 - 55), super phosphate (15 - 30), pig manure (560 - 1630), poultry manure (110 - 225) and cattle or horse manure (670). Alternatively, integrated animal-cum-fish husbandry is possible. Animal pens can be built either over the fish pond or on the banks and all liquid and solid wastes are lead into the pond. Yields expressed as t/ha/yr per animal stock rate are: pigs (70 - 100/ha) = 5 - 10, ducks (1000 - 2000/ha) = 4 - 8, chickens (1000 - 1200/ha) = 3.5 - 7 and geese (500 - 800/ha) = 2 - 3. Pond production can be improved by supplementing the natural foods by artificial feeds.

Pond harvest can be intermittent by netting or total drainage with potential yields as high as 5t/ha/yr; however for tilapia 2.5t/ha/yr is more common due to prolific precocious breeding producing smaller fish. Higher yields can be obtained by curbing reproduction (Balarin and Hatton, 1970). Monosex culture can be achieved by feeding fry a male hormone diet containing 30mg/kg methyltestosterone. If administered within the first week after hatching for 45 days, all male fish result. More popular is the use of select species hybrids which tend to yield all male offspring. Predator stocking with *Clarias, M. salmoides, Hemichromis spp* or *Serranochromis spp* can be effective as they prey on and control fry numbers. This polyculture increases yields. Other methods such as hand sexing for monosex, gynogenesis, irradiation, chemical castration or size grading have also been used.

Such semi-intensive practices have found application in Zimbabwe, Zambia, Malawi, Central African Republic, Kenya and Nigeria but are generally at a small scale where there is competition for feeds and fertilisers with traditional livestock and crop use. In Asia this integration is long established to the extent that sewage finds ready use in ponds, a concept considered unethical in Africa. There is however scope in Africa for integrated irrigation, farming of livestock and fish; large projects are planned or underway in Zambia, Nigeria, Kenya, Madagascar and Central African Republic.

4.3.4.3 Intensive Pond Culture

To achieve yields above 5t/ha/yr biological processes need to be assisted. This includes aeration, waste removal and a trend toward an independence of natural foods. Ponds now are of an elaborate design, with reproduction control mechanisms a must; feeds are a pelleted, balanced ration, formulated from basic stockfeed ingredients. In such a regime, feeding in ponds becomes regular, daily at 10% body weight for juveniles (+1g and 1.5%) for adults (+250g). Food conversion ratio of dry feed to fish flesh is nearly 2:1 and yields can, under super-intensive conditions, be as high as 25t/ha/yr (Table 3). To sustain such a fish biomass, aeration, using either paddle wheels, venturi type blowers, permeable plastic tubes or floating impeller units are necessary to provide oxygen.

4.3.5 Cage Culture

If deep, lagoons, irrigation reservoirs, lakes or waterways can support cage culture, net enclosures or pens in the shallows. Cages are a floating collar made of either old oil drums, styrofoam and wood, supporting a bag made of fine mesh, nylon netting. Currents are created by winds for the oxygen needs of the fish. This permits stocking of densities upto 250 fish/m3 of cage. Intensive feeding with a pelleted balanced diet can yield an equivalent of up to 700t/ha/yr. The system is ideal for tilapia as the mesh of the cage floor does not permit successful breeding and is an effective reproduction control mechanism.

Although tested in Egypt, Zimbabwe, Kenya, Tanzania and Nigeria, tilapia are now commercially raised in cages in the Ivory Coast (Balarin and Haller, 1982). Pen culture on the other hand has had limited development in Africa. Tested in Ivory Coast, Togo and Upper Volta the only major development has been in Benin (Balarin, 1984e) as a means of an alternative to the acadja. Although not yet complete, trials suggest yields of 25 - 220t/ha/yr.

4.3.6 Tanks and Raceway Culture

Tanks are generally circular or rectangular, constructed of concrete or metal and have long found use in trout production in Zimbabwe and more recently in Kenya and have been used for turtle farming in Reunion. Only in the last decade has this technique been applied to a food fish such as tilapia with pioneering work initiated in Kenya resulting in the development of the 'Baobab Tilapia Production System'(Balarin and Haller, 1982). This technique is now being considered for development in the Congo, Nigeria, Zambia and Zimbabwe.

Through intensive feeding of a nutritionally balanced, pelleted feed, yields upwards of an equivalent 2000/ha/yr are possible.

