OPENION Management and Conservation of Natural Fish Population

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Abstract

Genetic diversity plays an important role in the survival and adaptability of a species. When a population's habitat changes, the population may have to adapt to survive; the ability of the population to adapt to the changing environment will determine their ability to cope with an environmental challenge. Genetic diversity is what enables us to survive and thrive. The capacity of species to adapt to new circumstances, whether this is resource scarcity, a changing environment or other disturbances to their natural environment, depends on genetic diversity. Essentially, genetic diversity is the total number of characteristics in the genetic makeup of a species. The greater the variation in genes, the more likely is that individuals in a population will possess the differentiated genes which are needed to adapt to an environment. In scientific literature, these differentiated genes are called *"alleles"* and their presence is what help species to survive. The theory of natural selection suggests that it is this variety of genes that allows species to evolve, adapt and propagate successfully. Many studies have also highlighted how species diversity (i.e. biodiversity) and genetic diversity are inter-linked, inter-dependent and equally important. Lead researcher Dr. Richard Lankau, whose team illustrated how genetic diversity and species diversity depend on each other, has highlighted that *"Diversity within a species is necessary to maintain diversity among species, and at the same time, diversity among species is necessary to maintain diversity within a species. And if any one type is removed from the system, the cycle can break down, and the community becomes dominated by a single species"*. The more is the diversified forms, the more the chance of a species to exist, otherwise known as portfolio effect, means if one form fails then the other form may be advantageous for the changed situation.

Key Words: Genetic diversity; species diversity; alleles; portfolio effect

1. Introduction

Genetic variation occurs at intra-population and inter- population level within a species. Meiotic recombination gives rise to innumerable combinations of alleles which Intra-population genetic variability, whereas inter-population genetic diversity occurs due to allelic frequency differences in a number of gene loci. Mutation creates new genetic variation in a population and recombination, genetic drift and gene flow reshuffle it, which is either preserved or rejected by the natural selection.

2. Natural genetic variation in fishes

Intra-Population genetic diversity is more pronounced in freshwater fishes than in marine ones and the estuarine fishes are between the two. The inter pop-ulational genetic variability in freshwater and marine fishes was estimated to be about 29.4% and 1.6% respectively, by isozyme analysis since freshwater bodies are small and discontinuous, the fish living there in have limited dispersal ability and this prevent inter- breeding between different populations. Prevention of inter-breeding is of utmost importance for the evaluation of inter-population genetic diversity. On the other hand, the marine environment is vast and continuous. Fish can move and inter-breed freely in the absence of any effective barrier. larvae and eggs can also disperse passively to distant places. So, unlike freshwater fishes the gene flow in marine fishes is not disrupted in a vast geographical locality. tuna (*Katsuwonus pelamis* L.), for example, shows high degree of genetic similarity from the Atlantic to Pacific oceans. This is because of the fact that the members of this species are active swimmers and they lack discrete spawning. Thereof, inter-breeding between Atlantic and Pacific Populations takes places. Similarly, the populations of Milkfish (*Chanos chanos*) sampled from localities 10,000 km apart in Pacific Ocean also did not show allelic frequency difference at polymorphic protein coding genes. but in some marine species like Black perch *Embiotoca jacksoni*, genetic differentiation between individuals are due to some peculiar life history traits. However; intra-populational genetic variability is quite high in marine fishes because the size of breeding population is very large.

3. Stock Concept

Different populations of a species showing some morphological and behavioural differences are referred to as stocks. The stock concept emerged from the observation of inter-population differences in some migratory fishes like Salmon. However, the term 'stock' is used very loosely in fisheries science. Fishery biologists use the term 'stock' to refer to a population or set of populations under harvest. This definition does not imply anything concerning genetic or phenotypic differences between the different populations. It only describes about a group of individuals whose abundance in the group depends upon natality, mortality, immigration and emigration. A number of other definitions have also been proposed by different user groups. Not a single definition, however, is universally applicable. The differences between the terms stock and strain that are used fisheries science are inter-changeable and often treated as synonymous. The term 'stock' refers to a genetically differentiated population of a species, which is evolved in the natural waters by the actions of natural selection and other evolutionary factors, whereas, a 'strain' is the variety of a species produced as a result of domestication by artificial breeding and culture.

