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EDITORIAL

Scientists are becoming more vocal about the need for conservation of aquatic resources that are increasingly under threat. The potential for aquaculture of a large number of species has yet to be assessed. However, their importance in capture fisheries should not be underestimated. A paper in a previous issue highlighted the importance of small size indigenous finfish as a valuable source of calcium, iron and vitamin A in Bangladesh. This issue has an article that highlights the decline in the availability of indigenous small fish to the rural poor as a result of agricultural intensification and the resultant habitat loss. It indicates a need for developing aquaculture of these species to protect this important source of nutrition for the rural population.

Introduction and reintroduction of exotics to increase production from aquaculture operations is going on in many countries with little or no concern for the impact of these introductions on the environment and biodiversity. The paper from India suggests a strategy for management and reintroduction of exotics based on ecological and genetic data.

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Conservation of the Nilgiri Rainbow Trout in India

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Abstract

Rainbow trout is one of the important exotic species that is well established in the upland waters of India. This paper presents the historical background of its introduction and the present status of the fish in the streams of the Nilgiri peninsula of India. The rainbow trout inhabits natural reservoirs and streams of the region as a self recruiting population. The growth rate is reported to be relatively low and conflicting views about its taxonomic status have been reported. Successful crossbreeding of the Nilgiri rainbow trout with trout stocks from the Indian state of Himachal Pradesh has indicated the scope for utilizing cryopreserved milt as a mode of introducing new genetic material into the Nilgiri rainbow trout population. This paper outlines the requirement of ecological and genetic data to develop a strategy for management and reintroduction of fresh stocks.

Introduction

The introduction of fast growing exotic species has long been considered a means of increasing aquaculture production. In India, some exotic carps have been incorporated into composite fish culture (polyculture) practices in confined ponds leading to higher production of fish per unit area. The exotic silver carp (*Hypopthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*) and tilapia spp. were introduced to utilize all the ecological niches of the pond culture system. These species have found their way into natural waterbodies through accidental and intentional stocking. There are also reports of exotic fishes endangering indigenous species in reservoirs in India (Natarajan and Menon 1989; Shetty et. al. 1989). In India, most introductions and transplantations have been done without any assessment of possible impact on native fish species or established ecological links. The issues related to such impacts have been a matter of considerable debate. On the other hand introduction of salmonids in Indian waters have not lead to any controversy of endangering native Indian species. The upland waters of India harbour only few indigenous fishes of commercial importance like the mahseer (*Tor putitora, T. progenicus T. khudree* and *T. mosal*) and the snow trout (*Schizothorax* spp.). This motivated the British colonialists in India to transplant various species of fish from Europe for food and sport. Several species of coldwater fish were introduced: the English carp or golden carp (*Carassius carasius*) and the tench (*Tinca tinca*) from the U.K.

in 1870; the brown trout (*Salmo trutta fario*) from the U.K. in 1899 and 1901; and the rainbow trout (*S. gairdneri*) from the U.K., New Zealand and Sri Lanka in the first decade of this century (Jhingran and Sehgal 1978).

Despite a long history of introduction and established aquaculture practices (Kumar 1998) in India, trout farming is not widely practiced on a commercial scale. In the Nilgiri peninsula streams, the rainbow trout occupies only natural habitats and does not support a commercial fishery. The populations are self recruiting, either through natural breeding or through introduction of hatchery produced stocks by artificial breeding of wild stock. Over time, the Nilgiri trout might have undergone inadvertent genetic selection and the variation that was originally present in the broodstock may have been lost or altered. This is likely because of the adaptive process, the repeated efforts of stocking with different strains and crossbreeding. This paper outlines a strategy for the management and reintroduction of trout stocks in the Nilgiri streams based on the present status of the rainbow trout fishery.

Trout in the Nilgiri Region[1]

The most important trout species in aquaculture is undoubtedly the rainbow trout native to the drainage of the Pacific coast of North America (west of the Rockies). It is found around all continents, except in Antarctica. Outside the temperate zones, it is capable of establishing itself in low latitudes at higher elevations. The Nilgiri region of India, located between 70 to 2 580 m above MSL, has lakes and streams with water temperature ranging between 6° to 20°C. The European settlers, tea planters and game associations found the cold clear waters of the Nilgiri streams well-suited for planting trout. The endemic fishes of these waterbodies were species of lower economic value like *Danio* sp., *Rasbora* sp. and *Puntius* sp. (Anon. 1987). The first attempt to transplant trout eggs and fry in India from abroad was made in 1863 by Francis Day in the Nilgiris and was soon followed by many others (Day 1873). The first transplants were the brown trout and the Loch Leven trout (*Salmo levensis*) but they did not become established despite continuous importation of eggs for about four decades (Jhingran and Sehgal 1978). In 1909, rainbow trout eggs were imported from New Zealand to initiate trout culture on a scientific basis. A hatchery was constructed at Avalanche in 1909-1910 and the efforts to develop culture practices were successful. Later, eggs were brought from Sri Lanka and planted in Parson's Valley. More streams like Devarpetta and Lakidi were stocked. The streams were opened for trout fishing in 1911 at Avalanche, Emerald, Mekod, Glenmorgan lakes and the Pykara reservoir. The Avalanche hatchery continued to produce eyed ova with brooders collected mostly from the Mukurti stream (Jhingran and Sehgal 1978).

