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Advances in tilapia broodstock management

1 October 2000

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Intensive management practices can significantly improve seed productivity



Red tilapia broodstock.

Producing tilapia seed is relatively easy, as all tilapia species mature early (in four to six months) and reproduce year-round under suitable environmental conditions. They produce large eggs and exhibit a high level of parental care that ensures high larval survival. However, tilapia females spawn asynchronously, producing only about 2,000 eggs per clutch. Tilapia hatchery operators, therefore, often run into low seed quantity and quality problems. Advances made by tilapia researchers are now addressing these problems.

Much of the following discussion is drawn from research conducted at the Asian Institute of Technology, which also provides consultation and training in tilapia hatchery management.

Traditional seed production

The simplest tilapia seed production system is the one in which fingerlings from natural reproduction, obtained as byproducts of tilapia grow-out systems, are sold or used as seedstock. A more intensive, widely practiced form of traditional seed production is the use of separate breeding ponds. Broodstock are maintained in these 0.01- to 0.1-ha ponds, where fry and fingerlings are periodically netted out.

The latter system is far more productive than the former. However, there are a number of problems associated with these systems.

Inadequate recruitment control

Uncontrolled reproduction results in overpopulation, which slows down growth and inhibits reproduction. In pond breeding systems, fry output normally increases rapidly after broodfish are stocked. It decreases gradually because it is impossible to harvest all the fry released. Ponds are quickly overpopulated with recruits from early spawns, resulting in increased competition for food and space, and gradual deterioration in water quality.

Asynchronous spawning, cannibalism, and predation

As spawning is not synchronous but continuous, high variation in size among fry is obvious. This occurs even among the same age fry because of inadequate food availability.

Cannibalism occurs among fry of various sizes, and predation by parent stock, other fish, birds, and other animals present in the system is common. The most serious predation problem occurs in the presence of carnivorous fish (e.g., snake head, catfish, sea bass, etc.), which may completely eliminate fry in breeding ponds.



Tilapia produce large, 2- to 3-mm eggs, which hatch into fry capable of immediately consuming dry feeds.

Cost of parental care

The time and energy spent in parental care is another cause of lowered productivity in seed production systems. *Oreochromis* females typically spend about a week mouth brooding, while feeding little or none. As a result, they need about two weeks of reconditioning before spawning again. Any reduction in the mouth brooding and/or reconditioning period increases broodstock productivity.

Demand for all-male seedstock

As tilapia grow-out systems intensify, demand for all-male fry or fingerlings increases. Commercial grow-out farmers prefer all-male seed stock in order to avoid unwanted reproduction in the system. More importantly, they can take advantage of the faster growth of males as compared to females. All-male stocks, therefore, give rise to larger fish of uniform size that fetch higher market prices.

Tilapia sex is determined in the first few weeks after hatching, during which it can be influenced by administering androgens like methyltestosterone. The most reliable means of androgen administration is via feed. Feed mixed with the hormone must be fed as early as possible after the fish hatch, and it should be the main nutrient source for fry in order to deliver the androgens at the dosage necessary for sex reversal.

This requires fry to be separated from their mothers as early as possible and incubated separately. There are other methods of producing allmale seed stock, e.g., genetic manipulation, hybridization, and hand sexing. However, these methods are somewhat less reliable for commercial-scale production.

Improving productivity through broodstock management

Ongoing international research on tilapia broodstock management has yielded a variety of productivity-enhancing techniques. As referenced in Table 1, even low-tech approaches have proven effective.

Table 1. Summary of tilapia seed production data published from 1991-1999.