4. Importance of genetic diversity

Genetic diversity of a species is its inherent ability to adapt and evolve with the changing environment. A species endowed with higher amount of genetic diversity is more capable than the less advantageous one to evolve in response to the changing environmental conditions (Frankie and Soule, 1981). The industrial revolution is a classic example that illustrates how genetic variability helped a species (*Beston betularia*) to adapt to the changed environmental condition. This moth occurred in light and dark coloured forms. Before industrial revolution light coloured forms enjoyed extreme advantage as the lichen covering the tree barks had matching colour with light forms and the befouled predator failed to detect the moth easily. With increasing industrialization and consequent turning of grey lichen to black made the light forms easy preyable and black forms, enjoying the advantage of the situation became the survival of the fittest. Had there been no genetic polymorphism, the moth would have gone extinct.

5. Genetic variation is essential for survival and maintaining the fitness of a population.

Genetic homozygosity reduces the fitness of an individual due to the expression of recessive deleterious alleles. Heterozygosity improves the individual's fitness in terms of better ability to resist diseases, faster growth rate and higher survival rate than homozygotes. Lack of genetic variations also reduces the inherent ability of a population to survive for a long time. The species *Poecilliopsis accidentilis* is now in the list of endangered fishes. Low genetic variation found by isozyme analysis has been attributed to be the cause of low rate of its survival.

Individuals with high level of genetic variation have great prospect in aquaculture in terms of higher growth rate, development, stress and diseases resistance (Carvalho, 1993). Therefore, detection of genetic variation at species and population level is of crucial importance for sustainable aquaculture practices. Genetic variation at species level helps to identify the taxonomic units and to determine the species distinctiveness that can provide essential information for conservation, systematic, ecological and evolutionary studies (Schieverwater et al., 1997).

Variation at the population level can provide an idea about how many different genetic classes are present and the genetic similarity among them, how much diversity is present in those classes and their evolutionary relationship with wild relatives. The genetic variability within population is extremely useful to gather the information on individual identity, breeding pattern, degree of relatedness and distribution of genetic variation among them.

Such studies are highly informative for the management of small group in ex-situ collection, cultivars identity, breed or clonal identification and for paternity testing. Williams et al., (1991) developed a PCR-based genetic assay named as Random Amplified Polymorphic DNA (RAPD) method, which detects nucleotide sequence polymorphism in genomic DNA regions by using short oligonucleotide primers of arbitrary sequence, typically a length of 10 nucleotides. RAPD assay reports numerous loci that allow the examination of genetic variation and phylogenetic relationship without prior knowledge of DNA sequence.

Since it is PCR based, RAPD is relatively easy, fast and efficient method which requires only a small amount of DNA for the study. This technique has been useful for detection of genetic variation in various fish species. It has been used for phylogenetic studies for species and subspecies identification in fish. Random Amplified Polymorphic DNA-PCR (RAPD-PCR) technique was used by Williams et al., 1990; Welsh & McClelland, 1990 for fish species identification. Investigation that directed towards the evaluation of the genetic diversity and the molecular phylogeny within and between the two stocks of a freshwater species, based on RAPD technique, provide valuable information for breeding, conservation, systematics and ecological and evolutionary studies (**Chattopadhyay et al., 2013)**

6. Genetic variation is essential for the present and future breeding programme.

Genetic variability provides raw material for the selective breeding programme. For example, the scientists of international Rice Research Institute in Philippines after screening of 6000 varieties found a virus resistant variety of wild species of rice called Oryza *nivara*. The germplasm of this variety was used for developing a virus resistant variety, IR36 which is widely cultivated across Asia. Had there been no genetic diversity in the wild population, this could not have been possible. Genetic diversity should, therefore, be conserved for: i) the survival of the existing species, ii) for maintaining the potential of a species for continual evolution and iii) for its utilitarian value.

