Chapitre 22

AQUACULTURE IN AFRICA

LA PISCICULTURE EN AFRIQUE

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1 - INTRODUCTION

Though aquaculture is of considerable antiquity especially in the Far East, and even though the first record of fish in ponds is from an Egyptian bas-relief of yet greater age (Arrignon, 1962; Balarin & Hatton, 1979), fish farming in Africa is an activity of very recent origin. This is because until recently, human populations in Africa were small enough for their needs to be met by the natural reproduction of fish, without having to breed and grow them artificially. So a tradition of the culture of fish and other aquatic organisms never became established in Africa as it did in the Orient. However though fish were not held in captivity, practices such as the trapping of fish behind fences or weirs, which are widespread in many areas, and especially the concentrating of fish in lagoons or floodplains in Benin by means of «acadjas» or fish-parks made of brushwood (Welcomme, 1971), are certainly steps in this direction. Given time, therefore, a fish culture tradition may have evolved independently in Africa, but events were overtaken and the process hastened by the importation of culture techniques from elsewhere.

Such importations generally began with the techniques of breeding sport angling fish, particularly trout and various bass species, also the «Sandre» (*Stizostedion lucioperca* into Morocco (J. Arrignon pers. com.), for sport fishing, but even the earliest hatcheries for this purpose are less than a hundred years old. The breeding of fish for food is still more recent and correlated with the great increases in human populations, whose impact, especially the need to provide more food, only began to be felt well into the twentieth century. The first keeping of fish for food was probably that of carp in South Africa, where they were introduced as early as 1859 (Harrison, 1951), while Copley (1954) records the first keeping of tilapia in a pond as occurring in Kenya in 1924.

But, apart from the game fishes, such culture was sporadic until an upsurge of interest in aquaculture in Africa began after World War II. Again, overseas methods were initially used or adapted through later some specific techniques were formulated such as that of intensive culture of tilapia (Balarin & Haller 1982). These are extremely valuable, but in general, aquaculture in Africa deserves special distinction not so much in the adoption of new techniques as in the use of several indigenous fish species which, either locally or elsewhere, have made a very significant contribution to aquaculture. These include several tilapias, especially *Oreochromis mossambicus*, *O. niloticus* and *Tilapis zillii*, the heterotis *Heterotis niloticus* and the clariid catfishes *Clarias lazera* and *C. gariepinus*. Other species will be mentioned below, but these six are perhaps pre-eminent in the impact that they have made on aquaculture both locally and, especially in the case of the tilapiines, elsewhere in the world.

This review briefly considers African aquaculture, the treatment being descriptive rather than technical, so only passing mention is given to generally applicable techniques which are described in standard textbooks such as those by Hickling (1962), Huet (1970), Bardach *et al*, (1972) and Woynarowitch & Horvath (1980). Diseases (Paperna, 1980) are similarly not discussed. The mere importation of ova for stocking into rivers and dams is not considered here.

2 - EXOTIC FISH

2.1 - Trout. The first fish cultured were carp and trout, both temperate-water species with which expatriates from Europe were familiar, and which seemed to have no local counterparts. Considerable trouble was taken, and much money expended, in the successful establishment of trout. Harrison (1951) puts it well (p 25) : «Many of our European settlers had been bred to trout angling. They had had to leave it behind with other home-ties, and try to put it out of mind; for surely there is no greater pang in all things connected with sport than the last hour on a beloved trout stream and the final abandonment of the cherished rods and tackle before departing abroad to a troutless region! Think of their reactions, when some leisure or other purpose allowed them their first views of those tantalisingly empty streams in the new land!».

Legislation allowing trout imports was passed in the Cape of Good Hope in 1867, but after several attempts, in 1890 brown trout (*Salmo trutta*) ova from Scotland were first hatched in Natal (Pike, 1980) and by 1895 three still functioning hatcheries were established at Umgeni, Pirie near Kingwilliamstown and Jonkershoek near Stellenbosch. Later it was found that the various strains of the rainbow trout were better suited, than brown trout to most African conditions in particular requiring water of a less cold temperature and it is this species which is commonly now bred in African hatcheries and used in fish culture. Unfortunately various strains such as *S. gairdneri irideus*, the steelhead, and *S. g. shasta* the Shasta were mixed in early importations and present African populations are the result of their unselective mingling. Hatcheries at present exist in South Africa, Zimbabwe, Kenya, Lesotho and Swaziland. In Tanzania both rainbow and brown trout have been introduced into the colder regions of Kilimanjaro and Mbeya, and great potential for their culture exists (Ibrahim, 1976). About 3 00 tons of fish per annum are marketed in South Africa at present, mainly for the hotel and restaurant trade (Safriel & Bruton, 1984). Trout were first introduced to Kenya in 1910, the state hatchery at Kiganjo inaugurated in 1948, there are several private farms and Kenya is today one of the major trout-producing nations of Africa, producing over 3 00 tons/year (Abolarin, 1985).

2.2 - Bass. The rationale for breeding bass (family Centrarchidae) from North America is that they are a useful sporting fish in fresh waters which are cool and clear but nevertheless too warm for trout. For these reasons they have been widely introduced, originally mainly to South African hatcheries (Jackson, 1976). The largemouth bass *Micropterus salmoides* was introduced in 1928, the smallmouth bass *M. dolomieu* in 1937 and the spotted bass *M. punctulatus* in 1937, the main agents being the Rand Piscatorial Association in Johannesburg and the Cape Department of Nature Conservation. Largemouth bass were introduced to Zimbabwe in 1932 (Toots, 1970). Nowadays they are less cultured in hatcheries, fry required being taken from established wild stocks, and few are marketed for consumption. A similar situation prevails elsewhere. e.g. in Kenya where largemouth bass were introduced in 1928 (Copley, 1954), now breeding far fewer, if any, bass since these are well established in suitable habitat such as Lake Naivasha (Robbins & MacCrimmon, 1974). Largemouth bass were introduced to Madagascar in 1951 (Kiener, 1957b) and Algeria in 1970 (Arrignon, pers. comm.), both from France.

2.3 - Common Carp. Apart from the goldfish *Carassius auratus*, the earliest exotic to be introduced was the carp *Cyprinus carpio*, introduced to South Africa from Germany in 1859, apparently of mixed genetic stock dating back to culture in Europe in the Middle Ages or even before so that scaleless «mirror» and scaled «king» varieties occur in approximately equal numbers.

By the turn of the century it was firmly established in many rivers and farm ponds and was since sent to many neighbouring countries e.g. Zimbabwe in 1925. It reached Morocco from France also in 1925 and adapted to local conditions (Welcomme, 1981). Elsewhere it was introduced much later, such as to Nigeria in 1954 (Zwilling, 1963).

Up to this point there was little formal culture of the carp though it was in some demand as a food in inland areas, and the general opinion was critical of its disturbance of the substratum causing turbid water and eradicating plant life; also, that it adversely affected indigenous fish. Modern opinion is however that these criticisms are often the result of poor management practices especially the overstocking of ponds, while most evidence is that carp exist peacefully with local species.

A change came about when, starting in the late 1950's, a period of comparative neglect was replaced by a much less random and increasingly more intensive culture of domesticated varieties. These, such as the Aischgrund carp, were introduced to the Transvaal from Israel (Lombard, 1961) and before long were being cultivated for sale by a number of farmers (Jackson, 1976). Similar varieties were introduced to Nigeria from Austria/Israel in 1960 (Zwilling 1963) and Cameroon in 1970 (Hogendoorn, 1977) and elsewhere (Lessent, 1977).

Until recently, however, there has been some discouragement of the culture even of desirable carp varieties in Africa because of the rapidity with which the original genetically mixed less desirable stocks established themselves in suitable waters, and the near impossibility of getting rid of them once established. Such a reaction has been somewhat uncritical, however. Two important considerations have become evident over the years. Firstly carp are not as adaptable as was first imagined. Escapes from culture do not become established in the wild universally and at random, but only from breeding populations in certain temperate areas which suit them. They will not establish in areas which are too hot or too cold for them, so are excluded by their own biological constraints from the great bulk of the continent of Africa. Admittedly, much of temperate southern Africa is ecologically favourable for carp, and it is here that they are most widely established in rivers and dams. In tropical Africa self-breeding populations occur only in cooler upland areas such as the Akokia and Koka lakes in Ethiopia. The second consideration then applies, that when established there is no evidence of any adverse affect upon the local populations. In the Orange River, where they have been established for probably a hundred years or more, they are still heavily outnmbered by indigenous cyprinid species (Allanson & Jackson, 1983).

2.4 - Chinese carps. The first introductions of Chinese carps to Africa were to Egypt, where the silver carp (*Hypophthalmichthys molitrix*) and the grass carp (*Ctenopharyngodon idella*) were introduced from Japan in 1962 and Hong Kong in 1968 (Eisawy & El Bolock, 1976). In South Africa the grass carp was imported in 1968 and silver carp in 1977 (Pike, 1980). The objective was the same in both cases. The grass carp was to control and make use of higher aquatic vegetation, such as grasses, *Potamogeton* and water hyacinth *Eichhornia crassipes* in ponds and dams, and the silver carp because of its value as a phytoplankton feeder in polyculture. Later, the bighead carp *Aristichthys nobilis*, a filter feeder on zooplankton and large phytoplankton items, was imported to South Africa from Israel in 1979 again for use in polyculture with other species (Prinsloo & Schoonbee, 1983).

