IV: FISH STOCK QUALITY AND QUANTITY

INTRODUCTION

Quality of fish stock is the third most important factor, after nutrition and environmental quality, to successful pond fish culture. Stock quality primarily refers to a fish's genetic potential for culture including its species and strain characteristics. Genetic quality factors are among several criteria for choosing a species, strain or a specific group of fish for farming. Stock quality also refers to general health, relative size and other physical and physiological characteristics of a given group of fish being stocked. Poor stock will give poor production performance regardless of other factors.

The principal identifying characteristic of 80:20 fish culture is species composition. Otherwise the technology system is similar to other modern feed-based technologies. Therefore, the objective of this section is to identify and discuss fish stock quality, stock density and stocking conditions as they relate to general feed-based fish farm production and specifically 80:20 production.

CRITERIA FOR SELECTING FISH STOCK

There are more than 20,000 known species of fishes in the world. Perhaps 200 of these have been successfully cultured for food, but only 20 to 25 species are cultured in significant commercial quantities. Although unknown hundreds or thousands of species have high potential for culture, they simply have not been screened for that purpose. Potential for culture fundamentally depends on quality of the fish measured by many criteria. Among the few "domesticated" species that are routinely cultured for food, only common carp and rainbow trout have been genetically selected into distinct, verifiable culture strains. Considerable research is underway to improve genetic potential of culture species. Genetic improvements and domestication are becoming increasingly possible with new technologies in breeding and genetic alterations such as gene transfer.

Suitability of a fish species for aquaculture is dependent on many criteria related to marketability, availability, culturability and stressability. Principal criteria are discussed in the following paragraphs in no specific order of importance.

Marketability

<u>Consumer acceptance</u> is the first consideration in selecting fish to be cultured, because the last step in a successful culture is to sell the fish at a profit. Obviously an adequate market must exist if fish are to be produced at a profit. Important characteristics of the species or strain directly influencing consumer preference include its body color, flesh color and texture, amount and type of bones, size, freshness and flavor.

Availability

<u>Reproduce in captivity</u>: Many major aquacultures have been developed using captured wild fry. Wild fry continue to be of major importance in many aquacultures, but only a few species are

still wild stock dependent. Almost all major culture species spawn readily in aquacultural facilities or can be induced to reproduce. Captive, aquacultural reproduction capability is an essential criterion for an aquaculture species for the following reasons:

1. Naturally produced fry are not generally available in consistent, sufficient quantities to support a significantly large culture on a consistent, reliable basis.

2. Captured wild fry are generally more expensive than aquaculturally produced fry, and they are usually available only on a seasonal basis.

3. Culture of a species, for physical and economical reasons, must normally be in the general area of where the wild fry are produced.

4. Domestication and controlled genetic improvement of the species is not possible without aquacultural reproduction.

5. Transmission of disease, parasitic and "pest" organisms can be more effectively controlled with aquacultural reproduction.

6. Wild populations can be seriously depleted by over harvest of fry.

Age/size at sexual maturity: Ideally a culture species will attain sexual maturity after reaching minimum marketable size. Some fish species, such as some tilapias, are sexually mature and spawning at 3 or 4 months of age and 50 g weight. Others, such as some of the carps, do not reach sexual maturity until 3 or 4 years of age and 3 or 4 kg in weight. Although early maturity at a small size has many advantages, it may be disadvantageous in some situations. For example, some species, such as nile tilapia, attain sexual maturity and begin reproducing in ponds several weeks before they reach marketable size. This may result in overpopulation and ultimately cause complete crop failure of a pond population unless preventive management practices are employed, as with 80:20 technology. To the other extreme, the longer the maturing period and the larger the size at maturity, the greater the cost of feed, space, labor and other management items to maintain the fish to maturity. Also, the longer the fish are held the greater the risks of loss to natural calamities, accidents, disease and other causes of mortality not uncommon in aquaculture. Because of these factors and lack of serious breeding programs, genetic qualities of cultured fishes have universally been negatively affected or unimproved by hatchery management procedures of both early and late maturing species. Ideally a species would not sexually mature during growout culture, because growth and feed efficiency are reduced by sexual development and by competition from the offspring.

Domesticated strain: Different strains of a given cultured species may perform differently under equal culture conditions. A "domesticated" strain that has been in continuous culture for several generations will generally produce higher yields with less management problems than a wild strain of the same species. Domesticated stains are also easier to manipulate with regards to reproduction procedures and harvest. Common carp is represented by numerous identifiable strains developed over centuries of selective breeding. Crucian carp is essentially a wild species with no definite strains. While most cultured species have strains in various degrees of domestication, they are not usually identifiable as such.

Availability of stock: Seasonality of stock may influence choice of an aquacultural production system, but a production system may also influence stock availability. Potential for year round marketing and restocking regardless of the growing season period is a distinct advantage. Nile tilapia may reproduce year round in the tropics, but it is not a potential fish for year round marketing and restocking in temperate climates where water temperatures seasonally drop below about 15°C. Channel catfish reproduce only once per year, but it has high potential for year round marketing and restocking in temperate regions.

