INTEGRATED TAXONOMIC TECHNIQUES FOR MARINE BIODIVERSITY CONSERVATION

ICAR Sponsored SHORT COURSE

18-28 February 2025

Organized by
Indian Council of Agricultural Research
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

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Course Manual

ICAR Sponsored Short course on

Integrated Taxonomic techniques for Marine Biodiversity Conservation

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ICAR - Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
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2. Taxonomy -Its Importance And Relevance Today

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Taxonomy, in a biological sense, is the branch of science concerned with the classification of organisms. It includes the processes of naming, organizing hierarchically, describing, and identifying various taxa. Marine taxonomy is essential for comprehending species diversity, supporting conservation initiatives, and assessing the potential effects of climate change and habitat loss. Due to the intricacy and variety of marine organisms, this discipline is vital for promoting marine exploration.

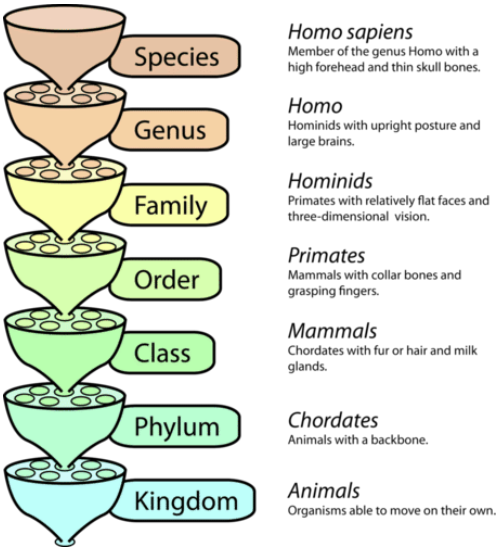
WHY TAXONOMY?

Taxonomy is the key to life, and plays a crucial role in understanding life, serving not only as a means to differentiate species but also as a gateway to insights about biodiversity. To gain a comprehensive understanding of all life on Earth, it is essential to support taxonomy, as it serves as the foundation for this research. The initial step involves assigning a name to a species, which paves the way for deeper insights into its evolution, ecology, and biology. The names assigned to species, being the sole standardized metric of biodiversity, are vital for effectively communicating information regarding the natural world. The species name acts as the first of three 'keys' that unlock the vast repository of knowledge about nature. Nevertheless, advancements in knowledge can lead to evolving perceptions of what constitutes each species over time. Online species databases are enhancing access to this information and expertise, offering a convenient method to stay informed about species nomenclature and classification.

Anthropogenic impacts on marine environments are primarily assessed through shifts in species distribution and abundance. The decline of specific populations can diminish the genetic diversity within a species, potentially jeopardizing its survival. Additionally, a reduction in ecosystem diversity limits the habitats available to species, further threatening their existence. Central to these interconnected consequences is the species itself. Identifying individual species is crucial for unlocking insights into community structure and function. However, across various marine ecosystems, the capacity to accurately identify present species is increasingly compromised due to a dwindling number of scientists equipped with the expertise to understand and document biodiversity. Furthermore, in numerous ecosystems, species diversity remains inadequately characterized, with many species and entire taxonomic groups still undescribed.

CLASSIFICATION

The classification system we use today was established by Carl Linnaeus in 1700 and serves as a crucial instrument in biological research and the conservation of biodiversity. The Linnaean system of classification consists of a hierarchy of groupings, called **taxa**(singular, taxon). Taxa range from the kingdom to the species. The **kingdom** is the largest and most inclusive grouping. It consists of organisms that share just a few basic similarities. Examples are the plant and animal kingdoms. The **species** is the smallest and most exclusive grouping. It consists of organisms that are similar enough to produce fertile offspring together. Closely related species are grouped together in a **genus.**



Without a precise classification framework and a systematic naming convention to delineate species relationships, scientists would face significant challenges in accurately characterizing the connections among various species. Gaining insight into these relationships is essential for forecasting how ecosystems may be influenced by both human activities and natural events. Taxonomy plays a vital role in the preservation of biodiversity. It allows for a more thorough analysis of species data, enabling researchers to assess the diversity within a community and understand how environmental pressures may impact these species. Phylogenetic trees, which illustrate the familial relationships among species, are instrumental in predicting the environmental effects on individual species and their relatives.