Species/Strain	System Type	Location	Management	Stocking Density (#/m ²)	Sex Ratio (F:M)	Female Weight (g)	Male Weight (g)	Duration (days)	Seed Type	Seed Productivity Per m ² /d	Per F/d	Per kg F/d	Reference
Florida red tilapia	Tank	Bahamas	Clutch removal every 15-23 days	8.2	4:1	244	423	232	Eggs & fry	78	12	50	Ernst et al. 1991
Florida red tilapia	Tank	Bahamas	Clutch removal every 15-16 days	5.9	3:1	172	172	140	Eggs & fry	52	12	49	Smith et al. 1991
Florida red tilapia	Tank	Bahamas	Clutch removal every 15-16 days	7.1	3:1	429	429	140	Eggs & fry	36	7	14	Smith et al. 1991
Florida red tilapia	Tank	Bahamas	Collection of free-swimming fry every 8-16 days	7.0	3:1	143	143	89	Fry	3	1	4	Watanabe et al. 1992
Florida red tilapia	Tank	Bahamas	Clutch removal every 15-16 days	7.0	3:1	143	143	84	Eggs & fry	92	17	101	Watanabe et al. 1992
<i>O. aureus</i>	Hapa	USA	Clutch removal every 7-13 days	3.7	1:1	225	415	50	Eggs & fry	82	45	202	Behrends et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Collection of free-swimming fry 5-6 times/day	8.0	1:1	70-300	70-300	155	Fry	-	-	31	Little et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Clutch removal every 10 days	8.0	1:1	70-300	70-300	155	Eggs & fry	-	-	106	Little et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Clutch removal every 5 days	8.0	1:1	70-300	70-300	155	Eggs & fry	-	-	279	Little et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Clutch removal and exchange of spawned females by reconditioned females every 10 days	8.0	1:1	70-300	70-300	155	Eggs & fry	-	-	123	Little et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Clutch removal and exchange of all females by reconditioned females every 10 days	8.0	1:1	70-300	70-300	155	Eggs & fry	-	-	226	Little et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Clutch removal and exchange of spawned females by reconditioned females every 5 days	8.0	1:1	70-300	70-300	155	Eggs & fry	-	-	232	Little et al. 1993
<i>O. niloticus</i>	Tank	Thailand	Clutch removal and exchange of all females by reconditioned females every 5 days	8.0	1:1	70-300	70-300	155	Eggs & fry	-	-	322	Little et al. 1993
<i>O. niloticus</i>	Hapa	Philippines	Collection of free-swimming fry every 4 days	2.0	1:1	86	50-200	90	Fry	6	6	73	Mair et al. 1993
<i>O. niloticus</i>	Hapa	Philippines	Clutch removal every 4 days	2.0	1:1	86	50-200	90	Eggs & fry	20	20	233	Mair et al. 1993
Hybrid red tilapia	Double-hapa	Indonesia	Broodstock rotation every 14-16 days	1.5	3:1	250	250	165	Fingerlings	9	6	150	Costa-Pierce & Hadikusumah, 1995
Hybrid red tilapia	Double-hapa	Indonesia	Broodstock rotation every 21 days	1.5	3:1	250	250	165	Fingerlings	3	2	50	Costa-Pierce & Hadikusumah, 1995
Hybrid red tilapia	Double-hapa	Indonesia	Broodstock rotation every 30-32 days	1.5	3:1	250	250	165	Fingerlings	2	2	40	Costa-Pierce & Hadikusumah, 1995
Hybrid red tilapia	Double-hapa	Indonesia	Broodstock rotation every 10-16 days	1.5	3:1	250	250	395	Fingerlings	22	15	350	Costa-Pierce & Hadikusumah, 1995
Hybrid red tilapia	Double-hapa	Indonesia	Broodstock rotation every 20-25 days	1.5	3:1	250	250	395	Fingerlings	4	3	60	Costa-Pierce & Hadikusumah, 1995
Hybrid red tilapia	Double-hapa	Indonesia	Broodstock rotation every 30-36 days	1.5	3:1	250	250	395	Fingerlings	2	2	40	Costa-Pierce & Hadikusumah, 1995
<i>O. aureus</i>	Earthen pond	Israel	Seining and rotating broodstock every 2-3 weeks	0.2	4:1	150-250	150-250	150	Fingerlings	0.006	13	67	Hulala 1997

Broodstock size/age

Larger tilapia females produce more and bigger eggs per batch. Smaller females spawn more frequently and generate more eggs per unit weight, resulting in more eggs of smaller size.

Various authors have reported that breeding ponds stocked with smaller tilapia produce more fry than ponds stocked with larger tilapia. In Thailand, large commercial hatcheries use broodstock starting at 6 months of age (about 80 grams weight) and replace them with new batches after two or three years. In Israel, some farmers consider second-year, 150- to 250-gram females the most productive animals, and replace them every year.

As male tilapias are aggressive and territorial in habit, larger, dominant males control most of the spawning activities. This results in many unspawned females, or spawned fish with unfertilized eggs. Thus, uniformity in broodfish size is very important. Hatchery operators should consider both age and size as criteria for selecting broodstock, to avoid inheritance of slow growth trait.

Sex ratio and stocking density

A sex ratio of 3:1 (female:male) is commonly used by tilapia hatchery operators. However, lower ratios typically result in higher seed production, probably due to the availability of more mature males per female.

Most commercial hatcheries in Thailand that have adopted the use of hapas – net cages – in ponds maintain a 1:1 sex ratio to ensure high spawning and fertilization rates. They stock 6 fish per square meter of hapa suspended in inorganically fertilized ponds and provide supplementary feeding. The density can be doubled in tanks when complete feeds are provided.

Clutch removal

A balanced diet with 28 percent to 32 percent protein is recommended for tilapia broodstock.

Mouth brooding is one of the main causes of reduced seed productivity. Females typically spend 10 to 15 days incubating eggs and caring for fry. They barely eat during this period, so they require another five to 10 days to recondition their ovaries.

Removal of eggs or newly hatched fry from the mouths of female *Oreochromis* helps them to quickly regain lost energy and become available for the next spawning cycle. Collection of eggs and yolk-sac fry from a large number of females at regular intervals – followed by artificial incubation and larval

rearing – allows grouping of fry by age, resulting in more uniformity in fry size. This enhances the effectiveness of hormonal sex-reversal and reduces cannibalism.

