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Popular Article

Application of Modern Tools and Techniques in Fish Taxonomy

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Abstract

Species identification is essential for identifying and characterizing biodiversity. Conventional morphology-based taxonomy often fails to offer unambiguous identification of groups showing little evolutionary differentiation, cryptic members of species complexes, members of closely related species that can only be identified at a particular life stage. The various modern tools such as karyo-taxonomy, chemotaxonomy, DNA barcoding and DNA polymorphism help us by providing additional characters to the morphological character-based identification of fishes. Molecular genetics provides a powerful tool for conservation of species protected by international regulations. In fisheries and aquaculture sector, inter-species and intra-species genetic variations are very common. Accurate genetic stock characterization is necessary for identification of new species. Development of DNA based molecular marker might be useful for studying genetic variability within a population. Allozymes, mitochondrial DNA, microsatellites, Single Nucleotide Polymorphism are commonly used DNA markers.

INTRODUCTION

Fish (in general) is a cold-blooded aquatic organism that breathes with gills and swims with fins; they are categorized as Finfish and Shellfish (*Nelson, 2006)*). Finfish are cold-blooded aquatic vertebrates that have gills, fins with rays, and scales covering the body. Shellfish are cold-blooded aquatic invertebrate that have gills, various types of locomotory organs and a shell/ exoskeleton covering the body. They include crustaceans and mollusc.

It is estimated that fish have been on the planet for 450 million years. For these gill-bearing creatures to survive and breed, they require an aquatic environment. Most of these creatures are

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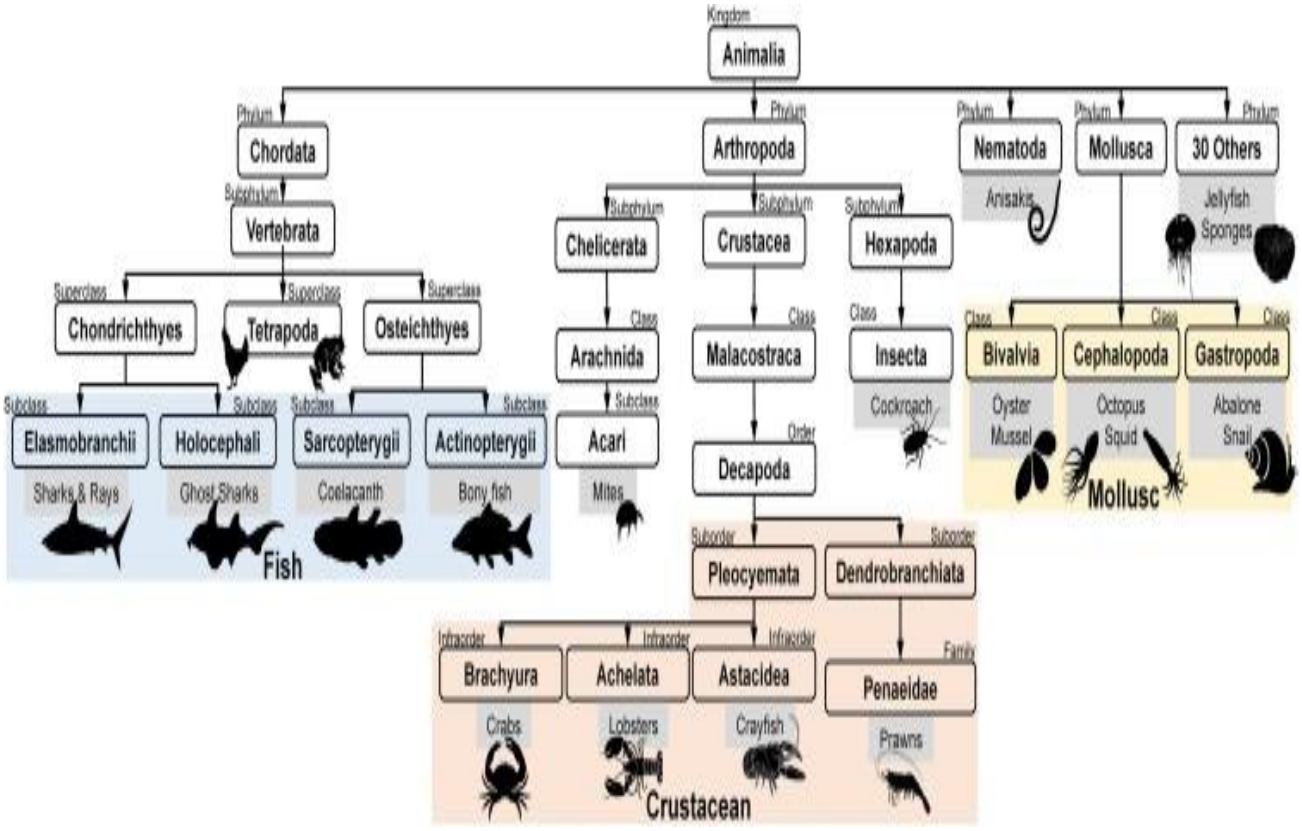
craniates and do not have digitized limbs. Fish are members of the sibling group known as tunicates, which collectively comprise olfactores. The process of fish evolution has gained interest because of various environmental influences that have altered fish. The shape of the bottom, its depth, current, and temperature and salinity of the water are other features. Numerous fish species have adapted to their natural environment.