Fears that these would escape from culture and form wild breeding populations to the detriment of indigenous species have been expressed by conservation agencies, who have sometimes prevented their importation on this account. However, their natural reproduction depends on a cold-temperate water temperature and the volume of a river large enough to enable eggs to remain in midwater for several days during incubation. Both these attributes are possessed by the great Asian rivers of their native lands, but no African river has both together. It is not surprising therefore that no record of any Chinese carp spawning in the wild in Africa exists, and induced spawning, as reviewed by Hickling (1966) and recently successfully achieved in Africa (Schoonbee *et al.*, 1978; Prinsloo & Schoonbee, 1983), is essential in any African situation. With these techniques now well established (Woynarovitch & Horvath, 1980) the valuable special attributes of Chinese carps in polyculture and weed control will probably find increasing use in Africa.

3 - INDIGENOUS SPECIES

3.1 - The tilapias. It is undoubtedly these fish which have had more effect on aquaculture in Africa than any other. Endemic to Africa, one or more members of this group are now firmly established in culture in most warmer parts of the world, including virtually every state in Africa. A recent study of the relevant literature has listed over 3 300 references (Balarin & Haller, 1982). Only a brief overview is possible here.

Bâlarin & Haller (op. cit.) list 10 tilapiine species of value in fish culture. Of these, according to the classification of Trewavas (1982), 6 are of the mouthbrooding, arena-breeding, mainly (in nature) vegetable detritus-phytoplankton feeding genus *Oreochromis,* and three of the pair-forming, substratespawning, mainly higher plant-eating genus *Tilapia* (Table 1). In general these are «secondary» or salt-tolerant species according to Myers' (1949) classification though such euryhalinity is much more marked in those species nearest the coast. Thus the Mocambique tilapia *O. mossambicus* and the Nile tilapia *O. niloticus* are able not only to thrive but to reproduce in sea water.

In the substrate spawning genus *Tilapia, T. rendalli* and *T. sparrmanii* are markedly freshwater-loving, but, paradoxically for this genus, *T. zillii* is reported to be one of the most euryhaline of all tilapias (Chervinski & Hering, 1973).

While *O. mossambicus* was apparently transported to Java in about 1939, where by 1952 it was producing 5OOO tons per annum (Schuster, 1952), and subsequently all over the world (Atz, 1954), the first farming of tilapia, while not gaining the magnitude that it so rapidly did in the Far East, probably took place in Africa. The first culture was in Kenya in 1924 (Copley, 1954). *O. mossambicus* was transported from the Transvaal to Malmesbury in the Cape in 1936 and subsequently to the Jonkershoek Hatchery in 1940 (Hey, 1944). In 1942 Hey, successfully used these fish in some of the first experiments in sewage fish culture (Hey, 1955). In 1943 important developments began in Zambia where Vaughan-Jones (1949) cultured the three spot tilapia (*O. andersonii*) at the Chilanga hatchery. In Zaire some culture of tilapia had already commenced on private farms (de Bont, 1948) and in 1946/47 the Mission Piscicole du Katanga began regular trials particularly with indigenous *O. macrochir* and *T. rendalli,* taken over by the Station de Recherches Piscicoles at Elizabethville (Lubumbashi). Here the potential of tilapias as a fish culture crop on high protein foods such as cotton-seed cake and maize-mill sweepings were realised (de Bont, 1952); very high yields of 8 tons/ha or more (Halain, 1952) were obtained especially when ponds were fertilized as well (Halain, 1952; Huet, 1957a).

Such results stimulated development on fish culture in many parts of Africa. Considerable research was done and promising results reported (Charpy, 1955, Maar, 1956, Kiener, 1957, van der Lingen, 1959; Mortimer, 1960; Lombard, 1960 and van Someren, 1962). Much experience was gained as a result of this work and most of the basic semi-intensive techniques of tilapia breeding and culture which are in use today were initiated during this period. A period of decline ensued (Meschkat, 1967; Huet, 1970) partly due to lack of expertise in newly independent countries and partly to culture difficulties. This is discussed more fully below.

The two main problems in tilapia culture have been much studied. These are the relatively high temperatures required for breeding and rapid growth and, the most important, the propensity in culture towards dwarfing, i.e. becoming sexually mature at an early age, ceasing to grow and breeding prolifically.

The constraint of temperature is unimportant over most of tropical Africa from whence tilapiines originate but assumes serious proportions in cooler upland areas and particularly in the more temperate parts of northern and southern Africa. Bishai (1965) gives a range of 17.2-19.6°C below which the growth rate decreases. For spawning, higher temperatures are required, Huet (1987) quoting a minimum of at least 20-21°C.

Hepher & Pruginin (1982) discuss a particular management technique, «young of-the-year culture», to minimise both the temperature and «stunting» problems. This takes advantage of the rapid growth of tilapias to rear a naturally mixed male-female population of young before they attain sexual maturity, then harvesting them, clearing the pond completely and repeating the process with a fresh set of juveniles for as long as the summer growing season lasts. This has a special advantage under African conditions where fish size is often unimportant and small

Table 1 : The most widely used tilapias in African aquaculture, with original distribution, salinity and temperature tolerances and breeding habits. Data from Balarin & Haller (1982) and Trewavas (1982).

SPECIES	ORIGINAL DISTRIBUTION	SALT/TEMP. TOLERANCES	BREEDING HABIT
Sarotherodon galilaeus	The Levant, especially Jordan valley, Soudanian region	Generally tolerates 13-29°/00. Able to feed & grow at 11-16°C.	Eggs and young brooded by both parents.
Oreochromis aureus	Soudanian region	Euryhaline. Reproduces at 19°/00 but grows up to 44°/00. Temperature preference 31-37°C	Arena spawner and maternal mouthbrooder. Nest saucer-shaped.
O. niloticus	Nile basin excluding Lake Victoria, Niger, Chad, Burkina Faso	Euryhaline. Reproduces up to 29°/00, survives up to 35°/00. Temp. below 12°C is lethal, prefers 31-36°C.	-do-
O. andersonii	Upper Zambezi, Okavango, Cunene, parts of Upper Zaire	Stenohaline; can acclimate to ca 22°/00. Lower lethal temp. : 8°C.	-do-
O. mossambicus	Lower Zambezi & South East coast to 33°S	Very euryhaline; can breed at 35°/00, grow at 40°/00 and survive higher. Tolerates 8°C, survives 40°C	-do-
O. spilurus niger	East coast rivers of Kenya	Euryhaline. High temperatures necessary; can breed at 40-43°C	-do-
O. macrochir	Upper Zambezi, Cunene, parts of Upper Zaire	Stenohaline, fresh water species. Lower lethal temp. around 11°C, prefers 23-24°C.	Arena spawner and maternal mouthbrooder. Nest with a raised area in centre.
Tilapia sparrmanii	Upper Zaire, Zambezi, south to lower Orange	Stenohaline, only fresh water, very hardy, survives below 7°C, spawns above 16°C	Substrate spawner sometimes in nests Pair formers (monogamous), both parents guard eggs & fry
T. rendalli	Upper Zaire, Zambezi, east coast southwards to Zululand	Fresh water only. Stenothermal, above 13°C only.	Monogamous substrate spawner, may make holes or nests. Both parents guard egges & young.
T. zillii	Nile, Levant, Soudanian region south-west Africa	Euryhaline up to 45°/00, reproduces to 20°/00	Substrate spawner in nests or holes, eggs & young guarded by female.

Table 2 : Growth rate data of *Clarias lazera* and *C. gariepinus* (adapted with additions from Clay 1977).

SPECIES	AGEING TECHNIQUE	LOCATION	SEX	*TOTAL LENGTH (cm) AT END OF TIME* DAYS						YEARS				
				1	7	15	60	120	270	1	2	3	4	AUTHOR
C. lazera	Vert.	Egypt	M							19.1	29.5	38.1	46.7	El Bolock (1972)
			F							19.2	29.8	37.2	44.8	
C. lazera	Obs.	Centr. Afr. Repub.				3								Pham (1975)
C. gariepinus	Obs.	Uganda		.4	.8									Greenwood (1955)
C. gariepinus	Vert.	Zambia								10.0	15.0	20.7	29.0	Pivnicka (1974)
C. gariepinus	Obs.	Zimbabwe							13					Bowmaker (1973)
C. gariepinus	Obs.	Zimbabwe				4.3	6.2							Holl (1968)
C. gariepinus	CCC	Zimbabwe	M							30.0	47.0	60.0	72.0	Munro (1965)
			F							27.0	37.0	50.0	58.0	
C. gariepinus	Spine	Transvaal	M							42.6	47.7	54.4	62.8	]*v.d. Waal &
		S. Africa	F							41.4	46.4	52.6	60.4	] Schoonbee (1975)
C. gariepinus	Obs.	Natal S. Africa		.36	.82	1.2	4							Bruton (1979a)
C. gariepinus	Spine	Natal	M							24.0	30.0	51.7	57.5	Bruton &
		S. Africa	F							24.0	40.6	51.2	56.4	Allanson (1980)
C. gariepinus	Vert.	Malawi								20	30	38	ca 46	Willoughby & Tweddle (1978)
C. gariepinus	Spine	Lake le	M							20.4	31.3	40.2	50.3	Quick & Bruton
		Roux	F							20.4	31.3	40.2	50.3	(1984)

Abréviations : Vert. - Vertebral ageing; Obs. Observation; Spine spine sections; CCC commercial catch curves.
*Possibly suspect through a ring not being counted owing to reabsorbtion.

specimens quite acceptable to the market. Thus even if a weight of only about 5Ogm is attained before the abnormally rapid onset of sexual maturity and consequent cessation of growth comes about, a profitable crop can be realised. This practice is preferable to that earlier advocated of continually netting out the larger fish. This has the twin disadvantages of unduly prolonging the reproductive season and of selecting against the faster growers with possible undesirable genetic effects (Silliman, 1975). It is important, as stressed by Hepher & Pruginin (op. cit.), to clear the growing pond completely and restock with a fresh set of juveniles separately bred for the purpose. Nevertheless an increasing demand exists for top-quality fish, making it profitable for managers to have part at least of the annual crop to be of older, larger fish.