The appearance of genotyping by sequencing technologies has provided the aquaculture research community with a hugely valuable method for identifying and concurrently genotyping large numbers of genetic markers in species with limited genomic resources. Further, these techniques have become multi-purpose tools for addressing several topics of research and commercial interest like genetic diversity, population and family structure, association analyses with traits of economic interest, and genomic selection. Despite the increasing availability of genomic resources and the increasing number of SNP arrays, RAD techniques will continue being important for aquaculture research and application to selective breeding in the next few years. RAD sequencing and other genotyping by sequencing currently offer unequalled versatility and cost-effectiveness for meeting the needs of many diverse research projects. (Diego Robledo et al., 2017)

7. THREATES TO FISH GENETIC DIVERSITY

Natural fish population are declining in many parts of the world at an alarming rate. This has been adversely affecting the sustainability of fisheries resources since their gene pools and genetic diversity is eroded. The factors posing threat to fish genetic diversity are classified and their impacts on gene pool are discussed.

I. Factors posing threat to fish genetic diversity

A. Fishing pressure
B. Habitat modification
   i. Damming
   ii. Deforestation

iii. Diversion of water for irrigation

iv. Conversion of marshy land and small water bodies for other purpose

C. Pollution load

i. Poisonous chemicals

ii. Suspended solids

iii. Sewages and organic residues

iv. Thermal pollution

D. Introduction

i. Deliberate introduction of exotic species/stocks

ii. Escapement of aquaculture stocks

A . FISHING PRESSURE

Over-fishing affects the demography of fish population. The population size gets reduced because of disturbances in age structure and sex composition. These demographic misbalances have some adverse effects as described below --

Growth rate and age of sexual maturity are heritable quantitative characters. Over fishing affects the performance of these characters. Efficient gears remove larger individuals, which mostly happen to be the quick growing ones in a population as a result, heterozygosity gets reduced. This is observed in the populations of Pacific salmon (*Oncthorhyncous* sp), where the selective capture of large fishes reduced than the average size of the individuals. Similarly, the over-exploitation of Nile tilapia. *Oreochromis niloticus* in Lake George of Africa during early 1950s had led to decrease in the mean size of the landed fish from 900 to 400 g and the mean length of maturity from 29 to 18 cm.

Over-exploitation causes increased morality of the adults. in this situation, the younger fishes tend to mature at an early age and divert more of their energy for reproduction. This fact was demonstrated trough a study on the Guppy, *Poecilia reticulate* by Reznick et aI, (1990). They studied the age of maturity in the wild populations of this species at two different sites, one with high predictions pressure and the other with a low predation pressure. The Guppies living in the site with high predation pressure matured at a young age and produced more number of smaller offspring per brood than those found at sites, where the predatory pressure was low on the adults. Over fishing cause change in genetic structure of fish populations due to the loss of some alleles. Thus, genetic diversity gets reduced (Sutherland 1990).

B & C. Physical modification of habitat and pollution load

B. Habitat modification

Habitat modification may lead to species extinction. A glaring example of loss offish fauna due to habitat modification is Madagascar the largest oceanic island in the world. because of its geological isolation, 90% of the ichthyofauna in this island are endemic and 84% of these endemic fishes are restricted to fresh-water habitat. Of these freshwater species, 61% are found exclusively in the rivers and streams of eastern and north-eastern humid forests. Because of excessive deforestation the endemic species once abundant have severely declined in 1990s (Stiassny, 1996). Construction of dams on rivers impedes upstream spawning migration of fishes and displaces populations from their normal spawning grounds. It may also result in separating a population into two smaller groups. In-breeding and genetic drift are the common problems in a small population that reduce genetic variability.