Culturability

Growth rate/size: A cultured fish must grow to a minimum acceptable marketable size in a reasonable growing period or season. Different fish species with equal minimum marketable sizes may grow at differential rates varying by more than 100%. Other factors excluded, absolute growth rate is generally directly proportional to the maximum potential size attainable. Fish large at maturity generally grow more rapidly than fish small at maturity. Warm water species generally grow at a faster rate than cold water species of comparable maximum potential sizes.

Trophic level: It is conditionally true that terrestrial environments have a two dimensional food producing zone confined to the soil surface, while aquatic environments have a three dimensional food producing zone that includes the bottom surface, top surface and entire water column in between. Consequently, aquatic ecosystems contain more food sources (niches) and food source levels (trophic levels) than terrestrial ecosystems. The quality and magnitude of each specific niche and the trophic level each cultured fish species occupies is the basis of all non feed-based and some feed-based aquacultures. The Chinese fish polycultures in ponds are an excellent example of practical application of these principles. A polyculture may contain filtering species (silver and bighead carps), foliage-feeding herbivores (grass and wuchang carps), facultative omnivores (common and crucian carps), molluscivore (black carp), insectivore (tilapia) and piscivore (bass). However, an essential criterion for a primary species for 80:20 culture is that it readily take and perform well on pelleted feed. Some fishes, such as nile tilapia, will utilize plankton as well as take pelleted feed. All omnivorous species will readily take pelleted feed while most specialized feeding fishes will not. For example, the highly specialized planktivore filtering silver carp and highly carnivorous grouper do not take pelleted feed while the non-specialized omnivorous common carp will take manufactured feeds at all stages of its life cycle. In 80:20 production systems, the secondary, service species are specifically selected because they efficiently feed on a specific food source (e.g. plankton or small fish) and do not take pelleted feed.

Feedability of the species or life stage: A primary species for 80:20 culture must readily accept manufactured feed during post-fry stages of its life cycle. All commonly cultured omnivorous fishes and most herbivorous and carnivorous fishes will take feed beginning as advanced fry. Criteria for service species are that they do not take pelleted feed, and that they have a specific feeding habit, such as filtering plankton or preying on wild fish, that provides a positive service to primary fish production.

Stressability

Poor water quality tolerance: Tolerance to normal but relatively extreme changes in water quality and often persistent adverse quality conditions is an important criterion on which to select fishes for culture. Diurnal changes in pH levels, dissolved oxygen and free carbon dioxide concentrations and other water quality parameters are normal in culture environments often to the point of causing fish stress, disease and death. Fish production performance, measured by growth rate, feed efficiency, incidence of disease, mortality rate, and fish yield, is adversely affected by decreases in water quality. Therefore, the greater the fish's tolerance for poor water quality, the less its production performance will be adversely affected.

Handling tolerance: Aquacultural fish must be relatively tolerant to essential handling practices such as transporting, seining, holding in tanks, and sorting. The greater the tolerance the greater the survival during handling and the less the incidence of disease and mortality after handling. For example, bacterial disease will usually be evident and cause some death in channel catfish but may not in nile tilapia where both are subjected to equal handling activity.

Temperature tolerance: Temperature is a major controlling factor in aquaculture imposed by nature and endured with few alternatives to the farmer. One of the few ways the farmer can cope with the temperature situation is to choose fish species that fit the temperature limits in the culture area. Salmonids (salmon and trout), cichlids (tilapia) and cyprinids (carps) are excellent examples for comparison. Salmonids are temperate fish that cannot be cultured in warm tropical waters. Cichlids are tropical fish that cannot be cultured in cold temperate waters. Cyprinids, on the other hand, may be raised with salmonids in cold temperate waters, or with cichlids in warm tropical water, or raised in waters between the temperate-tropical extremes. Certain individual species have a greater tolerance for cold or warm water than other species of their respective genus or group. Blue tilapia can tolerate lower temperatures than nile tilapia, and rainbow trout can tolerate warmer temperatures than brook trout.

Salinity tolerance: Salinity is a factor to be considered by culturists in coastal regions and some arid inland areas where there is enough salt in the soil or water to measure above 3 to 5 ppt. Each species has its specific tolerance. Most freshwater fish can tolerate up to 10 ppt but will not grow in salinities above 5 to 7 ppt or reproduce in salinities above 3 ppt. Many marine fish cannot live in salinities outside the range from about 15 ppt to 45 ppt. However, some marine fishes (e.g. milkfish) and some freshwater fishes (e.g. mossambique tilapia) can live in salinities from freshwater to 395 ppt (open ocean water is about 35 ppt). A fish's tolerance to sudden changes and extremes in salinity concentrations must be a consideration.

General environmental tolerance: Cultured fishes are subjected to numerous stressors in addition to handling, temperature extremes and poor water quality variables. Caged fish, for example, may be stressed by their inability to escape confinement, light, sound, movement of people or animals above the cage and other factors that may or may not be obvious to the culturist. Therefore, a general tolerance to all types of environmental stressors is a desired characteristic.

