

Pond Culture of Tilapia in Rwanda, a High Altitude Equatorial African Country

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ABSTRACT

Tilapia culture in Rwanda is practiced in ponds at altitudes from 1,300 m to 2,500 m. Air and water temperature are lower than those in other tropical countries where tilapia culture is typically practiced. These conditions require careful pond water management practices for tilapia culture to be successful. Results from experiments and rural harvests indicate that *Oreochromis niloticus* is superior to *Tilapia rendalli* and *O. macrochir* in Rwandan conditions.

Reproductive tendencies of *O. niloticus* are different from those seen elsewhere: age at first reproduction is higher, time before resumption of reproduction after restocking is longer, and number of fingerlings produced per surface area is less. Natural productivity measured in local ponds ranged from 40 to 210 kg/ha/year and net productivity in poorly managed ponds receiving inputs was generally less than 500 kg/ha/year. However, in well managed ponds, *O. niloticus* can show average growth of over 1.0 g/day and net productivity of 3,000 kg/ha/year.

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Introduction

Rwanda a mountainous, land-locked country in east-central Africa, has been the site of pond culture of tilapia since at least the 1930s. In the late 1950s, there were over 2,000 ponds in Rwanda, with an average production of 400 kg/ha/year (Aubray 1976). Most of these ponds were rural; but there were some governmental and institutional stations. Although institutional support for fish culture was curtailed in the early 1960s, there was continued interest in the rural sector. However attrition substantially reduced the number of active ponds.

In the late 1970s the Rwandan government began to encourage fish culture with the goal of supplementing the production of animal protein. However, there was some doubt as to the appropriateness of fish culture in Rwanda. These concerns arose largely from doubts as to the suitability of the culture of tilapia in the climatic conditions of Rwanda.

Climate

Although Rwanda is equatorial (approximately 2°S), its climate is tempered by altitude. The result is a temperature regime which is cooler than that found in most of the equatorial regions. The areas of the country where tilapia culture is practiced range from 1,300 m to 2,500 m. At these altitudes, minimum ambient air temperatures are often below 10°C while afternoon air temperatures rarely reach 35°C (Fig. 1).

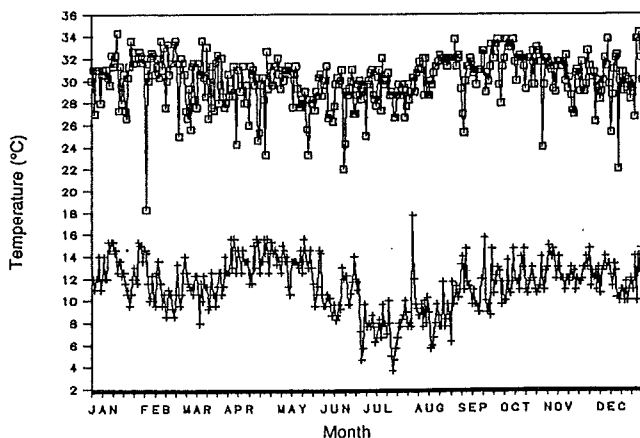


Fig. 1. Annual variation in daily minimum (+) and maximum (□) air temperature (in °C) at the National University of Rwanda fish culture station at Rwasave, near Butare, at an elevation of 1,700 m.

Since this temperature regime is inferior to that which is generally considered optimum for tilapia growth (e.g., Balarin 1979; Pruginin 1983), it is important to take advantage of the thermodynamic inertia of water through careful management of pond water. The heat retention capacity of standing water buffers the temperature fluctuations so that temperature variations in ponds are less than those of the air and the running water in feeder canals. In ponds with minimal water loss, minimum pond water temperatures are often 9-10°C higher than the minimum temperatures of nearby running water (Fig. 2). Ponds with good algal blooms may be an additional 3-4°C higher than those without blooms.