A possibility suggested by Jackson (1983) is the selective breeding of coldresistant strains to overcome the temperature constraint. That this is inherently possible is shown by the fact that strains of *O. mossambicus* have, after introduction some 20 years previously, established wild breeding populations in waters whose winter temperatures fall below the usual minima tolerated by *Oreochromis,* such as Lake Mentz on the Sundays River, South Africa, and the Hardap Dam on the Fish River in Namibia. Commencing with such stock, a lengthy period of selective breeding at a temperate-zone hatchery may be successful.

The problem of stunting or dwarfing is more serious since it affects tropical and sub-tropical Africa alike. Since it has long been known (Hickling, 1962) that male tilapias grow faster tha females, this can be overcome by growing a monosex culture preferably of all-male fishes. Several methods of achieving this have been devised, one of the most important being that of sexing the young fish by hand. This is especially suitable for African conditions where the providing of employment for numbers of workers is often of more value than high-cost capitalintensive systems. There are discernable differences in the external genitalia (Maar *et al.,* 1966, Fig. 70; Huet, 1970, Fig. 277) and the skill can readily be taught (perhaps especially to women because of their generally being more conscientious and patient than men). Sexing must be done carefully and as early as possible, since the females are discarded, but accurate sexing is mot usually possible until a weight of 30-50 gm is reached, so fingerlings must be nursed until this stage is reached before growing out the males.

The second method is that of hybridizing two species, first discovered by Hickling (1960) in crossing female *O. mossambicus* with male *O. hornorum* (then considered the «Zanzibar strain» of *O. mossambicus*), which produced all-male hybrids which were not sterile but capable of reproduction. Later the technique applied to various other species and the practice is evaluated by Lovshin (1982). A high degree of technological skill is however needed, pure genetic strains of broodstock are required, and the process in general better suited to large-scale commercial systems than to the extensive or semi-intensive farming normally practised in Africa. As Lovshin (op. cit.) puts it (p. 304) : «the level of technology needed to raise all-male hybrids is beyond the reach of most farmers in tropical developing countries and great care should be exercised in introducing all-male hybrid culture into countries with no fish culture tradition».

An important step in hybrid culture is the recent production, pioneered in Taiwan, of «red tilapias». This was done by crossing albino *O. mossambicus* with *O. niloticus* and selecting for red (albinistic) coloration. Selective breeding has produced a fast-growing strain which is predominantly red from an early age (Kuo & Neal, 1982). These often have a greater attractiveness in the market place than the conventional black and silver tilapia colours, as well as becoming popular in the aquarium fish trade (Anon, 1983).

Finally the reversing of the sex of female tilapias, by using steroid hormones at a very early age after hatching, has shown promise. The androgens methyltestosterone and ethynyltestosterone are used, and the method seems feasible on a commercial scale (Guerrero, 1979). Once again, extensive faciiities are required for the efficient holding of large quantities of fry and the method in general calls for sophisticated skills (Guerrero, 1982b).

The palatability, general popularity, rapid growth, hardiness, euryhalinity, ease of breeding and culture in extensive or semi-intensive systems, diversity of opportunities for intensive culture and relative cheapness of feeding in all situations have led to the unparalleled pre-eminence which the tilapias enjoy in modern fish farming. But a last consideration remains. The natural habit in *Oreochromis* of polygamous breeding in arenas or «leks», (Trewavas, 1982) each male mating with several females who then mouthbrood the young elsewhere, has led these tilapias to build up huge populations of many year classes under natural conditions. Paradoxically these very attributes of parental care of a few large eggs resulting in well-advanced juveniles which enjoy low natural mortality, which makes *Oreochromis* so fecund in nature, result in a very low fecundity under aquacultural conditions. A single artificially spawned carp or catfish will produce tens of thousands of young with high survival under culture conditions; the most the tilapia can manage is a hundred or two. So tilapia culture involves the keeping of very large numbers of broodstock relative to other fishes, which is the ultimate limiting factor in tilapia culture.

3.2 - Other Cichlidae. The palatability and the relative ease of culture of tilapias has prompted examination of other cichlid species as candidates for culture, particularly where these advantages confer a benefit additional to an attribute possessed by a species which is useful for an especial purpose. This is often molluscophagy for the control of schistosomiasis (De Bont, 1956; Jackson, 1973). Recommended species for this purpose include *Serranochromis macrocephalus* (De Bont & De Bont-Hers, 1952) : *Sargochromis mellandi* (De Bont & De Bont-Hers, 1956) : *Astatoreochromis alluaudi* (MacMahon, 1959 : Direction Piscicult. Côte d'Ivoire 1976), *Hemichromis bimaculatus* (Bard, 1960), and in Madagascar *Paratilapia sp.* (Kiener, 1957b).

In addition, the culture of ornamental cichlids for the home aquarium trade has assumed considerable importance. Many of these originate in Africa, especially the small brightly-coloured endemic species from Lakes Malawi and Tanzania (Axelrod & Burgess, 1977) but also various other genera such as *Pelmatochromis* and *Pseudocrenilabrus.* While such fish are bred by countless enthusiasts all over the world including Africa, most of the large-scale commercial culture takes place elsewhere, particularly in the Far East, Europe and the U.S.A.

In general, however, the culture of cichlid fishes other than those of the tilapia group has been little practised in Africa, whether for food, disease control or ornament. Further experimentation towards these three objectives would be very desirable.

3.3 - Clariid catfishes. Interest in the culture of African species is relatively recent, and was originally stimulated by the success of the long-established husbandry of the Asian *Clarias batrachus* and *C. macrocephalus.* In Africa two large members of the subgenus *Clarias* (*Clarias*) are chiefly used; these are *Clarias lazera* in West and North Africa, and *C. gariepinus* (of which *C. mossambicus* is a junior synonym) in Central and Southern Africa. While Teugels (1982) comes to the preliminary conclusion that *C. lazera* is a junior synonym of *C. gariepinus*, they are here considered separate species for ease of practical reference. Life histories and culture techniques are however identical.

Though some disadvantages exist. There are many advantages in the culturing of *Clarias.* From the economic viewpoint, maintenance is relatively inexpensive because catfishes have a catholic range of diet, though this must be of relatively high protein value (Bruton, 1979). Thus they respond to pond fertilization with animal manure by feeding on zooplankton and benthic invertebrates but can as well be fed on pelletized food, animal and fermented plant waste, etc. The rate of growth is rapid, though varying with climate and food availability, from about 22-32 cm TL in the first year, though even higher growths have been recorded (Table 2).

They also have a very wide range of temperature tolerance, exceeding any other indigenous African fish in this respect, and high growths are recorded even in *C. gariepinus* from an Orange River impoundment where winter water temperatures regularly fall to 8°C (Quick & Bruton, 1984). Another great advantage is that the danger of nocturnal mortalities through deoxygenation of heavily fertilized ponds is greatly diminished because they can breathe atmospheric oxygen through the accessory breathing organs, thus largely eliminating the need to aerate ponds at night in intensive culture.

Eating qualities are very good, rivalling the ictalurid catfishes of the U.S.A.They have excellent boneless fillets which «keep» well (i.e. do not rapidly become rancid or decay) in the unfrozen or lightly chilled condition, in comparison with many fish both marine and freshwater, making them comparatively easy to market. The species' popularity as a dried/smoked product over virtually the whole of Africa is well known, though in sophisticated markets the catfish is best sold filleted, since the heavy head, large mouth and barbels can lead to consumer resistance. Attractive packaging of fillets would do much to overcome such problems (Jackson, 1983). In 1984 *Clarias* fillets retailed for K7.50/kg in Zambia (T. Hecht, pers. comm.).

Both species were bred in ponds in the late 196Os, with important pioneering work being done on *C. lazera* in the United Arab Republic (El Bolock 1969, Aboul-Ela *et al.*, 1973), while *C. gariepinus* was first bred in the Cape Province, South Africa. Breeding is comparatively simple; grass-bottomed ponds are the most suitable. Unlike the Asian species no nests are made; on contact with water the fertilized eggs become extremely sticky and adhere to stems of vegetation. Spawning takes place at night and good results are obtained if males and females are kept separate in adjacent ponds. When access is allowed together with some additional water in spring spawning takes place immediately and the parents can be removed by seining.

Pond breeding in this way is simple, requires no elaborate equipment and results in the surviving fingerlings being well-grown and healthy, thus being eminently suitable for culture to market size in growing ponds. But since the survival rate is so low, this method, though easy and safe, is wasteful and space-consuming, and modern methods of inducing spawning by hormone injection are far better suited to intensive culture. For African catfish this was first done in Bangui, Central African Republic, for *C. lazera*; Hogendoorn (1979) stripped *C. lazera* using acetone-dried carp pituitary. Schoonbee *et al.* (1980) successfully stripped *C. gariepinus* females, and overcame serious problems of egg adhesiveness to hatch the larvae in Zuger-type flasks. Their rearing in intensive conditions is described by Hecht (1982).

An important development has been the recent success by Hecht & Lublinkhof, 1985 in successfully hybridizing males of the giant catfish or «vundu» *Heterobranchus longifilis* from the Middle Zambezi with female *Clarias gariepinus* from the Kafue system. *H. longifilis* is known to reach 60 kg (Bell-Cross, 1976), so that a considerable potential exists if such hybrids can be successfully cultured.

