

CONTRIBUTION OF AQUACULTURE AND AQUATIC RESOURCES MANAGEMENT (AARM) PROGRAM OF THE ASIAN INSTITUTE OF TECHNOLOGY (AIT) TO TILAPIA RESEARCH

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Background

Global increase in consumption of food fish is expected to take place predominantly in the water-rich, developing Asian countries, where population is growing and higher incomes are allowing the purchase of high value fisheries items. Fish production in the least developed countries, where fish protein is especially needed to prevent malnutrition, is a key element of food security in these regions and a critical area where innovative programs are needed to increase production. The aquaculture and Aquatic Resources Management (AARM) Program of the Asian Institute of Technology (AIT) aims to assist in improving food security by promoting aquaculture research, teaching and outreach.

Since the inception of the Aquaculture Program 23 some years ago in 1981, there have been over 150 peer reviewed and professional publications on tilapia alone from AIT. An equal numbers of non-peer reviewed reports and publications have been generated. Considerable tilapia expertise has been 'incubated' and 'spawned' at AARM that includes a numbers of internationally recognized professionals, staff and students (360 MSc and Ph.D theses). More than 1, 200 individual practitioners have gone through the AIT-style training in tilapia hatchery and production since the start of the program. The impact of this large scale training of individuals and a literature generated has, at least in a small part, added to the continued success of aquaculture in the region.

Recent aquaculture development in Asia has mirrored the introduction of tilapia and the growth of the industry. This growth is reflected in the research publications generated at AARM of AIT, although it is difficult to make judgments whether the publications/innovation came first and the industry followed or the other way around. At least publications and personalities reflect the passage of time. Aquaculture in some countries in Asia has gone through a rapid transformation from waste-fed semi-intensive to intensive culture systems. Publications have similarly followed this pattern of evolution. This paper explores the historical accounting of some of the AARM publications related to tilapia research and tries, to some limited extent, to draw parallels on the development of tilapia culture in Southeast Asian countries in particular. This paper however, while recognizing the importance of unpublished work in the generation of new knowledge in tilapia aquaculture, does not specifically address theses and dissertations generated at AIT

with the assumption that important, seminal work finds its way to peer reviewed publications or to review papers.

1981-1985

According to personal accounts (C.K. Lin), about 50 Nile tilapia, *Oreochromis niloticus*, was presented to the Thai king by the emperor of Japan some 40 years ago although only half a dozen survived. The Thai king distributed tilapia seed to the Department of Fisheries which made its way to the ponds of AIT during the late 1970s. The Nile tilapia from Japan seems to have been the base population from which Asian tilapia aquaculture has evolved. It was about this time when Aquaculture as a curriculum and discipline was being recognized and established by academia in the region. There were limited numbers of aquaculture academic programs even in the more advanced western countries. AARM was one of the earliest in the region.

During the early days (1981 to 1994), the main emphasis of research was to use tilapia as a model species for the utilization of sewage and other forms of human waste. Thus, many of the earlier studies examined tilapia in this context. Studies then moved towards the use of animal manure and thus the role of tilapia in small-scale integrated farming system and finally a focus on tilapia as a species to combat rural poverty.

A number of publications appeared during this period (1981-1985). Three of the earliest studies were in a newly established journal, Aquaculture. The papers were co-authored by Peter Edwards. All three papers were associated with the harvest and utilization of microalgae from sewage fed ponds using tilapia. Two years later (1983), another paper was published by Edwards and Polprasert on application of compost for tilapia feed. A similar paper in 1985 was published by the same authors in the Aquaculture and Fisheries Management journal which explored the use of locally available composted and dried water hyacinth in pelleted feed of tilapia. The excitement over this species during this period was due to its low-input requirements for culture, its potential for rural farm consumption and its ability to recycle organic waste.

1986-1989

With a slight variation to the earlier themes, Wee, Kerdchuen and Edwards in 1986 examined the use of tilapia silage as a feed for *Clarias batrachus*. A new set of authors (Diana and Lin) appeared during 1988, who examined the relationships between primary production and tilapia yield through the Collaborative Research Support Program (CRSP funded by USAID). Production optimization studies by improving primary production and husbandry practices then became a theme that continues today at AARM.

About this period there were three parallel studies related to tilapia. While Edwards (1988) continued with the theme of tilapia raised on septage as high protein animal feed, Lin and Tansakul (1988) examined their previous theme of primary production which investigated biological nitrogen fixation as a source of nitrogen input in fish ponds. A separate type of study involving the growth and sexual development of 17 α -methyltestosterone and progesterone-treated Nile tilapia reared in earthen ponds was reported by Macintosh, Singh and Little in 1988.