C. Pollution load

Four forms of pollutants can be distinguished **I) Poisons pollutants** like agrochemicals, metals, acids and phenols cause fish mortality, if present in high concentration. For example, 25 stocks of Atlantic salmon (*Salmo solar*) in the rivers of southern Norway are now virtually extinct due to acid rain (Hesthagen and Hansen, 1991). The reproductive functionality of fish is also affected **ii) Suspended solids,** which do not settle down easily, affect the respiratory process and the secretion of protective mucus making the fish susceptible to the infection of various pathogens, **iii) Sewages and other organic substances** cause deoxygenation due to eutrophication causing mortality in fishes. **iv) Thermal pollution** raises the ambient temperature reduces dissolved oxygen concentration leading the death of some sensitive species.

8. Genetic impacts of habit modification and pollution load

The severe reduction population size due to habit modification and pollution load precipitates genetic bottleneck. Since the effective population size minimum viable population size (MVP) gets reduced, the genetic diversity gets affected. MVP means under reproductively active individuals in a population that produce progeny. The impacts of reduced IVP are inbreeding depression and genetic drift. If the bottleneck situation persists for a long time, the population may go extinct.

9. Genetic Impacts of Introduction

The impact of introduction of exotics is a matter of concern because of ecological and genetic reasons. Predation on the native species or competition and spreading of pathogens or parasites are of some common ecological concern. The genetic impacts of introduction can be categorised under two points 1- reduction in **effective population size'** by the ecological and other effects of introduction 2- **Alteration/extinction of the gene pools of the species/ stocks by cross-breeding/hybridization and backcrossing.** cross-breeding means inter-breeding between different stocks and hybridization Is the inter-breeding between different species. Introduction of exotic species is one of the reasons for the increased frequency of hybridization in natural waters. Hybridization has resulted in species extinction in some cases for example; Apache trout (*Oncorhynchus apache*) and Gila trout (*o. gilae*) two native species of southwest USA namely, have faced extinction primarily due to the hybridization with the introduced species. The cross-breeding between cultured and wild populations affects the genetic structure of the concerned species. Cross-breeding may have positive or negative impacts. Cross-breeding increases heterozygosity in a population which may sometimes have some positive impacts due to improved performance of some productive traits. The F 1 progeny of the crossbreeds may back cross with the parental species leading to genetic in – egressions and inter-mingling of two partially diverged gene pools. This may have negative impacts on the gene pools due to genetic admixture or genetic modernisation, which affects the evolutionary potential of a species. high level of gene flow by introgression was detected among the crossbreeds of salmon and Trout using isozyme markers.

Out breeding depression occurs due to two reasons **Firstly,** by the breakdown of co-adapted gene complexes at different loci. Co-adaption depends on intrinsic interaction between genes themselves. Due to recombination it breaks down and the favourable genetic combinations are lost. **Secondly,** by the loss of local adaption which occurs due to inter-action between the genotype and the environment? If two different stocks interbreed, the gene-combination responsible for local adaption may get reshuffled by recombination, the new gene complexes may help the F_1 crossbreeds to adapt properly with the parental environments. But in F_2 generation, the fitness may fall due to the breakdown of co-adapted gene complexes of their parents. Thus, stock transfer which may initially appears to be beneficial or neutral may turn out to be bad in the long run in some cases.