African clariids are thus very suitable for both simple field and intensive hatchery culture, though several disadvantages exist. High mortalities caused by dietary problems and disease in newly hatched larvae have been a serious constraint, but successful artificial larval feeds have recently been formulated and evaluated (Uys, 1984). Apart from being highly cannibalistic and predatory, clariid catfish are very agressive, especially the males, and injury can result through fighting or males attacking females (Micha, 1972). Wounds so caused are prone to fungus and bacterial infection; however careful management, such as techniques encouraging rapid growth to allow marketing at a comparatively early age greatly alleviates this constraint. Because of this aggressiveness and because when crowded they tend to stab each other with the heavy sharp spines on the pectoral fins, adults are difficult to transport in bulk as can be done with other fishes, unless special precautions such as tranquillization are undertaken.

3.4 - Mullet species (Mugilidae). Mullet have excited a good deal of interest in African fish culture, by reason of the advantages they possess of tolerating a wide range of salinities, feeding on diatoms and other organisms low on the food web with concomitant economy in food costs, and palatability and relatively high market values. A number of African countries, particularly those with a coastal littoral, are therefore engaged in the extensive culture of mullet species (Table 3).

At present such culture must of necessity be extensive, since all mullet species breed in the sea, the juveniles thereafter coming into brackish, and in some cases completely fresh water to enter into an extensive phase of feeding and growth before returning to the sea and repeating the cycle. Thus in culture it is only possible to spawn mullet by hormonal induction in full sea-water. Both this and the subsequent rearing of the larvae present more than ordinary difficulty, but have been successfully achieved, though requiring practice and a high degree of expertise (Liao, 1977; Nash & Koningsberger, 1981).

Extensive culture involves the capture of wild-spawned fry, preferably as soon as possible after they have entered the inland water after having been hatched out in the sea. In Egypt, such juveniles are collected in the canals connecting the brackish lakes and reservoirs with the sea, frequently where the upstreem migration is held up at pumping stations. The scoopnet is marked with coloured thread showing when approximately 1 000 fry are collected, for ease of counting (El Zarka & Kamel, 1967). Multiple stocking of wild-spawned fry has proved successful in Tuni-

Table 3 : Species of mullet cultivated in African ponds, lagoons and estuaries. Species which in nature habitually penetrate into fresh water are indicated*.

SPECIES	COUNTRY
*Mugil cephalus**	Egypt, Tunisia, Nigeria, Tanzania South Africa
M. auratus	Tunisia
M. capito	Egypt, Tunisia, Nigeria
M. chelo	Egypt, Tunisia
M. saliens	Egypt, Tunisia
*Myxus capensis**	South Africa
Liza ramada	Tunisia, Tanzania

sia with *M. cephalus, M. auratus* and *L. ramada* (Ibrahim, 1975), while Bok (1979) used *M. cephalus* and *Myxus capensis* from completely fresh water well inland from the sea.

Both Ibrahim and Bok (opp.cit.) found the fastest growing species to be the cosmopolitan *Mugil cephalus,* and indeed a wide-ranging review of mullet culture (Oren, 1981) indicates this to the best all-round species for either brackish-water or fresh aquaculture. Flesh texture and taste appears to be best in fish from water of high salinity (Nash & Koningsberger, 1981). In all cases, mullet appear to do best in polyculture, rather than intensive monoculture, feeding low on the food web on benthic algae and plankton but also readily accepting small-particle supplementary feeds such as meal or bran. Because of this and their euryhaline capabilities, mullet, though relatively little used at present, appear to have a very bright future in African aquaculture.

3.5 - Heterotis. With the exception of Madagascar, where it was introduced, the culture of *H. niloticus* is confined to West Africa, especially Cameroon, Gabon, Nigeria and Zaire. The heterotis was first suggested as a candidate fish for aquaculture by Daget & d'Aubenton (1956), and has since become extremely important in West African fish farming (SOGREAH, 1982). This is because it is a microphagous feeder, low on the food chain but readily taking artificial feeds, but is also capable of extremely rapid growth, and can attain a weight of 1 kg in a year. An additional advantage is that it is slow to mature and does not spawn until an age of 19-20 months is reached (Daget, 1970). Thus the propensity to over-populate, which is such a major problem in tilapia culture' does not arise. As well, it can tolerate very low limits of dissolved oxygen through being able to undertake aerial respiration via the air bladder.

It belongs to a primitive order of fishes, the Osteoglossomorpha or bony-tongued fishes, and its feeding and breeding habits are specialized. In nature it is a denizen of extensive waters, i.e. swamps, weedy areas of rivers and shallow well-vegetated lakes, in large equatorial northern and west African river systems. Biology and growth are reviewed by Micha & Franke (1976). Elaborate nests 1-1.5m in diameter are constructed by clearing the bottom and building a wall of vegetation around the nest. Many thousands of young are produced, an additional aquaculture advantage.

The main difficulties in the culture of *Heterotis* lie in ensuring a good survival of young and, in general, in keeping the fish in intensive culture, though spawning is relatively easy. The young feed exclusively on zooplankton and thus a good secondary production of planktonic organisms is essential. The fish do not do well in small ponds and growth is adversely affected by crowding (Micha, 1976). The fish is best suited to culture of small numbers (500-1000 large individuals only) in big ponds exceeding 2 ha in extent or in impoundments. The species does well in extensive polyculture with *Oreochromis niloticus* due to partitioning of the available food supply (Bard *et al.*, 1976).

3.6 - Other African species. Table 4 lists a number of species, in taxonomic order, which have been used or studied for use in Africa aquaculture. Reviews are given in the papers read at the Symposium on Aquaculture in Africa, Accra, Ghana, and published in CIFA Technical Paper 4, Supplement 1, FAO Rome, in particular that of Bard *et al.* (1976).

Table 4 : Fish used or studied for freshwater aquaculture in Africa.

TAXA BY FAMILIES	COUNTRIES
PROTOPTERIDAE *Protopterus annectens*	Benin
ANGUILLIDAE *Anguilla anguilla* *A. mossambica*	Egypt, Tunisia, Togo South Africa
OSTEOGLOSSIDAE *Heterotis niloticus*	Benin, Central Afr. Republic, Ivory Coast, Burkina Faso, Zaire.
GYMNARCHIDAE *Gymnarchus niloticus*	Nigeria
SALMONIDAE *Salmo trutta, S. gairdneri*	South Africa, Lesotho, Zimbabwe, Kenya, Tanzania, Tunisia
CYPRINIDAE *Cyprinus carpio* and Chinese carps *Barbus barbus* *Carassius auratus*	Widespread in more temperate areas Tunisia Nigeria, South Africa
BAGRIDAE *Auchenoglanis occidentalis,* *Chrysichthys nigrodigitatus,* *C. walkeri, Bagrus docmac*	Ivory Coast, Nigeria, Uganda
SCHILBEIDAE *Eutropius depressirostris*	Uganda, South Africa
CLARIIDAE *Clarias gariepinus, C. lazera* *C. senegalus, Heterobranchus isopterus*	Widespread in Africa
CHANNIDAE *Parachanna obscura*	Benin
CENTROPOMIDAE *Lates niloticus*	Nigeria, Uganda
SERRANIDAE *Dicentrarchus labrax,* *D. punctatus*	Egypt, Tunisia
LUTJANIDAE SPARIDAE *Sparus auratus*	Nigeria Tunisia
CENTRARCHIDAE *Micropterus salmoides* *M. dolomieu, M. punctulatus*	Kenya, Malawi, South Africa South Africa

Table 4 : Fish used or studied for freshwater aquaculture in Africa.

TAXA BY FAMILIES	COUNTRIES
CICHLIDAE	
Oreochromis andersoni, S. galileus,	Widespread
O. aureus, O. hornorum, O. mossambicus	
O. macrochir, O. niloticus, O. shiranus,	
Tilapia rendalli, T. zillii.	Widespread
Astatoreochromis alluaudi	Ivory Coast
Hemichromis fasciatus	Burkina Faso
Serranochromis robustus	Malawi, Natal (South Africa)
MUGILIDAE	
Mugil cephalus	Widespread
M. capito, M. chelo, M. saliens	Egypt, Tunisia
Myxus capensis	South Africa
ANABANTIDAE	
Ctenopoma kingsleyae	Benin
SOLEIDAE	
Solea vulgaris	Tunisia

Cichlidae are mentioned in 3.2 above while of the other taxa, attention has been paid to *Chrysichthys nigrodigitatus, C. walkeri, Auchenoglanis occidentalis* (Hirigoyen & Petel, 1979, 1981), *Bagrus docmac* and, recently to *Eutropius depressirostris* (Kruger & Polling, 1984) among the siluroids. While all of these grow well in ponds once fingerling size is reached, serious constraints remain in the spawning and rearing of the larval and fry stages. Experience with the clariid catfishes has shown that these problems are not insurmountable, but considerable research is needed.

Some studies of non-cichlid predators have been done by Elliott (1976). It is of interest to note his observation that in Nigeria *Hepsetus odoe,* the African pike, is a serious predator of carp in ponds by attacking and removing their gills, a specialized feeding method not previously recorded.

Another voracious carnivore is the mormyriform fish *Gymnarchus niloticus* which is an active predator of small fish especially fry. Under pond conditions in Nigeria it fed voraciously on tilapia, *Hemichromis* and carp fry, an 8 kg individual being observed to consume 5O small tilapia in 24 hours (Elliott, op.cit.). A large nest of grass is made, extending above the water surface, which is actively guarded by both parents. Controlled breeding in ponds has not yet been accomplished. Research on this and the rearing of the probably large number of larvae which are produced is very desirable, because of the fish's value as a controller of overpopulation in extensive culture, and also because of its high market value, the highest of any western Nigerian fish.