In 1989, two different types of papers were published by Diana and Lin. The first paper reported on cascading trophic interactions: a test of a hypothesis using tilapia culture data, and the second paper reported on a more specific topic of integrated culture of walking catfish with tilapia in earthen ponds. The diversity of topics during this period reflects new entrants, diversification of interests and the changing focus for tilapia research.

1990-1992

The number of publications were significantly larger (>15) during this than the previous three-year period. While Edwards *et al.* (1990) held on to their earlier theme of direct or indirect reuse of septage for culture of Nile tilapia, Lin (1990) continued to report on the integrated culture of *Clarias* and tilapia. Following this, a set of three papers were published which dealt with issues related to sex control of tilapia (Mair and Little, 1991; Mair *et al.*, 1991b; Mair *et al.*, 1991b). Diana and Lin published two important papers during this year (Diana *et al.*, 1991a; Diana *et al.*, 1991b). The first one, published in the Canadian Journal of Fisheries and Aquatic Sciences established that Nile tilapia has a positive impact on the ecosystem of aquaculture ponds and the second paper in the Aquaculture journal explained that nutrient inputs, water nutrient concentrations and primary production can significantly improve the yield of tilapia in ponds.

A similar paper was published by Hassan and Edwards in 1992 which showed that duckweed has potential as feed for Nile tilapia. The same year (1992), Castanares, Little and Yakupitiyage also showed that feeding fresh perennial leguminous shrub leaves to Nile tilapia has potential as low cost feed. Looking at more intensive culture systems, Suresh and Lin (1992) published two papers, the first one on the effect of stocking density on water quality using a recirculation system and the second paper on the culture of tilapia in saline waters.

1993-1995

While Mara and Edwards *et al.* (1993) developed a feasible design for wastewater-fed fishponds, Little *et al.* (1993) tried to improve spawning synchrony in the Nile tilapia for egg collection purposes. Diana *et al.* (1994) established that supplemental feeding of tilapia in a fertilized pond is better than either no feeding or feeding 100% as part of continued study to understand the system and optimize production. Moving away from a sewage-fed systems, Edwards published papers on the use of animal manure. A series of studies on the use of buffalo manure for pond culture of tilapia were reported (Edwards *et al.*, 1994a; Edwards *et al.*, 1994b; Shevgoor *et al.*, 1994).

Important studies presented during the 1995 were the co-culture of hybrid catfish and tilapia in ponds (Lin and Diana), along with Little *et al.*'s study on the commercial production of tilapia fry. An interesting study on the microbiological and sensory quality of septage-raised Nile tilapia was also in Aquaculture journal (Eves *et al.*, 1995). There have been a relatively limited number of molecular level studies done at AIT. One of the earliest reported studies examined multilocus DNA fingerprinting and RAPD revealed similar genetic relationships between strains of *Oreochromis niloticus* (Naish *et al.*, 1995).

1996-1998

Following the CRSP theme of production optimization, Knud-Hansen and Lin (1996) reviewed various strategies for stocking Nile tilapia in fertilized ponds; Yi, Lin and Diana (1996) examined the stocking density in cages and ponds and the same authors reported on the timing of supplemental feeding for tilapia production. Little *et al.* (1996) showed that tilapia culture in rainfed rice fields of Northeast Thailand has potential and a comparison of tilapia monoculture and carp polyculture in fertilized earthen ponds was reported by Hassan, Edwards and Little (1997) a year later.

Moving away from publications with focus on the pond environment, fish and fish reproduction received greater focus during 1997 and 1998. A series of two papers was published starting with Abucay and Mair's (1997) review of the hormonal sex reversal of tilapias. This was followed by a paper on the genetic manipulation of sex ratios for large-scale production of all-male tilapia. A year later, Tuan, Little and Mair (1998) reported on the genotypic effects on comparative growth of all-male tilapia. Coward *et al.* (1998) also reported inhibition of spawning and associated suppression of sex steroid levels during confinement.

After the development of the GIFT strain there was a great deal of uncertainty about how this new strain would perform in different environments. A study was published by Yakupitiyage and Edwards (1998) indicating that there was no marked difference in nutritional energetics between the Chitralada and an early GIFT strain. During this period, the same number of important papers was published by Yi, Lin and Diana. Yi (1998) developed a bioenergetics growth model for tilapia based on limiting nutrients and fish standing crop in fertilized ponds. Diana and Lin (1998) showed that fertilization and management of deep pond water during the dry season can improve production of tilapia.

