



ZOOLOGICAL SURVEY OF INDIA

6 AUGUST 2025

CREATURE CHRONICLES

— WILD HEARTS, WISE MINDS —

On August 6th, we proudly present a special edition of our magazine to honour a groundbreaking achievement in the Zoological Survey of India (ZSI) — the appointment of Dr. Dhriti Banerjee as the first woman director in its illustrious history. This edition features a collection of insightful and engaging articles penned by talented women scientists, each contributing their unique perspectives and expertise in the field of zoology. Join us as we celebrate not only Dr. Banerjee's remarkable leadership but also the voices of women who are shaping the future of science. Together, we are redefining the narrative of women in zoology.

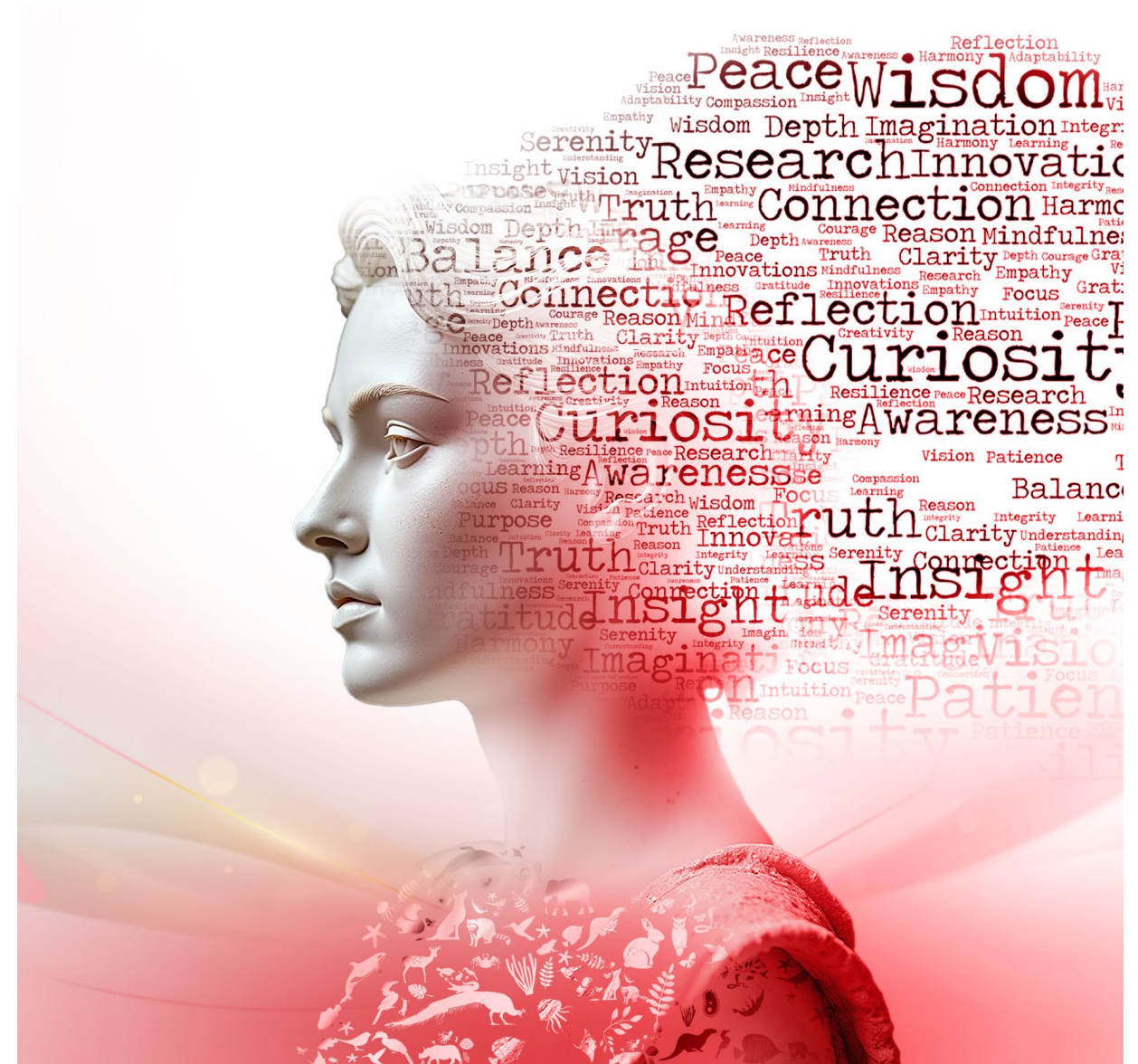




Creature Chronicles

WILD HEART, WISE MINDS

A Contribution by the Women Scientists of ZSI



Zoological Survey of India



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EXTRAORDINARY

— Wings of Wisdom —



Preface

It is with immense pride and profound satisfaction that I present "Creature Chronicles: Wise Hearts and Wild Minds"—an extraordinary collection of scientific narratives penned by the remarkable women scientists of the Zoological Survey of India. This magazine stands as a testament to the intellectual prowess, dedication, and pioneering spirit that defines the women researchers who have devoted their careers to unraveling the mysteries of India's magnificent biodiversity.

From the microscopic realms of dinoflagellates and testate amoebae to the ancient stories etched in the geological legacy, these 36 articles traverse the entire spectrum of life sciences with remarkable depth and accessibility. Our women scientists have transformed complex scientific concepts into engaging narratives that bridge the gap between rigorous research and public understanding—a skill that requires not only scientific expertise but also exceptional communication abilities.

The title "Creature Chronicles: Wise Hearts and Wild Minds" perfectly encapsulates the essence of this collection. It reflects both the passionate dedication ("wise hearts") and the innovative scientific thinking ("wild minds") that our women scientists bring to their research. In an era where scientific literacy is more important than ever, our women scientists have stepped forward as ambassadors of knowledge, making complex biological concepts accessible to students, policymakers and the general public.

As Director of ZSI, I have witnessed the dedication these scientists bring to their work—the long hours in remote field stations, the patience required for taxonomic identification, the innovative approaches to conservation challenges, and the commitment to mentoring the next generation of researchers. This magazine captures not just their scientific achievements but also their passion for discovery and their commitment to protecting India's natural heritage for future generations.

I appreciate the efforts of Dr. C. Raghunathan, Divisional in Charge, Publication Division whose valuable inputs and dedicated efforts have made this remarkable compilation possible.

I invite readers to embark on this journey through India's biodiversity, guided by some of the most knowledgeable and articulate scientists in their respective fields. Whether you are a student beginning your scientific journey, an educator seeking inspiration, or simply someone curious about the natural world, these articles will inform, inspire, and perhaps ignite a lifelong passion for understanding and protecting our planet's incredible diversity of life.

Dr. Dhriti Banerjee
Director
Zoological Survey of India

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Dr. Bindu L

Microfauna Hidden in Moss: Testate Amoebae as Nature's Bioindicators



Microorganisms, though often overlooked, play an indispensable role in maintaining ecological balance. Among them, testate amoebae stand out as a fascinating yet underexplored group of protozoans.

covered by an extracellular shell (test), mostly with a single main opening which extrude pseudopodia.

They are divided into two main groups based on the morphology of pseudopodia-

distributed worldwide from the tropics to the polar regions and occur in most terrestrial, freshwater, brackish and marine habitats, but are very abundant and diverse in the sphagnum mosses. They are a good model for taxonomy and evolutionary studies because of their abundance, diversity and presence of a test which is a reliable taxonomic feature for the diagnosis of species. Testate amoebae are very sensitive and quickly respond to environmental changes which makes them valuable biomonitors.

From Sample to Specimen Slide

Environmental samples for Testate Amoebae studies can be collected from diverse biotopes such as soil, water and moss. Using a spatula, samples are scraped and stored in polythene bags.

Testate amoebae are unicellular eukaryotic free-living protozoans in which the amoeboid cells are

Arcellinida (with lobose pseudopodia) and Euglyphida (with filose pseudopodia). Testate amoebae are

Accurate locality details, including GPS data, must be recorded. For processing, the non-flooded Petri dish method described by Foissner (1992) is followed. Samples (10-50 g) are air-dried and stored in plastic bags until examined. Reactivation occurs through saturation with distilled water, and cultures are routinely inspected. Microscopic examination involves preparing permanent slide mounts, which are observed under a high-magnification microscope equipped with a camera for species identification. These curated slides serve as references for further research. To ensure long-term accessibility and verification, permanent slides can be deposited in nationally recognized research institutions such as the Zoological Survey of India, where they contribute to scientific archives and future taxonomic studies.

Significance as Bioindicator Species

Testate amoebae use protective shells to exist as unicellular protists which function as essential bioindicators for climate change studies because

they display high sensitivity to environmental changes. The community distributions of these microorganisms depend heavily on water table depth together with humidity conditions which makes them suitable indicators for reconstructing paleoclimate patterns. Changes in traits of the protective-shelled testate amoebae correlate with ecosystem reactions

to climate changes which provide knowledge about environmental stability under different climate conditions.

The ability of testate amoebae to detect both hydrological changes and pollution levels makes them suitable bioindicators of ecosystem health and their assemblages clearly react to particular environmental factors.

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Cyclopyxis bharateii Bindu 2012



Galeripora scutelliformis Playfair, 1918

The existence, absence and variety of testate amoebae can indicate alterations in the conditions of the habitat, for instance hydrological characteristics or in the pollution level. For example, some species are adapted to acidic conditions while others to near neutral conditions hence the use of the species to deduce changes in pH and moisture levels over the years. Some species of *Arcella* genus can live well in water with low nutrient concentration but are affected by polluted water due to high levels of heavy metals and organic pollutants. Furthermore, the *Diffugia* species exhibited changes in community about eutrophication and change of sediment related to anthropogenic influence. Such findings depict testate amoebae as bioindicators that could

effectively show environmental alterations caused by pollution, hence being relevant in monitoring ecosystems and helping in the conservation of ecosystems. Besides being helpful in present day

environmental analysis, testate amoebae are also helpful in paleoecology. Fossils preserve their physical bodies, allowing their remains can be used to help study past conditions and thus long-term changes in the climate and its effects on the ecological systems.

As global environmental challenges intensify, a deeper understanding of microscopic lifeforms like testate amoebae becomes more crucial than ever. Further research should be conducted on testate amoebae to develop more precise site-specific research concerning the function of these organisms in ecological assessment, especially in disturbed habitats influenced by people.

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Dr. G. Sivaleela

“When Life gives you Lemons, you make Lemonade” – The Story of Marine Sponges



Marine sponges are the earliest multicellular organisms that have carved a space for themselves in the oceans of the world. Fossil evidence suggests that they date back to the Precambrian period. The primordial soup gave rise to the unicellular protozoans, and the protozoans then aggregated and evolved to form these multicellular organisms. They possess what is called a **cellular grade of organisation**. It can be postulated that unicellular organisms with unique and varied capabilities thought it would be better to work in unison. They have no organs or organ systems. Despite being so primitive, they have successfully survived a minimum of three ice ages. How are they so successful? There are plenty of reasons for this. They have very low metabolic demand, and

this is an important factor considering they survived the Permian-Triassic global mass extinction, which wiped out close to 90% of marine life. They have stuck by the Darwinian principle of “**use it or lose it**”, and boy, did they use it. By it, we mean the DNA plasticity of the animal. In due course of time, the animal has gone from simple

Asconoid type to **Syconoid** type and finally reached the **Leuconoid** type of marine sponges. What are Asconoid, Syconoid and Leuconoid sponges? The body of the sponges is just cells gathered together, as we mentioned earlier (to put it in layman's terms), but when they did aggregate to perform a unified function of reproduction and

How are they so successful? There are plenty of reasons for this. They have very low metabolic demand, and this is an important factor considering they survived the Permian-Triassic global mass extinction, which wiped out close to 90% of marine life. They have stuck by the Darwinian principle of “**use it or lose it**”, and boy, did they use it

survival, they had to “**take form**”. A sponge is put under “Phylum Porifera”; porifera, when translated, means “pore bearing”. The cells aggregated to form pore-bearing animals. Why do they need pores? As we all know, all life started from the marine environ – the primordial soup. The cells, when taking form, know that they have to ingest in unison to survive, so they left pores for the water to make its way in and out of the body. This is what we call ostia and oscula. Ostia are pores that allow water to enter the animal’s body, and oscula are pores that allow water to exit the body. How can they regulate the flow of water around them? Some cells assumed the role of regulating water currents around them. These cells are flagellated and did the logical thing, and lined the inner chambers of the animal and were accessorized with flagella. These cells are the choanocytes or collar cells. The cells knew that if they had to survive the harsh and constantly changing conditions of the ocean, they had to develop some kind of protective layer. Some cells evolved to form a thin, flat and tightly packed

outer layer. These cells are called the pinacocytes and are analogous to our integumentary system in many ways. If the pinacocytes are tightly packed, how can these animals bear pores, one might wonder. This is where this animal shows its **DNA plasticity**. A single cell opens out to form the pores. Maybe a single cell expanded and then opened out to form a ring-like structure to allow water to enter and exit freely. These cells are called porocytes. As the animal learnt to work together, other cells with more functions aided in the better survival of the animal. Cells that maintained motility and roamed around the animal, akin to “floaters” in

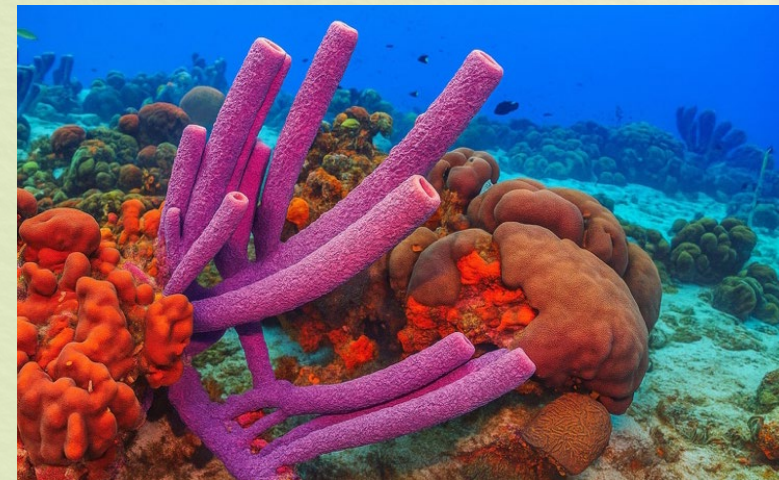


Old forms of Sponges
(Cambrian Period) –
Archaeocyatha

Credits: <https://en.wikipedia.org/wiki/Archaeocyatha>

Creative Rendering:
Kamaleshwaran E., Loyola
College (Autonomous),
Chennai.

a corporate system, are called archaeocytes or amoebocytes. These cells are totipotent, that is, they can become any cells that the animal needs. In humans, the zygote and the early blastomeres are totipotent in nature. These cells form all the organs and organ systems that the fetus needs for survival in vivo and ex vivo. If the animal is just a ball of cells, how come some sponges are erect and can even form large structures, like the barrel sponges which are very often captured by divers. The animal has specialized cells that are capable of secreting spongin and spicules which are the primary elements that provide structural integrity to the animal.



Modern-day Sponges

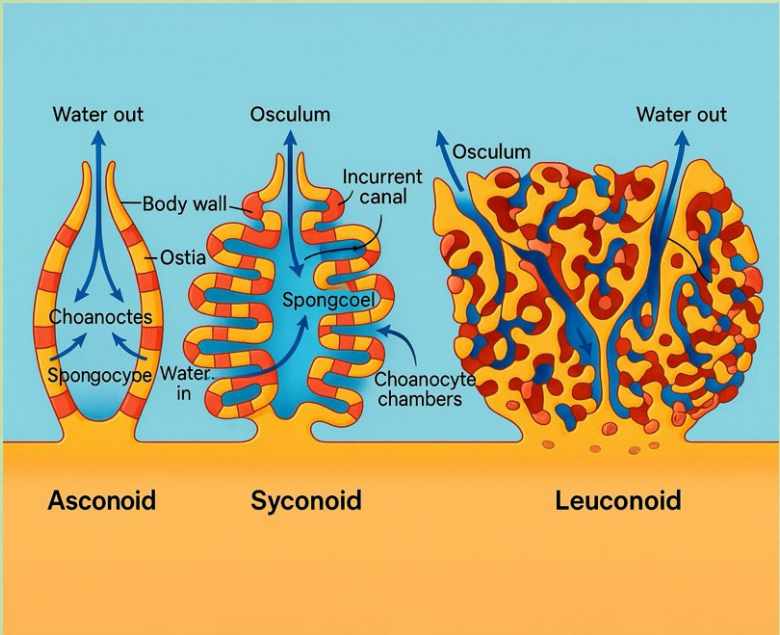
Credits - <https://www.snexplores.org/article/sea-sponges-spew-slow-motion-snot-rockets-to-clear-out-their-pores>

With this, let's go back to the “form” that sponges take. Asconoid are the simplest forms of sponges with a single central canal. The entire body has ostia and

a single osculum generally present at the anterior end of the animal. In syconoid form, the body of the animal shows multiple invaginations and the invaginations bear more

Asconoid are the simplest forms of sponges with a single central canal. The entire body has ostia and a single osculum generally present at the anterior end of the animal.

pores and a single central spongocoel (large central cavity) which opens into the osculum. Leuconoid sponges are the most complex form, with a network of chambers. Each chamber has multiple ostia, which pool into canals that open out into osculi. The animal possesses multiple oscula. Why this complexity? Why does the animal have to waste energy to add more layers while fighting off harsh environmental conditions? The answer is plain and simple, and yet perfectly logical. More pleating or more chambers translate to more surface area. More surface area provides more pores. More pores mean more water enters the body. More water means more food. More food means better survival. What an elegant solution to life's larger challenges? If you need to get bigger, be bigger. Seems like a good life lesson to abide by.



A Simple Illustration of Asconoid, Syconoid and Leuconoid Canal Systems
Credits: Hogg, M. & Tendal, Ole & Conway, K. & Pomponi, S. & van Soest, Rob & Gutt, J. & Krautter, Manfred & Roberts, J.. (2010). Deep-sea sponge grounds: Reservoirs of biodiversity. Clinical and Experimental Allergy - CLIN EXPERIMENT ALLERGY. 32.
Illustration Rendering: Mr. Kamaleshwaran. E., Loyola College (Autonomous), Chennai

The simplistic structure of the animal allows it to be diverse in its shape and size, which allows for better survival. When it comes to reproduction, the animal spawns, which means it throws its gametes into the water like a Hail Mary pass, except it is completely probable for the gametes to fertilize, as it has been happening since the Precambrian period (give or take!). They also

Say hello to “**PORIBACTERIA**”: bacteria that live in a symbiotic relationship with marine sponges. Some sponges host a microbiome within their body. The microbes get a haven while the sponge gets organisms that help in secreting toxins or even processing nutrients for ingestion.

reproduce by just breaking off and growing into another organism – budding and fragmentation.

Apart from morphological adaptations, the animal also developed chemical defences to fight off predators. They produce unpalatable toxins that deter animals from feeding on them. They have also learnt to allow other animals to enter into a symbiotic relationship with them. Say hello to “**PORIBACTERIA**”: bacteria that live in a symbiotic relationship with marine sponges. Some sponges host a microbiome within their body. The microbes get a haven while the sponge gets organisms that help

in secreting toxins or even processing nutrients for ingestion.

With all these adaptations, the animal is equipped to survive in places with low-nutrient content, even the deepest trenches of the ocean, where even rovers falter. Even the colouration the animal displays may have aposematic undertones. Aposematism is the process of warding off predators with a display of bright and contrasting colours. It is very similar to the danger signs erected in accident-prone zones. A bright red automatically created a caution in our minds, and it becomes muscle memory to slow our ride. Vertebrates such as the blue-poison dart frogs possess a dark blue colour with black spots on their backs to warn their attackers. This is what we call – “Fair and due warning notice”. This can also be compared to the “**Dhrishti Bommai**” in Tamil culture, where a brightly coloured and horrendous-looking doll is placed in front of the house to ward off “evil eye”. Do we as humans take cues from animals?

Marine sponges have successfully colonised ocean beds, freshwater ecosystems, coral reef ecosystems, and some are even boring and can break up rocks. These animals are perfect examples of how constant trial and error can perfect survival. From the shallow intertidal zones to the deep ocean, sponges have found their niche and



Marine Sponge from the Lakshadweep Archipelago

have proven that survival of the fittest is not a destination, but rather a journey that requires constant adaptation and evolution. With every stone that the ever-changing earth threw at them, they took it in stride and turned it into a life lesson and capacitated themselves to endure. They are the archetype for the proverb “When life gives you lemons, you make lemonade”. Another life lesson for us, maybe?

With every stone that the ever-changing earth threw at them, they took it in stride and turned it into a life lesson and capacitated themselves to endure. They are the archetype for the proverb “When life gives you lemons, you make lemonade”. Another life lesson for us, maybe?



Marine Sponge from the Gulf of Kachchh, Gujarat.