The Nile perch *Lates niloticus* has been used in polyculture in Nigeria by Zwilling (1963) and in Uganda by Biribonwoha (1976). However, while this again is a species showing promise, and exists well in fishponds, there are little or no quantitative data either on production of the predators or their prey or of breeding and raising in captivity.

4 - CAGE CULTURE.

Cage culture as defined by Coche (1982) is the rearing of fish stocks, generally from juvenile to marketable size, in a totally enclosed water volume through which a free water circulation is maintained.

This technique is world-wide, and comprehensive reviews have been published by Coche (1978, 1979, 1982), so the practice need only be briefly mentioned here within the Africa context. In Africa, the main fish used are tilapias and trout. While the treatment has been mainly experimental, thus far prospects are extremely promising (Ita, 1976; Vincke *et al.*, 1980)). With tilapias, a particular advantage is the possibility of controlling unwanted recruitment (Pagan, 1975).

Advantages of cage culture are numerous, and these, together with concomitant limitations, have been summarised by Coche (1979) and are reproduced in Table 5.

Table 5 : Advantages and limitations of cage culture (from Coche, 1979).

ADVANTAGES	LIMITATIONS
1. Possibility of making maximum use of all available water resources	Difficult to apply when the water surface is very rough
2. Economic use of water	
3. Helps reduce pressure on land resources	
4. Facilitates combination of several types of culture within one water body; treatments and harvests remaining independent	
5. Easy relocation of culture installations in case of emergency	
6.	Need for adequate water renewal in the cages for elimination of metabolites and maintenance of a high dissolved oxygen level. Sometimes rapid fouling of the cage walls require frequent cleaning.
7. Optimum utilization of artificial food for growth, minimizing its conversion rate of fish flesh	High dependence on artificial feeding. High quality balanced food desirable, in particular proteins, vitamins and minerals. Feed losses possible through the cage walls.
8. Easy daily observation of the fish population	
9. Easy control of fish reproduction (especially of tilapias)	
10. Easy control of competitors and predators	Sometimes important interference by the natural fish population round the cages (carps in particular)
11. Reduced fish handling and mortalities	
12. Parasite and disease control are easier and more economical (especially in floating cages)	Increased susceptibility of fish to a dissolved oxygen deficit
13. Fish harvest is easy and flexible	
14. Complete harvest of the fish production	
15. Harvest of a relatively uniform product	The risks of theft are increased
16. Storage and transport of live fish greatly facilitated	
17. Initial investment is relatively small	Period for amortization of the capital invested is relatively short. Increased labour costs of handling, stocking, feeding and cage maintenance.

In trout culture, very promising results have been obtained by MacGown (1977) in dams in the higher areas of Zimbabwe where maximum temperatures did not exceed 23° C, an important factor in trout culture in Africa. In the Transvaal, South Africa, trout are being increasingly farmed in cages.

In general, in Africa, certain constraints assume greater importance than in comparable situations in the Far East, where cage culture originated, or in various of the more developed countries. Most important of these are economic, where materials such as plastic netting may have to be imported, thus considerably increasing the capital cost, or where pellets or other suitable feed have to be transported for long distances thus increasing their cost. The prevalence of predators such as otters is another problem where even heavy plastic mesh or chicken wire may be bitten through. To obviate this MacGown (op. cit.) advocates making the sides and bottoms of cages of strong metal material such as 14 or 16 gauge woven black steel mesh, or expanded metal for larger fish, coated with bituminous paint to minimize rusting. The increasing costs of cage construction can be an important factor reducing profitability (Guerrero, 1982a).

5 - BRACKISH WATER AQUACULTURE.

The culture of fish in brackish water offers many opportunities in Africa. This is partly because the continent is the native home of many euryhaline species, particularly the tilapias. Also in many areas the supply of fresh water (here defined as that with a salinity of less than 5 parts per thousand) is erratic, depending on the vicissitudes of rainfall, or limited because the requirements of conventional irrigation of agricultural crops has a higher priority. Both these considerations apply along much of the coast of temperate northern and southwestern Africa, and along virtually the entire east coast where mean annual rainfall is low. Extensive coastal lagoons and areas of high natural rainfall are to a large degree confined to tropical west Africa. However even in these comparatively arid regions large numbers of river estuaries, great and small, occur, and here the supply of more saline water is practically unlimited. Inland, as well, saline waters occur, sometimes due to intensive irrigation leaching salts from the soil.

Coastal brackish water culture is a natural extension of fisheries for wild coastal species. A review by Ardill (1982) defines coastal aquaculture in a broad way as any increase in fish production from an area caused by human intervention beyond that of merely harvesting the fish. This includes facilitating seeding from natural sources, increasing the species diversity by the introduction of exotic species, provision of shelter from predation for younger fish, improvement of primary productivity by providing a substratum, fertilizing and finally intensive aquaculture practices such as feeding the fish.

Sivalingam (1976) lists the following species as suitable for culture in brackish water zones in Nigeria :

Tilapia	*Tilapia rendalli*
	Sarotherodon melanotheron heudelotii
Catfish	*Chrysichthys* spp.
Mullets	*Mugil cephalus*
	M. falcipinnis
	M. grandisquamis
Bonga	*Ethmalosa fimbriata*
Jewelfish	*Hemichromis fasciatus*
Snappers	*Lutjanus* sp.
Common carp	*Cyprinus carpio*

These embody most of the main genera suitable for African brackish water culture. Tilapias of the genus *Oreochromis* such as *O. mossambicus* and *O. hornorum* must be included. An important family is the Sparidae, especially *Sparus auratus*, but with promising species also in the genera *Rhabdosargus, Diplodus* and *Acanthopagrus.* A useful East Coast snapper able to tolerate virtually fresh water but needing a high temperature is *Lutjanus argentimaculatus.* Durand et *al.* (1982) show that 7 500 tonnes of sea fish, mainly *Ethmalosa fimbriata,* and 1 500 - 2 500 tonnes of euryhaline freshwater tilapias and bagrids are caught annually in the extensive Ivory Coast lagoons.

6 - RICE-FISH CULTURE.

Brief mention may be made of the practice of combining fish and rice culture, which has several advantages and at one time enjoyed a good popularity (Hickling, 1963; Coche, 1967; Vincke, 1980).

The fish may be a by-crop to the rice (or, less frequently, the other way round) with little extra effort and other advantages are that insects and molluscs, some possibly harmful or disease-carrying, are kept down by the fish, while the fishes excretory products help to fertilize the paddy. But several factors militate against the techniques; that pits or trenches must be dug for the fish which reduces the land available for rice, that the increasingly prevalent practice of spraying the rice with insecticides is harmful to the fish and also that the use, also increasing, of heavy machinery in rice cultivation is detrimental to the fish. But the advantages remain, and more feasibility studies should be undertaken, particularly in labour-intensive culture situations.

7 - CONSTRAINTS IN AFRICAN AQUACULTURE, AN OVERVIEW.

From the initial enthusiasm of the 1940's when there seemed no reason why African aquaculture should not soon emulate the mastery of the art so characteristic of the Far East (recent production figures are given by Shang, (1982), somewhat of a reaction took place. In the 1960's interest in fish culture in general, and of tilapia in particular, declined over the African continent, while in the rest of the world tilapia culture continued markedly to increase. Causes of this decline have never been fully evaluated but are worth discussing since many bear on modern African aquaculture problems.

There are probably four main reasons of which the first is social and the most important, namely that apart from a few special cases such as the acadjas of West Africa, no tradition of fish culture had built up in Africa as was the case in Asia and Europe, for the reason that there was no need for it. Because African human populations were in general small and the climate mild, they escaped the spur of sheer necessity forcing a more intensive agriculture in order to avoid famine or survive a cold winter. The first aquaculture developments were made by expatriate personnel during a period of some twenty years during the latter part of the colonial period; when they left they were replaced to some extent by various aid projects. However neither of these two sources of external expertise were able to do more than sow the seeds of local fish farming tradition, valuable though this initial inculcation has subsequently proved to be in laying the foundation on which a «father to son» tradition in this branch of farming can develop.

A second major social obstacle is the differing concept of the fish as an article of livestock. To the foreign fish farmer whether European or Asian, the important unit is the area of land; he speaks of ponda or hectares of ponds and what they can yield, rather than of individual fish or shoals of fish. The African concept is opposite, it is primarily of individual cattle or herds of cattle. The land, though of course important, is free, it is communally owned and the real ownership or sense of possession is of the sheep or cattle, often marked so as to be individually identifiable. Domesticated fish thus tended to fall into the same category, or even of less importance, as the poultry scratching round village doorposts. There was much less interest in these, they were fed desultorily or not at all, and fish, invisible and unrecognisable in ponds, were in many cases worthy of even less care. Their fate very often was indeed to receive less attention when the project ended and the experts departed. A third reason for the decline in fish farming interest in the 1960's was more universal; that is, that it was sometimes uneconomic. The early fish-culture work, being resource-orientated and experimental, often used feedstuffs such as oil-cake and artificial inorganic fertilizers such as superphosphate which, though perhaps cheap enough at the time, soon appreciated in value, being manufactured or imported, to more than that of the fish which were being produced. In general the costs of feed are 70-80% of the total recurrent costs of the fish farmer, as they are for other farmers producing animals for human consumption such as pigs or broiler chickens. So in many cases it was found that fish farming did not pay and projects came to an end for this reason.

Final reasons are technical and administrative constraints which have necessitated the solving of practical problems in almost all countries where aquaculture is practiced. Probably the most important is disease. Study into diseases caused both by dietary deficiencies (Mathieu, 1960) and parasites (Bard, 1960) were commenced, in Africa and are now well advanced (Paperna, 1980). Vested interest and cumbersome bureaucratic procedures involving a multiplicity of private, official and quasi-official agencies do much to retard aquacultural advancement (Arrignon, 1982). While by no means restricted to Africa, such curbs to progress are prevalent from one end of this continent to the other.