Table.1. Impact of various anthropogenic factors on fish gene pools

Cause	Effect	Consequence(s)
Over - exploitation	i) Extinction of population ii) Reduction in population size	i) Loss of genetic diversity ii) Inbreeding and genetic drift
Non-selective fishing pressure	Negative selection	Adversely affects quantitative traits such as growth rate
Pollution load	i) Population extinction ii) reduction in population size iii)Chromosomal and other Cytogenetic abnormalities	i) Loss of genetic diversity. ii) Inbreeding and genetic drift iii)Genotoxicity

Habitat modification	Reduction in population sized	Inbreeding and genetic drift
Stock transfer	Cross-breeding	Genetic admixture of different stocks
Species introduction	Hybridization and back-crossing Leading to introgression	Genetic pollution

10. Summary of genetic impacts of various threatening factors

Over exploitation, habit modification, pollution load and introduction of exotic species/stocks affect the fish genetic diversity directly or indirectly. Excessive mortality of fishes due to any of these factors may lead to two types of effects: I) Extinction of the species/population and ii) the reduction of population size. When population size gets small, inbreeding takes place which reduces the population viability and genetic drift causes the loss of rare alleles. Cross-breeding and hybridization combine and integrate the two incompletely diverged gene pools.

11. Genetic Management 0f Natural Fish Population

The aim of natural fish management, as in the case of any other natural biological resource management, should be to derive long-term sustainable benefit through conversation. Conversation is a multi-disciplinary scientific concept involving population biology, ecology, evolution, genetics and it also embraces the social, political and economic aspects. here, however, the accent of discussion will be towards the genetical aspects. While genetics is one of the aspects for the management of natural fish populations, it does not undermine the importance of considering ecological, demographic or other pertinent aspects for conservation planning. The importance of genetics in sustainable fisheries management is elaborated in a recent book by Mustafa (1999).

Considering genetical perspectives, the aim of natural fishery management should be to conserve intra-specific genetic diversity. The genetic diversity is the sum of total of all heritable variation present within a species at intra-populational and inter-populational levels. The importance of genetic diversity was recognised in 1980 by two important international symposia: i) The fish gene pool symposium held in Stockholm and ii) the FAO/UNEP Symposium on Conservation of the Fish Genetic Resources held in Rome. Both the symposia recommended the conservation of inter-populational and intra –populational genetic diversity. For the conservation of genetic diversity, it is of great importance to have necessary background knowledge on the pattern and amount of genetic diversity, ii) the status of a taxon with respect to population abundance, distribution etc., and iii) the genetic problems that the taxon faces.

12. Genetic diversity assessment

Understanding of genetic diversity between different (geographic) populations of a species and between closely related species is useful for genetic management of natural fish populations. So much so, genetic diversity assessment is discussed here under two sub-headings: i) Stock identification and ii) Species and hybrid identifications, Stock identification is the useful way of documenting intra-specific genetic diversity; the species identification is a pre-requisite for hybrid identification and for assessing the impacts of introgression.

13. Stock identification

For stock identification morphometric, meristic, cytogenetical, immunological, biochemical and molecular techniques can be applied. Before 19605$_s$ when the biochemical and molecular techniques were not developed, the sub-division of a species into some stocks could be speculated from catch data and tag recoveries of the migratory species, Morphological differences in morphometric and meristic traits are the low-cost method for stock identification. But the analysis of these traits is not reliable because the environmental." factors affect their heritability. Karyological method such as variation in chromosome number and banding polymorphism are the potential tools for stock identification. Although the inter-population chromosomal polymorphism is sometimes detectable in few species. It is not a very suitable method because sample processing and chromosomal data analysing are time consuming. Karyological data on stock identification are not much available. Fluorescent in situ hybridization technique is potentially a superior tool and may find use stock identification study in future

14. Importance of stock identification study

I) Stock identification will improve our understanding about the genetic structure of natural populations, the determination of genetic variation within and between populations can discriminate between genetically poor and rich population in terms of heterozygosity and polymorphism. This information will help to decide the best source of material for re-introduction or rehabilitating a threatened stock.

II) The stocks are believed to be locally adapted populations. Therefore, they should be treated as the unit of conservation and the management of endangered and the management of endangered and commercially important taxa.