Dr. Jasmine Purushothaman

Jellyfish Blooms and Boons: A Scientific Perspective



The term ‘jellyfish’ indicates any gelatinous organisms seen in the seas and oceans. Despite the name, jellyfish aren’t fish at all. It is a general non-taxonomic term

ocean currents, though some species inhabit freshwater too. Their size varies from a few millimeters (<2mm) to >2m. In India, around 49 species of jellyfish are found, out of

which 43 are Scyphozoans and 6 are Cubozoans.

They are fascinating creatures whose body constitutes 95% water. A typical jellyfish body is a medusa which is a bell shaped or umbrella-shaped transparent upper body part which is composed largely of a jelly-like mesoglea that provides buoyancy and flexibility. Numerous tentacles containing specialized cells called cnidocytes arise from the margin of the bell. Cnidocytes house nematocysts (stinging structures) for capturing prey and defence. Hanging from the underside of the bell are oral arms, usually 4 to 8 in number which aid in transporting food to the mouth. A mouth is present on the underside of the bell which serves as a common passage for food and waste. In addition, they have a gastrovascular cavity for digestion, rhopalia

Despite the name, jellyfish aren’t fish at all. It is a general non-taxonomic term to indicate a broad spectrum of jelly-like organisms such as medusae and siphonophores (Phylum Cnidaria), comb jellies (Phylum Ctenophora) and salps (Phylum Chordata: Subphylum Tunicata).

to indicate a broad spectrum of jelly-like organisms such as medusae and siphonophores (Phylum Cnidaria), comb jellies (Phylum Ctenophora) and salps (Phylum Chordata: Subphylum Tunicata). These

include a wide variety of stinging and non-stinging jellyfishes. They are very ancient animals which originated 500 million years ago on the earth. They are mostly found drifting in

containing statocysts for balance, ocelli (simple eyes) and nerve clusters and a nerve net. Jellyfish lack a brain or central nervous system and the nerve net helps in coordinating muscle

contractions and stimuli. Their movement is possible by creating jet propulsion in the surrounding water by their continuous contraction and expansion of their body.



Fig 1: Jellyfish species found from East coast of India

They play a vital role in the food web as they act as a prey for many sea turtles, sea birds, some fishes and marine mammals and also predate on fish eggs, fish larvae, zooplanktons and some small fishes. They are also considered as a delicacy. The harvest and consumption of jellyfish began in China 1700 years ago and extended to other Asian countries like

Thailand, Japan, Singapore, Taiwan and Malaysia. The common edible jellyfish species found in Indian coasts are *Crambionella annandalei*, *Crambionella orsini*, *Catostylus perezii* and *Rhopilema hispidum*. Jellyfish are a protein-rich, low-calorie meal containing minimal fat and cholesterol, minerals and omega 3. Collagen extracted from jellyfish is a very useful

material in the biomedical field such as wound-healing and tissue regenerating items like bandages. The bioactive compounds extracted from jellyfish can be used to treat hypertension, joint diseases, bronchitis and it helps to improve digestion and weight loss. It is also found that jellyfish venom has many pharmacological effects like anti-cancer, anti-tumour, anti-microbial and insecticidal properties. In the biomedical field, for the first time a novel work was done by O. Shimomura, M. Chalfie and R. Tsien in the year 1962 where they extracted Green Fluorescent Protein (GFP) from the bioluminescent jellyfish *Aequorea Victoria* and received Nobel Prize in Chemistry in 2008.

Though they have various positive and useful properties that are underutilised, they are still considered as 'nuisance' for its bloom forming nature. The aggregation of a species of jellyfish at a particular location during a period of time is considered as jellyfish blooms. This blooms not only causes economic losses to the fishing community but also to the tourism sector and marine-based

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industries. It affects fisheries and aquaculture sectors in multiple ways such as overturning boats, damaging fishing gears, clogging fishing nets, fouling cages, causing fish death by stinging and competing with commercially important fish for plankton prey. Their impact also flows towards the human health as their stings can cause allergic reactions. They also disrupt the functioning of desalination plants, nuclear power plants, naval facilities, seabed mining facilities, ships and aquaria. Indian coasts have witnessed jellyfish aggregations, swarms, and beach stranding in more than 23 locations.

It is seen that jelly fishing is done by many fishermen communities during this bloom season to export as a food product (oral arms or umbrella part) resulting a good source of income. The whole process of jellyfish

capturing, processing and packaging costs are very minimal. The processing generally involves, cleaning, sorting and cutting, brining and adding alum, drying and packaging. In India, Jellyfish fisheries began as a targeted fisheries in 2005, but it is still categorized as "unusual" or "miscellaneous" in the fisheries statistics.

Jellyfish can be considered as a potential economic resource in the context of Blue economy, but the bloom could be a threat to commercial fisheries. There is a lack of knowledge on jellyfish biology, bloom patterns and the fishery management which prevents the complete utilisation of jellyfish and its mitigation from devastating blooms.

The aggregation of a species of jellyfish at a particular location during a period of time is considered as jellyfish blooms. This blooms not only causes economic losses to the fishing community but also to the tourism sector and marine-based industries.



Mrs. Anindita Ghosh

Invisible Invaders: Parasitism in Trematoda

Trematoda, a class of Phylum Platyhelminthes are always endoparasitic in nature and are commonly known as 'Flukes'. They are usually pale cream in colour, but sometimes take distinctive colours of the nutrient content of the intestine of the host. They are of varying size i.e. from >1mm to 70-80 mm. Trematodes show a complex life cycle, show alternation of generation and undergo into one or two intermediate hosts. Larval form of trematodes are found mainly in invertebrates, particularly in molluscs and sometimes they may penetrate in another mollusc or any crustaceans or in small fishes; adult forms only invade vertebrates. Generally trematodes are found in stomach and intestine of

the hosts, but these also may penetrate lung, gall bladder, swim bladder and body cavity, some trematodes may also penetrate into body muscle. Trematodes are soft bodied, acoelomate, bilaterally symmetrical animal and mostly they are hermaphrodites. They are having unique morphological features. Adults are usually having two suckers, thus the name 'Trematoda' derives as it means "pierced with holes". Among the two suckers one is at anterior end, called oral sucker and other one is ventral sucker, position of which varies. Body may be smooth or spined. Mouth is usually in oral sucker. They have well developed pharynx followed by oesophagus. Their intestine usually bifurcates,

very rarely saccular. Usually trematodes are having two testes, very rarely one or more than two, ovary is generally one. Position of genital pore varies in different species of Trematoda. They are having vitellaria which may be follicular or single masses, extension of vitellaria varies with different species of trematodes. Excretory bladder may be 'Y', 'I' or 'V' shaped. Trematodes show a high degree of host specificity. Globally trematode parasites consist of more than 11,760 species of which India is having 1,351 species of trematode parasites.

*Genarchopsis goppo* Ozaki, 1925 (a common trematode parasite)

"Trematodes can infect almost all vertebrates. In comparison to other vertebrates maximum infection is found in fishes. Trematodes may cause developmental malformation

in fishes, thus a threat to the loss of population of fishes. Fish borne zoonotic trematodes are also a serious issue. In China it has been reported that 59 species of trematodes may cause fish

borne zoonotic diseases in human. People who are having habit to eat raw or undercooked fish are more susceptible to these diseases. Report shows that there is high infection rate of fish borne zoonotic diseases in People of China." *Clonorchis sinensis* (Cobbold, 1875) Looss, 1907, *Opisthorchis felinus* (Rivolta, 1884) Blanchard, 1895, *Opisthorchis viverrini* (Poirier, 1886) Stiles & Hassall, 1896, *Metagonimus yokogawai* (Katsurada, 1912) Katsurada, 1912 are common trematode parasites which spread fish borne zoonotic diseases. In USA, studies have been done on Fish borne trematodiasis which show that mainly *Haplorchis pumilio* (Looss, 1896) Looss, 1899 and *Centrocestus formosanus* (Nishigori, 1924) Price, 1932 are the two trematode parasites which spread the disease in people in almost all parts of America and here also the cause is same as they eat raw or undercooked fish. Earlier this problem was confined to certain countries that have the habit of eating such type of foods, but with the increase in global trades

Trematodes can infect almost all vertebrates. In comparison to other vertebrates maximum infection is found in fishes. Trematodes may cause developmental malformation in fishes, thus a threat to the loss of population of fishes. Fish borne zoonotic trematodes are also a serious issue. In China it has been reported that 59 species of trematodes may cause fish borne zoonotic diseases in human. People who are having habit to eat raw or undercooked fish are more susceptible to these diseases. Report shows that there is high infection rate of fish borne zoonotic diseases in People of China.

and population movements, risk is spreading in other countries too. In India, the risk of fish borne zoonotic diseases is less because of food habit, always fish is well cooked. However, in certain communities and with the increasing habits to have

continental food, particularly some Japanese food like 'Sushi' or 'Sashimi', the risk is increasing.

A good number of trematodes are found in Amphibian hosts. Sometimes, more than 100 individuals are found in the intestine of a single

frog. Adult Amphibia usually get infection when they eat molluscs having larval trematodes (Metacercaria) within their body. Echinostome trematodes and individuals of the Genus *Haematoloechus* Looss, 1899, *Diplodiscus* Diesing, 1836 and *Ganeo* Klein, 1905 are common to infect amphibian hosts.

Very few trematodes infest into reptiles. Individuals of the family Spirorchidae and Dicrocoeliidae are common to infect reptiles.

Birds usually get trematode infections when they eat small fish and snails which carry metacercariae of trematodes within their body. Thus carnivore birds are more susceptible for trematode infection than the herbivores. Studies have shown that although the main site of trematode infection is intestine in birds, but some particular trematodes may infest other organs like, liver, gall bladder, bile ducts, caecum, bursa Fabricii, air sacs or underneath the skin, even in kidneys. Report shows that schistosomes may be found in abdominal veins of the birds. A large variety

of trematodes are found in fowls causing economic loss in poultry farms.

Trematode infection in mammals is very important in terms of medical and veterinary issues. Individuals of the genus *Fasciola* Linnaeus, 1758 (Liver flukes) and *Schistosoma* Weinland, 1858 (Blood flukes) affect largely to the livestock causing substantial economic loss. Other important individuals of the genus *Paramphistomum* Fischöder, 1901, *Cotylophoron* Stiles and Goldberger, 1910, *Calicophoron* Nasmak, 1937, *Gastrodiscoides* Leiper, 1913, *Dicrocoelium* Dujardin, 1845 are common trematodes affecting domestic ruminants worldwide. Studies have proved that young cattle are more susceptible to infection than the older one.

Most of the trematode infection in human has been diagnosed in people in the developing countries. Liver, intestine, lung and blood vessels of human are the susceptible organs to be infected with trematodes. Liver flukes e.g. *Fasciola hepatica*

Linnaeus, 1758, *Clonorchis sinensis* (Cobbold, 1875) Looss, 1907, *Opisthorchis felinus* (Rivolta, 1884) Blanchard, 1895, *Opisthorchis viverrini* (Poirier, 1886) Stiles & Hassall, 1896, *Artyfechinostomum sufrartifex* Lane, 1915, intestinal flukes e.g. *Metagonimus yokogawai* (Katsurada, 1912) Katsurada, 1912, *Fasciolopsis buskii* (Lankester, 1857) Stiles, 1901, lung flukes e.g. *Paragonimus westermani* (Kerbert, 1878) Braun, 1899 and blood flukes e.g. *Schistosoma haematobium* (Bilharz, 1852) Weinland, 1858, *S. japonicum* Katsurada, 1904, *S. mansoni* Sambon, 1907 are the common flukes those infect Human. People get infection of these parasites by eating raw or undercooked fish, meat, chicken or crustaceans or by having vegetables which are not washed properly. Infection may also develop in eyes with the infestation of eye fluke, *Philophthalmus gralli* Mathis & Leger, 1910, *Procerovum varium* Onji & Nishio, 1916. In acute infection of liver flukes people will be having

fever, pain in costal margin or night sweat. Intestinal fluke infection causes abdominal pain and diarrhoea in human being. Infection in lung fluke shows fever, cough, chest congestion and in heavy infection blood-stained sputum. Blood fluke infestation may cause abdominal pain, dysentery, splenomegaly, hematuria, dyspnea in human being and in heavy infection it may cause neuroschistosomiasis i.e. deposition of eggs and cysts in human brain or spinal cord. Proper diagnosis of these trematodes is highly important. Eggs or cysts are diagnosed by examining feces for Liver flukes, Intestinal flukes, lung flukes and blood flukes, sputum for lung flukes and urine for blood flukes.

However, if proper measures are taken, the risk of trematode infection may be minimised or eradicated. People have to improve their dietary habit by avoiding raw or undercooked food and for that educational programmes have to be undertaken to explain the people about the risks of trematodiasis and to maintain hygiene and proper dietary habits.



Dr. Jasmine
Purushothaman

Water Bears Beyond Earth: Tardigrades from Moss to Microgravity



Tardigrades, or “water bears,” are small, eight-legged micro-animals renowned for their incredible hardiness. Most tardigrades are between 0.3 and 0.5 mm in length and can live in almost any habitat on Earth, from mossy forests to lichen trees, ocean depths, hot springs, and polar ice caps. Originally found in 1773, these creatures, who were nick-named “slow steppers,” were named for their slow, bear-like crawling and strong, clawed legs. An essential part of their ability to survive is a process known as cryptobiosis; when desiccation or toxins become a threat, a tardigrade curls into a dehydrated shape known as a “tun” and effectively halts metabolic processes. In this shape, they are able to survive for extended periods without

Tardigrades are genuine extremophiles capable of surviving conditions lethal to nearly any other animal. In the tun state they survive from -272°C to $+149^{\circ}\text{C}$, vacuum, boiling water, and intense radiation. E.g., dried tardigrades shot into space aboard a 2007 FOTON-M3 mission survived 10 days of vacuum and solar UV – more than 60% revived successfully on return. Likewise, a 2011 ISS test demonstrated that tardigrades can survive cosmic radiation and microgravity. These achievements are partly due to specialized proteins (e.g., the “Dsup” protein) that protect DNA under stress.

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Extreme Temperatures: Tardigrades in the tun state can survive temperatures close to absolute zero (-272°C) and brief exposures to extreme heat ($+150^{\circ}\text{C}$). **Radiation & Vacuum:** Dehydrated tardigrades can tolerate high levels of ionizing radiation and the vacuum of space. **Long-term Desiccation:** They can suspend their metabolism for years without food or

water and recover when it is better. This combination of superpowers renders tardigrades of immense value to science. Worldwide, approximately 1,500 species are known (in 160 genera and 36 families), living on land, in freshwater and in sea. Scientists research tardigrades in areas from astrobiology to biotechnology. Tardigrades are regarded as models for extraterrestrial life, as their durability suggests what organisms may endure on Mars or on ice moons. On the biotech front, tardigrade adaptations are the inspiration for new technology: for example, scientists have developed gels that emulate the tardigrade tun’s protective matrix for

application in biomedicine, energy storage and soft robotics. One species even secretes a blue fluorescent shield under UV light as a strategy of photo protection now investigated to create UV-blocking coatings and safeguard delicate cells. These examples illustrate the potential of tardigrade biology to drive frontier research and innovation.

India’s Cryptic Tardigrade Diversity

Tardigrades are found all over the world, and India is no exception; however, they are under-explored in India. Recent syntheses report the occurrence of approximately 50 species in India, represented by

Tardigrades are found all over the world, and India is no exception; however, they are under-explored in India. Recent syntheses report the occurrence of approximately 50 species in India, represented by 11 families and 27 genera, in four orders

11 families and 27 genera, in four orders. The animal has been found from the Himalayan areas and Western Ghats to coastal regions and islands. A significant percentage of Indian records belong to the high-altitude Sikkim and Uttarakhand mosses and Andaman-Nicobar Islands, reflecting both the completeness of survey work as well as the range of habitats. Some Indian tardigrade species are also distributed in other geographical regions (e.g., *Macrobiotus hufelandi* is found in Ladakh as well as Spain); however, Indian researchers are now discovering endemic species. In 2021, Vishnudattan reported *Stygarcus keralensis*, a new marine tardigrade species from the Kerala intertidal, reflecting the characteristic marine tardigrade diversity of India. Marine and coastal species are also well represented: some species of the genus *Batillipes* (sand-dwelling marine tardigrades) are found along the coastlines of India, and these represent over 10% of that genus worldwide.

India's work of tardigrades started more than a century ago (with Murray's Himalayan Survey of 1907 and McInnes's Island work in the mid-1900s), but no more than a few dozen papers in total have been published. Contemporary work is now refining the image. For example, a 2023 survey collated descriptions of some 50 Indian species (mostly in leaf litter and mosses) and found *Macrobiotus* species to be the most cosmopolitan of them. Fresh water tardigrades have been reported from Tamilnadu and Maharashtra rivers and ponds and sometimes take scientists by surprise with their ability to tolerate urban pollution. India's tardigrade checklist, as a whole, continues to expand, and most habitats probably harbor as-yet-undescribed species. Though Indian tardigrades are unknown to the world, they have attracted science for the same reasons everywhere: as bioindicators and biotechnological resources. Because tardigrades are so resilient, their presence (or absence) can indicate ecological change. For instance, a study in Mumbai's Sanjay Gandhi

National Park detected tardigrades even in polluted streams, demonstrating these "water bears" can survive poisons that repel other meiofauna. Thus, they complement larger animals as an indicator of ecosystem function. In biotechnology, Indian researchers have also started to exploit tardigrade properties. The Bangalore laboratory of Sandeep Eswarappa, for instance, isolated a *Paramacrobiotus* strain with exceptional UV protection: when exposed to lethal UV light, it emits a blue glow and lives. This "Bengaluru strain" – taken aboard the ISS on the Axiom-4 mission – has molecular defenses that researchers want to use to develop such products as sunscreen additives or DNA-protective therapies. Such research indicates how even neighborhood tardigrades can fuel global progress.

Tiny Heroes in Space

Tardigrades are perhaps most famous for taking space literally. Due to their extreme hardness, NASA and other space agencies have flown them on several missions. (In 2019 even an Israeli lunar

In May–June 2025, the Axiom-4 mission to the ISS featured a special Indian experiment Voyager Tardigrades. Veteran astronaut Shubhanshu Shukla – India's second citizen in space – took hundreds of Indian *Paramacrobiotus* tardigrades (the "Bengaluru strain") to orbit. During the two-week mission, Shukla conducted the experiment in the ISS laboratory, subjecting the dehydrated tardigrades to microgravity and radiation, then reviving them in orbit. Scientists will compare how many revive, how many eggs hatch, and even measure gene activity changes between the space-flown group and identical controls back on Earth.

lander carried a dehydrated sample of tardigrades – alas the lander crashed, but the experiment was intended to test life's limits on the Moon. The latest installment is India's own contribution to space-tardigrade science. In May–June 2025, the Axiom-4

mission to the ISS featured a special Indian experiment Voyager Tardigrades. Veteran astronaut Shubhanshu Shukla – India's second citizen in space – took hundreds of Indian *Paramacrobiotus* tardigrades (the "Bengaluru strain") to

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As per India Today and Times of India reports, Shukla had performed the Voyager experiment early in 2025. The experiment was to study "survival, revival, and reproductive behaviour in space" to observe how microgravity-stress was influencing these stress-resistant organisms. Initial results suggested that the findings would be helpful not just for astrobiology but for medical science on Earth as well; for instance, information about radiation resistance could provide new treatments. The Voyager experiment is the eighth Indian experiment to be performed on Axiom-4, following experiments on algae and human cells, a

giant leap for India in space biology.

Even beyond India’s mission, overseas missions still employ tardigrades as models for life in space. NASA’s 2011 STS-134 shuttle mission and others proved that hydrated tardigrades can breed after a ride in microgravity, supporting the hypothesis that such creatures might endure space travel. And the groundbreaking work on fluorescent UV shields and protective proteins within tardigrades offers valuable strategies for keeping seeds, vaccines or cells on extended space travel. In short, tardigrades are turning out to be space-exploration trailblazers: their genetic and physiological tricks teach us how life may survive beyond Earth.

**Future Frontiers:
Tardigrade Innovations**

In the coming years, research on tardigrades is bound to expand. Biologists and engineers are already discovering tardigrade secrets for new uses. Within the last few months, scientists chemically reverse-engineered a gel that replicates the tardigrade’s

tun-stable core: by dehydrating and rehydrating tardigrades, they charted how their cellular “glycerogel” shields them, and then replicated it. The result is a new extremotolerant hydrogel, with potential applications in blood or cell storage, flexible electronics, sensors, and even space-age materials. Likewise, discovery of tardigrades’ fluorescent UV trap is opening the door to bio-inspired sunscreen compounds and shield coatings for astronauts

In medicine, tardigrade proteins are already under the microscope. The tardigrade Dsup protein, for example, binds DNA and greatly reduces radiation damage. By introducing Dsup into human cells, some studies have made them more resistant to X-rays. Other tardigrade stress-proteins (CAHS, SAHS, LEA, etc.) are being tested to preserve enzymes and cells in dry storage. This could revolutionize everything from long-life vaccines (dry-preserved with no fridge) to robust cell therapies. On the farm side, scientists wonder whether genes from tardigrades could

one day be used to engineer drought-resistant crops, a bonus under climate change for food security.