This system has the potential to produce the greatest amount of animal protein per unit area than any other known form of livestock industry. Further, the nitrogenous and solid wastes of the fish provide a natural fertiliser enhancing production, if used to irrigate crops. Solids can also be settled and used as a manure, or in biogass production. During the process, fish are size graded selecting for only 50% of the faster growers for ongrowing. Fish rejected and normal trade mortalities can be used to feed an integrated crocodile farm which also uses fish farm effluent waters. The high requisite for constant water flow, nearly 10m3 p.h. for every 1t p.a. fish production (or 80000m3/t/yr) implies that this system is only suited for integration with high volume, constant pumping, irrigation schemes. However the system can be modified for water recycling and would require considerably less.

5. SPECIES CULTIVATED

About 130 - 140 different species have been tested or are cultured in Africa.

5.1 Tilapia

By far the most popular and widely used species are the tilapia, endemic to Africa. Over 31 species of this group have been tested and the most common in use are *O. niloticus* (31 countries), *T. rendalli* (27 countries), *O. macrochir* (25 countries) and *T. zilli* (23 countries). *O. mossambicus, S. galilaeus* and to a lesser extent *O. spilurus* are also popular. The greatest emphasis on tilapia farming has been in Tanzania, Kenya, Zaire and Cameroon but 36 countries mention some form of tilapia culture. As already mentioned (Section 4), if uncontrolled, tilapia can overpopulate and stunt in ponds. This is perhaps the only disadvantage of the group, because its hardiness, good growth, easy reproduction, efficient conversion of plankton artificial feeds and its tolerance of a wide range of environmental conditions, make it a prime candidate for aquaculture in Africa. The possibility of its culture in brackish or saline waters further extend the scope for production in areas less favourable for other species. Often overlooked however is that tilapia are a lowland fish restricted to altitudes below 2000m. Both reproduction and growth are affected by temperatures below 22'C and for every 10'C rise in temperature growth increases by a factor of 2.4 times. The following equation therefore expresses maximum potential pond production with respect to altitude.

$$P = 6.29a - 2.92$$

where: P = Yield t/ha/yr

a = altitude in 1000m

Tilapia production therefore declines by a factor of 2.2 for every 1000m increase in altitude and it is for this reason that carp were introduced for regions between 1000 - 2000m and trout for cooler areas above 2000m.

5.2 Introduced Species

Trout (*Salmo gairdneri*) were perhaps the first fish species to be introduced and farmed in Africa, mainly Zimbabwe and Kenya, representing 73 and 30% of fish farm production in 1982. Trout initially introduced as eggs for angling purposes was transplanted into over 20 countries. The intensive nature of farming requires high technology and artificial feeds such that it is unlikely to develop to any great extent at village level. The same applies to Black Bass (*Micropterus salmoides*) and *Macrobrachium*; although the former has found use as a predator in rural tilapia ponds, its application is limited due to the complexity of hatchery techniques.

Other minor introductions to Africa include *Esox* (5 countries), *Ictalurus* (3 countries), *Salvelinus* (4 countries), *Tinca tinca* (5 countries) but development is poor. Others include such fish as *Lepomis* as a forage fish for Black Bass and *Gambusia* for mosquito control.

Perhaps by far the most important introduction has been the carp, *Cyprinus carpio* in 22 countries for cool climate aquaculture, *Ctenopharyngedon idella* in 15 countries for farming and aquatic weed control and *Hypophthalmichtys molitrix* in 9 countries. Although hatchery technology is a problem these species offer potential scope for future small scale fish farming in cool, high altitude areas. State operated hatcheries are essential and are currently being developed in Egypt, Ethiopia, Ivory Coast and Kenya.

5.3 Indigenous Species

The most frequently used species other than tilapia are *Barbus* (8), *Chrysichthys* (7), *Hemichromis* (9), *Heterotis* (10), *Labeo* (10), *Lates* (10), *Mugil* (8), *Penaeus* (11), *Serranochromis* (7) and the most popular are *Clarias* (21) and *Crassostrea* (12). Although total yields of these and other species are not high, interest exists to increase production and intensive research on *Clarias* in Central African Republic. The problem with most of these species is poor technical advancement such that most are either pilot or research projects. Perhaps *Penaeid* culture, because of its high market value, represents the next likely species to advance in production.

6. SCOPE FOR AQUACULTURE IN AFRICA

Between 3 - 4 million tonnes were landed in 1981 to feed a population of 484.5 million representing an average per capita consumption of 6.1 - 7.8 kg/ind/yr. An optimum requirement however to meet the daily protein requirement is considered to be 10kg/ind/yr. Over 50% of countries listed consume less than this amount. Notably Algeria, Ethiopia, Lesotho, Libya, Niger, Reunion, Rwanda, Sudan, Swaziland and Upper Volta consume less than 20% of optimum. In Congo, Ghana, Senegal and Sierra Leone, fish provide more than 15% of total protein. Ideally 5% of protein in any diet should be fish, this coupled with a low food production index makes such countries as Algeria, Botswana, Ethiopia, Kenya, Lesotho, Mozambique, Somalia and Zimbabwe potentially likely to benefit the most from an increased fish production including aquaculture.