This becomes more difficult or impossible to identify. Moreover, identifying the early life stages (eggs and larvae) is significantly more difficult than identifying adults. Owing to tremendous advancements in molecular biology, particularly in clinical research, it is now possible to identify any species in almost any type of organic substrate, including blood, fins, and muscle. The information regarding genetic diversity and variation has Animal Diversity. The advent of DNA cloning and sequencing methods has immensely contributed to the development of population genetics and molecular taxonomy. The fields of population genetics and molecular taxonomy have been transformed using contemporary techniques.



Source: Ruethers et. al., 2018

Fig 1 Classification of fish

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Taxonomy of Fish

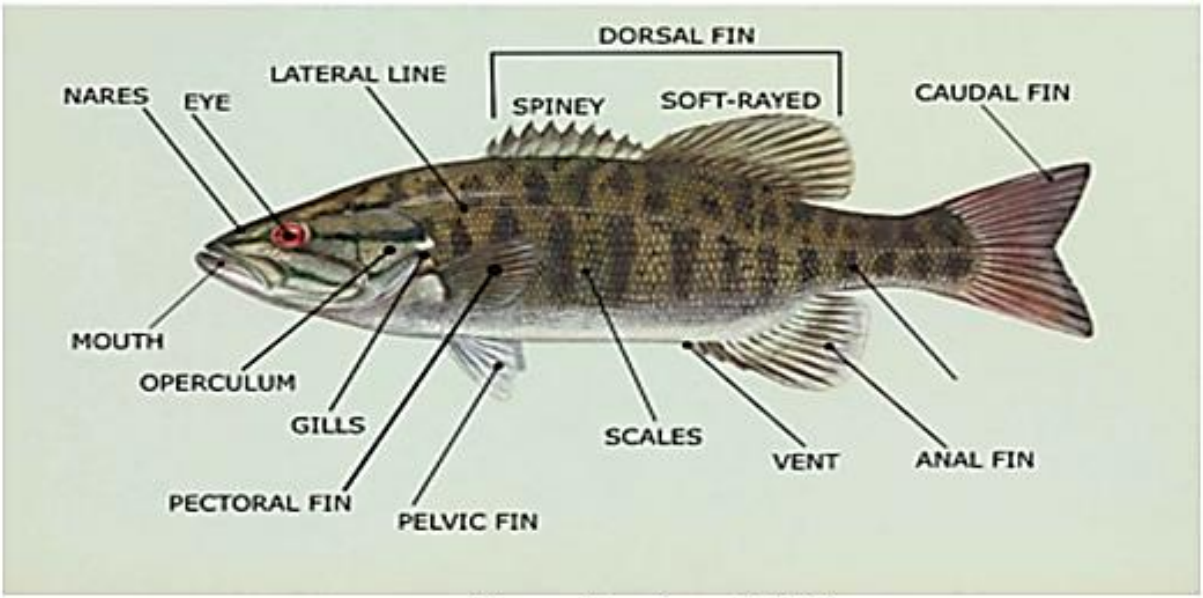
A stable naming and indexing system are essential to global communication about organisms, and such a system is maintained by the International Code of Zoological Nomenclature. The science of taxonomy, among other things, provides the methods and the manuals for the identification of organisms. Although largely based on observations of characters that local fishers may also use, taxonomic research offers the tools for a regionally and globally valid identification.