1999-2001

Two types of publications have been generated during this period. One type of research explored ways to utilize the pond environment in such a way as to optimize utilization of nutrients and a second type attempted to improve the production of seed for stocking. Shrestha and Bhujel (1999) indicated the possibility of tilapia and common carp polyculture fed with duckweed. Yi (1999), further developed his growth prediction model of Nile tilapia in a cage in pond integrated system. Tuan *et al.* (1999) on the other hand, examined sex determination and reported that it is possible to produce genetically male tilapia in the Thai-Chitralada strain.

Two important publications in the year 2000 were the result of a doctoral dissertation (Dan and Little, 2000ab). While the first one reported on the performance of monosex and mixed-sex, new season and overwintered fry in three strains of Nile tilapia, the second paper reported on the possibility of overwintering broodfish and seed at ambient temperature in North Vietnam. Along the same line of study, Little *et al.* (2000) also reported on the effect of a broodfish exchange strategy on spawning performance. Bhujel (2000) reviewed strategies on management of broodfish in a hapa-based seed production system. MacNiven and Little (2001) developed a stress challenge testing method for assessment of Nile tilapia fry quality.

Mair *et al.* (2001) discussed the use of genetic technology to address poverty using a case study of GMT in the Philippines. To further earlier studies on broodfish nutrition, Bhujel *et al.* (2001) evaluated commercial feed for Nile tilapia breeding in a hapa-in-pond system.

Some of the pond studies started to move towards environmental studies during this period. For example, Lin and Shrestha (2001) tried to determine the best management strategy to minimize the environmental impact of pond effluent. Yi and Lin (2001) also published on the effects of biomass and aeration of tilapia in cages on growth and yield.

2002-2003

There were a limited number of refereed publications during 2002 which was offset by a large number (14) of non-refereed publications. The most notable publication by Yi and Lin (2002) explored the recycling of pond mud trapped nutrients in integrated lotus-fish culture. In another interesting publication, Saelee *et al.* (2002) reported on the optimization of stocking densities of Nile tilapia in tilapia shrimp polyculture in low salinity conditions.

While 2002 had a low volume of research publications, the year 2003 was particularly fruitful with over 13 publications in peer reviewed journals. There was also greater diversity of publications during this year compared with the years before. Bart *et al.*, Hossain *et al.* and Little *et al.* reported on tilapia seed related topics. Patel and Yakupitiyage, Li and Yakupitiyage reported on feeding and nutrition. Yi, Lin and Diana reported on pond nutrient and effluent related topics.

Bart *et al.* (2003) explored the potential use of ultrasound to enhance the sex reversal of Nile tilapia with an androgen immersion protocol. They reported that high a level of consistently all-male populations could be achieved through the application of this method. In another report Hossain *et al.* (2003) nursed monosex tilapia fry and carps at various durations with varying results in order to reduce the time to market. Little *et al.* (2003) also examined mixed-sex and mono-sex tilapia fry nursing to advance stage and monitored growth in fertilized ponds.

In another series of studies relating to nutrition, Patel and Yakupitiyage (2003) used mixed feeding schedules in semi-intensive pond culture of Nile tilapia. They questioned the validity of two diets of different protein contents for tilapia in mixed feeding schedule. Another study developed a model for food nutrient dynamics of semi-intensive tilapia pond culture.

Yi and Lin (2003) published three papers. The first reported on the success of using various techniques to mitigate clay turbidity problems in fertilized earthen ponds to minimize environmental impact. In similar paper, they explored the reuse of pond effluents and mud. In a rather different study, Yi et al (2003) cultured hybrid catfish with tilapia in an integrated pen-cum-pond system where the nutrients fed to catfish provide nutrients necessary to sustain tilapia outside the pen. They provided growth and nutrient budgets.

Conclusion

This paper briefly outlined the various important peer reviewed publications on tilapia research generated by AIT's AARM faculty, staff and students over the course of 23 years. Clearly, tilapia research focus and direction have evolved from examination of this species as a model for researching waste recycling to a species of important commercial value. Studies have also diversified over time from examination of the culture system to examination of strains, feed and feeding, and reproduction. This evolution has been driven partly by regional research needs. While earlier research needs were on the identification of low-input aquaculture species, later studies were on polyculture with carps, catfish and shrimp and all the way from semi to intensive culture systems where fertilized, fed ponds and recirculating tanks were used. This large amount of literature and the people of AARM involved in research and dissemination have contributed significantly to the adoption and culture of tilapia and have, at least in a small part, contributed to the development of aquaculture in the Asia region.

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