By broadening our knowledge of tardigrades, we extend the frontiers of biological science. One study in Europe has just shown that *Paramacrobiotus* can pass on protective characteristics to other animals, in this case a nematode, using fluorescent chemicals, and sets out future directions for biocontrol or antimicrobial treatments. At the same time, the research into the diversity of the tardigrades goes on: new genera and families are still being discovered using DNA sequencing methods. Briefly, these small creatures—unobtrusive dwellers in moss—hold secrets that can bring new breakthroughs in cryopreservation, biotechnology, and even space exploration.

Tardigrades remind us that resilience and adaptability do not necessarily have to come in large packages. From the misty mountains of the Himalayas and tropical beaches of India to the void of outer space, these “water bears” have existed as almost

indestructible pioneers. With Indian research and global research progressing, tardigrades are set to be at the leading edge of science

– aiding our efforts to sustain life, venture into new worlds, and even prolong human life beyond the confines of Earth in the years ahead.

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Dr. G. Sivaleela

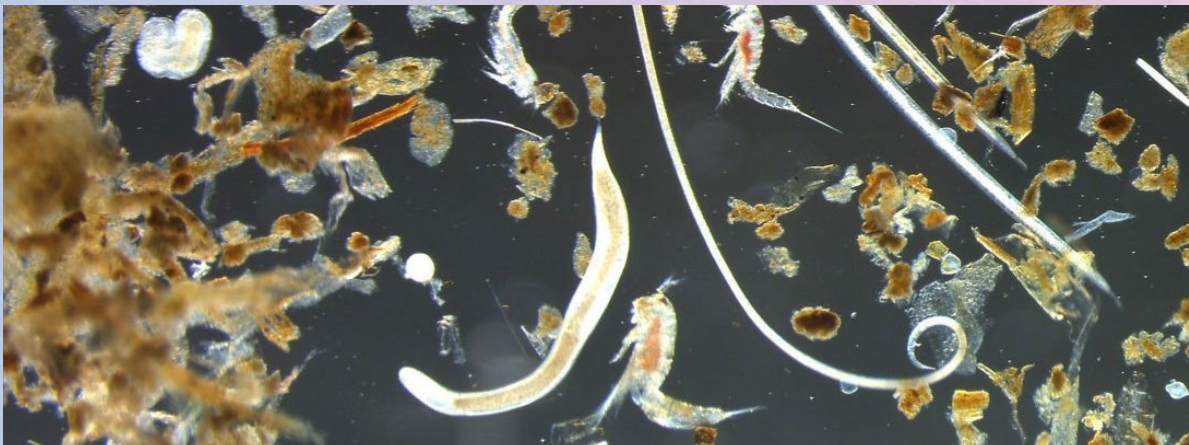
The Forgotten Kingdom Under Our Feet – Meiofauna



The oceans’ deepest secrets are told by organisms too small to see yet too vital to ignore. This encompasses the often too fascinating and also the widely ignored “**meiofauna**”. Meiofauna are microscopic, benthic organisms, with sizes ranging from 63 µm to 1000 µm. These are ecological groups that are classified based on their size alone, so they are neither macroscopic nor microscopic. They are not visible to the

naked eye and are capable of living within the spaces between grains of sand.

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Credits: Image courtesy of Jeroen Ingels, FSUCML.

Can you imagine a polar bear living in the thickets of the Amazon? Or an African Elephant in the freezing tundra? This seems almost impossible in higher vertebrates, but not for meiofauna. It is one of their most attractive features – **UBIQUITY**.

Can you imagine a polar bear living in the thickets of the Amazon? Or an African Elephant in the freezing tundra? This seems almost impossible in higher vertebrates, but not for meiofauna. It is one of their most attractive features – **UBIQUITY**. The ability to live in all places. Let’s take meiofaunal nematodes for example, they are parasitic and free-living, they are found in the Arctic and in the tropics, even as parasites, they can be endoparasitic or ectoparasitic, as endoparasites, they can be sedentary or migratory. They can be plant parasites or animal parasites. Even when they are in dormancy,

they can choose quiescence. Quiescence is a stage where the animal arrests all development and saves energy to tide them over

Tardigrades are known for anhydrobiosis - where, in the absence of water, they survive by turning into a tun; cryobiosis – they survive freezing temperatures by freezing themselves with ice-nucleating proteins; anoxybiosis – they survive in the absence of oxygen; osmobiosis – where they handle extremely adverse osmotic changes. They sound like the protagonist of any good Hollywood sci-fi drama.

unfavourable circumstances, and when they get a hint of good conditions, they revive themselves. This is akin to torpor exhibited by mammals, where the body temperature is reduced and metabolic rate is reduced to conserve energy to combat adverse conditions. Except in the case of nematodes, this is far more complex and requires complete cessation of all metabolic activity of the animal. A state of cryptobiosis. The best meiofauna to observe cryptobiosis is Tardigrada, or sea bears or moss bears or moss piglets. Tardigrades are these plumpy

and cute-looking meiofauna that are known for being extremophiles.

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Credits: Eye of Science/Science Photo Library

Meiofauna encompass many such groups with unique and varied capabilities. Apart from roundworms (nematodes) and water bears (tardigrades), they also include arthropods (copepods and ostracods), wheel animalcules (rotifers), hairy backs (gastrotrichs), flatworms (platyhelminthes; turbellaria) and mud dragons (kinorhynchs).

An important facet that is largely underexplored is

freezing themselves with ice-nucleating proteins; anoxybiosis – they survive in the absence of oxygen; osmobiosis – where they handle extremely adverse osmotic changes. They sound like the protagonist of any good Hollywood sci-fi drama.

the ability of the animal to expose how contaminated an area is just by their abundance. Some meiofauna and tolerant to changes and some are sensitive, some are susceptible to damage or deformation, and some outright succumb to the pressure of external stressors like anthropogenic interference or pollution or heavy metal toxicity or any other hazardous impact and cease to survive.

So what did scientists do with this little nugget? They started digging into sediments and checking what meiofauna respond to which interference, and started cataloguing them. Based on the extent of damage, a decrease in the abundance of one or certain groups, based on the dominance pattern within these groups and by enumerating the degree of presence and absence of meiofauna, they were able to establish how badly an area was affected. Maybe not up to the last microgram, but this gave valuable insights into the aftermath of pollution. This is why meiofauna can be termed as **“bioindicators”**. One very common and famous bioindicator is the northern leopard frog. They require healthy wetlands for survival, and when there is rapid urbanisation, their population reduces, which becomes a calibration scale for conservation studies.

Why are these sentinels still unsung heroes reduced to mere dust, and in dust they do remain? It is a two-fold issue – a) they are underexplored and underappreciated. It is very difficult to work with

and on these animals due to obvious reasons, even with advancements in technology, it takes patience and skill and b) the reliability of this data is still debatable but the good thing is that scientist have taken the task as a challenge and are standardising methods to use these animals as ecotoxicological indicators. There is still a long way to go but the path is being laid and a precedent is being set.

Now is the time for budding meiobenthologists to show their power. Meiobenthos combined with technological

advancements like eDNA will yield positive results in conservation biology. This is the pipedream and yes, there is hope. eDNA or environmental DNA is the DNA of organisms that is sequenced not from the animal but from environmental sources like air, water and soil. In the Mahabharatha, the Mahabhutas or the **“Pancha Mahabhutas”** – the five elements of nature, Earth (Prithvi), Water (Ap), Fire (Tejas), Air (Vayu) and Ether (Akasha) are considered to be the building blocks of

In the Mahabharatha, the Mahabhutas or the **“Pancha Mahabhutas”** – the five elements of nature, Earth (Prithvi), Water (Ap), Fire (Tejas), Air (Vayu) and Ether (Akasha) are considered to be the building blocks of the physical body and the material world. Science has finally caught up with Indian mythology, since eDNA can identify the animal that the has encountered and left its traces in environmental sources.

the physical body and the material world. Science has finally caught up with Indian mythology, since eDNA can identify the animal that the has encountered and left its traces in environmental sources.

Meiobenthology is a field of Zoology that has gained traction in recent years. But we are nowhere near where we need to be. We have only scratched the surface of the utility of these animals. Some meiobenthos possess anti-bacterial properties too. Just imagine, the grain of sand that one treads upon the beach can cure bacterial infections. But we have neglected these animals for far too long. With the focus being drawn by the larger mammals and the fancier microbes, the ‘meios’ have been left trailing behind. Better late than never, is the resounding cry of the meiobenthologists.

So the next time you take a stroll down the beach, think about the microcosm of animals you are stepping on. Animals with capabilities, which when possessed by humans would deem them superheroes! A whole forgotten kingdom lies beneath our feet crying for attention and waiting for their turn on the carousel, when the scientific community will tap their potential and

use them for the better good. For now – we dub thee **“Meiofauna – The Most Capable Superheroes of the Micocosmos”**.

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Creative Illustration: Florence Suganya R, MBRC/ZSI.



Dr. Anjum N. Rizvi

Roundworms: from Deep sea to the Sky



The nematodes commonly known as roundworms belong to an animal group that remained obscure for a long time except of course for some species since antiquity as parasites of man himself. Nematodes are very diversified lower invertebrates, possibly the most numerous multicellular animals on earth. They have successfully adapted to nearly every ecosystem from marine to fresh water, to soils, and from the polar regions to the tropics, as well as the highest to the lowest of elevations and are found in locations as diverse as mountains, deserts, oceanic trenches and within the earth's lithosphere.

They are omnipresent in all habitats that provide available organic carbon sources. Besides being free-living in

various ecosystem, they are also found to be parasitic in plant and all animal groups, from invertebrates to higher vertebrates. Besides, nematodes can swim as parasites of fishes and fly as parasites of birds.

The nematodes and their ecological roles can be best understood when they are categorized as

Soil and Aquatic Nematodes
Free-living Marine Nematodes

Arthropod parasitic Nematodes

Vertebrate parasitic Nematodes

1. SOIL AND AQUATIC NEMATODES

Soil and aquatic nematodes are known to dominate over all other soil fauna, both in number and species. Apart from the taxonomic classification, soil nematodes are also classified on the basis of their feeding habits as:

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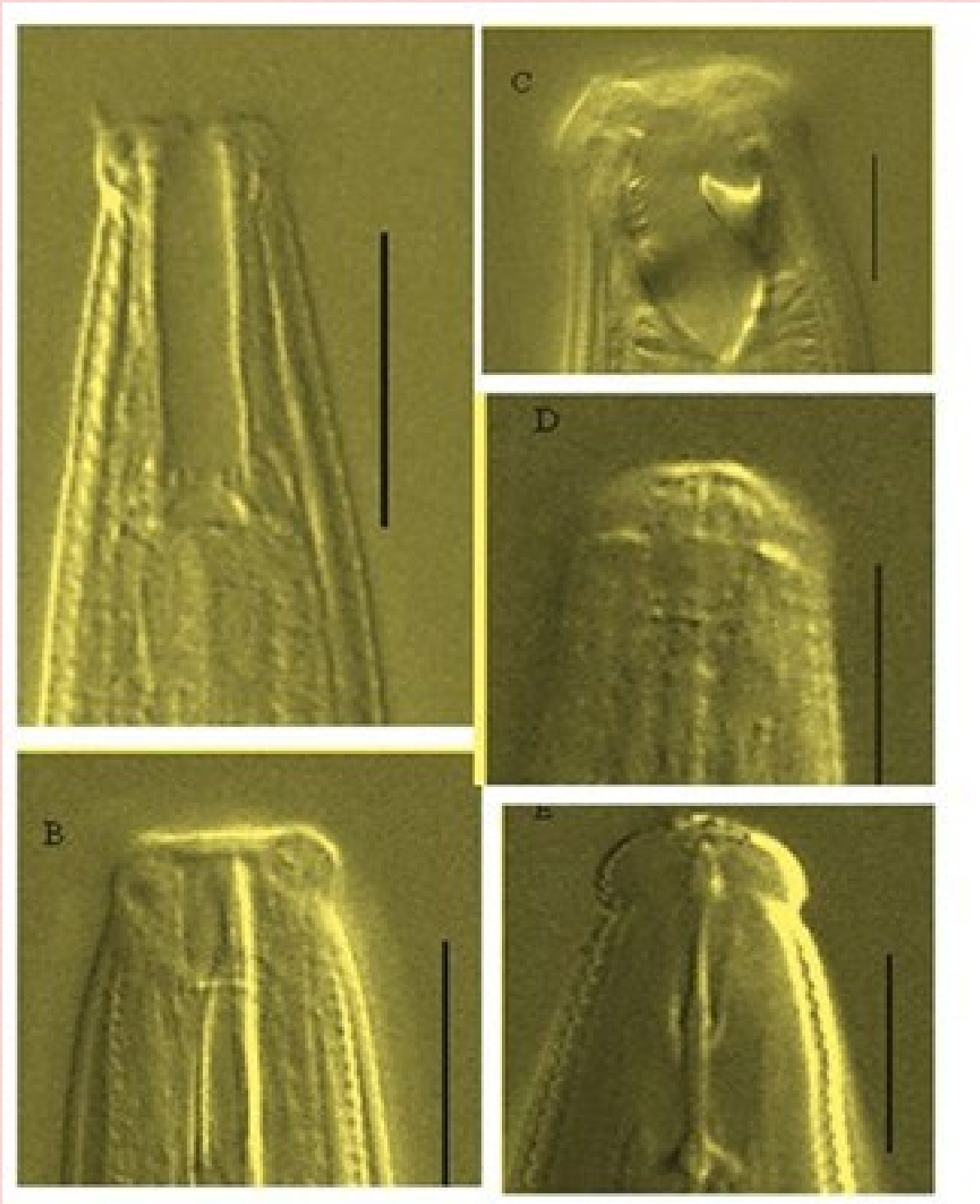
Plant-parasitic Nematodes (herbivorous): With Hypodermic needle like Stylet, Odontostylet or Spear, which is inserted through the plant wall and aids in the transfer of cell sap in to the alimentary canal of the nematode. Feed on vascular plants causing damage to plant roots and threaten the agricultural crops throughout the world, particularly in the tropics and subtropics. Example: Orders Tylenchida, Dorylaimida etc.

Bacterial feeding Nematodes (bacterivorous): Feed on bacteria symbiotic, pathogenic and saprophytic. They contribute to the decomposition of organic matter and the release of nutrients into the soil, making them available for plants and other organisms and can indirectly affect plant growth and productivity. Examples: Orders: Rhabditida, Araeolaimida, Monhysterida etc.

Fungal feeding Nematodes (fungivorous), Feed on saprophytic, pathogenic and beneficial Mycorrhizal fungi. Important in the decomposition process. Example: Order Aphelenchida etc.

Predatory Nematodes: They have strongly sclerotized buccal cavity which is armed with tooth or teeth, with or without longitudinal ridges. Sometimes denticles may be present on the sub-ventral wall of the buccal cavity. Examples: Order Monchida etc.

Omnivorous Nematodes: Apparently they feed at all trophic levels in the food web. As herbivores on plant root hairs etc. As predators, as consumers of bacteria & fungi. Usually occur in low densities. Examples: Tylenchida, Dorylaimida & Mononchida.



Types of buccal cavity in Soil Nematodes

2. FREE-LIVING MARINE NEMATODES

Free-living marine nematodes are important components of benthic marine ecosystem. They play significant role in decomposition of organic matter, recycling of nutrients, acts as food source for higher trophic groups and are important bioindicators. In addition to their taxonomic classification, they are also grouped into four trophic categories:

- 1. **Selective deposit feeders (1A):** Buccal cavity is poorly developed with small to minute mouth opening. The pharynx generates sucking force to consume fine, soft deposits and feeds on larger items by moving the lips and mouth. Examples: Anticomidae, Ceramonematidae, Diplopeltidae, Leptolaimidae.
- 2. **Non-selective deposit feeders (1B):** Buccal cavity spacious. Feeds on wide variety of food items, including organic deposits, bacteria biofilm through sucking, processing or crushing mechanisms.

Example: Axonolaimidae, Comesomatidae, Linhomoeidae, Tripyloididae.

- 3. **Epistratum/Epigrowth feeders (2A):** Buccal cavity opening small, equipped with tooth, denticles or sclerotized structures. They scrape off the bacterial films, microalgae, diatoms from the substrate surface and suck cellular contents. Examples: Chromadoridae, Cyatholaimidae,

Ethmolaimidae, Monoposthidae, Xyalidae

- 4. **Predators/omnivores (2B):** Buccal cavity well developed with powerful tooth or mandible. They prey on small animals, consume sediments, algae and follows chewing mechanism to process their food. Example: Enchelidiidae, Enoplidae, Oncholaimidae, Selachinematidae, Sphaerolaimidae, Thoracostomopsidae.

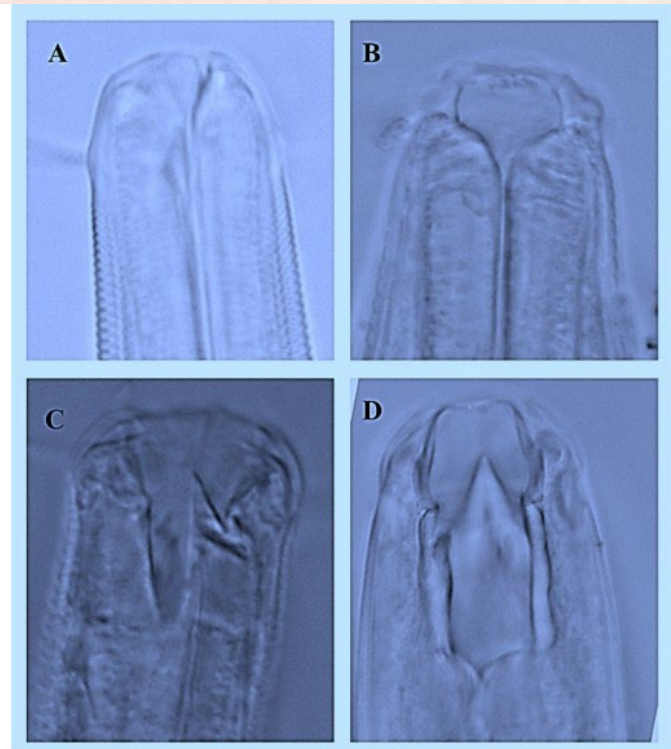


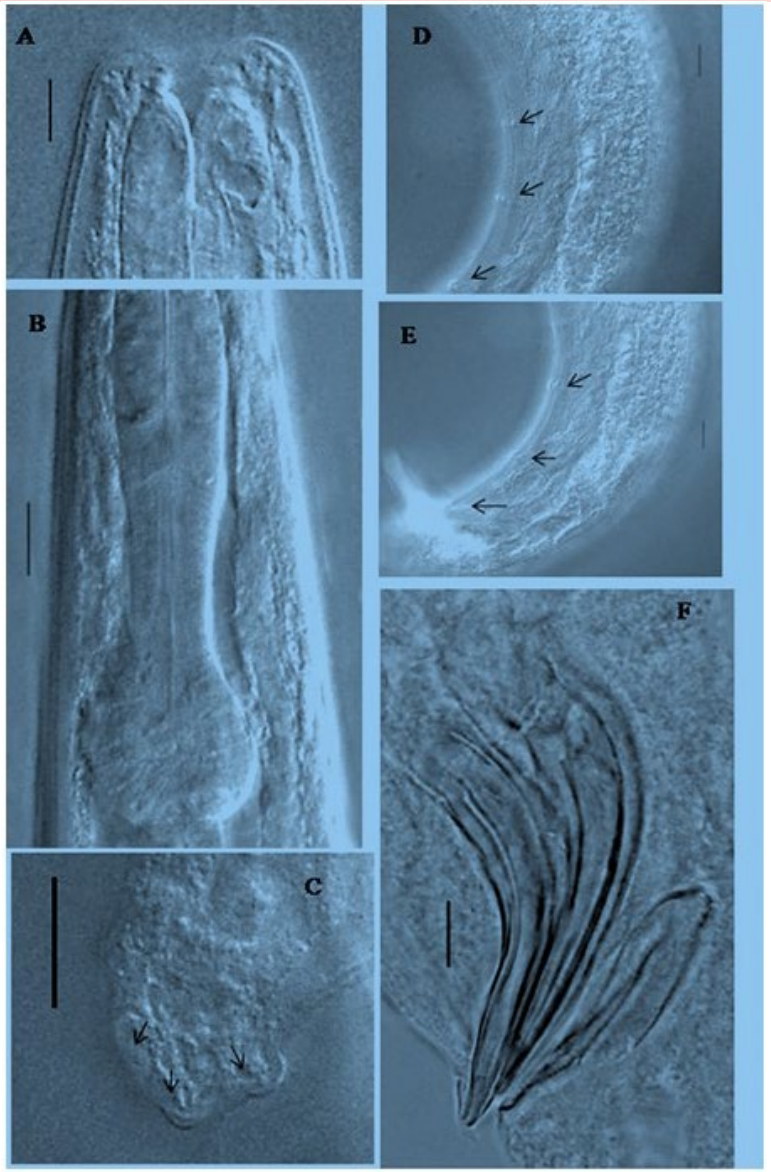
Figure: Trophic groups of free-living marine nematode. A. Selective deposit feeder (1A) B. Non-selective deposit feeder (1B) C. Epistratum/ Epigrowth feeder (2A) D. Predators/omnivore (2B)

3. ARTHROPOD PARASITIC NEMATODES

Nematodes parasitic in arthropods occur naturally in soil environments and find their host due to carbon dioxide, vibration and other chemical cues. The arthropod hosts include Diptera, Hymenoptera, Thysanoptera, Coleoptera, Dictyoptera, Orthoptera, Diplopoda and Chilopoda. The relationships between nematodes and its arthropod hosts vary from temporary to obligatory parasitism.