Trout fishing is only permitted for licensed anglers, with licenses issued by the Department of Fisheries, Tamil Nadu. Only spinning and fly fishing is permitted. The use of live bait is prohibited. The fishing of trout in the reservoirs and breeding grounds is prohibited during October-December (Anon. 1987). Based on the creel census data, the catch of rainbow trout in Lakidi and Devarpetta streams was estimated at about 2 to 3 trout (457 g/hr/rod) during 1966-1968 (Jhingran and Sehgal 1978). The average catch of the species in Emerald, Avalanche, Mukurti and Upper Bhavani reservoirs dropped from 545 g/rod/hr during 1966-1967 to 212 g/rod/hr during 1969-1970. The average catch during 1997-1998 was estimated at about 86 g/rod/hr, equivalent to approximately 4 fish(2 kg)/rod/day or 75 fish/rod/yr with maximum catches during January and February (M. Sadanandan, pers. comm.).

Decrease in the size of the trout caught already began to be noted in 1913. This led to the imposition of restriction on size and number of fish to be taken by anglers. Subsequently efforts were also made to transplant eyed eggs of other strains. In 1920, eyed eggs of the "irideus" rainbow trout (*S. gairdneri irideus*) were brought from Kashmir to the Avalanche hatchery for stocking in various streams. There was also a possibility of admixture of the above variety with another steel head variety (*S. gairdnerii gairdnerii* synonym *S. gairdnerii rivularis)* in the consignment (Mackay 1945). This was followed by another consignment of eyed eggs of the golden rainbow trout (*S. gairdneri aguabonita*), tiger trout (a hybrid between female brown trout *S. trutta fario* and male Eastern Brook trout *Salvelinus fontinalis*), Kokanee salmon (*Oncorhynchus nerka*) and brown trout (*S. trutta fario*) from Japan. To provide faster growing strains of rainbow trout, 10 000 eyed ova of the albino strain of rainbow trout (*S. gairdneri*) were introduced from Japan in 1974. Though its growth rate was faster, the albino strain was highly susceptible to fungal infection that led to the extinction of the strain in 1981 (Anon. 1987). In order to improve growth performance, efforts were also made to crossbreed the Ooty stock of trout with the Shasta rainbow (*S. gairdneri shasta)* from Munnar (Kerala) in 1989. In this attempt, eyed ova of trout stocks of yellow-bellied Shasta from Munnar were transplanted to the Avalanche hatchery and grown till sexual maturity. The Shasta males of Munnar stocks reared at Ooty were artificially crossed with females of the local Nilgiri stock and the hybrids produced were either

[1]Editor's note: *Salmo trutta fario, S. gairdneri, S. gairdnerii, S. gairdneri rivularis* are regarded as synonyms of *Oncorhynchus mykiss*; *S. levensis* as synonym of *Salmo trutta*; and *Salmo gairdneri aquabonita* as synonym of *Oncorhynchus aquabonita* (FishBase 98).

stocked in reservoirs or released into the streams. Unfortunately, no subsequent studies have been undertaken to record the growth rate and performance of these hybrids. Various methods of augmenting the insect fauna of the streams were used by the Department of Fisheries to increase the availability of natural food supply. These included: (i) improvement of the calcium content of trout streams by dumping coral rocks at the stream head; (ii) planting of water weeds for providing shade and shelter to insects, freshwater prawns and shrimps; (iii) transplantation of shrimps and prawns (*Palaemon* spp., *Caridina* spp.) and crabs to serve as trout food; (iv) construction of boulder dams in selected sections of the streams to impound water, especially in the summer, for better resting places for the trout; and (v) afforestation of stream banks (Jhingran 1991). However, the problem of diminishing size still continues and a satisfactory solution is yet to be found out.