But while skills and techniques to overcome such constraints can be devised, the development of an aquaculture tradition is a longer process. There are encouraging signs of progress but perseverance is essential. The need for aquaculture is just as real in Africa as in Asia, and no-one should be discouraged by the inevitable setbacks which occur. Direct comparisons also of techniques such as the intensive culture of poultry in batteries with conventional pond aquaculture are also specious. since two different levels of intensity cannot be logically equated. A fairer comparison would be with aquaculture performance in raceways.

A great necessity in Africa at present is the undertaking of properly organised economic analyses, with comparisons of the advantages of various management systems, which previous planning in inland fisheries has often tended to neglect. The various options available should be objectively tested, such as comparisons of the species, extensive and intensive systems, monoculture or polyculture and efficient land use generally in integrating with other agriculture systems, especially in terms of quantity and quality of water available.

Any new aquaculture project should be preceded by an economic feasibility study, having regard to cost inputs and market acceptability of the product with or without various degrees of processing, and without expecting an unreasonably high return such as 50% or more per annum on capital invested. Socio-economic factors must also, however, be taken into consideration. Thus the provision of employment to as many people as possible is often more important than elaborate capital-intensive ventures. Similarly the calculation of benefits solely in terms of economic analysis must be tempered by social considerations. Thus in strictly economic terms it might be argued (and often is by big fishing companies) that the fish produced by an inland village costs just as much as, and often more than the inexpensive types of fish caught in greater quantity at sea by a large fishing vessel. This kind of argument ignores the two facts that firstly the producing of fish in the village is needed to provide employment, and secondly that the village simply does not have the cash flow to purchase the sea fish, however cheap it is.

As Shang (1981) has put it (p. xiii) : «At the present time a shortage of reliable data and a lack of understanding of the importance of aquaculture impedes economic analysis. The economic study of aquaculture provides a basis for decision making for fish farmers and assists in the formulation of public policies. However, in many developing countries such interest and the capacity to carry out extensive economic studies is presently lacking, thus making it difficult for sound development policies to be formulated».

RÉSUMÉ

Certaines techniques traditionnelles de pêche utilisées dans des lagunes comme le piégeage utilisant des clôtures et concentrant les poissons dans des parcs contenant des broussailles (acadjas) sont un premier pas vers l'aquaculture. Mais l'élevage ds poissons proprement dit est d'origine récente en Afrique et n'a débuté qu'avec l'importation de techniques utilisées dans d'autres régions. C'est le cas pour la carpe introduite en 1859 en Afrique du Sud et pour le premier élevage des tilapias au Kenya en 1924. Seuls les poissons de pêche sportive (truite, perche) furent élevés à l'origine jusqu'à ce que l'élevage extensif du tilapia se développe.

Après une période durant laquelle l'intérêt pour l'aquaculture s'est ralenti (les causes en sont discutées ici), il y a maintenant une forte demande dans beaucoup de pays africains. Les poisons indigènes les plus intéressants sont différentes espèces de *Tilapia* qui ont été exportées et élevées dans d'autres régions du monde, les *Heterotis* et les *Clariidae*. Leur élevage en Afrique, de même que celui d'espèces exotiques (comme la truite, le black bass, les carpes chinoises) a été passé en revue. Certains aspects de la biologie de ces espèces et des procédés utilisés pour les élever sont également présentés.

Les principales espèces de *Tilapia* ont besoin de températures élevées pour croître et se reproduire, et ont une propension à se reproduire plus précocement en élevage et à donner des individus de petite taille. La recherche de solutions en vue de surmonter ces problèmes est en bonne voie, grâce notamment aux hybridations. Certains travaux sont également en cours sur les espèces de Cichlidae se nourrissant de mollusques, en vue de les utiliser dans la lutte contre la bilharziose. L'élevage des Clariidae apparaît très prometteur à l'heure actuelle avec notamment l'hybridation réussie de *Clarias gariepinus* avec *Heterobranchus longifilis.*

L'élevage des *Heterotis* et des mulets est passé en revue ainsi que les techniques d'élevage en eau saumâtre et en cage utilisées en Afrique. Une liste la plus complète possible a été établie pour les poissons qui ont fait l'objet de travaux d'aquaculture expérimentaux.

Il est nécessaire de connaître les contraintes socio-économiques liées à l'aquaculture en Afrique afin d'envisager son développement futur. Si celui-ci paraît être brillant il faut cependant développer les études de faisabilité et renforcer la formation dans le domaine économique notamment.

REFERENCES

ABOUL-ELA I., AMER F. & EL BOLOCK A.R., 1973 - Studies on spawning behaviour of *Clarias lazera* Cuv. and Val. in fish farms of the A. R. of Egypt. *Bull. zool. soc. Egypt,* 25 : 25-32.
ALLANSON B.R. & JACKSON P.B.N., 1983 (Eds.) - The fisheries potential of Lake Le Roux, Orange River, South Africa. South African National Scientific Programmes, Report No.77, CSIR, Pretoria, 180 p.
ANON, 1983 - Editorial. *Natal Aquaculturalist. Univ. Zululand,* 2 :1.
ARDILL J.D., 1982 - A general review of coastal aquaculture in the African region. In COCHE A. (Ed.) Coastal aquaculture : development perspectives in Africa and case studies from other regions pp. 1-24 CIFA Tech. Pap. 9, FAO, Rome.
ARRIGNON J.C.V., 1962 - *Tilapia mossambica* Peters, *Tilapia macrochir* Blgr, *Tilapis zillii* Gervais, trois nouveaux venus dans les eaux douces Algériennes. *Ann. Cent. Rech. Exp. For. Alger.,* 1 : 1-321.
ARRIGNON J.C.V., 1982 - Regards sur l'aquaculture mondiale. *Aquaculture,* 27 : 165-186.
ATZ J.W., 1954 - The peregrinating *Tilapia. Anim. Kingdom,* 57, (5) : 148-155.
AXELROD H.R. & BURGESS W., 1977 - *African cichlids from Lakes Malawi and Tangayika.* TFH, Hong Kong. 384 p.
BALARIN J.D. & HALLER R.D., 1982 - The intensive culture of tilapia in tanks, raceways and cages. pp. 265-356. In J. F. MUIR, & R. J. ROBERTS, (Eds), *Recent advances in Aquaculture.* Croom Helm, London.
BALARIN J.D. & HATTON J.P., 1979 - *Tilapia : a guide to their biology & culture in Africa.* University of Stirling, Scotland, 175 p.
BALARIN J.D., 1984 et seq. - National reviews for aquaculture development in Africa : 1-12. FAO Fish. Circ. 770, 1-12 : pag. var.
BARD J., 1960 - Ichthyopathologie. *Publs. Cons. scient. Afr. S. Sahara,* 63 : 166-9.
BARD J., DE KIMPE P. & LESSENT P., 1976 - Nouveaux poissons et nouvelles méthodes d'élevage en Afrique. Symposium on Aquaculture in Africa. CIFA Tech. Paper 4, Suppl. 1 : 365-
BARDACH J.E., RYTHER J.H. & McLARNEY W.O., 1972 - *Aquaculture, the farming and husbandry of freshwater and marine organisms.* Wiley Interscience, New York.
BELL-CROSS G., 1976 - *The fishes of Rhodesia.* National Museums and Monuments of Zimbabwe, Harare. 268 p.
BIRIBONWOHA A.R., 1976 - Status of aquaculture in Uganda. Symposium on Aquaculture in Africa : CIFA Tech. Paper 4, suppl. 1 : 203-206.
BISHAI H.M., 1965 - Resistance of *Tilapia nilotica.* I. to high temperatures. *Hydrobiologia* 25 : 31-39.
BOK A., 1979 - The distribution and ecology of two mullet species in some fresh water rivers in the Eastern Cape, South Africa. *J. limnol. Soc. sth. Afr.,* 5 (2) : 97-102.
BOWMAKER A.P., 1973 - Potamodromesis in the Mwenda River, Kariba. In ACKERMAN W. C. *et al.,* (Eds), *Man-made lakes. Their problems and environmental effects.* Geophys. Mon., 17.
BRUTON M.N., 1979 - The breeding biology and early development of *Clarias gariepinus* (Pisces : Clariidae) in Lake Sibaya, South Africa, with a review of breeding in species of the subgenus *Clarias (Clarias). Trans. Zool. Soc. Lond.,* 35 : 1-45.
BRUTON M.N. & ALLANSON B.R., 1980 - Growth of *Clarias gariepinus* in Lake Sibaya, South Africa. *S. Afr. J. Zool.* 15 : 7-15.
CHARPY B., 1955 - La pisciculture du Tilapia. *Bull. fr. Piscic.* 27, (178) : 5-20.
CHERVINSKI J. & HERING E., 1973 - *Tilapia zillii* (Gervais) (Pisces, Cichlidae) and its adaptability to various saline conditions. *Aquaculture,* 2 (1) : 23-9.
CLAY D., 1977 - Biology of the tropical catfish (Family : Clariidae) with special emphasis on its suitability for culture (including a bibliography of Clariidae and related topics). Fisheries & Marine Service Canada : Manuscript Report, No. 1458 : 68 p.
COCHE A.G., 1967 - Fish culture in rice fields, a world-wide synthesis. *Hydrobiologica,* 30 (1) : 1-44.