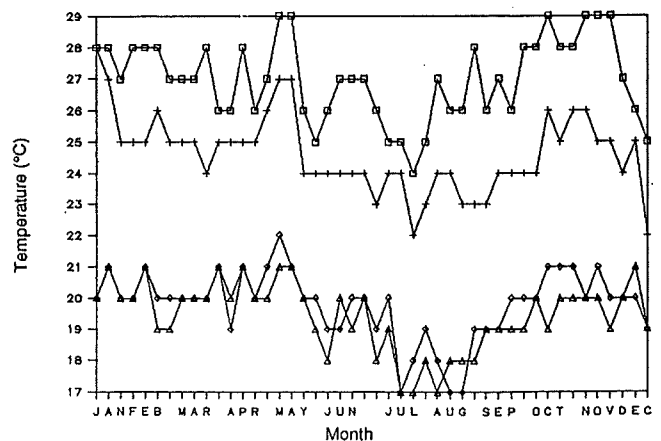


Fig. 2. Annual variation in weekly minimum and maximum water temperatures (°C) measured at depths of 25 cm and 50 cm at the National University of Rwanda fish culture station at Rwasave, near Butare. Symbols: min. at 50 cm (Δ); min. at 25 cm (◇); max. at 50 cm (+); max. at 25 cm (□).

The minimization of pond water losses becomes especially important at high altitude stations such as the National Fish Culture Program (PPN) station at Ndurwa (2,200 m) where minimum morning water temperatures in the canal fall to 10°C but are higher in the ponds (Table 1). Maximum (afternoon) water temperatures in the ponds are also usually 3-4°C higher than those in the canal.

Seasonal variations in temperature also influence tilapia growth and reproduction, although the magnitude of the effect is not well quantified. Rwanda

Table 1. Annual variation in monthly extreme (minimum and maximum) and mean morning and afternoon temperatures at the Ndorwa station of the National Fish Culture Program, Rwanda, located at an altitude of 2,200 m. Means are calculated from daily measurements in °C

	Morning				Afternoon			
	Minimum		Mean		Maximum		Mean	
	Canal	Pond	Canal	Pond	Canal	Pond	Canal	Pond
Jan	12	14	14	16	22	25	20	22
Feb	10	13	13	15	23	26	18	20
Mar								
Apr	15	18	16	19	22	26	20	24
May	11	16	16	18	24	26	21	24
Jun	12	16	16	19	23	27	20	22
Jul	13	16	16	19	24	27	20	22
Aug	10	15	13	17	20	24	18	21
Sep	12	17	15	18	21	24	20	23
Oct	13	16	15	19	23	26	21	24

has four seasons: a long dry season, which lasts approximately from mid-June to mid-September; a short rainy season, from mid-September to mid-December; a short dry season, from mid-December to mid-February; and a long rainy season from mid-February to mid-June. Pond water temperatures remain cooler in the dry periods; they drop lower at night and do not warm up during the day to levels experienced during the rainy periods.

Species cultured in Rwanda

Three species of tilapia have been cultured in Rwanda; of these, only one, *O. niloticus* is indigenous (Philippart and Ruwet 1982). The other two, *O. macrochir* and *T. rendalli*, were introduced. Pure native *O. niloticus* stocks were lost through hybridization with *O. macrochir*. Similar hybridization has been reported by Ruwet et al. (1976) and Moreau (1983). The loss of native *O. niloticus* stocks was unfortunate in view of the evidence of the superiority of this species in pond culture.

Maletougou (1976) recommends *O. niloticus* after comparing it with *O. macrochir* and *T. rendalli*. His experience is that *O. macrochir* production is low and that mortality is high. *T. rendalli* growth is slower than *O. niloticus*; however reproduction is greater. He also notes that *O. niloticus* grows rapidly and is resistant to traditional methods of manipulation and transportation. George (1976) states that *O. niloticus* fry are hardy and tolerate long distance transportation, whereas Ruwet et al. (1976) note that *O. macrochir* and *T. rendalli* seem fragile. Bard et al.

