AN OVERALL VIEW OF DIFFERENT TAXONOMICAL PARAMETERS FOR IDENTIFICATION OF FISHES

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For identification of fishes, different taxonomical (conventional and non-conventional) parameters of usage have been reviewed here. Among non-conventional parameters, cytotaxonomical and chemotaxonomical parameters have been discussed. All the scientists in the field of cytotaxonomy and chemotaxonomy of fishes have advocated to use cytotaxonomical and chemotaxonomical parameters as additional tools for the characterisation and classification of fishes. Till to-day, classification of the fishes are mainly based on conventional parameters. A fool-proof classification of the fishes in the world as far as practicable is demand of the day, basing on both conventional and non-conventional parameters.

INTRODUCTION

Fishes are vertebrates, primarily live in water. The number or representatives of this class are many and constitute more than half of the total number of vertebrates. Over 21,723 fish species, so far known to science, over 40% live in freshwater and majority of them live in tropics (Nelson 1976; Talwar and Jhingran, 1991). They respire with air dissolved in water by gills or branchi. The limbs are represented by paired fins supported by finrays. The paired fins are supplemented by unpaired and median fins. The skin is normally covered with dermal scales. With a few exceptions, all fish are oviparous.

Among different taxonomical parameters, both conventional and non-conventional parameters, in usage for identification of fishes have been discussed here under.

CONVENTIONAL PARAMETERS

In early period, taxonomical studies in fish were based on four different types of scales-placoid, ganoid, ctenoid and cycloid. Later some criticisms were made regarding the distinction between scales.
Keeping this in view, Gunther (1963) opined that the general morphology, patterns of circulatory system, gill structures, nature of the fins, etc. should also be taken into consideration. Day (1878) made an exhaustive study on the bionomics, distribution, colouration, body contour and other morphological features of different fishes of India, Burma and Ceylon; and introduced the respiratory mechanism as an additional parameter for the study of inter-relationship and classification of different fish types.

Regan (1906, 1909, 1929) surveyed and studied the anatomy and the bones of a large number of living fish, and suggested the usage of skeletal peculiarities in the classification. Taking all those characters and differences into consideration, Jordon (1967) made some changes in the classification of fishes and split different groups into 71 orders and 638 families. Further, Berg (1947) consolidated all the principles and informations on piscian classification in his time. Berg’s classification is still widely followed in different countries. Norman (1975) studied the development of gill arches, weberian ossicles, etc. of different fishes and tried to draw inter-relationship among different groups. So far as the Indian types are concerned, Misra (1962) made classification of Indian fishes basing on morphological characters. Menon (1974) also prepared a checklist of fishes of the Himalayan and Indogangetic planes, considering their morphological characters only. Later Jhingran (1991) regrouped different types of fish of Indian territory. The first attempt to define orders and higher taxonomical positions for the various fish types was made by Bertin and Arambourg (1958). They tried to speculate the origin of fish from the known teleostean fossils. Greenwood et al. (1966) considered the skeletal elements of different fish and classified them accordingly. A revised classification of fish and their phylogenetic relationships were proposed by Nelson (1969), who considered the advance type of gill arch dentition and the related musculatures in various fish groups. Talwar and Jhingran (1991) advocated for the use of taxonomic information to provide definite conclusion on fishery value. They gave emphasis on behaviour, feeding, reproduction, growth, habitat and population structure. They used taxonomy as a tool for identification of fishes. Thus, a uniform principle for the classification of fish depending on the morphological, skeletal or similar other characters is not readily available, because it is observed that fish as a group presents heterogeneous assemblage of types with enormous diversity in their morphology and in the habitats they live as well as their biology.

NON-CONVENTIONAL PARAMETERS

Keck (1957) opined that taxonomy should be studied not only from the phylogenetic point of view but also from comparative morphology, geographical distribution, genetics, anatomy, cytology, embryology, physiology, etc. to give a synthesis of all knowledge of biology.
In the principle of animal taxonomy, Simpson (1961) attributed the genetical concepts regarding speciation. He advocated that in the slow process of evolution, a species evolves gradually and the process is not abrupt. Hence it is very difficult to classify animals into various species considering some external features only, because there is a possibility that external features of two different species often overlap. Thus other comparative data, apart from the morphological ones, should also be given proper weightage.

Among non-conventional parameters, scientists so far worked on cytotoxic and chemotaxonomical parameters.

Cytotoxic parameters

Retziat (1890) and Ketschenko (1890) initiated the study on the fish chromosomes (quoted from Rishi, 1989). Studies of the chromosomes of fishes have not been as successful as in other vertebrates. Standard karyotypes are reported for about 10% of the existing 21,000 species. The limiting factors are to obtain proper chromosome spread from fish tissues and a large number of comparatively small chromosomes in most fish complements (Gold, 1979).

Data on taxonomic diversity in the Suborder Notothenioidel (Perciformes) basing on karyotypic studies have been reviewed. Different taxonomic levels (species, genus, family) have been discussed basing on karyological investigation. A correlation between taxonomic diversity and geographical aspects have been drawn. A significant correlation between taxonomic and karyotypic diversity and evolutionary advancement of the taxa have been noted (Prirodina, 1994). According to Arkipchuk (1995), the importance of karyotypic diversity increases with increase of taxonomic rank.