COCHE A.G., 1978 - Revue des pratiques d'élevage des poissons en cages les eaux continentales. *Aquaculture,* 13 : 157-189.
COCHE A.G., 1979 - A review of cage fish culture and its application in Africa. In PILLAY T.V.R. DILL W.A. (Eds) *Advances in Aquaculture,* pp. 628-641. Fishing News Books Ltd, Farnham, Surrey, England.
COCHE A.G., 1982 - Cage culture of tilapias. In PULLIN R.S.V. & LOWE-McCONNELL R.H.·(Eds). *The biology and culture of tilapias,* pp. 205-246 ICLARM Conference proceedings 7. International Center for Living Aquatic Resources Managment, Manila, The Philippines.
COPLEY H., 1954 - Some random notes on pond fish culture in Kenya. *Symposium on African Hydrobiology, Inl. Fish CSA/CCTA Publ.,* 6 : 90-91.
DAGET J. & d'AUBENTON F., 1956 - *Heterotis niloticus,* peut-être un poisson du pisciculture? *Publs. Cons. scient. Afr. S. Sahara,* 25 : 109-111.
DE BONT A.F., 1948 - Fish farming in the Belgium Congo. *Nature, Lond,* 16 (2) : 998.
DE BONT A.F., 1952 - La production de poisson de consommation au Congo Belge *Bull. agric. du Congo Belge,* 43, 4.
DE BONT A.F., 1956 - Contrôle biologique des mollusques d'eau douce et des maladies qu'ils transmettent. *Ann. Soc. Belge Méd. trop.,* 36 (5 bis) : 667-672.
DE BONT A.F. & DE BONT-HERS M.J., 1952 - Mollusc control and fish farming in Central Africa. *Nature, Lond.,* 170 : 323-324.
DE BONT A.F. & DE BONT-HERS M.J., 1956 - *Haplochromis mellandi* Blgr. Poisson malacophage *Rev. Zool. Bot. afr.,* 53 : 370-376.
DE KIMPE P. & MICHA J.C., 1974 - First guidelines for the culture of *Clarias lazera* in Central Africa. *Aquaculture,* 4 : 227-248.
DURAND J.R., ECOUTIN J.M. & CHARLES-DOMINIQUE E., 1982 - Les ressources halieutiques des lagunes ivoiriennes. *Oceanol. Acta,* Actes Symp. International sur les lagunes côtières. SCOR/IABO/UNESCO, Bordeaux, 8-14 Sept. 1981 : 277-284.
DIRECTION DE LA PISCICULTURE, CÔTE D'IVOIRE, 1976 - Etat actuel de l'aquiculture en Côte d'Ivoire. *Symposium sur l'aquiculture en Afrique,* CPCA T.4 Supp. 1 : 23-28.
EISAWY A. & EL BOLOCK AA., 1976 - Status of aquaculture in the Arab Republic of Egypt. Symposium on Aquaculture in Africa. CIFA T.4, suppl. 1 : 5-15.
EL BOLOCK A.R., 1969 - Catfish culture. *FAO Fish Culture Bulletin,* 2(1) :7.
EL BOLOCK A.R., 1972 - The use of vertebrae for determining age and growth in the Nile catfish *Clarias lazera. A.R. Egypt Bull. Inst. Oceanogr. Fish,* 2 : 53-82.
ELLIOTT O.O., 1976 - Biological observations on some species used for aquaculture in Nigeria. *Symposium on Aquaculture in Africa.* CIFA T.4 : Suppl. 1 : 373-385.
EL-ZARKA S. EL-D. & KAMEL F., 1967 - Mullet fry transplantation and its contribution to the fisheries of inland brackish lakes in U.A.R. *Proc. Tech. Pap. Gen. fish. Coun. Mediterr.,* 8 : 209-226.
GEORGE T.T., 1975 - The history and status of fish culture in Sudan and the urgency of an experimental project for its development into an industry : a review. In Symposium on aquaculture in Africa : reviews and experience Papers CIFA T.4, Suppl. 1, FAO Rome : 109-131.
GREENWOOD P.H., 1955 - Reproduction in the catfish *Clarias mossambicus. Nature, Lond.,* 176 : 516-518.
GUERRERO R.D., 1979 - Culture of male *Tilapia mossambica* produced through artificial sex-reversal. In PILLAY T.V.R. and DILL W.A. (Eds), *Advances in aquaculture,* pp. 166-168. Fishing News Books, Farmam, Surrey, England.
GUERRERO R.D., 1982a - Developments, prospects and problems of the tilapia cage culture industry in the Philipines. *Aquaculture,* 27 : 313-315.
GUERRERO R.D., 1982b - Control of tilapia reproduction. In PULLIN R.S.C. & LOWE-McCONNELL R.H. (Eds). *The biology and culture of tilapias,* pp. 309-316. ICLARM Conf. Proc. 7, 432 p.
HALAIN C.F., 1952 - Vidange d'un étang de la Cotonco à Sentery, Territoire de Tshofa. *Bull. agric. Congo Belge.* 43 (2) : 539-44
HARRISON A.C., 1951 - Introduction of exotic fishes to the Cape Province. *Piscator,* 17 : 22-32.

HECHT T., 1982 - Intensive rearing of *Clarias gariepinus* larvae (Clariidae : pisces). *S. Afr. J. Wildl. Res.*, 12 (3) : 101-105.
HECHT T. & LUBLINKHOF W., 1985 - *Clarias gariepinus* x *Heterobranchus longifilis* (Pisces : Clariidae) : A new hybrid for aquaculture? *S. Afr. J. Sci.*, 81 : 620-621.
HEPHER B. & PRUGININ Y., 1982 - Tilapia culture in ponds under controlled conditions. In PULLIN R.S.C. and LOWE-McCONNELL R.H. (Eds), *The biology and culture of tilapias*, pp. 185-203. ICLARM Conf,. Proc. 7, 432 p.
HEY D., 1944 - The culture of freshwater fish in South Africa. Dept. of Inland Fisheries, - Stellenbosch, South Africa.
HEY D., 1955 - A preliminary report on the culture of fish in the final effluent from the new disposal works, Athlone, South Africa. *Verh. int Verein. theor. angew. Limnol*, 12 : 737-742.
HICKLING C.F., 1960 - The Malacca *Tilapia* hybrids. *J. Genet*, 57 : 1-10.
HICKLING C.F., 1962 - *Fish Culture.* 1st Ed., Faber & Faber, London.
HICKLING C.F., 1966 - The artificial inducement of spawning in the grass carp *Ctenopharyngodon idella* Val. A review. *Proc. Indo. Pacific Fish. Council*, 12 : 236.
HIRIGOYEN J. & PETEL C., 1979 - Nouvelles données sur la croissance en étang du poisson bagridae *Auchenoglanis occidentalis* Val. 1840. *Notes Doc. Pêche Pisc., (Nouv. Sér.)*, 18 : 20-26.
HIRIGOYEN J. & PETEL C., 1981 - Contribution à l'étude de *Chrysichthys walkeri* Günther. Elevage en étang. *Notes Doc. Pêche Pisci. (Nlle Séri.)*, 23 : 27-37.
HOGENDOORN H., 1977 - Aspects of two years of fish culture development in the Republic of the Cameroon. FI : CMR 172/010/1, FAO, Rome.
HOGENDOORN H., 1979 - Controlled propagation of the African catfish *Clarias lazera.* C. & V. I - Reproductive biology and field experiments. *Aquaculture*, 17 : 323-333.
HOLL A.E., 1968 - Notes on the spawning behaviour of the barbel *Clarias gariepinus* Burchell in Rhodesia. *Zool. Afr.*, 3 (2) : 185-188.
HUET M., 1957 - Dix années de pisciculture au Congo Belge et au Ruanda-Urundi. Publ. Direct. Agric. For. Elev. Bruxelles, 109 p.
HUET M., 197O - *Traité de pisciculture.* 4me ed. Editions Ch. de Wyngaert, Bruxelles.
IBRAHIM K., 1976 - Progress and present Status of aquaculture in Tanzania. Symposium on Aquaculture in Africa : CIFA T.4, suppl. 1 : 132-147.
ITA E.O., 1976 - Observations on the present status and problems of inland fish culture in some northern states of Nigeria and preliminary results of cage culture experiments in Kainji Lake Nigeria. *Symposium on Aquaculture in Africa. CIFA T.4, Suppl.* 1 : 241-247.
JACKSON P.B.N., 1973 - Fish. In STANLEY N.F. & ALPERS M.P. *Man-made lakes and human health.* pp. 259-275. Academic Press, London.
JACKSON P.B.N., 1976 - Water resources and freshwater fish in Southern Africa. In BAKER G. (Ed.). *Resources of southern Africa, today and tomorrow*, pp. 196-207. Associated Scientific and Technical Societies, Johannesburg.
JACKSON P.B.N., 1983 - The aquaculture potential of indigenous species. *Natal Aquaculturist, Univ. Zululand*, 2 : 2-6.
KIENER A., 1957a - Afrique, Madagascar, sous le signe du Tilapia. *Bull. de Madagascar* 129, Antananarivo, 23 p.
KIENER A, 1957b - Poissons, pêche et pisciculture à Madagascar *Centre Technique Forestier, Tropical, Nogent-sur-Marne.*
KONRADT A.G., 1968 - Methods of breeding the grass carp, *Ctenopharyngodon idella* and the silver carp, *Hypophthalmichthys molitrix.* FAO Fish. Rep., 44(4) : 195-204.
KRUGER E.J., & POLLING L., 1984 - First attempts at artificial breeding and larval rearing of butter catfish *Eutropius depressirostris* (Pisces, Schilbeidae). *Water S.A.* 10(2) : 97-104.
KUO C.M. & NEAL R.A., 1982 - ICLARM'S Tilapia Research. ICLARM Newsletter 5 (1) : 11-13.
LESSENT P., 1977 - Méthodes de pisciculture intensive - Afrique tropicale. *Le Courrier* N° 41, Nogent sur Marne.
LIAO I.C., 1977 - On completing a generation cycle of the grey mullet, *Mugil cephalus*, in captivity. *J. Fish. Soc. Taiwan*, 5 : 119-130.
LOMBARD G.C., 1961 - The first importation and production of Aischgrund carp in South Africa. *Fauna & Flora*, 12 : 78-85.