There are several stages of taxonomy such as

- Alpha taxonomy: In this stage species are identified and characterized on the basis of gross morphological features.
- Beta taxonomy: In this stage species are arranged from lower to higher categories, i.e., hierarchical system of classification.
- Gamma taxonomy: In this stage intraspecific differences and evolutionary history are studied

Steps to be used in fish taxonomy

Steps:

1. Collection from wild/harbours
2. The fish is to be first cleaned well, with all debris and slime removed. It is then to be spread out on a thermocol with all fins expanded to get full coverage.
3. A photograph is to be taken in fresh condition to note the colour in fresh
4. All external characters is to be noted down The morpho and meristic features of the fish is to be measured using the basic pictures

HISTORY OF TAXONOMY

Taxonomy may be one of the oldest sciences, and is even referenced in the Bible and Sikh scriptures about 2,500 and1,000 years ago respectively. The Bible says that God asked man to name all species (Boero 2010) and the Sikh scriptures reported there were 8.4 million 'species' on Earth.

Ichthyology: The Study of Fishes

Ichthyology is the scientific study of fishes. The term originates from the Greek word *ichthy*, derived from *ixthu*, a form of *ixthus*, meaning "fish." This field encompasses the study of bony fish, cartilaginous fish, and jawless fish. Historically, ichthyologists were naturalists primarily focused on identifying and describing fish species they encountered.

Fish represent the most diverse group of vertebrates, comprising more than half of all vertebrate species. To date, approximately 33,000 species of fish have been documented. Modern ichthyology extends beyond classification, delving into fish populations, their ecological needs, and fisheries management.

The origins of ichthyology trace back to the Upper Paleolithic period, around 40,000 years ago. Over centuries, it has evolved into a well-established scientific discipline. While fish would continue to thrive without scientific study, our understanding of their vast diversity results from centuries of dedicated research conducted by experts worldwide.

In the modern era, ichthyology incorporates advanced technologies such as DNA analysis, acoustic tracking, and ecological modeling to study fish species and their interactions with the environment. This field continues to evolve, providing essential knowledge for biodiversity conservation and sustainable resource management.

Early Ichthyology

The formal study of ichthyology dates back to the Greek philosopher and naturalist Aristotle (335–322 B.C.E.), who made significant contributions to the classification of fish. He was the first to develop a taxonomic system, accurately describing 117 Mediterranean fish species. Aristotle also distinguished fish from marine mammals by noting their anatomical and behavioral differences. However, his classification system contained inaccuracies due to the limited scientific knowledge of the time.

By the first century B.C.E., the Romans had advanced their understanding of fish through aquaculture. The Roman scholar Pliny the Elder documented their practice of breeding fish, particularly trout and mullet, in artificial ponds. The Romans developed sophisticated aquaculture techniques, constructing fish farms near coastal areas and using controlled breeding methods. These innovations provided a reliable food source and influenced early fisheries management, laying the foundation for modern aquaculture.

The Development of Modern Ichthyology

From the 16th century onward, several scholars made significant contributions to ichthyology. Pierre Belon, Guillaume Rondelet, and Hippolyte Salviani extensively studied and documented Mediterranean and European fish species.

Pierre Belon traveled across the eastern Mediterranean between 1547 and 1550, gathering valuable scientific knowledge. His most influential work, *De Aquatilibus Libri Duo*, documented approximately 110 fish species. Although his illustrations were somewhat crude, they were generally identifiable. Belon's comparative approach to fish and other vertebrates marked an early step toward comparative anatomy in ichthyology.

Guillaume Rondelet (1507–1557) provided a more comprehensive contribution in *De Piscibus Marinum*, where he described 197 marine species and 47 freshwater species. His descriptions were more detailed, and his illustrations were significantly more accurate than those of Belon. Rondelet’s work advanced ichthyological studies by providing a more precise and systematic approach to fish classification.

Hippolyte Salviani (1514–1572), a Roman ichthyologist, focused on the fishes of Italy. He produced detailed illustrations of 92 species on 76 plates. Unlike Belon and Rondelet, Salviani did not attempt a natural classification system, but his artistic accuracy provided valuable resources for later ichthyologists.

Meanwhile, W. Piso and G. Margrav studied the fauna of Brazil, publishing their findings in *Historia Naturalis Braziliae* (1648). The fourth book of this work was dedicated to fishes, describing around 100 species with accompanying colored illustrations. This was one of the earliest ichthyological works covering South American fish species, contributing to the global expansion of fish studies.

During the 17th century, scholars conducted anatomical research on fishes. Giovanni Alfonso Borelli (1608–1679) wrote *De Motu Animalium* (1680), explaining the mechanics of fish swimming and the function of the air bladder. Marcello Malpighi (1628–1694) examined the optic nerve of the swordfish, while Jan Swammerdam (1637–1680) described fish intestines. Joseph Duverney (1648–1730) furthered the study of fish respiratory organs. These anatomical discoveries laid the groundwork for modern functional morphology in ichthyology.