(1976) criticize *T. rendalli*'s slow growth rate and emphasize that reproduction starts early and is abundant. They suggest that among the tilapias, *O. niloticus* is the most suitable for pond culture. Pullin (1983) states that an ongoing worldwide survey by the International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines, on the status of tilapia as a cultured food commodity is confirming the superiority of *O. niloticus* in many tropical situations. Schmidt and Vinke (1981) recommended *O. niloticus* for Rwanda, although they felt that *O. macrochir* and *T. rendalli* also may be useful for polyculture.

These considerations, as well as others, resulted in a proposal to reintroduce *O. niloticus* to Rwanda. After consideration of the logistics involved in transporting a satisfactory number of fish to Rwanda, it was decided that stocks from Auburn University, USA, would be used for the reintroduction. In 1984, three shipments, totalling approximately 450 fingerlings, were transported to Rwanda to be used as broodstock. The performance of the offspring has been examined in on-station trials, and fingerlings have been distributed for use in the rural sector.

Results

Comparison of species

There has been some question as to the appropriateness of tilapia culture in Rwanda. The body of data and observations, both experimental and anecdotal,

pertinent to pond culture of tilapia in Rwanda is growing rapidly but there are still unanswered questions and certain data are inconclusive.

Survival and growth of *O. niloticus* and *O. macrochir* were compared in a 13-month growth experiment conducted at the Gitarama station of the PPN. *O. niloticus* showed higher productivity (1,001 kg/ha/year vs. 780 kg/ha/year) and higher survival (82% vs. 48%) than *O. macrochir*. Adult fish accounted for a higher percentage of the total harvest weight for *O. niloticus* than for *O. macrochir* (74% vs. 53%).

We have also noted in Rwanda a marked difference between the survival rates of *O. niloticus* and *O. macrochir* fingerlings exposed to the same handling conditions. *O. niloticus* and *O. macrochir* fingerlings have been fished from adjoining ponds on the same day, and whereas mortality of *O. niloticus* fingerlings is generally less than 10%, that of *O. macrochir* fingerlings may approach 50%.

The performance of *T. rendalli* has been compared to that of *O. niloticus* at the Rwasave station, as well as at the Gikongoro station of the PPN. At Rwasave, *T. rendalli* production was 515 kg/ha/year, whereas *O. niloticus* production was 1,553 kg/ha/year. *T. rendalli* production was similar at Gikongoro; 597 kg/ha/year. The size attained by *T. rendalli* is less than that of *O. niloticus*. In growout ponds, *T. rendalli* adults seem to reach a weight plateau of about 100 g.

An additional factor influencing the choice of *O. niloticus* over *T. rendalli* is the apparent sensitivity of *T. rendalli* to *Aeromonas hydrophila*. At the Rwasave station, there have been two serious outbreaks of this bacterial infection in *T. rendalli*, which were evidently stressed by abnormally low temperatures. *O. niloticus* in neighboring ponds were unaffected. Both *T. rendalli* and *O. macrochir* have suffered similar infections and high mortalities (> 50%) at the PPN stations of Kigembe and Gikongoro, although the infection was not conclusively identified.

Reproduction of *O. niloticus*

Reproductive patterns of *O. niloticus* in Rwandan ponds are strikingly different from those observed in other countries. For example, the age at first reproduction is higher under Rwandan conditions. In

grow-out ponds at medium altitudes *O. niloticus* rarely reproduce until they are 6-9 months old. The first spawns are minimal and only after another 2-3 months is there significant spawning. At higher altitudes, in cooler waters, reproduction is further retarded. At Ndurwa, 4-5 month old *O. niloticus* (average weight 69 g) were stocked at 1/m² and after 6 months had not begun to produce fingerlings, even though they had reached an average weight of 231 g.