The fish contained within this informative literature were arranged in a provisional system of classification. The classification used within the Historia Piscium was further developed by Carl Linnaeus, the "father of modern taxonomy". In traditional classification fish divides into three extant classes Agnetha (jawless fish), Chondrichthyes (sharks, rays. Skates) and Osteichthyes (Bony fishes) (*Benton et. al., 1998*)

There are approximately 34,000 species of creatures classified as vertebrates (phylum Chordata) that can be found worldwide in both fresh and saltwater. From the earliest jawless lampreys and hagfishes to cartilaginous sharks, skates, and rays to numerous and varied bony fishes, there are many different types of living things. The majority of fish species have cold blood, but opah (Lampris guttatus) is a warm-blooded species.

Morphology In Fish Taxonomy

Historically, the basic framework of the classification and evolution of fishes has come from analysis of their morphology (*Miya et. al., 2007*). Ultimately, morphology of fishes has served as the basis of much of what is known about the evolutionary relationships among fishes, and these hypotheses of relationships are then translated into classifications Fish morphology refers to the study



Source: Negash et. al., 2018

Fig 2 Important Morphological of Fish characters

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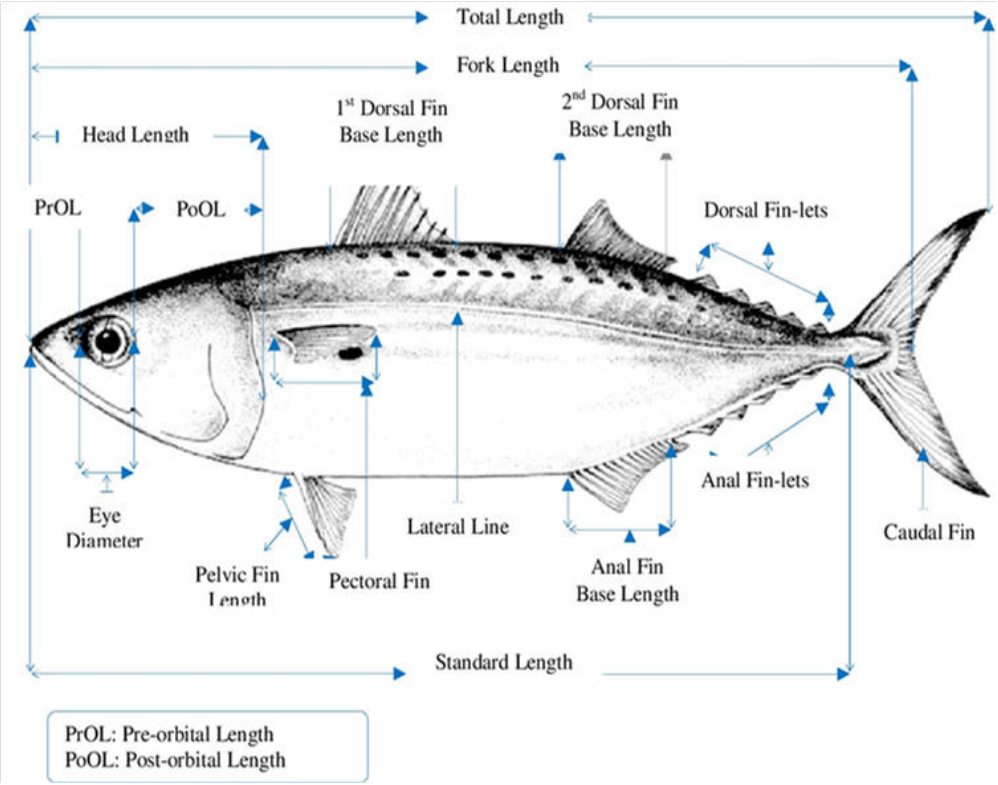
of the external form and structure of fish, including their overall shape, size, and arrangement of body parts. It focuses on the physical characteristics and variations among different fish species. The shape, size, and structure of body parts permit different fishes to live in different environments or in different parts of the same environment. The external anatomy of a fish can reveals a great deal about where and how it lives.