Arthropod nematode associations can be grouped into three basic types:

- » **Phoretic relationship:** a non-parasitic relationship where nematodes use insects as a means of transportation. Dung beetles carrying phoretic nematodes that emerge in fresh dung. Examples: *Pelodera Coarctata* nematodes
- » **Facultative parasitism:** Facultative parasitic nematodes are nematodes that can live independently but



Insect nematode: *Steinernema* sp.

4. VERTEBRATE PARASITIC NEMATODES

Vertebrate parasitic nematodes infect all animal species and are highly diverse group of organisms. All the vertebrate organisms starting from Fishes to Mammals have been known to be parasitized by the nematodes.

can also switch to a parasitic lifestyle when they encounter a suitable insect host. These nematodes don't need to parasitize insects to complete their life cycle, but they can exploit insects for nourishment and reproduction if the opportunity arises. Several nematode

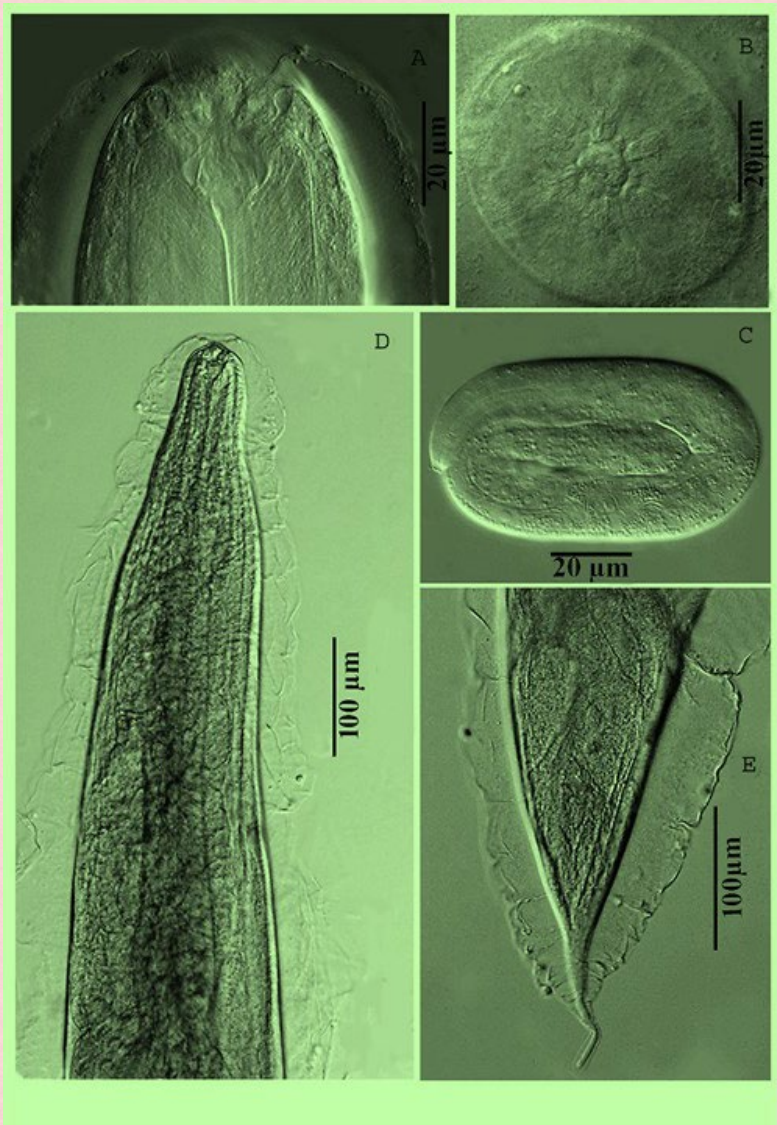
species from the orders Rhabditida and Tylenchida are known to exhibit this facultative parasitic behavior. Examples include certain species within the genera Rhabditis and Pristionchus.

» **Obligate parasitism:** Obligate parasitic nematodes of insects

are nematodes that can only complete their life cycle by parasitizing an insect host. Examples include species within the genera *Steinernema* and *Heterorhabditis*, which are commonly used as biological control agents for insect pests

Some of the Nematode diseases of Human

Disease and Parasite	Location in host	Mode of transmission	Geographic distribution	Treatment of choice
Ascariasis <i>Ascaris lumbricioides</i> Nematode (roundworm)	Small intestine; larvae through lungs	Eating viable eggs from feces-contaminated soil or food	Worldwide	Mebendazole, pyrantel pamoate
Dracunculiasis <i>Dracunculus medinensis</i> Guinea worm	Subcutaneous; usually leg, foot	Drinking water with Cyclops	Africa, Arabia, Asia	Mechanical or surgical extraction, Mebendazole
Strongyloidiasis <i>Strongyloides stercoralis</i> threadworm	Duodenum, jejunum, larvae through skin. lungs	Through skin and by internal autoreinfection	Worldwide	Thiabendazole, ivermectin



Nematode parasite of Frog: *Rhabdias* sp.

Let's summarize role of nematode in ecosystem and health

The moment the word nematode occurs, we associate it with diseases and consider them harmful organisms, but not all nematodes are harmful, many are useful too.

Good Nematodes

- » **Model system:** Studies using bacterial feeding nematode *Caenorhabditis elegans* has fetched 4 Nobel Prizes to scientists by now and more may come in future
- i. As model system the nematode *Caenorhabditis elegans* used for studying developmental studies, genetics etc. fetched Nobel prize in 2002 in Physiology or Medicine to Sydney Brenner, H. Robert Horvitz and John E. Sulston
- ii. The Nobel Prize in Physiology or Medicine in 2006 was awarded to Andrew Z. Fire and Craig C. Mello for their discovery of RNA interference (RNAi), also known as gene silencing, using the nematode *Caenorhabditis elegans*.

Model system: Studies using bacterial feeding nematode *Caenorhabditis elegans* has fetched 4 Nobel Prizes to scientists by now and more may come in future

- iii. In 2006, the Nobel Prize in Physiology or Medicine was awarded to scientists for the discovery of gene silencing, a process that involves using RNA molecules to regulate gene expression, the model organism was *Caenorhabditis elegans*. While the 2006 prize recognized the broader concept of gene silencing, the subsequent Nobel Prize in Chemistry in 2008 recognized scientists who utilized *C. elegans* to develop cellular "lanterns" that allowed for visualization of cellular processes.

- iv. Victor Ambros and Gary Ruvkun were awarded Nobel Prize in 2024 in Physiology or Medicine to for the discovery of

microRNA and its role in post-transcriptional gene regulation in model system as *Caenorhabditis elegans*

If all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable... -N.A. Cobb, 1914

- » Biological control agents: The nematodes *Steinernema* species have been used for the biological control of many harmful insects
- » Soil Health: Bacterial and fungal feeding nematodes are important soil mineralizers and decomposers

Bad Nematodes

- » Causing damage to plants
- » Causing several diseases in animals and humans"

If all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable... -N.A. Cobb, 1914



Dr. Shelley Acharya

THE TINY TERROR- Understanding the threat of Ticks

Ticks are nothing but tiny blood sucking ectoparasite. They range in size as small as a pin's head to as large as a pencil eraser. As they take in more blood they grow and get engorged. When you think about ticks, you might have portrayal of awful little parasites, stalking you on daylong survey in the forest.

Your concern is logical. Tick-borne diseases are the most prevalent vector-borne diseases – those transmitted by living organisms – in the whole world.

Each tick survives on several animals throughout its life, absorbing viruses and bacteria along the way and passing them on with its next bite. Some of those viruses and bacteria are detrimental to humans, causing diseases that can be fatiguing and sometimes deadly without

treatment, such as Lyme, Babesiosis and Rocky Mountain spotted fever.

There is a Tick on my pet !!!

Veterinary hospitals in India have reported a 200% rise in tick fever cases this year, particularly among dogs (Source: The Times of India, Coimbatore, 2025).



Pets are often infested with ticks

According to veterinarians, 10 in every 100 dogs get infected with tick fever every day. Out of the total cases, at least 20% end up fatal, which is one in every 10 infected dogs. While most dogs recover with treatment but the disease progresses rapidly in few with the severe damage to the vital organs such as kidneys, brain followed by death.

So beware those who have pets!! These blood-sucking parasites can transmit

multiple diseases to your furry friend, ranging from Lyme disease to tick paralysis, and tick-borne fever to ehrlichiosis, babesiosis, and anaplasmosis.

Lyme disease- an apparently rare disease in India

Lyme disease is a bacterial infection by *Borrelia burgdorferi* spread through the bite of infected ticks, primarily Ixodes ticks. The global distribution

of which corresponds to the distribution of *Ixodes ricinus* tick that transmits the organism. Lyme disease is a multisystem inflammatory disorder with a broad range of skin manifestations. Reportedly, 3000-5000 people in India suffer from the disease. It's characterized by a rash (often resembling a bull's-eye), flu-like symptoms, and can, if left untreated, affect joints, the heart, and the nervous system.

*Ixodes ricinus* causing Lyme disease: showing the system

A suspected case of Lyme disease caused by the bite of a tick carrying *borrelia* bacteria has been reported from Koovapady in Ernakulam district (The Indian Express, 2024). A farmer with no known comorbidities, was referred to the hospital with high grade fever.

Kyasanur Forest Disease

Kyasanur Forest Disease also known as "Monkey fever" is an exceptional tick borne disease that causes severe febrile haemorrhagic illness in humans and monkeys specially in southern part of India. The disease is caused

by highly pathogenic KFD virus which belongs to the genus Flavivirus. Hard tick *Hemaphysalis spinigera* are the reservoirs of KFD virus. The assault of the tick as the news headline was in recent cases in Karnataka where sixty eight people

Kyasanur Forest Disease also known as “Monkey fever” is an exceptional tick borne disease that causes severe febrile haemorrhagic illness in humans and monkeys specially in southern part of India

to the neighbouring district of Uttara Kannada in 1972 and eight years later, in 1980, cases were reported from Chikkamagaluru and from Dakshina Kannada in 1982. In 2012, the disease was reported from Chamarajanagara district and the Nilgiri district of Tamil Nadu. The following years saw it spread to neighbouring states of Kerala, Goa, and Maharashtra. Humans are infected mainly through the bite of this infected hard tick. Human beings are incidental hosts and do not play a role in the transmission. The virus exist in forest ecosystem among small mammals, monkeys and ticks.

have been tested positive with two death cases(Source: The Hindu, 2024).A serious health concern for the people who live in and around the forest belts.

What is actually the KFD? It is a vital haemorrhagic fever that is due to Kyasanur Forest Disease virus (KFDV) was initially detected in Kyasanur forest of Karnataka in 1957. It started spreading



Primates such as Hanuman langurs (in the photo) and bonnet macaques are amplifying hosts of the KFD virus spread through ticks. The virus undergoes amplification within their bodies, leading to symptomatic infection similar to that in humans.

(Photo by Abhishek N. Chinnappa/Mongabay).

Babesiosis

Babesiosis is a zoonotic disease of humans caused by the parasite “*Babesia*”. The primary hosts are usually rodents. Human act

as alternate host and acquire infection by the bite of Ixodid ticks. Several wild and domestic animals serve as incompetent reservoir hosts. Babesia is usually spread by young nymphs, which can be as small as a poppy seed.



The blacklegged tick (*Ixodes scapularis*)

Most of the infections are caused by this black-legged tick. Severe cases of Babesiosis, particularly

people with weaker immune system. This can be life threatening for elderly people, also cause Haemolytic

anaemia, jaundice, low blood pressure, joint pain, soar throat, acute respiratory distress syndrome.

The shocking story of Maria Palen

Maria Palen was everything one might visualise when picturing a fitness motivation. A 31-year-old chemical engineer from California, she followed a clean, plant-based diet, exercised regularly, and even gathered over 20,000

followers on Instagram for her transformation voyage. But in a kink, her story moved from fitness triumph to a health nightmare. After months of unexplained joint pain, swelling, and fatigue, Maria was diagnosed with babesiosis, an infection caused by parasites

transmitted through tick bites. By late 2024, she had become paralysed from the waist down.

Her journey retells us that sometimes the body can look flawlessly healthy on the outside, but something undistinguishable is silently conducting a warfare inside.

According to the Centres for Disease Control and Prevention (CDC), cases of babesiosis have doubled over the last decade, jumping from 1,000 in 2011 to around 2,500 annually today.

Not all dangers wear a warning label....

Tick bites often go unnoticed. They're small, painless, and easy to miss. What's more concerning is how long some infections can lie dormant. Maria's story is not a case of being careless; it's a case of how little is known or spoken about lesser-known tick-borne diseases like babesiosis.

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Even the fastest are not spared!!

Ectoparasites can harshly impact wildlife species, both through their feeding behaviour and by facilitating secondary infestations or bacterial infections.



Tick infestation troubles Cheetah cub in Indian reintroduction (Source: The Independent- Asia Edition, 2024)

Wildlife officials at Kuno National Park are keeping a close watch on seven cheetah cubs who have a tick infestation (The Indian Express, 2024). Sixteen free-ranging cheetahs in the Kuno National Park (KNP) in Madhya Pradesh's Sheopur district have been given prophylactic treatment to protect them from tick-infestation during the current monsoon season (Deccan Chronicle, July, 2025).

Outbreak of tick infestation has caused widespread panic

in a village of Angul district in Odisha recently. Countless ticks are seen on streets of Shreerampur village under Batisuan panchayat in Pallahada area of the district.

As per reports, tick infestation has flashed panic in Shreerampur village. Instead of animals, the ticks are clinging to the walls of houses.

As per the villagers, in the evening hours, ticks are seen everywhere, including inside and outside of the house. Starting from the walls and

fences, they are grazing on humans and animals. The villagers call this the 'Pataria Tinka'. These worms have made life difficult.

Fowl Tick

The fowl tick, *Argas persicus*, a menace worldwide in tropical and subtropical countries and a potential vector of *Borrelia anserina* (avian spirochetosis) and the rickettsia *Aegyptianella pullorum*, which causes fowl disease. These ticks are particularly active in poultry houses during warm and dry

weather hiding themselves in cracks and crevices during the day.

Fowl tick infestation can lead to anaemia (most important), weight loss, depression,

toxaemia, and paralysis. Egg production decreases.



The fowl tick (*Argas persicus*)

Ticks are a significant concern for cattle farmers in India, impacting animal health and productivity, and

causing substantial economic losses. These tiny parasites infest cattle throughout the year, with varying prevalence

depending on the region, season, and breed of the animal.

Bovine Anaplasmosis

A rickettsial disease primarily transmitted by *R. (B.) microplus*, causing fever, anaemia, and weakness, leading to reduced milk and meat production, and even death. Young calves (<1 year) and females, particularly during lactation, are found to be more susceptible to tick infestations.

The precautions

What is KFD?
It is a tick-borne viral haemorrhagic fever which is commonly found in Western Ghats region of India (Karnataka, Kerala, Tamil Nadu, Maharashtra and Goa).

Who is at risk of getting KFD?
Forest workers, hunters, people visiting forest areas, people working in forest areas, people visiting forest areas, people working in forest areas.

How do humans contract Kyasanur forest disease?
The virus is transmitted to humans through the bite of a tick or when humans come in contact with an infected animal.

Life Cycle of a Tick: A circular diagram showing the stages: Egg, Larva, Nymph, and Adult. It indicates the seasonal occurrence from November to May.

Signs and Symptoms of KFD: Acute onset of high grade fever, Headache, Myalgia, Nausea, Vomiting, Diarrhoea, Abdominal pain, Rash, and Generalised neurological symptoms.

When to suspect from KFD? When there is a history of exposure to tick bite, Person is travelling or living in and around forest areas where laboratory confirmed KFD cases have been reported previously, Person is from a KFD endemic area or has visited KFD endemic area, Person is from an area where monkey deaths have been reported.

First rule out common etiologies of acute febrile illness like Dengue/DHF, Typhoid, Malaria.

Diagnosis of KFD: By light microscope (1st 8 days of onset of symptoms), By PCR (1st 8 days of onset of symptoms), By ELISA (1st 8 days of onset of symptoms).

Treatment: Only prompt symptomatic and supportive therapy like Maintenance of hydration, Hemodynamic stability, Management of neurological symptoms may prevent complication. No specific treatment is available for KFD.

Prevention: Do's: Wear protective clothes covering the body, Apply insect repellents, After visiting the forest wear a bath and wear your clothes, Apply insecticide to your body and clothes, Report monkey deaths to animal husbandry department. Don'ts: Pick up dead monkey from KFD infected areas or near your house as it may contain deadly virus, Handle dead animal with care, protect yourself with gloves, Do not touch or handle dead monkey/deer as they may have been infected.

SELF-PROTECTION PREVENTS KFD

If you see the symptoms of KFD, visit the nearest health centre. Notify the local authorities, in case you notice dead monkeys in your area.

For more information, visit the nearest Health Centre.

National One Health Program for Prevention & Control of Zoonoses

Ticks are most active in warmer months and tend to thrive in grassy or wooded areas

Protect yourself by wearing full clothing, avoiding contact with sick animals, and reporting symptoms early.

Wear long sleeves and long pants, even tucking your cuffs into your socks if there's a gap.

Spray exposed skin with repellent.

Shed your clothes before heading back indoors.

And don't forget to check your pets and kids.

A protein found in human sweat may protect against Lyme disease. Researchers also found that a variant of the protein is not as protective against the bacteria and increases susceptibility to the disease (MIT News, 2024).

Routine checks must include overlooked areas. Ticks love warm, hidden places, behind ears, under arms, behind knees, along the hairline, and even between toes.

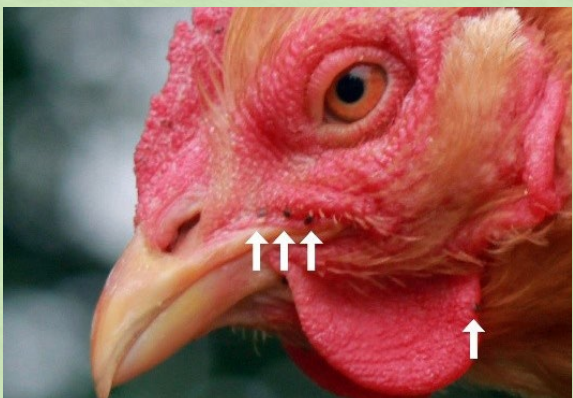
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Tick Infestation-A major Impediment

Managing tick infestations in rural areas is challenging due to limited resources, lack of awareness, and difficulties in accessing veterinary services.

Acaricide resistance and the risk of residues in food and the environment also complicate control efforts.

When Animals and Mankind - Both are the victims!!



Source: www.google.com

Way Forward.....

Ticks and tick-borne diseases constitute a major threat for human and animal health worldwide. Vaccines for the control of tick infestations and transmitted pathogens still represents a challenge

for science and health in our country. Improving habitat management and public awareness is must to do. The One Health approach, endorsed by the Government of India (GOI),

is a collaborative effort to address health challenges at the intersection of human, animal, and environmental health.



Dr. K. Valarmathi

The Alluring World of Crustaceans: Nature's Resourceful Creatures

Crustaceans might not always grab the spotlight when it comes to discussions about wildlife, but these fascinating creatures play a crucial role in our planet's ecosystems. From the familiar crab scuttling along the beach to the shrimp swimming in the depths of the ocean, crustaceans are an incredibly diverse and important group of animals. Whether you're a marine biology enthusiast or someone who simply enjoys seafood, there's a lot to love about these arthropods. Let's dive into the world of crustaceans!

What Are Crustaceans

Crustaceans are small, boneless animals belonging to the arthropod group, which also includes spiders, scorpions, centipedes, millipedes, and insects etc. These animals include

familiar creatures like prawns, shrimp, crabs, lobsters, and barnacles, as well as smaller planktonic organisms like water-fleas. Their size can vary a lot – from as tiny as 0.1 mm to as large as 4 meters, like the giant Japanese spider crab. Crustaceans are different from other arthropods (like insects) because they have two pairs of antennae, special appendages, and a unique eye. They are sometimes called “Insects of the Sea” because of their abundance, the variety of species and their importance. While most live in the sea, some live in freshwater, and a few even live on land (like woodlice). Some crustaceans are also parasitic and live off other animals. Crustaceans are characterized by their hard exoskeletons, jointed limbs, and segmented bodies. They

have a wide range of body shapes, sizes, and behaviors, but they share some common traits that set them apart from other types of animals. Globally around 67000 species of crustaceans are known and in India around 5090 species are known to occur.

Some crustaceans are very common and many are not very familiar to us. Now let us see what they are.