After starting to reproduce, mature broodstock, when moved to a different pond, require a longer adjustment period before resuming reproduction. In the Congo (Brazzaville), *O. niloticus* fingerlings can be observed 45 days after the stocking of mature broodstock. In Côte d'Ivoire, the first fingerlings can be removed from broodponds 45 days after ponds are stocked with 100 g fish (Holl 1983). In Rwanda, at the Rwasave station and at the PPN station at Runyinya, when broodstock which are already reproducing are moved to different ponds, the first fingerlings are not seined until 90 days after stocking. Fingerling production does not reach its peak for an additional 2-3 months. The adjustment period in Rwanda is 2 or 3 times longer than that noted in other countries.

The number of fingerlings produced per unit area is substantially less in Rwanda than that reported elsewhere. In Côte d'Ivoire, broodstock given a supplemental feed of 23% protein at a daily rate of 6% of the initial body weight produced 210,000 fingerlings/ha/month. At Rwasave, fingerling production averaged 82,500 fingerlings/ha/month in a pond with a good algal bloom receiving supplemental feeding of wheat bran and rice bran at a rate of 5% of the body weight of the broodstock. The station averages 20,000 to 30,000 fingerlings/ha/month. At Runyinya, the average production is within the same range.

The average production per female is comparable in Rwanda to that observed elsewhere. The number of fingerlings per female at Loka, Côte d'Ivoire, averaged 41 (Holl 1983). At Runyinya the range is from 23 to 87 with 5-8 times fewer females per unit area than stocked at Loka.

The seasonal effect on reproduction is evident. Fingerling numbers dwindle following the colder months of the dry season, however, reproductive activity does not stop completely.

Fingerling production in the rural sector is often inadequate to provide for

stocking needs, therefore fingerling production centers have been established (Veverica et al., in prep.). Research is ongoing to determine the most effective system of fingerling production. Stocking densities and sex ratios are being examined, as well as the period between stocking and draining. The delay between stocking of broodstock and their first reproduction precludes a system with frequent drainings, such as is practiced in the Congo. Even draining ponds after 5 months as practiced in Côte d'Ivoire would result in ponds being unproductive half the time.

Another factor being examined is the time interval between seinings. In Côte d'Ivoire, the interval time was 15 days. In Rwanda, several intervals (2 weeks, 1 month and 2 months) have been tried but the results are inconclusive. Nevertheless, it does appear that a 1-month seining interval is preferable to a 2-month interval. In some cases the number of fingerlings recovered after 2 months is equal or slightly superior to the number which would have been recovered after 1 month. In other cases, the number after 2 months is approximately double the number expected after 1 month. Cases in which the 2-month harvest is greatly superior to that which would have been expected with two 1-month seinings are rare. Seining once a month does not appear to have a deleterious effect on spawning females.

Another advantage to monthly seining is the periodic elimination of tadpoles and frogs, mostly *Xenopus* sp., which can cause severe problems when handling fingerlings. The total weight of frogs taken in a seine may exceed that of the fingerlings. In addition to the handling problems caused by the frogs themselves, their foamy secretion increases fingerling mortality due to suffocation.

Conclusion

The definitive answer to the question of the appropriateness of tilapia culture in Rwanda is still forthcoming. Many questions remain relative to the biology of tilapia in this climate and the optimum management techniques for the culture of tilapia in the conditions of Rwanda. But there is little doubt that in certain conditions, with an appropriate management scheme, tilapia culture is suitable to Rwanda.

As cited above, average production in the late 1950s was estimated at 400 kg/ha/year. Average production in the early 1980s similarly was found to be between 300 and 500 kg/ha/year. Both these results are some improvement over the natural productivity which was found to be from 40 to 210 kg/ha. Generally, production in ponds which are poorly constructed, poorly managed and receiving minimum inputs is less than 500 kg/ha/year. However, ponds which are carefully constructed and well managed are much more productive. Generally, ponds at Rwasave and at the PPN stations produce 1,500-2,000 kg/ha/year, with *O. niloticus* showing individual growth rates of 0.5-0.7 g/day. At the Rwasave station, *O. niloticus* grown in ponds receiving inputs of 500 kg/ha/week of chicken manure showed growth rates of 1.3 g/day and productivity exceeding 3,000 kg/ha/year. Although such inputs are not within the procurement possibilities of Rwandan farmers, the results show that such growth and production are possible in the climatic conditions of Rwanda. Thus, the body of data and observations which is accumulating indicates that there is certainly a future for the pond culture of tilapia in this high altitude, equatorial African country.