III) By suitable markers a stock can be labelled to its geographical origin this will help in understanding the migration pattern between populations and deducing past events of colonisation. The genetic ad-mixture due to the unthoughtful stock transfer from one region to the other may also be detectable.

15. Determining the Status of Taxon

The status of a taxon can be understood by surviving its range of distribution, abundance and population composition and decision can be taken accordingly for its conservation management. The International Union of Conservation of Nature and Natural Resources (IUCN) maintain the record of the species, including fishes, which are declining in nature. This record is called as **red data book.** The IUCN has categorised the situation for assigning the certain status to a declining species. The term Threatened is used for referring to the status of a species mentioned under following categories-

1) **Extinct –** The species that lived till recently but not found at all present is extinct A species gets extinct if it cannot maintain its population recruitment due to the stressful factors.

2) **Endangered -** The taxa whose numbers have been reduced to such a critical level that they are under the danger of extinction, if the casual factors.

3) **Vulnerable –** The taxa which are like to move into the endangered category in the near future if the casual factors continue to operate. Consequently, the populations get drastically depleted and their survival is under the threat.

4) **Rare –** The taxa with small population size which are not endangered or vulnerable at present but at risk. Their distributions have been reduced or are thinly scattered over its geographical range.

5) **Data deficient –** Taxa that are suspected but not definitely known to belong to any of the above categories, because of the lack of information.

16. Determining the genetic problems

To determine the genetic problems, gene pool monitoring is essential having prior knowledge about the status of a taxon and its genetic diversity, the managers with the help of the geneticists can determine the type of genetic problem to resolve through formation of some management strategy. The following questions may be addressed to find out the type of genetic problems:

i. Has population size reduced? if yes, the occurrence of inbreeding and genetic drift is probable cause which can be ascertained by heterozygosity and polymorphism analysis.
ii. Is inter-breeding between different stocks going on due to purposeful introduction and inadvertent escapement? If yes, does genetic admixture lead to genetic contamination?

iii. Does inter-specific hybridization occur between closely related species? If yes, is genetic pollution occurring due to genetic introgression?

iv. Does chemical pollution (at a lower dose) affect fish gene pool by causing genetic toxicity?

Once the goal and tasks of conservation are decided, a specific management approach can be designed.

17. CONSERVATION APPROACHES TO NATURAL FISH POPULATION

The genetic goal in a conservation programme is to conserve the genetic diversity. Any such conservation programme, however, is inherently very much complex. Therefore, dissecting it into some simpler components would be useful in conservation planning. For this, it is essential to address the three fundamental questions: what to conserve? where to conserve? How to Conserve? What to conserve? 'Everything' can be conserved by protecting an eco-system. This is broad- based, non-specific, cost-effective and a relatively simplistic approach of conservation. It does not require any specific knowledge about the biology and genetic diversity of a species for the conservation management. This is advantageous since our knowledge on genetic diversity and its potential or actual value is poor. However, since the role of a particular species is ignored in favour of ecological process and community organization, this approach may prove ineffective for the conservation of an endangered species. Conservation may aim in at a '**specific species'.** A species becomes prominent in conservation planning for a number of reasons: i) when it is declining due to anthropogenic stress in the natural waters, ii) when it is crucial for the general well – being of its ecosystem, or iii) when it is endangered and chosen for recovery by special management measures. To conserve a declining species, we should have knowledge about its biology, biogeography and genetic diversity. Without proper knowledge, inter-population genetic diversity cannot be conserved.

a) Where to conserve?

Conservation can be done **in situ** in the safe refuge or **ex situ** in the laboratory. In situ conservation means conserving the whole ecosystem or the total community in its natural location without any specific attention on any particular species. However, as stated above, when a species is of special concern to man, a general conservation approach by in situ conservation may not prove adequate. for example, habit degradation may affect the reproduction of a species leading to the reduction in its population size. In such a situation ex situ conservation would be required. The fish should be provided with safe refuge like a large tank or a hatchery pond for reproduction. Induced breeding may be conducted in this species, if it does not breed spontaneously in the captive conditions. After habit restoration, it may be transplanted back to the natural water. Sometimes the natural populations become so small and fragmented that they are not genetically and demo graphically viable unless the population density is in-creased. In this situation, population caught from the natural waters may be bred artificially in the hatchery and released for supplementing the natural populations.