However, the clutch-removal method is labor-intensive and requires periodic handling of broodfish. Broodfish are, therefore, kept in hapas, which can be of any size and are easily set up in ponds, lakes, or reservoirs. For example, a 40-square-meter hapa can be used to hold broodfish and produce 3,000 to 5,000 fry per day when the clutch-removal method is used.

Hapa-based broodstock management improves productivity, but is labor-intensive.

A unique hapa-based broodfish management system commercialized in Thailand uses large (120 square meters) nylon hapas, each of which can hold 720 broodfish. About 80,000 eggs or yolksac fry are collected every five to seven days from each hapa. One of these hatcheries using AIT technology manages up to 60,000 working broodfish and sells up to 10 million fry per month.

Double-net hapas

Clutch removal is labor- and timeintensive, and requires facilities and techniques for the artificial incubation of eggs and larval rearing. A larvalrearing system has been developed in southeast Asia that uses double-net cages. The larger cage, constructed of fine, 2- to 3-mm-mesh net, contains a slightly smaller cage constructed of 4- mm-mesh net. Broodstock are placed in the inner cage and allowed to spawn. Periodically, the inner cage is lifted and moved out. When this happens, the fry swim through the larger mesh of the inner cage, but are retained within the fine-meshed outer cage. The fry continue feeding and growing in the outer cage, while the broodstock in the inner cage are placed in an empty outer cage.

By alternatively rotating the cages for breeding and nursing, a skillful hatchery operator can expect productivity levels higher than those of traditional fry production systems. A typical double-net system in the Philippines produced 29 fingerlings per female per day. Frequent broodstock rotations – every 14 to 16 days – can yield greater fry productivity than less-frequent rotations made up to 20 days apart.

Broodstock reconditioning

Tilapias spawn year-round under suitable environmental conditions, but a significant decrease in productivity occurs after three to four months of continuous spawning. At this time, males and females should be removed from the breeding system and stocked separately for a period of reconditioning. This improves seed productivity and also synchronizes spawning, even when clutch removal is practiced.

A more aggressive approach to broodstock conditioning has been developed at AIT, in which two or three female groups are rotated at 5- to 10- day intervals. Each female group is rested without males at a high density (18 to 20 fish per square meter) in a separate conditioning hapa, and fed high-quality feed after a spawning opportunity of five to seven days. This method improves seed productivity as well as spawning synchrony.

Broodstock nutrition and feeding

Feeds with greater than 40 percent protein content were previously thought to be necessary for tilapia broodstock. However, various authors have reported that these protein levels do not confer any specific advantage.

In a recent study, tilapia fed 32 percent and 40 percent crude protein levels grew and matured faster than those that were fed less than 25 percent crude protein. In another study, broodstock fed with 35 percent protein feeds reconditioned their ovaries faster than those fed less than 20 percent protein. In general, feeds with 28 percent to 32 percent crude protein appear to

High density and restricted feeding can be used to hold tilapia without spawning.

provide satisfactory broodstock performance.

Broodfish are typically fed at 1 percent to 3 percent biomass per day, divided into two or three equal meals. Large commercial tilapia hatcheries in Thailand that use hapas in fertilized ponds feed floating pellets with 25 percent to 27 percent protein, twice a day at 0.6 percent to 1.5 percent biomass per day.

Management of environmental factors

Optimum temperature for tilapia breeding is 28 to 30 degrees-C. A 50 percent reduction in seed output and some broodfish death occur in Thailand when summer temperatures in ponds exceed 35 degrees-C. Shading the culture system, sprinkling with cool water pumped from deeper parts of the ponds, and lifting or churning the cool water from pond bottoms using aerators are helpful measures.

In cold regions, tilapias are bred either inside greenhouses or in systems that use effluent water from thermal power plants to maintain optimum temperature. Low dissolved oxygen (less than 0.5 ppm) has negative impacts on quantity and quality of tilapia seed.

Excessive phytoplankton growth is undesirable in the breeding system. Inorganic fertilizer applications of 4 kg N per hectare per day and 2 kg P per hectare per day have been recommended in Thailand, instead of manure or other organic fertilizers.

Other management practices

Broodfish can be stunted up to 12 months at high density with restricted feeding before they are used for breeding. Stunted broodfish produce more seed when they are returned to normal feeding. This technique may also be used to manipulate seed supply, based on market demand for seed.

Various hormones have been tried to induce spawning in tilapia with some success. However, the use of hormone seems to be prohibitively expensive, as large numbers of broodfish are required to produce fry on a commercial scale.

Attempts were made to reduce aggressive behavior and social dominance of males by removing maxillary bones, but it did not help improve seed productivity. Provision of artificial nests (bricks, stones, etc.) in the breeding system helps to reduce social dominance, thereby improving seed productivity and quality.

Conclusions

Several significant advances have occurred in tilapia broodstock management in the past 10 years. Intensive management practices can significantly improve seed productivity. Even relatively simple practices, such as periodic replacement of broodstock, provide significant productivity gains.

(Editor's Note: This article was originally published in the October 2000 print edition of the Global Aquaculture Advocate.)

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