DECAPODS: All of us are aware of the prawns/shrimps, Crabs, Hermit Crabs and lobsters which possess 10 or 5 pairs of walking legs and technically known as Decapods. Globally more than 14756 species of decapods are known in India we have 1941 species of decapods of which crabs alone contribute 1135 species.



Banana prawn *Penaeus merguensis* (De Man, 1888) – Marine



Freshwater prawn scampi *Macrobrachium rosenbergii* (De Man, 1879)



A village woman with a freshwater crab captured from a paddy field



Charybdis (Charybdis) feriata (Linnaeus, 1758)-Marine crab

BRANCHIOPODS (from the Greek *branchia* meaning “gills” and *pods* meaning “foot”) are small, aquatic crustaceans like **Fairy shrimp** (graceful swimmers found in seasonal pools), **Brine shrimp** (salt-tolerant species famous for their eggs that can survive for decades), **Tadpole shrimp** (helmet-headed creatures that look like prehistoric tanks); **Clam shrimp** (tiny bivalved swimmers that resemble floating beans) Branchiopods are the ultimate survivalists. Many of them specialize in **temporary water bodies** like vernal pools, desert puddles, and salt flats that only exist for days or weeks each year. They’ve evolved **incredible eggs**. Called “resting eggs”

or “cysts,” these can remain dormant for years , even decades — waiting for the perfect wet conditions. Once submerged, they spring to life, hatch, grow, reproduce, and lay new eggs — all in a matter of days. When the water dries up, the cycle pauses and waits.



Clam shrimp -*Cyzicus annandalei* Daday, 1913



Tadpole shrimp -*Triops granarius* (Lucas, 1864)



Cladocera *Daphnia - pulex* Leydig, 1860

COPEPODS are a group of small aquatic animals, some live freely in the water, while others are parasitic, hitching rides on fish or other marine creatures. You’ll find them drifting with plankton, crawling along the seabed, or even living inside other animals. They’ve evolved to thrive almost anywhere there’s water.

Copepods are the fast food of the sea. Fish, whales, seabirds, and even jellyfish snack on them daily. In fact, the massive baleen whale—one of the largest creatures ever to exist—relies

heavily on these microscopic crustaceans for food. They’re also voracious eaters themselves. Most copepods feed on phytoplankton (microscopic plants), making them a vital link in the ocean

food chain. Think of them as the middlemen who help turn sunlight (captured by algae) into a form of energy that can nourish larger animals. In India we have more than 1500 species of copepods.

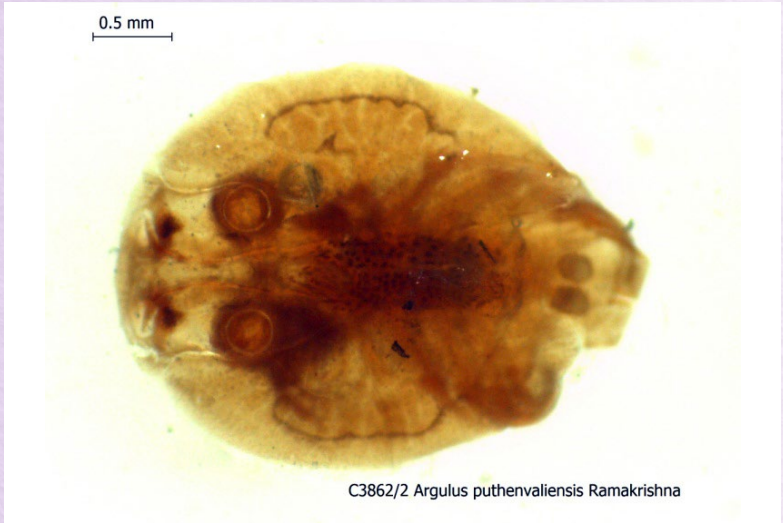


A freshwater calanoid copepod carrying egg mass



A fish infested with a parasitic copepod (Thread like structure)

FISH LICE (BRANCHIURA) are small ecto parasites of fishes which causes a diseases called Argulosis in fishes. Globally 156 species of fish lice are known in India we have around 17 species.



C3862/2 *Argulus puthenvaliensis* Ramakrishna

BARNACLES: These are the immobile relatives of crabs and lobsters, attaching themselves to rocks, ships, and even whales. Globally around 1400 species of barnacle reported in India around 149 are available. They begin life as free-swimming larvae but eventually undergo a dramatic transformation, they glue themselves headfirst to a hard surface like a rock, a whale, or even the bottom of a ship and build a hard, volcano-shaped shell around themselves, once

they stick, they stay remain immobile forever. One of the most amazing things about barnacles is their ability to attach to nearly any living or non living structures in the habitat.



Barnacles attached to rocks in sea shore



Barnacles attached to a mangrove plant

TANAIDS are minute shrimp-like crustaceans, mostly within the size ranges of 2.0-5.0 mm with the exceptions of a few species, the adults of which can reach up to 50.0-75.0 mm. They are mostly marine or brackish water

forms although a few species also occur in freshwater habitats.



MANTIS SHRIMPS: a colorful, alien-looking marine crustacean is an impressive (and underrated) predator in the ocean, its nick name is “thumb-splitter”. It is one of the most fascinating creatures on Earth, lives in coral reefs and sandy seafloors. Globally around

500 species of mantis shrimps are known, in India we have 76 species of mantis shrimps (Stomatopods).



Lysiosquilla tredecimdentata Holthuis, 1941



Miyakella nepa (Latreille in Latreille, LePeletier, Serville & Guérin, 1828)

AMPHIPODS are small, shrimp-like crustaceans found in oceans, rivers, lakes, and even the leaf litter in your backyard. With over 13,312 known species globally and 402 species in India and likely many more yet to be discovered, they range in size from just a couple of millimeters to nearly a foot long. They're like nature's utility players—tough, adaptable, and surprisingly complex. Unlike shrimp, amphipods don't have a carapace (a hard protective shell over their head and thorax), giving them a more flexible and almost insect-like appearance. Their name comes from Greek, meaning

“different-footed,” which refers to their limbs that are specialized for swimming, crawling, or burrowing.

Amphipods may be tiny, but their role in the food chain is massive. They're scavengers, decomposers, and grazers, helping to recycle organic material and keep ecosystems clean. They feed on everything from dead fish and algae

to microscopic detritus, essentially acting as nature's janitors. In turn, they are a vital food source for fish, seabirds, and even whales. In freshwater systems, a healthy population of amphipods is often a sign of good water quality. Some species are so sensitive to pollution that scientists use them as “bio-indicators” to monitor environmental health.



ISOPODS: Isopods are a surprisingly diverse group of crustaceans that live almost everywhere—from the depths of the ocean to rivers, lakes, and even dry land. While most of them are found in the sea, many have adapted to life in freshwater and on land as well. They come in all shapes and sizes, ranging from tiny ones barely visible to the naked eye to giant deep-sea species like *Bathynomus*, which can grow up to half a

meter long! Isopods live very different lifestyles too—some roam freely and feed on waste or small animals, others bore into wood, live in caves, or even act as parasites on fish. Scientists have identified over 10,000 species around the world, including more than 300 in India. Many of these creatures play an important role in nature by breaking down waste and becoming food for other animals. But not all of them

are helpful—some damage mangroves and wooden structures, while parasitic ones can harm fish. On the bright side, land-dwelling isopods are also being used to monitor pollution, thanks to their sensitivity to environmental changes. Whether helpful or harmful, isopods are an important part of the ecosystems they live in—and they’re more interesting than you might think!



Parasitic Isopod



Wood Boring Isopod



A fish infested with parasitic Isopod



Attack of wood boring Isopod

OSTRACODS: sometimes nicknamed “seed shrimp” because of their small, oval-shaped bodies encased in a protective shell, are microscopic crustaceans that have been quietly thriving on Earth for over 500 million years. They live in almost every aquatic environment imaginable—from deep ocean trenches to freshwater ponds, and even damp soil. And though they’re small (most are less than 1 mm long), they’ve had an outsized impact on science, ecology, and even evolution.

Despite their size, ostracods are incredibly diverse with both living and extinct species. Their hard shells fossilize well, making them one of the best-documented organisms in the fossil record. Paleontologists use them to study ancient environments, date rock layers, and track climate change over millions of years. Some ostracods are bioluminescent i.e., they can produce light. Bioluminescence in ostracods has even contributed to military science.



Freshwater Ostracod - *Stenocypris major* (Baird, 1859)

HOW CRUSTACEANS EVOLVE AND ADAPT

One of the most impressive aspects of crustaceans is their remarkable ability to adapt to a wide variety of environments. Over millions of years, these creatures have evolved diverse ways to thrive in nearly every aquatic habitat imaginable—from the deepest ocean trenches to the muddy shores of coastal wetlands. Crustaceans also possess some unique evolutionary features, like

Exoskeleton for Protection: Crustaceans are equipped with a tough exoskeleton made of chitin, a biopolymer that serves as armor to

protect their delicate internal organs. However, this exoskeleton comes with a limitation: it does not grow as the crustacean does. So, crustaceans must molt, or shed their exoskeletons, in a process known as ecdysis. After molting, the crustacean’s new exoskeleton is soft, making them vulnerable until it hardens.

Complex Eyes: Crustaceans are known for their impressive vision. Many species have compound eyes, which are made up of thousands of small individual lenses, allowing them to detect movement and see in a wide range of directions simultaneously.

Some crustaceans, such as mantis shrimp, have even been found to have the most complex eyes in the animal kingdom. These creatures can see ultraviolet and polarized light, as well as detect colors that are invisible to the human eye

Diverse Feeding Strategies:

Crustaceans are opportunistic feeders, and their diets can range from plankton and algae to other animals. Many, like crabs and lobsters, are scavengers, using their strong claws to break apart dead or decaying matter. Others, like the shrimp, have evolved to be filter feeders, drawing in water and capturing tiny particles of food. Some crustaceans, such as the predatory mantis shrimp, even hunt other animals with remarkable speed and precision

Complex Behavior and Communication:

Crustaceans communicate through a variety of methods, including visual signals, chemical cues, and vibrations. For example, some species of crabs use their large claws to perform displays to attract mates or warn rivals. Shrimp, on the other hand, release

Some species of crustaceans have also developed complex social structures. In particular, certain shrimp species live in large colonies, and some crabs have been observed to work together to dig communal burrows. In these cases, group cooperation plays an important role in survival.

pheromones into the water to signal other shrimp about danger or potential food sources.

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WHY CRUSTACEANS MATTER

While many people may not realize it, crustaceans are vital to the health of marine

ecosystems. They play key roles as both predators and prey. As filter feeders, they help maintain water quality by removing plankton and detritus. At the same time, they are an important food source for many marine animals, including fish, seabirds, and marine mammals.

In fact, one of the most important creatures in the ocean—krill, a type of shrimp-like crustacean—forms the foundation of the marine food web. These tiny animals are eaten by larger fish, which are, in turn, consumed by even bigger

predators, like whales. Without krill and other small crustaceans, the entire ocean food chain would collapse.

Crustaceans also contribute to the health of coastal ecosystems. For example, crabs help break down organic matter in tidal flats, enriching the soil and aiding plant growth. Mangrove forests, which provide habitat for many crustacean species, serve as nurseries for young fish and act as natural buffers against storm surges and erosion.

Crustaceans: Nature's Unsung Heroes of Ecology, Economy, and Medicine

Crustaceans—those curious creatures of the sea like crabs, prawns, shrimp, and barnacles—are far more than just seafood. From playing vital roles in marine ecosystems to featuring in traditional medicine and even crab racing, their significance spans far and wide.

Ecological Powerhouses

Crustaceans are essential to the health of our oceans and coastlines. Acting as scavengers, they help keep

ecosystems clean, while some species, like burrowing crabs, contribute to beach health through a process known as bio-turbation. Certain barnacles (called cirripeds) serve as indicators of heavy metal pollution in marine environments, while others may become bio-fouler, attaching themselves to ships and underwater structures. Some species like limnoriids and sphaeromatids can even cause damage to wooden piers and live mangrove trees.

A Staple of Global Commerce

Crustaceans are also big business. Crabs, shrimp, and prawns are consumed worldwide as a delicacy, forming a crucial part of the seafood industry. Prawns are a lean source of protein, low in fat and calories, and rich in essential nutrients like iodine, selenium, and vitamin B12. They're also a solid source of omega-3 fatty acids, which are great for heart and brain health. Many nutritionists recommend incorporating seafood into your diet several times a week — and prawns are an easy, tasty way to do just that.

But their value goes beyond the dinner plate. Ground crustaceans are used in fish meal for poultry, agriculture, and aquaculture, playing a vital role in food production systems.

Eco-Warriors of the Seashore

Beyond the plate, crabs play a vital role in marine ecosystems. As scavengers, they help clean up the ocean floor, recycling nutrients and maintaining balance. Fiddler crabs, with their one oversized claw, actually help aerate marshland soil—making them mini environmental engineers.

Healers from the Deep

Traditional medicine systems across Asia and coastal regions have long recognized the healing properties of crustaceans. For instance, the mud crab (*Scylla serrata*) is used in folk remedies to treat ailments ranging from asthma and tuberculosis to rheumatism and gynecological disorders.

Other crabs, like *Sartoriana spinigera*, *Ocypode platytarsis*, and *Spiralothelphusa hydrodroma*, are used for

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various treatments, while shrimp and prawns—like the tiger prawn (*Penaeus monodon*)—are believed to help with conditions such as diabetes, kidney problems, and postpartum recovery.

Freshwater prawns like *Macrobrachium malcomsonii* and *Macrobrachium rosenbergii* are also consumed to relieve lumbago, hay fever, and bone fractures. Even mantis shrimp (stomatopods)

are used in treating asthma and skin diseases.

Beauty and Entertainment in a Shell

Crustaceans aren't just functional—they can be fun and beautiful, too. Many vibrant shrimp species are popular additions to home aquariums. In some parts of the world, crabs are even used for entertainment. In the West Indies, land hermit crabs (*Coenobita*) and other species like *Cardisoma* are raced in bars, while crab fighting is a traditional pastime in the Seychelles.

Fish Bait and Feed

Lastly, crustaceans like decapods and stomatopods are commonly used as bait in fishing and as feed in aquaculture, helping sustain fish populations both in the wild and in farms.



In search of freshwater prawns and crabs in rivers flowing in Arunachal Pradesh



The author in search of mole crabs in West cost

CONCLUSION

Crustaceans may be small, but their impact on the planet is anything but insignificant. From their essential role in marine ecosystems to their contributions to human culture and science, these creatures are among the most

ingenious and diverse animals on Earth. The next time you spot a crab scuttling along the shore or enjoy a seafood meal, take a moment to appreciate the complexity and wonder of these fascinating arthropods. From cleaning our oceans

to healing our bodies and spicing up our aquariums, crustaceans are much more than meets the eye. These fascinating creatures play an extraordinary role in supporting life both underwater and on land.



Dr. Honey U.K. Pillai

From Microscopic to Mighty: The Crucial Role of Zooplankton in Shaping Marine Ecosystem Dynamics



Zooplankton constitute a highly diverse group of heterotrophic organisms that inhabit the pelagic zones of aquatic ecosystems, ranging from microscopic unicellular protozoans to multicellular metazoans. This assemblage includes copepods, cladocerans, amphipods, rotifers, and the larval stages of various fish and crustaceans, reflecting a wide spectrum of taxonomic groups and life histories. Based on their size, zooplankton are conventionally classified into three categories: microzooplankton (20–200 μm), which primarily consist of protozoans and small metazoans; mesozooplankton (200 μm –2 mm), which include the most abundant and ecologically significant taxa such as copepods and cladocerans; and

macrozooplankton (>2 mm), encompassing larger organisms like krill and jellyfish. Functionally, zooplankton occupy a critical trophic position as primary consumers that mediate the transfer of energy and

nutrients from autotrophic phytoplankton—responsible for primary production—up to higher trophic levels, including commercially valuable fish species, marine mammals, and seabirds.

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In the context of Indian aquatic ecosystems, zooplankton exhibit significant spatiotemporal variability influenced by regional oceanographic and climatic factors. The Arabian Sea and Bay of Bengal, two major marine basins flanking the Indian peninsula, experience distinct monsoonal forcing, coastal upwelling, and freshwater influx from large river systems, which profoundly affect zooplankton abundance, biomass, and species composition. Estuarine environments such as the Sundarbans, Godavari delta, and Chilika Lake serve as critical nursery grounds where zooplankton populations flourish, providing essential food resources for the larval and juvenile stages of numerous pelagic and demersal fish species. The strong trophic reliance of these fish larvae on mesozooplankton underscores the pivotal role of zooplankton in sustaining fisheries productivity and recruitment success, thereby supporting the livelihoods of coastal communities dependent on marine resources. Moreover, in

Indian aquaculture practices, live zooplankton such as rotifers and copepods are cultured and employed as indispensable live feed in hatcheries to optimize larval survival, enhance growth rates, and improve overall yield in finfish and crustacean farming. This integration of zooplankton into aquaculture highlights their economic importance beyond natural food webs.

In addition to their trophic functions, zooplankton act as sensitive bioindicators of aquatic ecosystem health. Variations in their community structure, abundance, and spatial distribution have been extensively correlated with environmental stressors including nutrient enrichment (eutrophication), ocean acidification, temperature fluctuations, and salinity changes.

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Such ecological responses make zooplankton invaluable for monitoring environmental changes and assessing the impacts of anthropogenic activities and climate variability on aquatic ecosystems. Long-term observational studies from Indian waters have documented the responsiveness of zooplankton communities to large-scale climatic phenomena such as the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), emphasizing their potential utility in predicting ecosystem responses to climate change. Furthermore, zooplankton contributes significantly to the biogeochemical functioning of marine systems through their diel vertical migration and grazing behavior. By feeding on phytoplankton near the surface and migrating to deeper waters, zooplankton facilitate the biological pump, a process that transports carbon from the surface ocean to the deep sea, thus playing a critical role in carbon sequestration and nutrient recycling. This function not only influences oceanic carbon cycles but

also has implications for global climate regulation. Collectively, the ecological roles and economic significance of zooplankton in Indian waters highlight their indispensability in maintaining aquatic ecosystem resilience and productivity. Their presence ensures the stability of food webs, supports fisheries and aquaculture, and contributes to the broader biogeochemical cycles that sustain marine biodiversity and ecosystem services in the Indian subcontinent.

Economic Importance to Ecosystem and Mankind

Zooplankton play a crucial economic role by supporting the foundational levels of aquatic food webs that sustain global fisheries, including many commercially important fish and shellfish species. Their abundance, diversity, and community composition directly influence fish recruitment and population dynamics, making them indispensable for the productivity and sustainability of both capture fisheries and aquaculture operations. In India, where millions depend on coastal

fisheries for livelihood and nutrition, zooplankton form the primary food source for larval and juvenile stages of key commercial species such as sardines, mackerels, anchovies, and prawns. The seasonal variability of zooplankton populations in the Arabian Sea, Bay of Bengal, and estuarine systems closely correlates with monsoonal cycles and nutrient fluxes, thereby affecting fishery yields and aquaculture success. In aquaculture hatcheries across India, live zooplankton such as rotifers and copepods are cultivated extensively as essential feed for early developmental stages of finfish and crustaceans. This practice significantly enhances larval survival rates, growth performance, and overall productivity, contributing to the country's growing aquaculture industry. Beyond their role in food production, zooplankton serve as sensitive bioindicators of environmental changes, providing early warning signals for water quality deterioration, eutrophication, and pollution in coastal and inland waters. Monitoring zooplankton dynamics aids in

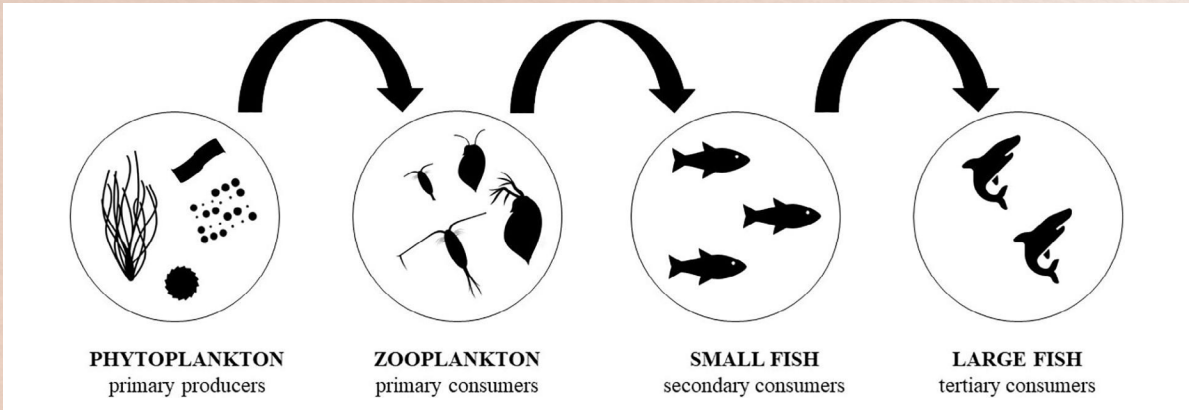
the sustainable management of aquatic ecosystems, which is critical given the increasing anthropogenic pressures and climate variability affecting Indian marine environments. Moreover, zooplankton contribute substantially to biogeochemical cycles through their grazing activity and diel vertical migrations, facilitating carbon sequestration and nutrient recycling. These processes play a significant role in climate regulation and maintaining marine biodiversity, which underpin the economic stability of coastal communities and national food security. Thus, the ecological and economic importance of zooplankton extends far beyond their size, highlighting their integral role in sustaining India's aquatic resources and the livelihoods dependent on them.