Morphometrics In Fish Taxonomy

The measurable characteristics shared by all fish species were morphometric. Morphometric characters are frequently used to identify fish species and determine whether a stock is heterogeneous or homogeneous. The length-weight relationship of fish is a useful index for evaluating growth, survival, maturity, reproduction, and general well-being (*Syarif et. al.,2021*). A somewhat braided collection of extensive statistical techniques called morphometrics is used to examine variability in an organism's size and shape. It is acknowledged that morphometric variations between species stocks are crucial for assessing population structure and providing a foundation for stock identification. Improvements in morphometrics have made it possible to identify stocks of species with distinct morphological traits, separate shapes from size variation, test and display shape differences, and better manage the species. In order to stay current with knowledge and obtain more accurate data, traditional or standard morphometry has occasionally been improved with cutting-edge techniques thanks to technological advancements like geometric morphometrics, image analysis, principal component analysis, truss network analysis, and multivariate analysis, among many others

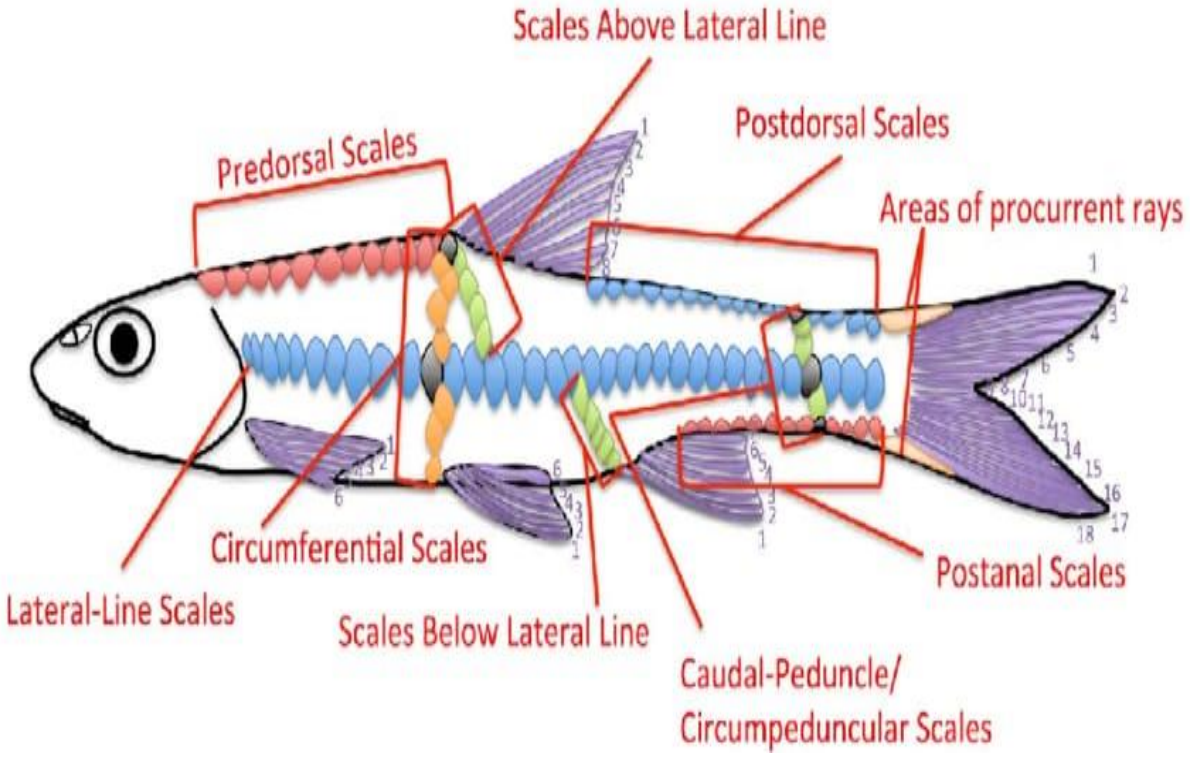


Source: Rawat *et. al.,* 2017

Fig 3 Important morphometric characters

Meristics In Fish Taxonamey