Manna (1989) reviewed fish cytogenetics in relation to taxonomy and evolution. According to him, about 100 fish species from India have been cytogenetically investigated. Since fish taxonomy based on morphological characters is a debatable issue, presently special importance has been paid to fish cytogenetics, review of chromosome data and sexchromosome mechanism.

Rishi (1989) have reviewed on the current status of fish cytogenetics. A limited features of the karyotype help in determining cytotoxic and taxonomic relationships among fishes, particularly in higher taxa. However, the presence of higher numbers and lower numbers may be useful. If DNA values are correlated with the chromosomal data in different fish species, it becomes a better tool for drawing relationship and evolutionary pathways. The chromosomal banding will finally answer the question of evolutionary mechanisms in fish karyotypes.
Arkhipchuk (1995) analysed DNA content of 155 fish species. Fish contain smaller amount of DNA per chromosome. Chromosomal size does not influence body size and number of species in the order. Sudheesh and John (1993) compared two populations of *Lates calcarifer*, one from Cochin and another from Tuticorin cytogenetically on the basis of chromosome morphology, their total length, relative length and arm relations. Rishi and Mandhan (1994) studied cytogenetic features of 52 Indian endangered fish species. The cytogenetic feature pinpoints a remarkable genetic diversity. Gold et al. (1990) focussed evolutionary cytogenetics of the family *Cyprinidae*. Identification of homologous chromosomes within and among fish species have been attempted by the application of chromosome banding. It is clear that most types of metaphase chromosome banding can be carried out on fish chromosomes and is useful for identifying homologies both within and between few species.

John et al. (1994) studied nuclear organiser region (NOR) chromosome banding pattern in five Indian fish species, *Labeo rohita*, *L. bata*, *L. calbasu*, *Catla catla* and *Mystus vittatus*. As revealed through this study, this technique is helpful in drawing homologies and analogies in chromosome structure, and thereby inter-specific and possible intra-specific variations.

**Chemotaxonomical parameters**

The chemotaxonomical study in fishes was initiated in mid 20th century. According to Blackwelder (1967) to adjust and strengthen the procedure of taxonomical study of the animals, data from biochemical field are meagre. Tsuyki and Roberts (1966) stated that the relationships among different fish could be established on a firm ground, if some biochemical factors were considered. The range of usefulness of muscle myogens in determining species character is much.

Genetic relationship and protein variation were investigated in the two morphologically similar fishes, *viz.*, *Hypomeria nipponensis* and *H. prellosus Japonicus* from Japanese water by enzyme electrophoresis (Narimasa et al., 1995). Their distinct allele composition suggested that they are more genetically differentiated from each other though they are morphologically similar. Mahobia and George (1993) studied the taxonomical status of the species of Indian cichilids from different geographical areas of peninsular India through morphometric and meristic variations as well as isozyme studies.

The total gene diversity were estimated within populations, within rivers and between rivers etc. of four salmonid species at electrophoretically loci. There are considerable differences between the variability patterns of different species. The implications of these findings have been assessed in order to formulate different
strategies for identification of existing genetic resources in different species (Raymon, 1983).

Hazra and Sinha (1995) studied serum protein pattern of *Tenulosa ilisha* population above (river Ganga) and below (river Padma) the Farakka Barrage through polyacrylamide gel electrophoresis. The banding pattern of the two populations differed.

The importance of yolk in the ontogenesis of fish is immense (Kafiani, 1970). The essential components of yolk are proteins, phospholipids and neutral fats along with the nucleic acid, which are metabolised during the embryonic development (Bellaire, 1964; Smith, 1957). It is known that the synthesis of protein and other cellular components in a species depends on its genome. Two to three types of proteins could be detected and identified from mature salmon eggs (Young and Phinney, 1951; Jared and Wallace, 1968; Markert and Vanstone, 1968, 1971). The concept of heterogeneity of yolk protein in fish was developed by Alabaster and Durban (1964); Moller (1970) and Wilkins (1972). These heterogeneity in the protein types is stated to be related with genetic variants (Mano and Lipman, 1964; Wallace *et al.*, 1966; Taborsky, 1974).

The biochemical pattern for proteins, phospholipids and ribonucleic acid from the mature eggs of five major carps, viz., *Labeo rohita*, *Cirrhinus mrigala*, *Cyprinus carpio*, *Hypophthalmichthys molitrix* and *Ctenopharyngodon idella* have been studied through polyacrylamide gel electrophoresis for protein, thin layer chromatography in silica gel G for phospholipid and agarose gel electrophoresis for RNA. The biochemical patterns have shown much heterogeneity both in quantity and quality. The authors have suggested to consider the biochemical pattern of the mature eggs as an additional parameter for characterisation and classification of the above mentioned fishes (Mukhopadhyay *et al.*, 1981, 1984, 1986).