Given their foundational role in aquatic food webs and their sensitivity to environmental fluctuations, zooplankton must be prioritized in future research and management strategies. Comprehensive and long-term monitoring of zooplankton communities in Indian waters can provide

critical data to predict and mitigate the impacts of climate change, pollution, and habitat degradation on marine biodiversity and fisheries productivity. Furthermore, fostering sustainable aquaculture practices that optimize the use of live zooplankton as feed can enhance food security and economic development along India's extensive coastline. Interdisciplinary approaches combining ecology, oceanography, and

socioeconomics will be essential to fully understand and harness the potential of zooplankton in maintaining ecosystem balance and supporting human livelihoods. Ultimately, recognizing and preserving the intricate linkages that zooplankton create within marine ecosystems will be key to ensuring the health and resilience of India's aquatic environments in an era of rapid environmental change.

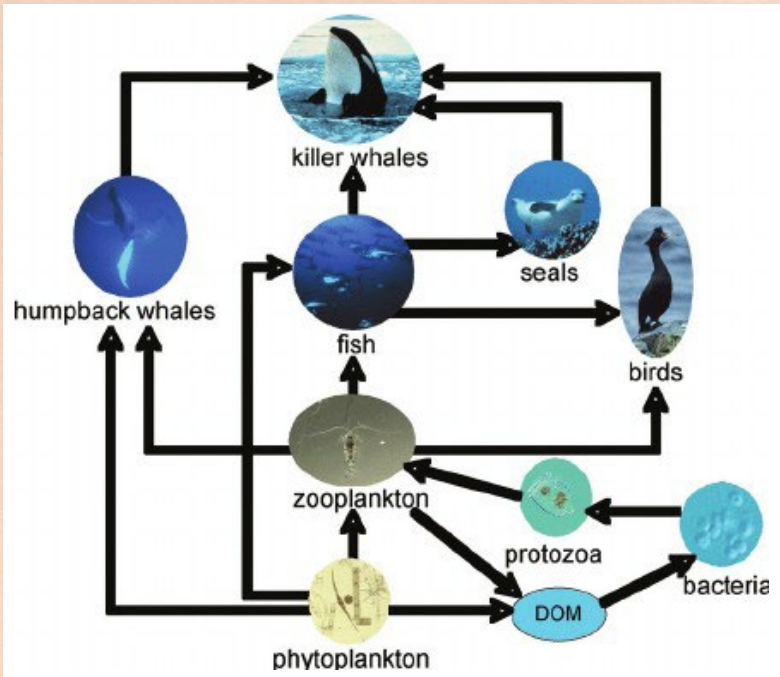
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Aquatic food chain. Image courtesy of Silvia Lomartire, João C. Marques, and Ana M. M. Gonçalves. Adapted from Lomartire, S., Marques, J. C.,

& Gonçalves, A. M. M. (2021). The key role of zooplankton in ecosystem services: A perspective of interaction between zooplankton and

fish recruitment. Ecological Indicators, 129, 107867. <https://doi.org/10.1016/j.ecolind.2021.107867> (accessed July 20, 2025).



Marine food web. Image courtesy of the National Oceanic and Atmospheric

Administration (NOAA), U.S. Department of Commerce, and the Bigelow Laboratory

for Ocean Sciences. Source: Ambler, J. W., & Butler, N. M. (2008). Microscopic plants and animals of the oceans: Introduction to marine plankton. Retrieved July 20, 2025, from http://www.kilroyacademy.org/content/Microscopic_Plants_and_Animals_of_the_Oceans_Introduction_to_Marine_Plankton.



Dr. Chitra J

Tiny Magicians in Waters



Our Earth surface is covered by 71% of water in various forms like ocean, polar ice caps, glaciers, lakes, ponds, rivers, hot springs, temporary pools, reservoirs, dams, tanks, canals, streams, groundwater wells etc., These diverse habitats enriched with biological resources of living

plays widely in permanent and temporary water bodies where the aquatic organisms do have impact in their quality of life. Plankton acts as primary producers in the form of phytoplankton and primary consumers by zooplankton. These zooplankton are the planktonic organisms, weak swimmers categorized to picoplankton nanoplankton, microplankton, mesoplankton,

macroplankton and megaplankton based on the size ranging from 2 microns to 200mm. Holoplankton leads entire life of organisms in planktonic mode as in copepods, rotifer, cladocera, protozoa whereas meroplankton remain planktonic nature in part of lifecycle. Examples., Larval forms of mollusca, crustacea, insecta, echinodermata, pisces etc.,



Pivotal Role of Zooplankton in ecosystem dynamic services

We really concern on the organisms in aquatic systems because of their immense role in food chain implicit on human health. Most of the aquafood delicacies with high protein content, fatty acids, vitamins, minerals etc., support higher vertebrates and human health. To understand the food chain/web from microbes to higher vertebrates, generally animals acts as primary, secondary and tertiary consumers in food web to balance the aquatic ecosystem. Based on feeding behaviour, they have been categorized as producers (autotrophs), consumers (heterotrophs) and decomposers (detritivorous). Zooplankton involves in carbon cycle converts carbondioxide to organic matter by faecal matter termed as process of biological pump. Their diel vertical migration also transport carbon in terms of carbon sequestration in marine ecosystem. Through food chain bioaccumulation and biomagnification of toxins, heavy metals, persistent

organic pollutants which ultimately affect the human health. They are commonly called as bioindicators of water quality and biocontrol agent in aquaculture and

agriculture. Due to their lipid accumulating capacity they also been used in biodiesel production as similar to algal biofuel production.

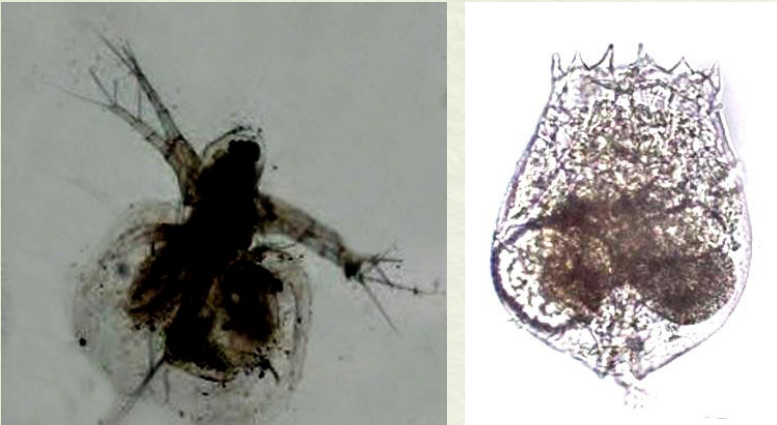
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Zooplankton and economy

Zooplankton are the live feed served for cultivable fish larvae and shell fish in hatcheries due to it high value of nutrition. Mass culture of zooplankton on batch, continuous and polyculture are being cultured in the form of live specimen feed, powder and in pellet forms for the use of research purposes as well as marketed in aquaculture industries to promote livelihood of fishermen, young business professionals. Stocking density of zooplankton harvesting at maximum level involvement of young educated individuals has to take up proper training with professional to gain and promote proper knowledge on zooplankton biology to avoid contamination in cultures and environmental fluctuations. This may be a profitable ventures in terms to manage the resources in the complexities of zooplankton production. There are researches that explored their potential antimicrobial, anticancer and other therapeutic properties and copepods and cladocerans role in drug resistant pathogens and antibiotic resistant strains.

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Zooplankton as vectors

They are the carriers and vectors of waterborne diseases in aquatic ecosystem. Even infection cases of cholera through crustacean zooplankton by bacteria viz., vibrio cholera, virus reservoirs. Due to their migration in waterbody it spreads the pathogens to prey and predators in the system and which also affect the food chain and nutrient cycling and leads to deterioration of water quality and major threat to the animals and human health. They become resistant to environmental stressors and potential in spreading dreadful pathogens.

White band disease in corals caused by the zooplankton which spreads the disease. And even the toxin bloom

of phytoplankton also been carried to the entire aquatic ecosystem.



Pollution threat and Challenges

These ecofriendly zooplankton organisms faces threats by microplastics, nanoplastics ingestion with food articles. The impact of chemical pollution by various factors influences on decline in population dynamics, fecundity of zooplankton. The other factors like nutrient pollution, eutrophication, hypoxia, anoxia, turbidity were other challenges to zooplankton. Addressing the pollution threats, research on baseline data on the diversity and distribjution of zooplanktonic organisms to assess the pollution status.

Future scope in zooplankton research

Monitoring zooplankton biodiversity is highly challenging due to their microscopic size, diverse

and studies in morphological features are highly neglected by the beginners has to be promoted through funded programmes by Government. Extensive research long term monitoring in cascading effects of zooplankton in food web dynamics. Identification of Multiple stress creating factors in aquatic systems and designing the research requirement to be investigated globally which would be the major solution. Research grant for long term and short term projects in zooplankton,

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fellowships through funding agencies by Ministry of Environment Forests and climate change, Ministry of Earth Science, Department of science and technology,

Extensive research long term monitoring in cascading effects of zooplankton in food web dynamics. Identification of Multiple stress creating factors in aquatic systems and designing the research requirement to be investigated globally which would be the major solution.

Council of Scientific and Industrial Research, National science foundation, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, Department of energy,UK Natural Envornment research council, Germany”s Federal Ministry of education and Research promoting research in zooplankton in marine and freshwater ecosystem. Traditional morphology based techniques involving microscopes, ZOOSCAN, FlowCAM) and DNA (meta

barcoding, qPCR). Their role in environmental change impacts, ecosystem services,

Conservation of waterbodies in large scale from microplastics, pollution and other challenging threat is real concern to each one of us to take part in clean pollution free environment for all natural biological resources. In overall these tiny organisms serve astonishing magical services to aquatic system.

Biomedical Applications, climate change effects, Status on distribution and diversity awaken young professionals to seek opportunities and promote in research in zooplankton. Conservation of waterbodies in large scale from microplastics, pollution and other challenging threat is real concern to each one of us to take part in clean pollution free environment for all natural biological resources. In overall these tiny organisms serve astonishing magical services to aquatic system.



Dr. Avtar Kaur Sidhu

Nature's Tiny Winged Wonders: Butterflies

Butterflies have long fascinated humankind with their vibrant colours, delicate flight and ethereal presence. They seem to dance through gardens and meadows as if painting the air with strokes of living rainbows. These winged wonders are not only symbols of beauty and transformation but are also vital contributors to ecosystems across the globe. Beyond their aesthetic charm, butterflies play crucial roles as pollinators, indicators of environmental health, and even sources of inspiration for science and culture. Butterflies, belonging to the order *Lepidoptera*, are not just nature's decoration — they are vital players in our environment, helping plants reproduce, supporting other wildlife, and even inspiring breakthroughs in science.

Across the world, there are more than 20,000 species of butterflies, found on every continent except Antarctica. India alone is home to 1318 species, thanks to its rich landscapes ranging from the Himalayas to tropical forests. Iconic species like the Apollos, Birdwings, Common Jezebel, Blue Mormon, Crimson Rose, and the Indian Nawab can be seen across the country, while rare and endemic species thrive in biodiversity hotspots such as the Himalayas, Western Ghats and Northeast India.

Why Are Butterflies Important to Nature?

1. Pollination Partners

Like bees, butterflies help pollinate flowers while they sip nectar. As they flit from bloom to bloom, pollen clings

to their legs and wings, transferring it between plants. This process helps wildflowers, crops, and trees produce seeds and fruits — keeping ecosystems healthy and ensuring food for humans and wildlife alike. Although bees dominate pollination networks, butterflies contribute significantly, especially to diurnally blooming plants with bright flowers and deep corollas. Species such as swallowtails (*Papilio* spp.) and skippers (*Hesperiidae*) are efficient pollinators of orchids, milkweeds, and lantanas, among others. While their pollination efficiency is generally lower than bees, their mobility and ability to traverse large areas make them important

in maintaining genetic connectivity among plant populations.

2. A Vital Food Source and Food Web Dynamics

Caterpillars and adult butterflies are an essential part of the food chain. Birds, frogs, lizards, and even other insects rely on them for survival. Without butterflies, many animals would lose a key source of nutrition. Butterflies serve as critical prey for birds (e.g., flycatchers, warblers), bats, amphibians, and predatory insects (e.g., dragonflies, mantids). Their larvae are particularly important energy sources in terrestrial food webs. Some species, such as *Spindasis* butterflies, also engage in mutualistic relationships with ants during larval stages adding complexity to their ecological roles.

3. Nature's Warning System

Butterflies are very sensitive to environmental changes, habitat alteration including pollution, habitat destruction, and climate change, making them reliable bioindicators. When

butterfly populations decline, it often signals that an ecosystem is in trouble. This makes them excellent bioindicators for scientists studying environmental health.

Why Are Butterflies Important to Humans?

1. Supporting Agriculture and Economy

While butterflies are not as famous as bees when it comes to crop pollination, they still play a role in supporting fruits, vegetables, and other plants we rely on. Butterfly gardens and sanctuaries also boost eco-tourism,

bringing income to local communities.

2. Scientific and Technological Inspiration

Although butterflies as a group have not directly won Nobel Prizes, research involving them has influenced Nobel-recognized fields. Investigations into mimicry (Batesian and Müllerian), genetics, and nanostructures of wing scales have been foundational for evolutionary biology and optical sciences. Additionally, butterfly conservation initiatives

Additionally, butterfly wing patterns have inspired innovations in solar panels, textiles, and optics, as their microscopic scales manipulate light in ways humans now use in technology. In 2014, Japanese physicist Isamu Akasaki (along with others) won the Nobel Prize in Physics for work on blue LEDs.

in India have received global recognition through IUCN and international biodiversity awards.

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While not directly about butterflies, scientists studying structural colours — like those seen in butterfly wings — have drawn from similar nanostructures to improve light technology.

4. Cultural and Artistic Value

Across cultures, butterflies symbolize transformation, hope, and the soul. In Greek mythology, the word *psyche* means both “soul” and “butterfly.” In Mexico, Monarch butterflies are believed to carry the spirits of ancestors during Día

de los Muertos. Beyond symbolism, they also inspire art, jewelry, literature, and even fashion.

The Fascinating Life of a Butterfly

Every butterfly begins its life as something seemingly unremarkable—an egg, no larger than a pinhead, carefully laid on a leaf. From this tiny beginning unfolds one of nature’s most miraculous transformations, known as complete metamorphosis. This process occurs in four stages:

1. Egg – The starting point, often laid on plants that will later serve as food for the larva.
2. Larva (Caterpillar) – A voracious eating machine, the caterpillar feeds on leaves, storing energy for its next stage.
3. Pupa (Chrysalis) – Inside this seemingly lifeless shell, the caterpillar undergoes a stunning transformation, reorganizing its body entirely.
4. Adult Butterfly – Emerging with wings, the adult

seeks nectar, mates, and begins the cycle anew.

This metamorphosis is more than a biological marvel; it has inspired countless works of art, spiritual teachings, and even psychological metaphors for personal growth and rebirth. The butterfly’s short but vibrant life—often lasting only a few weeks as an adult—reminds us of life’s fleeting yet beautiful nature.

Diversity of Indian Butterflies

Globally, about 20,000 butterfly species are known, of which 1,318 species have been recorded from India. These belong to five major families:

1. Papilionidae (Swallowtails): Large, colorful butterflies, including the Common Mormon (*Papilio polytes*) and the endangered Southern Birdwing (*Troides minos*), India’s largest butterfly with a wingspan up to 190 mm.
2. Pieridae (Whites and Yellows): Medium-sized species, such as the Common Jezebel (*Delias eucharis*), often

associated with open habitats.

3. Nymphalidae (Brush-footed Butterflies): The largest family, including Blue Tiger (*Tirumala limniace*) and Indian Red Admiral (*Vanessa indica*).
4. Lycaenidae (Blues, Coppers, and Hairstreaks): Small, delicate butterflies like the Pea Blue (*Lampides boeticus*).
5. HesperIIDae (Skippers): Small, fast-flying species like the Indian Skipper (*Spialia galba*).

Threats to Butterflies

Sadly, many butterfly species face serious challenges.

Habitat loss from deforestation, farming, and urban expansion.

- » Pesticides that harm caterpillars and the plants they depend on.
- » Climate change, which shifts migration patterns and disrupts food sources.
- » Invasive species that destroy native plants and compete for resources.
- » **Illegal Collection and Trade**, particularly of rare

species like Apollos and Kaiser-i-Hind, Birdwings

How Can We Help Protect Them?

- » Planting native flowers and host plants: Butterflies rely on specific plants for nectar and as breeding sites. Creating butterfly-friendly gardens helps sustain local populations.
- » Avoiding pesticides: Reducing chemical use preserves both butterflies and the plants they depend on.
- » Support conservation groups, which works to protect pollinators.
- » Promoting habitat corridors: Connecting fragmented habitats allows butterflies to migrate and maintain genetic diversity.
- » Promote eco-tourism and awareness by visiting butterfly parks and sanctuaries.

Even small actions — such as leaving a patch of your garden wild — can create a haven for these winged wonders. On a broader scale, governments and organizations can help by protecting critical habitats,

enforcing sustainable agricultural practices, and conducting scientific research to monitor populations and address emerging threats.

Guardians of Beauty and Balance

Butterflies of India represent not only an irreplaceable component of biodiversity but also a crucial part of ecosystem functioning and cultural heritage. Their contributions to pollination, scientific research, education, and ecotourism highlight their multifaceted value. Conserving these insects is essential for maintaining ecological balance and ensuring that future generations continue to benefit from their presence, both scientifically and aesthetically. Butterflies, with their iridescent wings and ephemeral lives, are more than emblems of natural beauty. They are vital components of ecosystems, performing functions that sustain biodiversity. Butterflies may seem delicate, but their role in the natural world is powerful. They help plants thrive, support entire food chains, signal changes in our environment, and even inspire cutting-edge science.

They remind us that beauty and utility can coexist in nature.

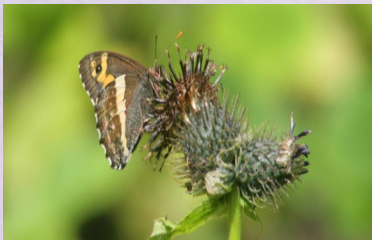
As we admire these living rainbows fluttering through fields and forests, we are reminded of our responsibility to protect the natural world. For in preserving the butterfly,

we preserve the very essence of life's beauty and diversity. Protecting butterflies requires a combination of science, conservation, and public will. By safeguarding their habitats and reducing anthropogenic threats, we not only ensure the survival of these delicate creatures but

also uphold the integrity of the ecosystems on which we all depend. Butterflies often serve as umbrella species, protecting their habitats indirectly benefits other insects, birds, and plants sharing the same ecosystems.



Aporia leucodice- Arrowhead blackvein



Aulocera saraswati taking nectar from flowers of *Saussurea costus*, - a medicinal plant grown in a nursery at Udeen



Gonepteryx rhamni -Common Brimstone



Parnassius charltonius- the regal apollo near Komic, Asia's highest village, altitude 4650 m asl



Parnassius epaphus hillensis sucking nectar from flowers of *Potentilla arbuscula* (Rosaceae) at Khardungla



Dr. Deepa Jaiswal

Wanderers of the Water: Hidden Beetles of Eastern Ghats

The taxonomic order Coleoptera derives its name from the Greek word “koleopteros” which means Coleo = Sheath; Ptera = Wings, given by Aristotle for their elytra, hardened shield-like forewings. Coleopterans are commonly known as beetles represent the largest group of insects (>400,000 described species), with a broad range of anatomical and biological diversity; they represent about one-fourth of the total animal diversity of the world and the present era can be said to be the ‘Age of the Beetles’.

Coleopterans are found in nearly all ecosystems except arctic and marine environment. Aquatic beetles spend either part of their life or whole life in aquatic. They inhabit wide variety of aquatic habitats, like

ponds, pools, rivers, streams, reservoirs, dams, springs, ditches, puddles, seepages and lakes. Aquatic beetles are further classified into six groups, which are true water beetles, false water beetles, phytophagous water beetles, parasitic water beetles, facultative water beetles and shore beetles, based on their association with aquatic life. True water beetles are remaining submerged for most of the time in the water where their larva and pupae are aquatic. False water beetles spend a portion of their lives or a single stage in aquatic. Phytophagous beetles are those associated with aquatic weeds and plants. Parasitic water beetles are mostly spending as parasites on the other animals for food. Facultative water beetle larvae spend their part of life in aquatic

form, then turn to terrestrial life.