Meristic is a quantitative calculation of the characteristics (body parts) of fish, for example the number and size of fins. Meristic characters that are counted as many as 9 characters, among others: Dorsal Rays, Anal Rays, Pectoral Rays, Ventral Rays, Caudal Rays, Linea Lateralis, Caudal Peduncle Scale, Transverse Scale, Predorsal Scale (Haryono et. al., 2001) Fish taxonomy research has made extensive use of countable meristic traits. In contrast to physical characteristics, such as color or dimensions, meristic traits are typically fixed during or prior to metamorphosis and do not change throughout the course of an individual's lifetime. To identify any differences across species or populations within a species, each meristic feature should be handled independently and their frequency distribution should be provided. The various modern tools such as karyo-taxonomy, chemotaxonomy, DNA barcoding and DNA polymorphism helps by providing additional characters to the morphological character-based identification of fishes. Molecular genetics provides a powerful tool for conservation of species protected by international regulations.



Source: Armbruster, J. W. (2012).

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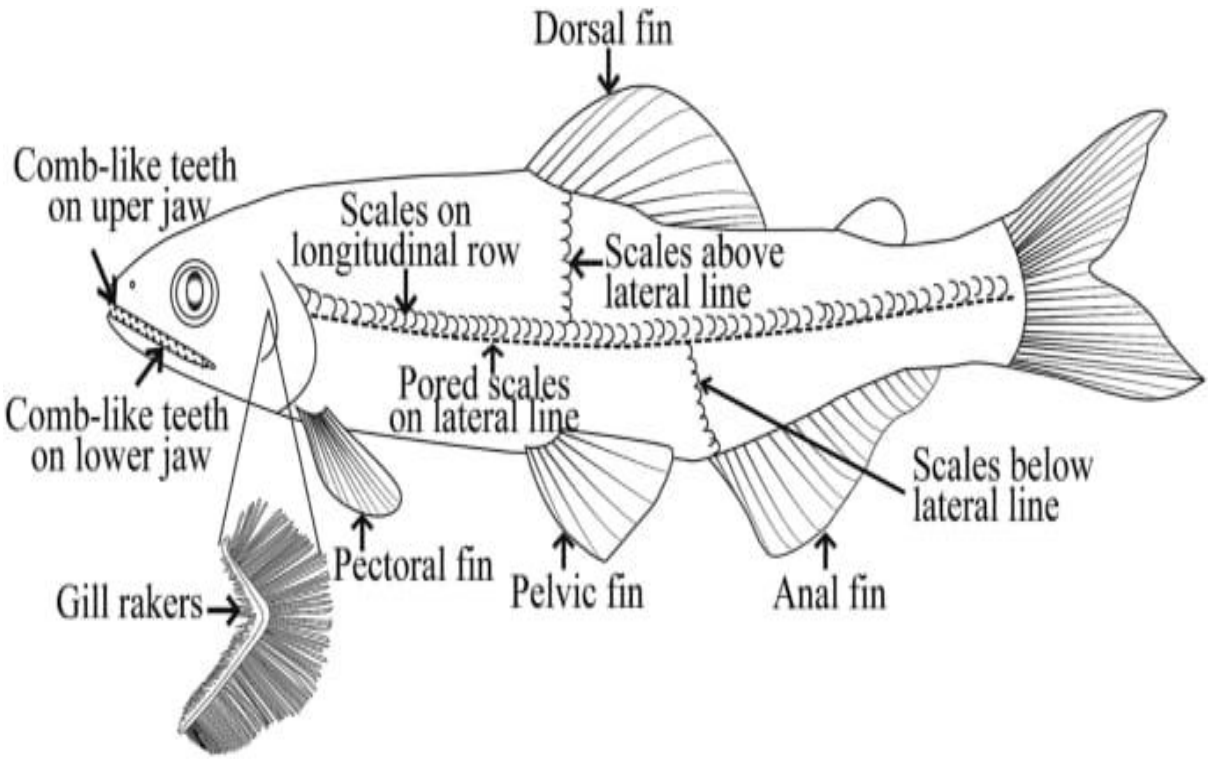

Source: Ha, L. M., & Iguchi, K. I. (2021)

Fig 4 Important meristic characters

Application of Modern Tools and Technology in Fish Taxonomy

Fish taxonomy, the science of classifying fish species, has traditionally relied on morphological characteristics such as fin structure, scale patterns, and body shape. However, advancements in technology and scientific techniques have revolutionized this field.