Extrapolating from expected population growth by the year 2000 an estimate for fish requirement has been derived assuming that either present levels or an optimum 10kg/ind/yr are to be maintained. Africa would need between 5.4 - 10.4 million tonnes of fish and it can be considered that this may represent virtually double the potential maximum yield of all fishery resources. The deficit in fish protein budget would have to come from fish farming. An attempt to estimate the actual requirement of aquaculture is incomplete for lack of data.

Generalising, Balarin (1984h) estimates national fish production in Africa must be stepped up to yield 4.1 (+1.6) t/ha/yr and development rate of ponds in the order of 1820 ha/yr per nation at a capital cost of US$955 t/yr. Although these estimates are based on a sample survey of only 8 representative states, the demand nevertheless suggests that efforts must be stepped up if the future scope for aquaculture is to benefit mankind in Africa.

7. DEVELOPMENT RATIONALE

In conclusion therefore it is possible to examine the development potential of aquaculture. FAO estimates consider that tilapia culture alone in Africa has a potential to yield over 8 million tonnes production. Bell and Canterberry (1970), give country ratings considered to have the greatest scope for development and indicate 30 million hectares of coastline suitable for fish farming. Anon (1981) in an unpublished FAO model survey analysed the potential for development and obtained a mean rating for Africa of 0.98, below the world average of 2.44. In particular Benin, Gabon, Ghana, Liberia, Rwanda, Senegal, Sudan, Tanzania and Upper Volta were implicated as below average for development.

To meet food requirements, Africa could benefit from aquaculture production. However development strategy requires that at present production levels, vast tracks of land need to be converted to fish farms. This represents a physical and economically difficult task. Intensification is necessary but the requirement for technological inputs precludes any short term development. This calls for a consolidation of resources, a limitation of activities to a few species, preferably tilapia and carp and establishment of regional pools of manpower in the form of a network of aquaculture development centres.

TABLE 1
COMPOSITE OF 1965-85 AQUACULTURE STATISTICS: AFRICA

COUNTRY	*PONDS* *nos.*	*AREA* *(ha)*	*PRODUCTION* *(t/yr)*
Algeria			
Angola			
Benin	113-155	6-2000	5-2500
Botswana			
Burundi	352	65	
Cameroon	6000-12,000	10-200	10-273
Capverde			
Comoros			
Central Africa Republic	900-25000	33-43	43-105
Chad			
Congo	2120-12200	69-242	15-44
Djibouti			
Egypt	11300	2500-48850	2600-25000
Equatorial Guinea			
Ethiopia	10	1	1
Gabon	1500	-	5-27
Gambia, The			
Ghana	30	204	30-120
Guinea			
Guinea Bissau			
Ivory Coast	340	-	10-300
Kenya	12200-32140	610-3000	122-585
Lesotho			14-27
Liberia	95-300	7-73	10-350
Libya			
Madagascar	85000	1280-2000	300-17400
Malawi	370-1000	72-200	46-104

TABLE 1 *(continued)*
COMPOSITE OF 1965-85 AQUACULTURE STATISTICS: AFRICA

COUNTRY	*PONDS* *nos.*	*AREA* *(ha)*	*PRODUCTION* *(t/yr)*
Mali			
Mauritius	20	3-270	60-120
Mauritania			
Morocco			
Mozambique	250	10	
Namibia			
Niger			
Nigeria	300	61-2000	127-75000
Reunion			
Rwanda	448-2662	78-84	10-180
Sao Tome/Principe			
Seychelles			
Senegal			191
Sierra Leone	162	2	3-4
Somalia			
Sudan	37	30-60	30-50
Swaziland	250	20	
Tanzania + Zanzibar	8000-10000	1000	500-1800
Togo	514	8-60	
Tunisia	7		30-168
Uganda	11000	410	31-2300
Upper Volta	32-50	11	200-400
Western Sahara			
Zaire	122070	4000-4200	700-5000
Zambia	1230-1708	100-460	29-6000
Zimbabwe	5000	12500	800
TOTAL	269650-97215	23090-63742	5922-137857