Aquatic beetles are biologically important as bio-indicators and play crucial role in aquatic food chain and food web. They significantly contribute to energy transfer within aquatic ecosystem, serve as prey for various aquatic animals, including fish, crustaceans, and birds. Some aquatic beetles also feed on aquatic weeds helping to control their growth. Additionally, certain Asian countries these beetles are part of the human diet.

Globally, approximately 13000 species of aquatic beetles have been documented from different habitats. The fossil records include 31 families and 2,928 species worldwide. A total of 902 species of aquatic coleopteran

species belonging to 140 genera and 17 families has been reported from India. Among the biodiversity hotspots in the country Indian Himalayan landscape alone has 357 species. The suborder Polyphaga consist of aquatic and semi aquatic beetles, contributes 543 species which make it most diverse suborder followed by Adephaga with 352 species and Myxophaga 7 species. Indian aquatic beetles are mainly belonging to seventeen families which are Gyrinidae, Haliplidae, Noteridae, Dytiscidae (Adephaga), Hydroscaphidae, Sphaeriusidae (Myxophaga), Elmidae, Dryopidae, Psephenidae, Scirtidae, Hydrophilidae Georissidae, Helophoridae, Epimetopidae, Hydrochidae, Spercheidae, Hydraenidae (Polyphaga)

India is one of the world's mega biodiversity countries, recognized for its exceptional biodiversity. The county is home to four of the world's 36 global biodiversity hotspots. such as Western Ghats, Trans Himalayans, Indo- Burma and Sunda. In the southern eastern part of India, Eastern Ghats are holding significant

ecological and biological importance. This mountain ranges are located between latitudes 11°30' and 22°0' N and longitudes 76°50' to 86°30' E (Plate I). Locally, this Eastern Ghats are also known as Toorpu Kanumalu (Telugu), Kizhakku Thodarchi Malaigal (Tamil), Purva Ghats (Odia). The Eastern Ghats are extended in northeast, southwest along with east coast of India. The Eastern Ghats are almost covering 75,000 Km² an average width 220 Km in the north and 100 Km in the south, covers 1750 Km of length between the rivers Mahanadi in Odisha to Vaigai River in the Tamil Nadu. Altitude of Ghats are ranging from 400m to 1600 m Above Sea Level. Three major rivers Mahanadi, Godavari, Krishna are flowing through the Eastern Ghats, which resulted to form discontinuous mountain ranges. The river Mahanadi basin makes the northern boundary of the Eastern Ghats in the state of Odisha while southern boundary is the Sirumalai hills in the state of Tamil Nadu. The northern parts of the Eastern Ghats are lies in state Odisha; middle region spread in the state of

Andhra Pradesh and south part of the Eastern Ghats are spread over in the state of Tamil Nadu. The peaks of the Eastern Ghats are including Kambakkam, Nallamalai, Palakonda, Seshachalam, Velikonda and Yerramalai, Alagar, Javadu, Kalrayans, Kollimalai, Pacchmalai and Shervoy's hills.

Taxonomical studies on aquatic beetles from the region was carried out by Deepa Jaiswal and team. Previously only 56 species of aquatic beetles are known from Eastern Ghats, India. However, the taxonomy and validation of many aquatic beetle species remain uncertain and incomplete; numerous species taxonomic descriptions are uncertain and inadequate; taxonomic details often lacking diagnostic features of external morphology and genitalia. Several species were misidentified and incorrectly reported from India. Only a few scattered studies have been carried out on DNA based identification.

Molecular systematics is an exciting and recent advancement in biological sciences, centred around

the use of nucleic acid data (DNA and RNA) to study interrelationships among organisms through genetic distance. DNA plays a vital role in exploring the diversity of aquatic beetles in the Eastern Ghats, India, by providing accurate and reliable tools for species identification and evolutionary analysis. Traditional morphological methods often fall short, especially when dealing with cryptic species. DNA barcoding, particularly using the mitochondrial COI gene, enables precise identification and helps uncover hidden or previously unrecognized species. This is particularly important in the Eastern Ghats, a region with rich but underexplored biodiversity. Molecular data also aids in understanding the phylogenetic relationships among species, offering insights into their evolutionary history and adaptation to diverse aquatic habitats. Additionally, DNA analysis supports population genetic studies, revealing patterns of genetic variation and connectivity between populations, which is essential for effective

conservation planning. Overall, DNA-based approaches significantly improve our understanding of aquatic beetle diversity and play a crucial role in biodiversity conservation and ecological monitoring in the Eastern Ghats.

Integrative studies on aquatic beetles from the Eastern Ghats, India, have revealed significant hidden diversity, documenting a total of 93 species. Among these, 37 species were newly recorded from the region, marking important

Integrative studies on aquatic beetles from the Eastern Ghats, India, have revealed significant hidden diversity, documenting a total of 93 species. Among these, 37 species were newly recorded from the region, marking important additions to the known beetle fauna of the Eastern Ghats. The study also generated 36 novel DNA barcodes for aquatic beetles, which were submitted to the NCBI database for the first time, enhancing the molecular reference library. Notably, the occurrence of *Scoliopsis spinosa*, a species previously known to be endemic to Sri Lanka, was confirmed in the Eastern Ghats through DNA barcoding, indicating a range extension.

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known to be endemic to Sri Lanka, was confirmed in the Eastern Ghats through DNA barcoding, indicating a range extension. Furthermore, the exploration indicated the presence of several potentially undescribed species that require detailed taxonomic and systematic studies

for proper classification. DNA barcoding results strongly suggest a high number of undescribed species, particularly within the genera *Coelostoma*, *Microdytes*, *Amphiops*, and *Limnebius*, highlighting the need for continued research and integrative taxonomic approaches in the region.

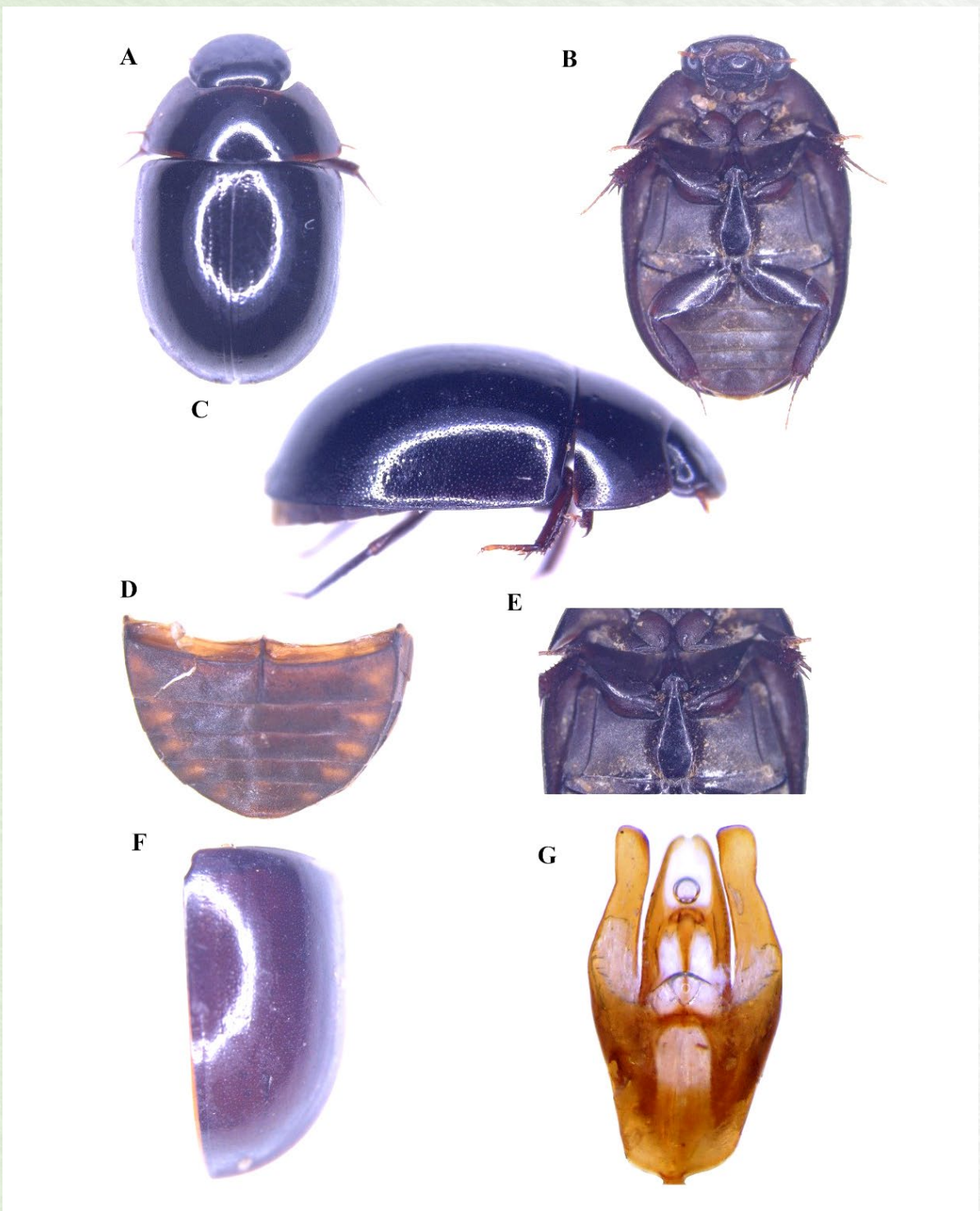
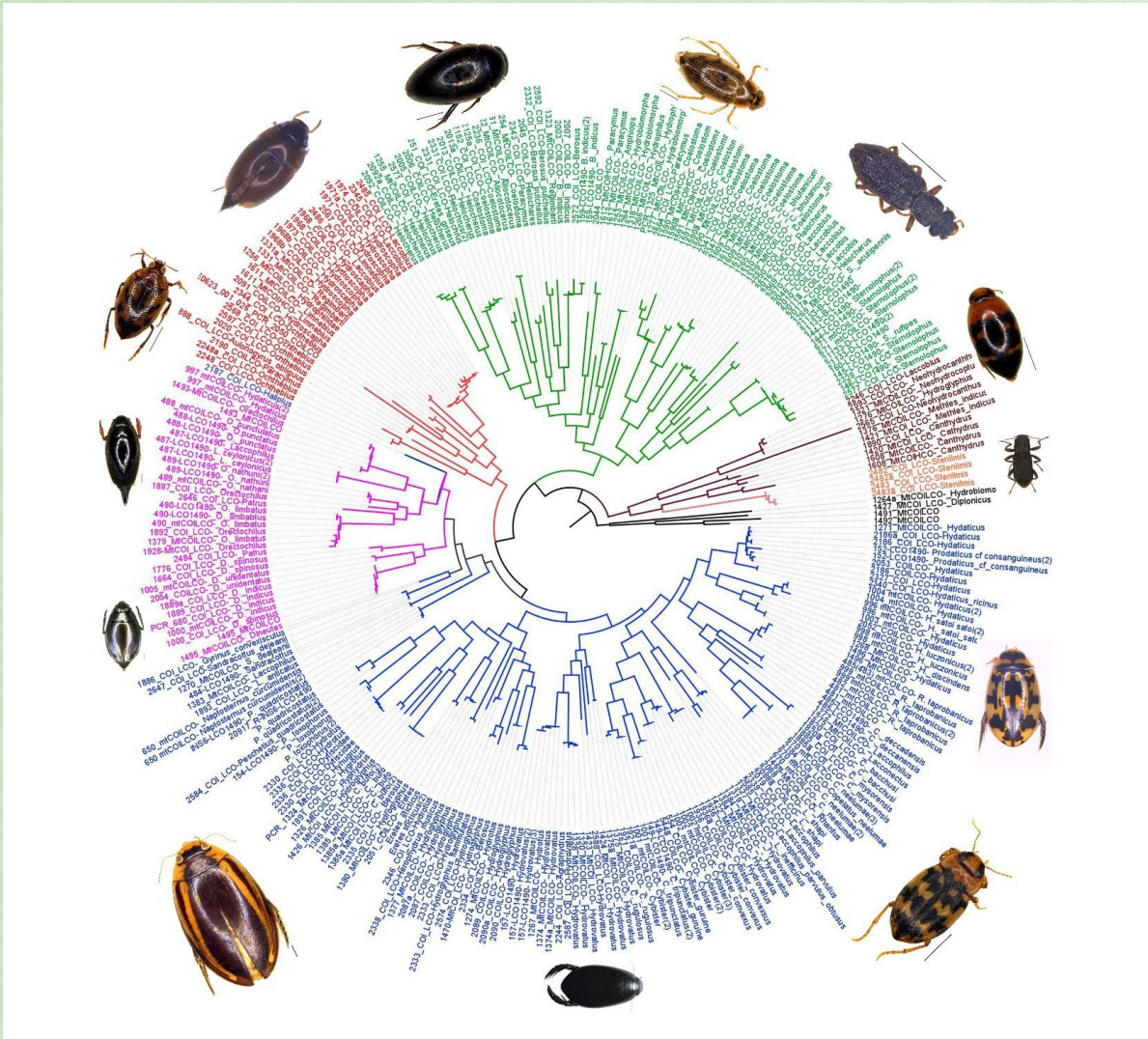


Figure. *Coelostoma* sp: Adult **A.** Dorsal view **B.** Ventral view **C.** Lateral view **D.** Abdominal segments **E.** Prosternum process **F.** Elytra **G.** Median lobe of aedeagus.

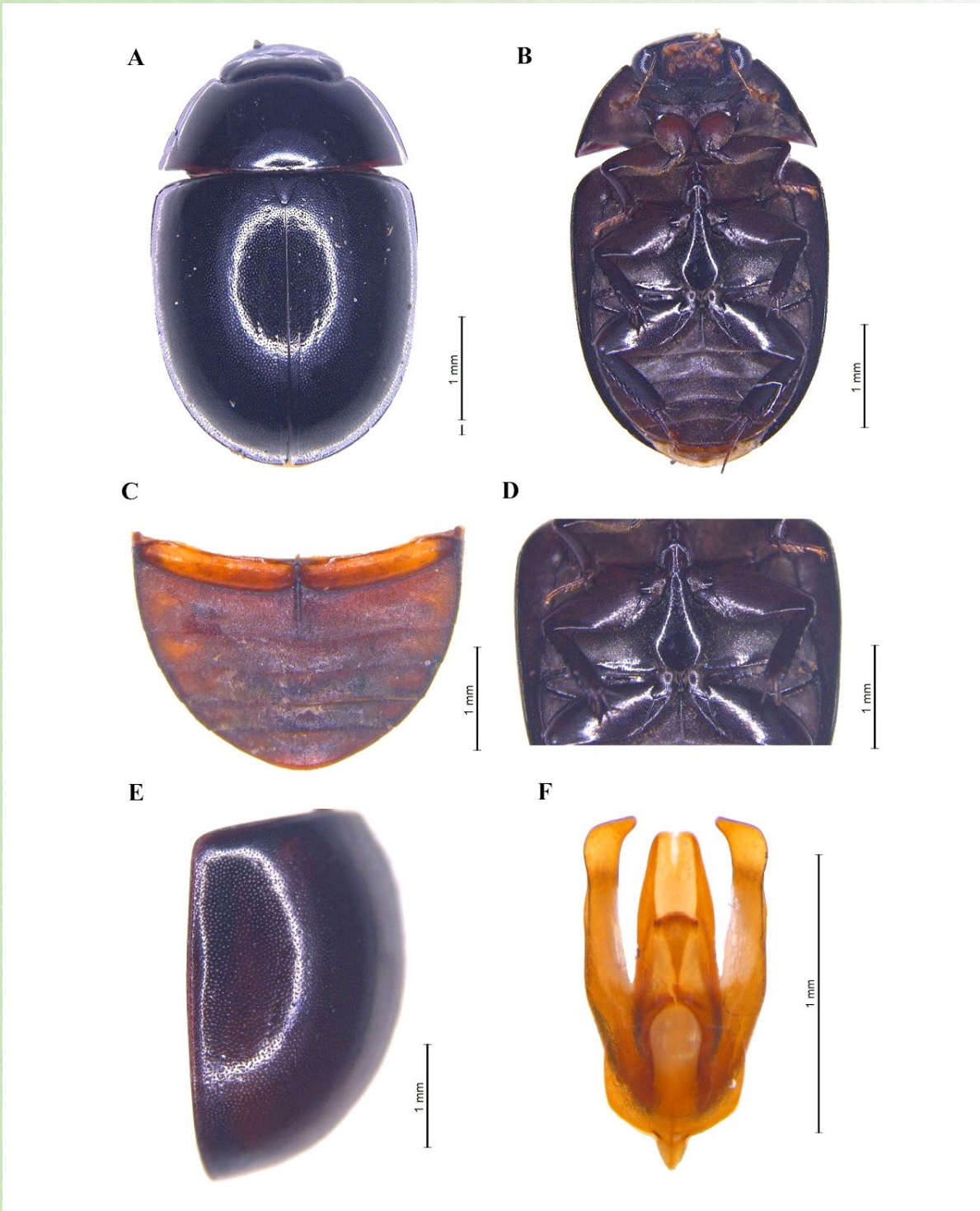


Figure. *Coelostoma andhra* sp. nov. Adult **A.** Dorsal view **B.** Ventral view **C.** Abdominal segments **D.** Prosternum process **E.** Elytra **F.** Median lobe of aedeagus.



Dr. Ruquaeya Bano

Legumes Storage under Siege: The Pulse Beetle Threat



Pulse beetles are commonly known as seed beetles and best known as *Daal ka ghun* are small sized (1.0-6.0 mm) insects belong to family Bruchidae. It has more than 1700 species under 62 genera worldwide while bruchid fauna of India is represented by 119 species belonging to eleven genera under three subfamilies. Bruchid are serious pest of legumes storage and found in every continent except Antarctica. The largest number of species lives in the tropical and subtropical regions of Asia, Africa, and Central and South America. Many species are of economic importance because they breed on grain legumes and consume valuable that would otherwise be eaten by man and many species also

destroy seeds of an immense number of leguminous trees and shrubs of the world. Many bruchid species have crossed the geographical boundaries and have become cosmopolitan in

distribution through human mediated migration import/export of the food grains. The significance of bruchid infestation is evident from the large number of species

Many bruchid species have crossed the geographical boundaries and have become cosmopolitan in distribution through human mediated migration import/export of the food grains. The significance of bruchid infestation is evident from the large number of species attacking on various plant genera belonging to more than 70 plant families.

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The adult female lays eggs on a seed or pod. The first stage larva chews through the egg shell, pod wall and/or seed coat and then enters into a seed. Larval stage spent life inside a seed which is most destructive life stage. They feed vigorously within seeds. The larva usually feeds inside one seed, or in some bruchids, two to several seeds, molts usually three more times as it continues to feed and increase in size. It usually then pupates inside a single seed, although some species leave the seed and pupate in a cocoon, while other species glue several seeds together as a pupal chamber. After pupation the adult completes a rounded exit hole which was almost completed and eaten up by the larva and leaves the seed to begin a new life cycle. The duration of the life cycle varies but it usually is about 30 days. Infestation starts in the field and continues in the storage. Adults depend on pollen and nectar. Bruchid larvae feed entirely within

seeds, making their detection and control difficult. Infested grains are unfit for human consumption. In general, pulses are the main source of protein (20–25%) and other essential nutrients for human nutrition. About 30 species of bruchids in the world are serious pests, and at least 9 species are cosmopolitan as the result of commercial activities. In India, several studies have been conducted on taxonomy, biology, phylogeny of bruchids. The most significant Indian taxonomic contribution on bruchids was carried out by Arora who described forty-eight species from Northwest India. Pajni also has remarkable contribution particularly focusing on aspects like biosystematics, biology and phenotypic plasticity of seed beetles and their interactions with their environment.

To manage bruchid infestations in pulses storage, several methods can be employed. These include cultural practices, chemical controls like insecticides etc. and biological control. The first and foremost to insure the storage area is well-ventilated, keep pulses in a dry place to prevent pest problems. Store pulses in airtight containers to prevent insect infestation. To remove insects from pulses, pulses can sun-drying which helps eliminate moisture that attracts pests, using natural deterrents like neem leaves, cloves, or bay leaves, salt and turmeric can repel insects. Cleaning and sieving can also remove visible insects and their eggs. Discard or replace infested materials to prevent further spread. Regularly monitoring of the storage grains is also required for sign of any infestation.



Callosobruchus maculatus (Fabricius)



Callosobruchus sp.



White tiny eggs and pulse beetles on infested Cowpea



Dr. Aparna
Sureshchandra Kalawate

Insects for Justice



Imagine a crime scene in a remote village somewhere in India. The police arrive to find a body, but the circumstances are unclear. When did the person die? How long have they been there? Are there clues about what happened? Surprisingly, some of the most powerful clues don't come from fingerprints or DNA but from tiny insects crawling on the body. From the buzz of blowflies to the silent scuttling of beetles, these tiny organisms can reveal astonishing truths about death, time, and even foul play.

Welcome to the fascinating world of **forensic entomology**, the science of using insects to solve crimes. Insects, especially flies and beetles, have been silently telling stories at crime scenes for centuries. Although

this field has made great strides in countries like the United States and the United Kingdom, in India, it is still in its infancy. This article explores how insects contribute to justice and why India needs to invest in this promising field.