Here are some of the modern tools and techniques currently applied in fish taxonomy:

1. Molecular Techniques DNA Barcoding: DNA barcoding involves sequencing a short, standardized region of the genome (*Singh et. al., 2016*), which is typically performed using the mitochondrial cytochrome c oxidase I (COI) gene, even from small or damaged samples, and can distinguish between closely related species. Next-Generation Sequencing (NGS): NGS technologies provide comprehensive genomic data, enabling detailed phylogenetic studies and the discovery of cryptic species (species that are morphologically similar but genetically distinct). Techniques such as RAD-seq (Restriction site Associated DNA Sequencing) and whole-genome sequencing are commonly used. Environmental DNA (eDNA): eDNA involves collecting DNA from environmental samples (e.g., water) to detect the presence of fish species. This non-invasive method is particularly useful for monitoring biodiversity, detecting invasive species, and studying species in inaccessible or protected habitats.

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2. Morphometrics and Imaging Geometric Morphometrics: This technique uses statistical analysis to study the shape of organisms. By analysing coordinates of specific morphological landmarks on fish bodies, researchers can quantify shape variations and better understand evolutionary relationships. High-Resolution Imaging: Tools like CT (Computed Tomography) scans and MRI (Magnetic Resonance Imaging) provide detailed, 3D images of fish anatomy, allowing taxonomists to examine internal structures without dissection. This is particularly useful for studying delicate or rare specimens. Automated Image Analysis: Machine learning algorithms and software can analyse images of fish, identifying species based on morphological features. This automation accelerates the identification process and reduces human error.
3. Bioinformatics and Databases Phylogenetic Analysis Software: Software tools such as MEGA (Molecular Evolutionary Genetics Analysis), BEAST (Bayesian Evolutionary Analysis Sampling Trees), and Mr Bayes are used for constructing and analysing phylogenetic trees, helping to elucidate evolutionary relationships among species. Genetic Databases: Public databases like GenBank, Fish Base, and the Barcode of Life Data System (BOLD) provide repositories of genetic and taxonomic information. These resources support research by offering access to a vast number of genetic sequences and taxonomic data. Species Distribution Modelling: Geographic Information Systems (GIS) and ecological niche modelling predict the distribution of fish species based on environmental variables and species occurrence data. These models help in understanding habitat preferences and potential impacts of climate change on fish distributions.
4. Integrative Taxonomy Combined Approaches: Modern fish taxonomy often employs an integrative approach, combining molecular, morphological, ecological, and behavioral data. This holistic method ensures more robust species delimitation and a comprehensive understanding of biodiversity.

Importance of Fish Taxonomy

Fish identification is important for the export of processed edible fish because consumers are aware of proper fish identification and both scientific and colloquial names (Principles of Taxonomy).

- This reveals a wealth of fascinating ichthyological evolutionary phenomena.
  developed a strategy for all biological issues necessary for maintaining the equilibrium and health of fish biology.
- Creates handbooks, revisions, monographs, catalogues, keys, etc.

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- stay away from alien species that can damage natural ecosystems and wildlife.
- Fish identification accuracy aids the creation and maintenance of museums.
- Fish identification is important for the export of processed edible fish because consumers are aware of proper fish identification, in addition to their common and scientific names.
- For aquaculture to be effective, it is crucial to correctly identify certain prospective finfish species.
- Before beginning any biological research, one needs to find the correct scientific name for any organism on which they plan to operate.
- The correct scientific name is a useful label that can be used to access several types of information about that creature.

CONCLUTION

Fish classification is the act of identifying and recognizing fish species and families relying on their features. It identifies and categorizes the target fish into species relying on the similarity with the representative specimen image. This process is essential for feature extraction, pattern and contour matching, determination of behavioural and physical traits, and quality control of fish species Fish classification is considered helpful for fish population assessments and counting, monitoring ecosystems, and description of fish associations. Precise fish species recognition is vital because of the legal restrictions on fishing practices, especially when their existence is endangered or threatened. The application of modern tools and techniques in fish taxonomy has greatly enhanced the accuracy, efficiency, and scope of species identification and classification. Molecular techniques, advanced imaging, bioinformatics, and integrative approaches are pivotal in addressing the challenges of traditional taxonomy, such as cryptic species and incomplete morphological data. As technology continues to advance, these tools will further refine our understanding of fish biodiversity and evolution.

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