Adaptability to aquacultural environments: Related to stress tolerance is the ability of a fish species, strain or life stage to adapt to the aquacultural environment to which it is subjected. To adapt means to adjust to the environment to the extent that production performance is normal or unaffected. Larger fish of a species are less adaptable to procedural stressors (e.g. handling and confinement) than smaller fish. Also, some species (e.g. nile tilapia) adapt to procedural stressors faster and apparently more completely than others (e.g. silver carp).

Disease resistance: Diseases, especially from protozoan ectoparasites and bacteria, are problems in aquaculture. Diseases affect fish culture in ponds in such adverse ways as decreasing growth, survival, feed efficiency, yield, reproduction and profit. Some fishes, such as milkfish, have high resistance to pathogenic diseases. Others, such as brown bullhead, are so susceptible to disease that they are impractical to culture. Aquacultural management practices are necessarily more demanding in terms of major inputs and costs for fish with low disease resistance than for ones with high resistance.

A perfect aquacultural fish species that ideally meets all of the above criteria does not exist. However, channel catfish, common carp and nile tilapia are model species to which others may be compared, because they meet practically all the criteria for choosing species for culture in ponds, and more scientific data and farm history are available than for any other species. However, all presently cultured feed-taking species, and probably most other omnivorous fishes that have acceptable market demand may be successfully cultured with 80:20 technology. In southern Brazil, indigenous fish species are being screened and developed for culture. Although these species are tropical, undomesticated and some are carnivorous, they show promise as new culture species with marketability and culturability characteristics superior to currently farmed species. Some of these species will undoubtedly become major farmed species within a decade.

FISH STOCK QUALITY

The production performance of fish in ponds or any culture environment will be directly related to the quality of fish stocked. Selection is critically important to culture success, and should be done with concern for quality relative to genetic history, general health and individual size.

Genetic history should be assessed relative to the potential production performance of a specific fish species, strain or group. The aquacultural ecosystem concept of "fitting the fish to the environment" is demonstrated in this process. The concept is to stock the most appropriate strain, which has been genetically improved through selection for a specific environment. Both the fish and the environment have been purposely modified to best match the other. In practice, the farmer cannot genetically modify his fish stock but should try to obtain stock already modified. This is accomplished by interviewing the fish supplier and other farmers to determine how well a specific strain or group has performed under culture conditions.

Fish for stocking should be in good general health and "disease free." Inspection by a certified fish disease specialist is recommended. In lieu of inspection, some key indicators of good health are uniformity of skin color among the group, absence of sores, blotches, spots, frayed fins and deformities, and all the fish vigorously avoid being captured.

Individual size of fed fish is important relative to group uniformity, size of any predaceous service species, and desired size at harvest. Fish for stocking should be of relatively uniform size, too large to be consumed by any stocked predator during culture, and large enough to attain desired size during the culture period. Smaller fish (15 to 50 g) are generally less stressed by stocking procedures than larger fish. Effects of transporting, handling and stocking procedural stressors on fish during the first 5-10 days after stocking generally increase with increasing size of the fish. Fish stocked at a uniform size will tend to grow uniformly. However, with non-uniform stock the size difference will become progressively greater during culture. Size uniformity is important to production efficiency and to marketability.

STOCK DENSITY

Fish stock density refers to the number or weight of fish per water surface area of pond. An "overstocked" fish population is one where density-related factors are directly negatively affecting production performance of growth rate, feed efficiency, survival and yield. The primary concern about overstocking is the indirect impact on water quality, because the higher the stock density the higher the amount of feed required and, consequently, the higher the quantity of metabolic wastes.

NUMBERS OF FISH TO STOCK

For stocking purposes fish density is measured in numbers per area of pond, volume of cage and volume flow of raceway. In ponds, measures of fish density for expressing standing crops, carrying capacities and yields are given in weight per water surface area (kg/ha). Numbers of each species group to stock in ponds are dependent upon total yield and mean weight expected for that species at harvest:

$$\mathbf{N}\ \text{(Number to stock)} = \frac{\mathbf{W}\ \text{(Expected total species weight/ha at harvest)}}{\mathbf{w}\ \text{(Desired mean weight of species at harvest)}}$$

Primary 80% species and each secondary 20% species are stocked separately using the above formula. Expected optimum pond yield is based only on the weight of feed-taking fish, and is usually equal to optimum pond carrying capacity. Both will vary directly with feed quality and water quality. Expected optimum carrying capacities given in Table II-1 generally reflect expected water quality conditions based on nutrient enrichment (fertility) level of the water. Highest optimum carrying capacities and yields would be in ponds with highest water qualities.

Fish mortality in ponds during culture is usually insignificant (<5%) when healthy fish are stocked and proper management provided. Therefore, the above equation is applicable without compensation for mortality. Higher mortality (6-10%) is common after stocking at water temperatures above approximately 22°C, and additional fish may be stocked under such conditions to compensate for expected loss.