Recent developments in biotechnology may prove useful for conserving the gene pool in the laboratory. Cryopreservation of spermatozoa in the sperm bank is one of the biotechnological tools for the purpose. Spermatozoa could be cryopreserved in many species of fishes and the embryo preservation is under trail this technology is useful in the following situations: i) if a strain gets extinct, it may be recovered from its cryopreserved sperm by diploid androgenises. To recover the original genome of a strain in the hatchery, which has experienced deterioration or erosion in its gene pool? The germplasm can also be stored in the laboratory in the form of DNA bank in three ways -

i) as total genomic DNA, ii) in the form of DNA library i.e. genomic DNA or cDNA library or iii) as cloned DNA fragments. Although DNA banks are easy to prepare in the laboratory, it requires proper documentation, labelling of samples and proper preservation. The handling of the samples also require technical expertise the problems of ownership may sometimes create dispute. The stored DNA may be useful for the recovery of some genes and not the genome as a whole. Thus, this is primarily helpful for research use and it cannot replace the natural genetic diversity.

b) How to conserve?

Management's approaches will differ in the case of a species which is declining and the species which has become endangered

c) Managing the declining population

If the populations of a species are declining some corrective measures based on genetic principles may be implemented by the managers:

i. The effective population size (Ne) should be maintained as large as possible to maximize the contribution of a large number of adults for reproduction.

ii. The causative factors that reduce the effective population size should be controlled. If there is a genetic bottleneck, the duration should be reduced as far as practicable.

iii. The barriers that create discontinuity in an interbreeding population should be disrupted to maintain the continuity of gene flow.

To attain these objectives, it is essential to protect the species and habit in situ against anthropogenic stress. What kind of management measures are needed for in situ reserve? One of the approaches is the **regulation of human activities.** The regulation may be **self –imposed or state –impose.** Self –imposed regulation means public understanding and awareness through education. This may act as the deterrent to owner-exploitation and misuse of the resources through public activism. This may be supplemented by the state-imposed regulation such as formulation and implementation of suitable laws. The law will take care of the offenders who play mischief with the resources and can be done through following measures: i) imposing ban on finishing particularly during breeding season for allowing the matured ones to spawn, ii) restricting the fishing gear for not catching small and immature fishes, and iii) imposing quota system for maintain the population size. In some situations, as in the case of rivers, certain stretch may be declared as the sanctuary. The sanctuary location may be shifted to different stretches from time to time safeguarding the ichthyofauna. However, it is difficult to safe-guard the natural fisheries resources due to its openness without conservation activism and public participation. If population density is critically reduced, it may be necessary to enhance the natural populations by captive breeding. This kind of breeding programme for conservation management is called as **supportive breeding** by Ryman and Laikre (1991). In this programme a fraction of the wild parents is bred in captivity and the progeny are released in the natural waters. The **supportive breeding** programme needs cautious approach since only a small fraction of population is allowed to produce progeny for the next generation.

d) Managing the endangered species

The main concern of endangered species management is its small population size. It may be noted that the absolute population size (N) is generally much larger than the genetically effective population size (Ne), which is determine largely by the number if sexually active individuals and the sex ratio. In a certain situation, the effective population size (Ne) gets reduced if some females cannot spawn. As mentioned earlier, inbreeding and genetic drift are the common genetic problems associated with the small population size.