Milt Cryopreservation for Crossbreeding

An alternative to introduction of exotic stocks is to use cryopreserved milt for crossbreeding with native stocks (Das and Ponniah 1996; Ponniah et al. 1996). This approach incorporates the possibility of retaining the adaptive features of the feral population in the crossbred stocks. Long term cryopreservation of fish milt would also be beneficial for the aquaculture industry as it would provide a method of retaining specific genetic lines of fish and wild stocks as well as feral populations to be used for crossbreeding without the expense of maintaining the broodstock populations. Under the gene banking program of the National Bureau of Fish Genetic Resources (NBFGR), sperm cryopreservation technique for eleven endangered as well as commercial species have been standardized (Ponniah and Lal 1996). Besides endemic fishes, successful milt cryopreservation of exotics like the rainbow trout (Thakur et al. 1997), brown trout (Gopalakrishnan et al. 1999) and common carp (Ponniah et al. 1998, 1999) has been achieved. Crossbreeding can be more advantageous if the genetic profiles of the stocks are also known. NBFGR initiated a crossbreeding program for the rainbow trout of the Nilgiri waters at Avalanche with stocks from Himachal Pradesh in 1997. The sperm was collected and cryopreserved at the Barot hatchery (Thakur et al. 1997) and used for fertilizing eggs from wild spawners at Avalanche. Fifty-five percent of the fertilized eggs reached the eyed stage. As the source of the water in the hatchery is a natural stream, untimely rains with heavy silt load resulted in poor hatching percentage (0.5%) in the cryopreserved group.

Management Plan

Information on the genetic profile of the Nilgiri rainbow trout is lacking and the taxonomic status is a subject of controversy. Menon et al. (1954) concluded from the study of morphological parameters that the stock is a mixture of several species viz. *Salmo gairdnerii irideus, S. gairdnerii gairdnerii, S. trutta fario, Salvelinus fontinalis and O. nerka*). This contradicts earlier reports that the stock was a representative of a migratory steelhead variety, *S. gairdnerii gairdnerii*. Mackay (1945) has indicated that some of the original eyed ova introduced in the Nilgiri streams were not pure *S. gairdneri irideus* but its hybrid with *S. gairdnerii*. He attributed this to the annual migration of a large number of trout specimens.

Fishery management practices have an impact on the genetic integrity of natural populations (Allendorf et al. 1987). The major handicap in developing any strategy for the management of an existing resource and reintroduction of exotic stock is the total lack of knowledge on the genetic structure of the population and its commercial traits. This emphasizes the need for a systematic study to generate data on population characteristics using isozyme and molecular markers as well as to quantify traits of commercial value. There is an urgent need for generating ecological data to evaluate whether reintroduction is a feasible option and to monitor the impact of introductions. Such data will provide baseline information to (i) solve taxonomic conflict; (ii) keep track of genetic or ecological alterations and (iii) evolve a management strategy for existing populations and for future introductions, using transplantations and crossbreeding from cryopreserved milt.

Some of the necessary steps in a management plan for the fishery are:

1. Field observations indicate that the rainbow trout stocks of the Nilgiris have assumed a distinct genetic make-up and adaptive capabilities and are a mixture of different stocks. Hence, it is necessary to study the genetic characteristics of the naturalized stock before further exotic stocks are introduced. Genetic characterization of the stocks will establish the differences from rainbow trout stocks in other countries and will provide the baseline data for evaluating the impact of further introduction of exotic stocks.
2. Though the Nilgiri stocks have shown reduction in body size, they might have acquired other unique characteristics such as adaptability to fluctuations in temperature and the high silt load characteristic of the Nilgiri streams. It is important to study the adaptive life history characteristics of this feral population.
3. Records indicate that the reduced size was noted as early as 1913, soon after the first introduction in 1909. It is important to find out whether the reduced size is due to deteriorating genetic stock or due to the

environmental conditions of the Nilgiri streams.

4. A study needs to be undertaken to determine whether the Nilgiri streams can support the fast growing exotic stocks before further introduction of any new strain is considered.
5. Feral populations of exotics are potential stocks to be utilized in future genetic improvement programs. These feral populations of rainbow trout that have adapted to local conditions will be of interest to trout breeders in other countries. Therefore, germplasm of these locally adapted stocks needs to be preserved prior to any further crossing with new exotic varieties.
6. Rainbow trout strains with very distinct characteristics relating to the breeding period and production parameters have been bred in other countries. Appropriate strains suitable for local conditions can be selected for crossbreeding after the objectives have been clearly established depending on whether it is for culture of the species for food or as sport fish in natural streams.
7. The technique for introduction, i.e., whether it is the crossbreeding of locally adapted stocks with the new exotic strains or introduction of eyed eggs of new exotic stocks, will depend on the objectives and the ecological and genetic considerations.
8. Controlled introductions can then be carried out along with monitoring of "key" local species to assess any adverse impacts and discontinue introduction or modify the strategy of introduction. Proper quarantine procedures must be followed.

Conclusion

Introduction of exotic species and stocks can lead to increased fish production in some cases. For long term sustainability, they must be preceded by scientific study and evaluation of objectives and risks. After an introduction there should be monitoring to assess the genetic, ecological and socioeconomic impact.

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