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References

- Aubray, R. 1976. La pêche au Rwanda. Rapport mimeo. FAO, Rome. 24 p.
- Balarin, J.D. 1979. Tilapia: a guide to their biology and culture in Africa. University of Stirling, Scotland.

- Bard, J., P. de Kimpe and P. Lessent. 1976. Nouveaux poissons et nouvelles méthodes d'élevage en Afrique, p. 365-372. *In* Supplement 1 to the Report of the Symposium on Aquaculture in Africa. Accra, Ghana, 1975. Reviews and experience papers. CIFA Tech. Pap. 4, Suppl. 1. FAO Rome. 791 p.
- George, T.T. 1976. Observations on the growth of *T. nilotica* L. in tropical freshwater fish ponds treated with different fertilizers, p. 625-641. *In* Supplement 1 to the Report of the Symposium on Aquaculture in Africa. Accra, Ghana, 1975. Reviews and experience papers. CIFA Tech. Pap. 4, Suppl. 1. FAO Rome. 791 p.
- Holl, M. 1983. Production d'alevins de *Tilapia nilotica* en station domaniale. Project PNUD/FAO/IVC/77/003. Développement de la pisciculture en eaux continentales en Côte d'Ivoire. Doc. Tech. No. 10. 11 p. (mimeo).
- Maletoungou, Z. 1976. Avenir de la pisciculture commerciale en Afrique Centrale, p. 781-791. *In* Supplement 1 to the Report of the Symposium on Aquaculture in Africa. Accra, Ghana, 1975. Reviews and experience papers. CIFA Tech. Pap. 4, Suppl. 1. FAO, Rome. 791 p.
- Moreau, J. 1983. A review of introductions of tilapia in open inland fisheries of Africa, their influence on ecology and fisheries, p. 77-85. *In* L. Fishelson and Z. Yaron (comps.) Proceedings of the International Symposium on Tilapia in Aquaculture, 8-13 May 1983. Nazareth, Israel. Tel Aviv University, Israel.
- Philippart, J.-Cl. and J.-Cl. Ruwet. 1982. Ecology and distribution of tilapias, p. 15-59. *In* R.S.V. Pullin and R.H. Lowe-McConnell (eds.) The biology and culture of tilapias. ICLARM Conference Proceedings 7. International Center for Living Aquatic Resources Management, Manila, Philippines.
- Pruginio, Y. 1983. Planning aquaculture projects in developing countries, p. 544-549. *In* L. Fishelson and Z. Yaron (comps.) Proceedings of the International Symposium on Tilapia in Aquaculture, 8-13 May 1983. Nazareth, Israel. Tel Aviv University, Israel.
- Pullin, R.S.V. 1983. Choice of tilapia species for aquaculture, p. 64-76. *In* L. Fishelson and Z. Yaron (comps.) Proceedings of the International Symposium on Tilapia in Aquaculture, 8-13 May 1983. Nazareth, Israel. Tel Aviv University, Israel.
- Ruwet, J.-Cl., J. Voss, L. Hanon and J.-Cl. Micha. 1976. Biologie et élevage des tilapias, p. 332-364. *In* Supplement 1 to the Report of the Symposium on Aquaculture in Africa. Accra, Ghana, 1975. Reviews and experience papers. CIFA Tech. Pap. 4, Suppl. 1. FAO, Rome. 791 p.
- Schmidt, U.W. and M.M.J. Vincke. 1981. The technical, economic, financial and social feasibility of small-scale rural fish culture development in Rwanda. *In* USAID Project Paper, Rwanda Fish Culture Project. United States Agency for International Development, Kigali, Rwanda.

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