Captive breeding programme are a useful approach for the conservation of endangered species. It is essential to avert extinction through rehabilitation of the endangered species. The success of a captive breeding programme depends on the rapid growth of population in such a manner that genetic variability is enhanced, Meffe (1986) gave some useful suggestions to maintain the genetic health endangered fishes: i) The founding population should be maintained as which will minimize inbreeding and loss of rare alleles. For this purpose, the effective population size (Ne) is recommended to be 500. this prevent inbreeding and genetic drift to occur ii) If the population size is very small, selective mating should be done to avoid inbreeding iii) The stocks should be kept for a brief period in the artificial environment, like the hatchery, to avoid the problem of domestication. iv) Different genetic stocks should be preserved to protect inter-populational genetic variability. captive breeding programme is costly and therefore, it should be planned very meticulously the high cost of maintenance and high fecundity in fishes may discourage the fisheries managers to maintain adequate brood stock, which may prove genetically deleterious.

Use of cryopreserved spermatozoa on captive breeding would be a useful way for increasing the effective population size and the recovery of a severely endangered population. In comparison to the captive breeding programme, the gene banking through sperm cryopreservation is relatively cheaper, easy to maintain, less prone to risk due to system failure or mortality due to disease. Therefore, it should serve as a useful adjunct to the captive breeding programme.

18. Concluding remarks

Conservation planning operates at many levels from whole ecosystem and communities down to individual organism. At each of these levels, molecular genetics techniques may provide appropriate tools to evaluate process and to develop management strategies. The severity of the problem means that two kind of conservation planning decision are going to be especially important. First, the conservation action must be appropriate-threats need to be identified clearly and steps taken to alleviate them. With a good understanding of the processes there can be significant improvement. Second there is an increasing need to identify priorities for conservation action, that is to single out taxa and sites where action needs to be taken immediately, if the situation is not to deteriorate rapidly and irrevocably. In both the cases, molecular genetics analyses can play a role. The concepts of genetic diversity conservation any have an apparent 'simplistic' look but the measures to be taken for conservation require certain creative approaches. Well-investigated scientific data are essential for effective conservation planning. For the implementation of conservation management programme be participation of public, voluntary organisations, government agencies, scientists, planner and administrators is required.

Various studies indicate that the RAPD technique provides a reliable and useful tool for identification and estimation of genetic variability, both within and between the two stocks of a population. Furthermore, the technique is simple, fast and less expensive than other related techniques of PCR, such as microsatellite or RFLP analysis (Caetano-Anolles, 1994; Jones et al., 1997; Harry et al., 1998). Besides the data generated from RAPD assay can be extended further to dissect traits in a more refined way to get information on specific genes and genetic pathway using other molecular methodologies. There is also the opportunity and need to study sequence of specific polymorphic bands as in SCAR analysis (Paran & Michelmore, 1993) to determine the genes detected by RAPD experiments. The possible use of DNA markers in future by genetic engineering may create many vistas for fish molecular biological research.

Species are primarily exposed to threat out of the decline of habitats followed by its fragmentation and quality deterioration. Fragmentation creates extinction risk as the isolated subpopulations, subsequently one after the another, get extinct without being repopulated. A random decline in small sub populations makes it more liable to go extinct, and is further exaggerated by the steady decline of variability out of isolation. For aquatic and semi-aquatic species, the declines in habitat quality results from the diversion of ground water along with subsequent drying up of streams and other water bodies. The condition worsens further from increased siltation, and pollution load. Another avenue of threat, to Freshwater sector in particular, are the introduction of non - native species which may lead to the extinction of native species. Considering the negative impact of exotics stringent regulations should be framed regarding the import of non-native fishes. As per rule, the exotic fish varieties should be cleared by the National Committee on Introduction of Aquatic Species in Indian Waters, New Delhi before introduction. The committee represented by fisheries development commissioner and exports will study the relevance of import and the potential impact that the new species is likely to produce on Indian environment. However, illicit import and trade of exotic fishes, particularly of the carnivorous in nature continues unabatedly and there are no effective methods or the political will to enforce the law.

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