Sackin (1969) suggested a new parameter in classification of living objects and opined that amino acid sequence of some particular type of protein from different species should also differ. He thus claimed that the study of the proteins has much potentiality in taxonomical procedure specially for distantly related organisms, when morphological characters are difficult to study.

Whitt (1987) advocated to utilise isozyme tissue pattern for systematic and evolutionary analysis. Padhi (1987) gave stress on isozyme research in the effective conservation and management of capture fisheries resources. Padhi and Khuda Buksh (1989) studied lactate dehydrogenase isozyme pattern in four species of *Mugil*, namely *M. cephalus*, *M. corsula*, *M. parisi* and *M. tale* collected from estuarine water near Bay of Bengal through polyacrylamide gel electrophoresis technique. Lactic dehydrogenase banding pattern in some tissues showed inter-specific variations. Chatterjee and Dhar
(1985) reported species-specific pattern of lactate dehydrogenase isozyme in five snakeheads and emphasized on its tremendous application in conservation and management of captive fisheries resources.

Some polymorphic electrophoretic markers—the serum transferrin, blood malic dehydrogenase esterase have been detected and used in the fish breeding experiments in *C. carpio* (Brody et al., 1976; Moav et al., 1976). This study helps to select fish not only differing in the species but also in the strains.

Barat et al. (1992) studied electrophoretic patterns of transferrin in thirty-four teleostean fish species belonging to 28 genera and 18 families through polyacrylamide gel electrophoresis. The majority of the species had either one or two band phenotype(s) suggesting homozygous and heterozygous states at the transferrin loci. The authors also suggested to consider the biochemical factors as substitute of morphotaxonomy. Suttan et al. (1983) used simple immunological techniques and electrofocussing pattern to identify trout and salmon broods. According to Poonniah et al. (1994), isoelectric focussing is a better tool than ordinary electrophoretic study of isozyme.

Reviewing in the field of DNA, fingerprinting have been attempted in detecting genetic variation among fishes and fish population (Waldman and Wirgin, 1993; Wright, 1993; Carvalho and Pitcherteds, 1994; Fergusson et al., 1995; O’ Reilly and Wright, 1995). According to Andrew (1991), DNA fingerprinting is a powerful tool for the identification of individuals and pedigrees. The results of DNA fingerprinting study in tilapia, *Oreochromis niloticus* suggested the application of DNA fingerprinting in aquaculture genetics, including assessment of inbreeding rate as genetic markers to identify individuals and groups, and labelling brood stocks. Hartley et al. (1994) stated DNA fingerprinting technique is a powerful additional tool for population genetic analysis in salmonid fishes. DNA fingerprinting revealed genetic variability among individuals in all population studies. Padhi (1996) stated about natural genetic variation at DNA level in different species, individuals, populations (stocks) and higher order of taxonomical organization. Jaysankar (1997) applied RAPD techniques in genome analysis by detecting DNA fragments of unknown sequence in Indian mackrel (*Rastrelliger kanagurta*) and king seer (*Scomberomorus commerson*). Majumdar et al. (1997) studied DNA fingerprinting pattern of Indian major carps and tilapia. Patterns of DNA fingerprint were compared in three strains of angel fish-black marble angel fish (BMA), gold marble angle fish (GMA) and silver angel fish (SAF) through RAPD technique. It was observed that the resemblance between patterns of BMA and GMA was greater than the resemblance to SAF. According to the authors, DNA (RAPD) fingerprinting is an useful parameter to establish genetic relationships among the strains (Degani et al., 1997).
Kapila and Kapila (1996) observed that isozyme and structural proteins did not detect sufficient variability among fish species. So far accurate identification of the fish species, nucleotide sequence of fish DNA using agarose gel electrophoresis is regarded as a better tool. DNA level research in fish is in its infancy, especially in case of tropical fishes. It is widely accepted that the synthesis of RNA mainly depends upon transcription of DNA in the nucleus and thus it is gene controlled. X-ray crystallography of RNA may be considered as an additional tool for the characterisation of fish species.

Fish as a species has given a big blow to the theory put forwarded by Mayr et al. (1953) on speciation basing on reproductive isolation. In case of fish, several interspecific fertile hybrids have been produced, leading to hybrid vigour (heterosis). Israel and Hungary have exploited heterosis in their commercial culture. In India, Kowtal (1987) have produced 36 intergeneric and inter-specific hybrids, many of which are fertile.

Till to-day, classification of fishes of the world is based on conventional parameters. For field identification of fishes, the morphological characters still play the major role and all other methods only supplements the identification. Non-conventional parameters-cytotaxonomical/chemotaxonomical parameters may be helpful as an additional tool for confirmation of specific identity where morphological characters are overlapping. The authors hope, in future, fish taxonomists working on conventional parameters, cytotaxonomical and chemotaxonomical parameters, will come closer and take a joint venture to classify fishes of the world, blending all parameters, so that the classification of fishes becomes a foolproof one as far as practicable.

According to Nelson (1994), the study of fish taxonomy is very much exciting. Many school of thoughts exists with difference of opinion. Fish taxonomists have ample scope to discover new taxa and do answer phylogenetic and biographic questions.

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