LOVSHIN L.L., 1982 - *Tilapia hybridization.* In PULLIN R.S.V. & LOWE-McCONNELL. R.H. (eds), *The biology and culture of tilapias.* ICLARM Conf. Proc. 7, 432 p.
MAAR A., 1956 - Tilapia culture in farm dams in Southern Rhodesia. *Rhod. Agric. J.*, 53 (5) : 667-687.
MAAR A., MORTIMER M.A.E. & VAN DER LINGEN I., 1966 - Fish culture in Central East Africa. FAO, Rome. 160 p.
MACGOWN A.R., 1977 - Cage culture : a new approach to rainbow trout farming in Rhodesia. *Zimbabwe Agricultural Journal* 74(4) : 103-109.
MACMAHON J.P., 1959 - Preliminary observations on the control by fish of snails and mosquitoes in dams. *Ann. Rep. E. African Fisheries Research Org. Jinja* : 41-46.
MATHIEU Y., 1960 - L'alimentation artificielle du *Tilapia zilli. Bull. Agric. Congo Belge*, 51(3). 661-682.
MESCHKAT A., 1967 - The status of warm-water pond fish culture in Africa. In PILLAY T.V. R. (Ed.) - Proceedings of the world symposium on warm-water pond fish culture FAO Fish Report 44(2) : 88-122.
MICHA J.C., 1972 - Induced breeding of *Clarias* spp. *FAO Aquacult Bulletin*, 4 (2) : 3-4.
MICHA J.C., 1976 - Potentialités de la faune piscicole de l'Ubangui pour la pisciculture. *Rev. Trav. Inst. Pêches marit.*, 40(3&4) : 675-676.
MICHA J.C. & FRANKE V., 1976 - Biologie des principales espèces utilisées en pisciculture africaine. Doc. Tech. CPCA 4, Suppl. 1 : 292-331.
MORTIMER M.A.E., 1960 - Hybrid *Tilapia* in Northern dhodesia. *Publs. Cons. scient. Afr. S. Sahara.* (63) : 185-195.
MUNRO J.L., 1965 - Feeding relationships and production of fish in a Southern Rhodesia lake. PhD thesis, University of London. 277 p.
MYERS G.S., 1949 - Salt-tolerance of freshwater fish groups in relation to zoogeographical problems. *Bijdragen tot de dierkunde*, 28 : 315-322.
NASH C.E. & KONINCSBERGER B.M., 1980 - Artificial propagation. In OREN D.H. (Ed.) *Aquaculture of grey mullets*, pp. 265-312. IBP Vol. 26. Cambridge University Press, Cambridge.
OREN D.H., (Ed.) - Aquaculture of grey mullets. IBP Vol. 2. Cambridge University Press, Cambridge, 507 p.
PAGAN F.A., 1975 - Cage culture as a mechanical method for controlling reproduction of *Tilapia aurea* (Steindachner). *Aquaculture*, 6 : 243-247.
PAPERNA I.I., 1980 - Parasites, infections and diseases of fish in Africa. CIFA Tech. Pap. 7, FAO, Rome : 1-216.
PHAM A., 1975 - Données sur la production en masse d'alevins de *Clarias lazera* Val. à la station de Bouvaké (Côte d'Ivoire). *Notes Doc. sur la pêche et la pisciculture.* 49-57.
PIKE T., 1980 - An historical review of freshwater fish hatcheries in Natal *Piscator* 105 : 49-53.
PIVNICKA K., 1974 - The Zambezi barbel *Clarias gariepinus* (Burchell 1822). In BALON E.K. (Ed.). *Lake Kariba, a man-made tropical Ecosystem in Central Africa.* pp. 318-325. *Monographiae Biologicae*, 24. Junk, The Hague.
PRINSLOO J.F. & SCHOONBEE H.J., 1983 - Induced spawning of the Chinese bighead carp *Aristichthys nobilis* Richardson (Pisces :Cyprinidae) at the Umtata Fish Research Centre, Transkey. *S.Afr.J.Sci.*, 79 : 229-231.
QUICK A.J.R. & BRUTON M.N., 1984 - Age and growth of *Clarias gariepinus* (Pisces : Clariidae) in Lake le Roux, South Africa. *S. Afr. J. Zool*, 19(1) : 37-45.
ROBBINS W.H. & MACRIMMON H.R., 1974 - *The black bass in America and overseas.* Biomanagement & Research Enterprises, Sault Ste Marie, Canada. 196 p.
SAFRIEL O. & BRUTON M.N., 1984 - Aquaculture in South Africa. A cooperative research programme. South African National Scientific Programmes, Report n° 79 : 79 p.
SCHOONBEE H.J., BRAND F. & BEKKER C.A.L., 1978 - Induced spawning of the two phytophagous chinese carp species *Ctenopharyngodon idella* (Val.) and *Hypophthalmichthvn molitrix* (Val.) with reference to the possible use of the grass carp in the control of aquatic weeds. *Water S.A.*, 4 : 93-103.
SCHOONBEE H.J., HECHT C., POLLING C. & SAAYMAN J.E., 1980 - Induced spawning

of and hatchery procedures with the sharptooth catfish *Clarias gariepinus* (Pisces : Clariidae) *S.Afr. J. Sci.*, 76 : 364-367.
SCHUSTER W.H., 1952 - A provisional survey of the introduction and transplantation of fish throughout the Indo-Pacific region. *Proc. Indo-Pacific. Fish. Council* (3rd Meeting Madras 1951) - Phra Atit Rd, Bangkok, pp. 187-196.
SHANG YUNG C., 1981 - Aquaculture economics : basic concepts and methods of analysis. Westview Press, London. 153 p.
SILLIMAN R.P., 1975 - Selective and unselective exploitation of experimental populations of Tilapia mossambica. *Fish. Bull.*, 62 : 21-52.
SIVALINGAM S., 1976 - The biology of cultivable brackish water and marine finfish in Africa. *Symposium on aquaculture in Africa.* CIFA Tech. paper 4, Suppl. 1 : 283-291.
SOGREAH, 1982 - Cameroun. Etude de l'aquaculture et de la pêche continentale. Tome 3 : fermes piscicole commerciale. Faisabilité technique et économique. Grenoble, SOGREAH 181 p.
TEUGELS G.G., 1982 - Preliminary results of a morphological study of five African species of the subgenus *Clarias (Clarias)* (Pisces : Clariidae) *J. Nat. Hist.* 76 : 439-464.
TOOTS H., 1970 - Exotic fishes in Rhodesia. *Rhodesia Agric. J.*, 67 (4) :
TREWAVAS E., 1982 - Tilapias : taxonomy and speciation In PULLIN & LOWE-McCONNELL (Eds.), *The biology and culture of tilapias* pp. 3-13. ICLARM Conf. Proc. 432 p.
UYS W., 1984 - Investigations into the dietary requirements of *Clarias gariepinus larvae* (Pisces, Clariidae) and the formulation and manufacture of an artificial dry feed for use in intensive larval rearing. MSc Thesis, Rhodes University, Grahamstown.
VAN DER LINGEN M.I., 1959 - Some observations on the growth of *Tilapia mossanbica* under different population densities and on different levels of feeding at the Fisheries Research Centre. Proc.First Fisheries Day, S. Rhodesia. Govt. Printer, Salisbury, pp. 63-68.
VAN DER WAAL B.C.W. & SCHOONBEE H.J., 1975 - Age and growth studies of *Clarias gariepinus* (Clariidae) in the Transvaal, South Africa. *J. Fish Biol.*, 7 : 227-234.
VAN SOMEREN V.D., 1962 - Pond culture studies on *Tilapia nigra. Ann. Rep. E. Afr. freshwater Fish Res. Org.* 1961, appendix D : 33-35.
VAUGHAN-JONES T.G.C., 1949 - Experiments in fish culture and in stocking dams ad streams in Northern Rhodesia, 1942-47. Government Printer, Lusaka.
VINCKE M., 1980 - La rizipisciculture. *Afr. Agr. Paris* 61, 24-26.
VINCKE P., NUGENT C. & ARRIGNON J., 1981 - Construction de cages flottantes pour un élevage commercial de *Sarotherodon niloticus.* In KAPETSKY J.M. (Ex) *Séminaire sur l'aménagement et la mise en valeur des bassins fluviaux. Blantyre, Malawi, 8-10 Décembre 1980,* pp. 273-291. Doc. Tech. CCPA 8 FAO, Rome.
WELCOMME R.L., 1971 - A description of certain indigenous fishing methods from Southern Dahomey. *Afr. J. trop. Hydrobiol. Fish.*, 2(1) : 129-140.
WELCOMME R.L. (Ed.), 1981 - Register of International transfers of inland fish species. FAO, Rome. Fish Tech. paper No. 213, 120 p.
WILLOUGHBY N.G. & TWEDDLE D., 1978 - The ecology of the catfish *Clarias gariepinus* and *Clarias nganensis* in the Shire Valley, Malawi. *J. Zool.*, 184 : 507-534.
WOYNAROVICH E. & HORVATH L., 1980 - The artificial propagation of warm-water finfishes. A manual for extension. FAO Fish. Tech. Pap. 201, 183 p.
ZWILLING K.K. (Ed.), 1963 - Carp farming in the Jos Plateau. *Bull. Inst, Fr. Afr. noire,* 25(A) : 285-298.