Genetic Considerations on Acquisition and Maintenance of Reference Populations of Tilapia[1]

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Acquisition and maintenance of reference populations of tilapia would be an important development in aquaculture, because they could be used to supply aquaculturists with broodfish of good genetic quality. A number of reference populations should be established, because there are several important species of tilapia, and because there are populations or subspecies within each species. Each reference population should be managed so that it will not be contaminated with genetic material from another population.

The most important genetic goal in the acquisition and maintenance of a standard reference population is conservation of the gene pool to prevent genetic drift and to prevent detrimental levels of inbreeding, so that gene and genotypic frequencies will not change significantly over time. This may be accomplished by managing the population's effective breeding number (N_e), which is a function of the number of males and females that produce viable offspring, the sex ratio of the fish that produce offspring, the system of mating and the variance of family size. Most tilapia culturists use random mating, and when this is used, N_e is:

$$N_e = \frac{4\,(♀)\,(♂)}{(♀) + (♂)}$$

where ♀ and ♂ are the number of females and males that produce viable offspring.

Knowledge of a population's N_e is crucial, because it is inversely related to inbreeding and to genetic drift. Restrictions in N_e can create irreversible damage to a population's genetic and biological potential.

Conserving a stock's biological potential involves managing its N_e so that it does not go below a pre-determined number. Minimum desired N_e is determined by the maximum desirable level of inbreeding, frequency of the rarest alleles to be saved and the probability of saving the alleles that is desired, and number of generations involved (broodstock replacement interval). If N_e is allowed to decline below the minimum desired number for even a single generation, a genetic bottleneck can occur, which can permanently damage the genetic quality of a population.

To properly manage a standard reference population's gene pool, the following genetic goals should be incorporated: inbreeding should not exceed 5%; alleles whose frequency = 0.01 should be saved and the probability of saving the alleles should be 99% (P = 0.01). Finally, long-term planning must be incorporated into the management program, and 25 to 50 generations (usually 25-50 years) is appropriate. To achieve these goals, N_e should be 390-500 per generation.

Founder stocks gathered from the wild should have broad genetic bases and minimal inbreeding. Most hatchery stocks have some inbreeding and have reduced heterozygosity. Wild populations should be studied prior to acquisition to determine sample areas and to provide base-line data on genetic variance and gene frequencies, which will be used as standards during acquisition and management of the population. Depending on goals, the reference population can be created from a single wild population or from several wild populations.

Care should be taken to ensure that the gene pool is adequately sampled. The N_e for the foundation generation will be determined when they reproduce, so sample sizes should be adequate to compensate for mortality and lack of spawning success.

In order to manage a reference population's N_e, reproduction must be stringently controlled. Traditionally, tilapia are spawned in ponds, and fish are allowed to choose their own mates. Knowledge of and management of N_e is impossible with this type of reproduction.

Fish should be paired in spawning nets or tanks. A 1:1 sex ratio maximizes N_e in a closed population. Pairing must be random; intentional or unintentional selection of broodfish must be prevented. This mating scheme will allow calculation of N_e. To maximize genetic variance, a fish should not be allowed to spawn more than once, unless all of its offspring die.

Each family should be raised in an individual net or tank for 20-30 days. Fry can then be transferred to ponds or tanks. Before stocking, family size should be equalized, because unequal family size lowers N_e.

When the fish become sexually mature, a random sample should be taken to be used as replacement for the previous generation. The sample should be larger than the desired N_e, because some fish will die, some will not spawn, and some fish must be killed for electrophoretic analysis to determine the effects of genetic drift. If this reveals that there were drastic changes in gene frequencies and that more alleles were lost than expected (based on N_e), the fish should be discarded and the parents should be mated again.

Requests to establish replicate reference populations must be received well in advance, so that production of the new generation for the reference population and production of fish for other hatcheries will be coordinated. Each request should be filled by spawning 195-250 pairs in nets or tanks, which is an N_e of 390-500. Total number of requests should be known before the spawning season to determine how many matings will be needed to fill the requests. Each request should be filled by shipping an equal number (minimum of 4) from each spawn. By including at least 4 fish per spawn, sample size will be at least 780-1,000 fish, which should be adequate to compensate for mortality and lack of spawning success.

1 For a more detailed treatment of this topic, see: Tave, D. 1986. Genetics for fish hatchery managers. AVI Publishing Co., Westport, Connecticut; and Smitherman, R.O. and D. Tave. 1987. Maintenance of genetic quality in cultured tilapia. Asian Fisheries Science 1(1): 75-82.