TABLE 2

SUMMARY OF THE CHARACTERISTICS, INPUTS AND EXPECTED PRODUCTION OF TRADITIONAL AQUACULTURE SYSTEM TYPES IN AFRICA

System Type	*Dimension*	*Essential Inputs*	*Accessory Equipment*	*Expected Harvest Time*	*Seed Stock (n/ha)*	*Mean Havest Size (g)*	*Productivity Range (t/ha/Yr)*	*Characteristic Features*
Barachois/Lagoons	0.5 0/5-50 ha	Stone wall	Seine net	1/Yr	1000 (+wild)	100-250	0.1	- Shallow lagoon - High capital cost - Low depreciation
Fish Holes: a. Whedos	20-1500m trench	NIL	Net/traps	4 months	Wild	50-1000	1.0-2.1	- Flat flood plain - Minimal input
b. Ahlos	30m trench	Branches	Net	1/year	Wild	50-1000	1.0	
Howash	1-20 ha shallow pond	Earth dyke	Manures(opt) pump boat nets	1-10/years	1000-5000 (+ wild)	20-250	0.5-4.5	- Flood plain either coastal, lake-shore or delta - Shallow lake/ lagoon
Acadja(Brush Park)								
a) Amedjerotin	250-1250m^2 circle	Palm fronds	Canoe/nets	2/year	Wild	50-200	5.0-6.0	- High depreciation
b) Adokpo	250-4000m^2 groups	Branches	Canoe/nets	4-8 months (2/yr)	Wild	50-200	8.0-10.0	- High capital cost
c) Ava	0.2-7.0 ha rectangular	Branches	Canoe/nets	1-2/yr	Wild	50-200	4.0-21.0	
d) Hanou	20-150m^2 composite	Branches	Canoe/nets	2 months (6/yr)	Wild	50-200	up to 17.0	
e) Akadjavi	Vars. circle	Branches	Canoe/nets	Var	Wild	50-200	2.0-25.0	
f) Godokpono	20-150m^2 circle	Branches	Canoe/nets	4-5/year	Wild	50-200	6.0-25.0	
g) Aula	Var.	Branches Vegetation	Canoe/nets	10/year	Wild	50-200	28.0	
h) Hanoumecodjia	20-150m^2 composite	Branches	Canoe/nets	2-3/year	Wild	50-200	3.6-38.0	

TABLE 3

SUMMARY OF THE CHARACTERISTICS, INPUTS, AND EXPECTED PRODUCTION OF CONVENTIONAL AQUACULTURE IN AFRICA

System Type	*Essential Inputs*	*Accessory Equipment*	*Expected Harvest Time (days)*	*Seed Stock Size (g)*	*Most Common Harvest size (g)*	*Optimum Stocking Range (n/hax1000)*	*Productivity Range (t/ha/yr)*	*Characteristic Features*
1. Lakes and rivers	Fishing effort	Boats nets	Seasonal	N.A.	1-1000	5-50	0.2-0.5	– Low intensity
2. Rice Paddy stocking	Seed stock	Nets	90-120	5-10	50-70	10-20	0.3-1.5	– Simple technology – Minimal management
3. Dam stocking	Seed stock, Manure	Nets	Seasonal	5-25	50-200	10-50	0.3-1.5	
4. Ponds: a) Subsistence	Seed stock, Domestic wastes	Nets or Hook & Line	Intermittent	5-10	25-100	10-30	0.2-2.0	INCREASE ↓ – Feeding – stock density
b) Semi-intensive	Seed stock Fertilisers Manure/Waste Feeds	Nets (± Drainage)	Variable 180-365	5-25	50-250	10-30	1.0-5.0	
c) Intensive	All-male seed, animal-cum-tilapia manure (±Pelleted feeds) (±aeration)	Nets, drainage, harvesters, catch-box graders, water test kit	100-180 Often only partially harvested	25-50	150-250	20-50	5.0-12.0	– energy inputs – flow or aeration – capital investment
d) Superintensive (often experimental)	All-male seed, manures & fertilisers, Pelleted Feeds Aeration or flow	Nets, drainage, harvesters graders, auto-feeders, water test kit	100-180	25-100	200-300	30-100	10.0-25.0	– running costs – crop value
5. Cages (in ponds or Lakes)	Pelleted feeds, seed stock	Graders, auto-feeders water test kit (+/– boats)	100-180	10-25	150-250	50-2500	10.0-700.0	
6. Tanks and raceways	Seed stock, pelleted feeds, flowing water, aeration	Graders, Auto feeders, pumps, water test kit	100-180 As required	25-50	200-300	100-300	20.0-2000.0	High intensity – Complex technology – Demanding management