What is Forensic Entomology?

Forensic entomology is the study of insects and their developmental stages to provide information in legal cases. When a person dies, their body becomes a hotspot for insect activity. Blowflies are often the first to arrive, laying eggs on the corpse. These eggs hatch into larvae (maggots), which feed on the body. By studying the types of insects present and how far they've developed, forensic entomologists can estimate

the post-mortem interval (PMI), essentially, how long someone has been dead. While flies are the most well-known participants in this process, particularly blowflies (Calliphoridae), beetles (Coleoptera) play an equally important role, often arriving later in the decomposition process. Together, they form a biological timeline that can speak for the dead.

This information of insect activity and their life cycle estimates can be critical in criminal investigations, helping police establish timelines, identify suspects, and corroborate witness statements.

Why Insects?

Insects are nature's recyclers and detectives. They colonize dead bodies in predictable patterns and timeframes that

depend on environmental factors like temperature and humidity. Unlike other forensic evidence, insects are often more resilient and can survive conditions that degrade DNA or fingerprints.

For example, blowfly larvae develop at a rate that's closely linked to temperature. If scientists know the species of fly and the weather conditions, they can accurately back-calculate the time since eggs were laid, giving a clue to when death occurred.

Beetles are the **second major group of forensic insects**, following the early arrival of flies. Species such as **dermestid beetles** (Dermestidae), **rove beetles** (Staphylinidae), and **carion beetles** (Silphidae) are key players in breaking down soft tissue and even bones in the later stages of decay. Keratin beetles (Trogidae) arrive last in the order of succession, they can be the first in succession on burned and charred bodies. After the burned skin is eaten away by the trogids, the exposed surface allows for viable colonization by other forensically important insects. This may help determine accurate post

mortem interval in case of charred carcass.

Insects don't just arrive randomly, they follow **predictable patterns** depending on the stage of decomposition. Their presence (or absence) can provide important clues, especially when the body has been undiscovered for weeks or even months.

Current Status of Forensic Entomology in India

1. Emerging Recognition and Application

Over the past decade, some Indian forensic

laboratories and research institutions have begun exploring the role of insects in criminal investigations. Cases involving unidentified bodies, suspicious deaths, and disputed PMIs have seen the incidental application of entomological evidence.

2. Limited Expertise and Resources

There is a scarcity of trained forensic entomologists, specialized laboratories, and standardized protocols.

It might seem odd to think of insects as part of the criminal justice system. But these unsung heroes of decomposition are already helping uncover truths in the silence of death. Their role in natural decomposition is vital, and in the hands of trained forensic scientists, their presence on a corpse can illuminate the past.

3. Research and Academic Initiatives

Few universities and research centres are conducting preliminary studies on insect fauna associated with decomposing remains in India.

Insects and the Justice System: An Unlikely Partnership

It might seem odd to think of insects as part of the criminal justice system. But these unsung heroes of decomposition are already helping uncover truths in the silence of death. Their role in natural decomposition is vital, and in the hands of trained forensic scientists, their presence on a corpse can illuminate the past.

CSI: Crime Scene Insects

Insects cannot come to testify in court, but are frequently important witnesses to criminal activity.

Way Forward

1. Institutionalization and Capacity Building

Establish dedicated forensic entomology units within major forensic laboratories.

Develop specialized training modules for law enforcement, forensic scientists, and medical examiners.

2. Research and Data Collection

Conduct region-specific research to build comprehensive databases of insect succession, species distribution, and environmental factors. Long-term studies across different Indian ecoscapes are essential.

3. Policy and Standardization:

Formulate national guidelines and standard operating procedures (SOPs) for collecting, preserving, and analyzing insect evidence. Integrate

forensic entomology into routine forensic protocols.

4. Awareness and Collaboration:

Increase awareness through workshops, seminars, and academic courses. Foster collaborations between forensic institutes, entomologists, universities, and law enforcement agencies.

5. Technological Advancements:

Adopt molecular techniques, such as DNA analysis, for species identification and age estimation of insect larvae, improving the accuracy and reliability of forensic entomology evidence.

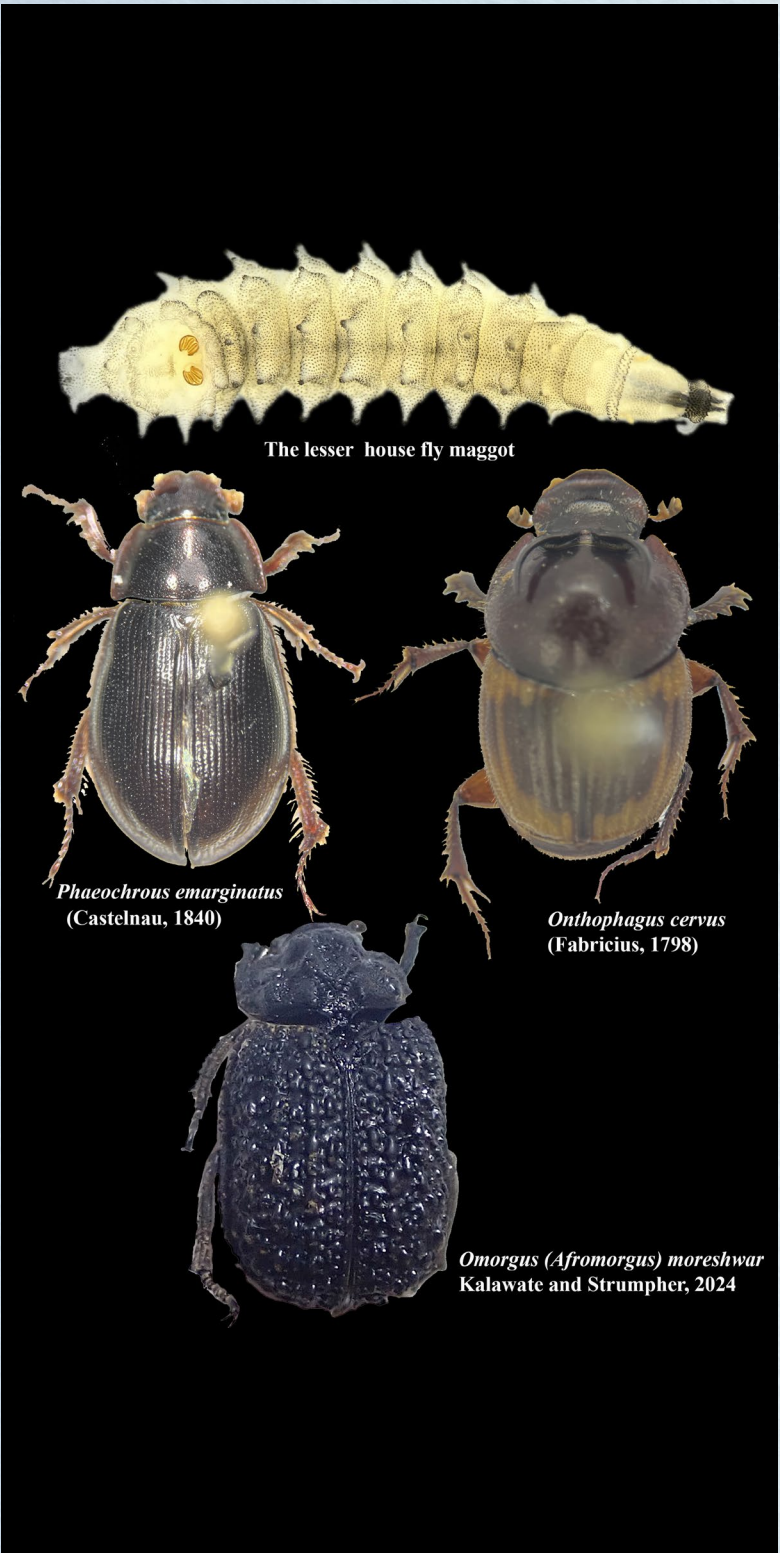
Challenges Faced:

- » Less importance among law enforcement and judiciary about forensic entomology's utility.
- » Insufficient training programs and workshops.
- » Poor documentation and database of insect species relevant to Indian environments.
- » Logistical issues in collecting and preserving insect samples from crime scenes.

Forensic entomology is about more than just bugs on bodies, it's about justice, science, and truth. In India, where the need for reliable forensic tools is growing, insects offer a promising solution. Flies may speak first, but beetles often have the last word. It's time we must start listening to these tiny heroes.

Be careful at the crime scene

Ants can feed on body fluids or bite the skin, creating marks that mimic bloodstains or ante-mortem injuries. They may make you completely.



Insects cannot come to testify in court, but are frequently important witnesses to criminal activity.



Dr. Rita Deb

The Tiny Water Engineers

When we think of aquatic life, fish, frogs, or turtles often come to mind but lurking just below the surface, another fascinating group thrives: **aquatic beetles**. These often-overlooked insects are silent contributors to freshwater ecosystems, playing critical roles in nutrient cycling, food webs, and water quality maintenance.

What Are Aquatic Beetles?

Aquatic beetles are insects with hard bodies that go through four stages in their life: egg, larva, pupa, and adult. Their front wings are tough and act like a shield, covering and protecting the softer back wings that they use for flying. When they are not flying, these flying wings stay safely folded under the hard wings known as elytra. They have chewing mouthparts and

antennae with up to 11 tiny segments. Their young ones, called larvae, look like worms. Their streamlined bodies, air-retaining hairs, and specialized limbs allow them to swim swiftly, dive deep, and even stay submerged for extended periods.

How Are They Built for Water Life?

Aquatic beetles such as Dytiscidae family don't need oxygen tank, trapping air underneath the thin layer of film under the wings and to keep their air bubble from popping, aquatic beetles cleverly store it under their hard wings (called elytra) on their backs. This protects the bubble while they're underwater.

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Sometimes, you can even see a little part of the bubble sticking out near their rear end that's because they breathe through tiny openings (spiracles) located near that area. Talk about a natural diving trick! With their fringed, paddle-like hind legs, they swim with more grace than a ballerina in flippers. Whirligig beetles of family Gyrinidae have **split eyes**. One pair looks above water and one below, perfect for watching predators *and* potential prey at the same time. Many water beetles are good fliers. They can quickly find and move into new ponds, water bodies and they often fly from one pond or stream to another throughout the year. But not all beetles are fast movers. Some can't fly at all, or can only fly when it's really warm. That means they can't easily travel from one pond to another. Most of the beetles are benthic insects, some are very good swimmers, some can be walking in the water while some can be seen on aquatic plants, family Elmidae beetles can be found below 10m below the water surface.

Jäch described aquatic beetles, or beetles that live in or around water, can be grouped into six types depending on how they live as adults and larvae:

1. True Water Beetles – live fully in water
2. False Water Beetles – look like water beetles but don't always live in water.
3. Phytophilous Water Beetles – stay near water plants
4. Parasitic Water Beetles – live on or inside other water animals
5. Facultative Water Beetles – live both in water and on land
6. Shore Beetles – live near the edges of ponds and streams

Status of Aquatic Beetles

Aquatic beetles belong to the suborders Adephaga, Myxophaga and Polyphaga. With over 13,000 described species, water beetles constitute one of the most abundant groups of aquatic insect worldwide belonging to 30 families and are distributed across three of the four coleopteran suborders.

India consists of 813 species of aquatic beetles belonging to 138 genera, 17 families reported. A hypothesis suggesting that a significant portion approximately 70-95%, of all beetle species still remains undiscovered. It estimated that it could take approximately 200 years to fully explore and document the entire beetle species worldwide. This hypothesis suggests the probability of beetle diversity and highlights the on-going need for continued exploration and scientific research on Coleoptera.

Why Should We Care?

These beetles are often in danger because if their habitat becomes polluted, they can't move to a better place easily. They aren't just survivors they're **ecosystem guardians**. Many are predators, feeding on mosquito larvae and other aquatic pests, while scavenger species help break down decaying matter, keeping water bodies clean. Beyond their ecological role, aquatic beetles hold significant **aesthetic value**. With glossy, metallic bodies, intricate patterns, and mesmerizing surface dances

like the spinning of whirligigs they add a touch of natural elegance to aquatic habitats. Their vibrant hues have long fascinated naturalists, artists, and collectors. Intriguingly, **aquatic beetles also have a place in human history**. In ancient Egypt, certain beetles were revered as symbols of rebirth and the sun's cycle. In some cultures, beetles were even used in traditional medicine or as inspiration in jewellery and carvings due to their shimmering exoskeletons. In some cultures, aquatic beetles are consumed as food. While this is not a wide spread practice, they can serve as a source of protein and nutrition in certain regions. Even today few countries are known to consume aquatic beetles as food; Mexico consumes more than 35 species, China consumes 26 species followed by Japan with 15 species. Globally 72 species belonging to 22 genera has been recorded edible. Large sizes aquatic beetles like *Cybister* (Dytiscidae) and *Hydrophilus* (Hydrophilidae) are being sold in China market as well as Korean markets and restaurants.

Today, aquatic beetles serve as reliable **bio indicators**, their presence or absence reflects the ecological health of ponds, wetlands, and streams. A decline in beetle diversity often points to pollution, habitat degradation, or climate stress. Aquatic beetles may not be famous, but they are tiny heroes of the water world

keeping the ecosystem clean, balanced, and full of life. So next time you look into a quiet pond, remember: beneath those still waters, tiny engineers have worked for centuries purifying, protecting, and quietly adding both function and beauty to our freshwater ecosystems.

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Fig 1: Whirligig beetles *Dineutus (Cyclous) indicus* (Aube, 1838) on the surface of water



Fig 2: *Hydaticus luczonicus* (Aube, 1838) under water



Fig 3: Collection of aquatic beetles from pool



Fig 4: Dorsal view of *Sandracottus dejeanii* (Aube, 1838) of family Dytiscidae.



Dr. K. Rajmohana

Into the World of Parasitoid Wasps



Have you ever waited excitedly for a tiny caterpillar to hatch from a butterfly egg, only to see small black flies emerge instead? Or looked forward to seeing a butterfly break free from a shiny golden chrysalis hanging under the *Nerium oleander* leaf in your garden, only to find tiny flies flying out instead? Moments like these not only spark awe and curiosity but also lead us into something entirely unexpected—in this case, the fascinating world of parasitoid wasps. Though these tiny creatures often go unnoticed, they play a significant role in maintaining nature's balance. These wasps act as natural regulators, laying their eggs inside or on the developmental stages of mostly insects and spiders. As the young wasps develop, they eventually kill their

hosts, helping to keep the host populations in check. Their role is especially vital in agriculture and natural ecosystems, where they provide an effective, eco-friendly alternative to chemical pest control.

Hymenoptera: A Megadiverse Order Fuelled by Parasitism

Hymenoptera, which includes bees, ants, and wasps, is a mega-diverse insect order, highly species-rich, a distinction largely due to the vast radiation of parasitic lineages. It is estimated that nearly 70% of all hymenopterans are parasitoids, reflecting a staggering diversity of species and behaviours. With a documented diversity of approximately 12,000 species of Hymenoptera in India, the number may

rise significantly as more parasitoid taxa are sure to be discovered in the future. A parasitoid is distinct from both predators and parasites, as it completes a significant portion of its life cycle in or on a single host, ultimately leading to the death of the host. Most known insect parasitoids are hymenopterans, though some belong to at least six other insect orders, comprising flies and beetles. They parasitize a broad array of hosts, including the eggs, larvae, and pupae of at least ten insect orders, as well as spiders. When the host insect is a herbivore or pest, the impact begins at the earliest stages, such as the egg stage, often preventing it from ever causing ecological or economic damage. This form of regulation is particularly effective when

it targets pests at their most vulnerable stage, long before they begin to feed, disperse, or reproduce. There are categories like egg, larval, and pupal parasitoids, based on the host stage that parasitoids are specialized to attack.

Interesting Developmental and Life Strategies

Technically speaking, parasitoid wasps are currently grouped into nearly 90 families, globally, under 12 superfamilies. Among these, three superfamilies dominate in terms of ecological roles and species richness: Ichneumonoidea (including Ichneumonidae and Braconidae); Chalcidoidea (including Trichogrammatidae, Eulophidae, Encyrtidae, and others); and Platygastroidea (mainly Platygastriidae and Scelionidae). Members of each family and subfamily have evolved their own host preferences, oviposition strategies, and developmental adaptations—some shared, others unique—creating a vast and complex network of life cycles tightly linked to host biology.

Parasitoid wasps display remarkable diversity in developmental strategies. Some are solitary, where only one larva develops per host. In gregarious parasitism, multiple larvae may share and complete development within a single host, especially if the host is large or nutrient-rich. Some species, previously believed to be solitary, have now been observed exhibiting gregarious behavior under



certain ecological conditions. More complex behaviours include superparasitism, where repeated parasitism of the host egg, larva, or pupa occurs by several individuals of the same parasitoid species. The strategy is termed multiparasitism when

a host stage is attacked by several parasitoid species simultaneously.

Kleptoparasitism reminds us of the association between the Asian koel and the crow. For instance, the cuckoo wasp stealthily utilizes the active mud nest of its host sphecid wasp to lay its own eggs, or its larvae develop alongside the host sphecid larvae, consuming the food

provisioned by the sphecid mother. One particularly interesting strategy is phoresy, exhibited at least by a few egg parasitoids. In this behaviour, the parasitoid hitches a ride on an adult host, usually a female moth or plant bug, and disembarks

precisely at the time and place of egg-laying.

This ensures the parasitoid has immediate access to fresh host eggs, enhancing efficiency and reproductive success.

The specificity with which parasitoid wasps target their hosts varies widely. Some species exhibit high host specificity, often parasitizing a narrow range of species or even a single host. This makes them ideal candidates for targeted biological control, particularly when dealing with invasive or high-priority pest species. In contrast, other groups such as many Trichogramma species display a broader host range. These generalist parasitoids can parasitize the eggs of several insect orders, increasing their utility in pest control, but also demanding careful ecological assessment before release to avoid unintended effects on non-target species.

Parasitoids typically occupy the third trophic level, when it preys on the immature or developing stages of herbivorous insects. Hyperparasitoids, the parasitoids that attack other

parasitoid often represent the fourth trophic level. The ecological networks involving parasitoids can be far more intricate. It is interesting to note that parasitoids of predatory insects and spiders are also at the fourth or even fifth trophic levels. These multilayered interactions influence not just individual host-parasitoid dynamics

but also broader food web structures, pest suppression efficiency, and the stability of entire host communities. For example, an overabundance of hyperparasitoids can reduce the effectiveness of primary parasitoids in controlling pests. Understanding such dynamics is essential when designing or implementing conservation biocontrol strategies.

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Applied aspects

Parasitoid wasps form the backbone of many sustainable pest management practices to control whiteflies, scale insects and mealybugs, that infest, a wide range of crops like sugarcane, vegetables, and fruits. In Indian agriculture and elsewhere, egg parasitoids too have been widely used against a range of pests like stem borers and plant bugs.

In India, one well-established method involves the distribution of *Trichogramma* cards, strips embedded with parasitized moth eggs. These are placed strategically in crop fields, allowing adult wasps to emerge and seek out pest eggs to parasitize. In this case, the host eggs are that of *Corcyra* sp., the rice meal moth. The host eggs are sterilized to prevent them from hatching, ensuring that only the parasitoids develop on the cards. The simplicity, cost-effectiveness, and scalability of this approach have made it popular among farmers, particularly in integrated pest management (IPM) programs. However, mass rearing and breeding of the parasitoids face challenges due to factors

like genetic variability, host preferences, and fitness, limiting their utilization to their full capacity and potential.

Another approach is the direct release of adult parasitoids. They are mass-reared in insectaries and released during critical pest outbreak periods. In South Indian states like Karnataka and Kerala, *Goniozus nephantidis*, a bethylid wasp, is widely used for controlling the notorious coconut black-headed caterpillar, *Opisina arenosella*. This gregarious larval parasitoid

is mass-reared and released in coconut plantations, the releases are timed to coincide with the presence of pest eggs in the field, ensuring effective biological suppression. However, the success of such programs depends heavily on ecological compatibility, accurate species identification, and proper monitoring of parasitoid establishment and performance.

Traditional taxonomy of parasitoid wasps relies on detailed morphological characters such as wing

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venation, antennal structure, and body sculpture for taxon identification. However, many parasitoid species are minute, morphologically similar, and difficult to distinguish, particularly in field-collected or immature stages. To overcome these limitations, integrative taxonomy, which combines classical morphology with molecular tools such as DNA barcoding and metabarcoding has emerged as a powerful approach. These methods allow identification of species from even fragmentary samples, eggs, or larval tissues, and can uncover cryptic diversity and hidden host associations.

High-throughput sequencing technologies have made it possible to detect parasitoid DNA even within host eggs, revealing entire parasitoid communities along with their hosts in a single analysis. These insights are crucial for understanding species turnover, niche partitioning, and the role of parasitoids in diverse ecosystems, from grasslands and wetlands to agri-horticultural fields and forests.

Despite their immense ecological and economic importance, parasitoid wasps remain poorly known outside scientific circles. Their minute size, starting from 0.13 mm (as in the case of the fairy fly mymarid wasp), partly explains why this remarkable group remains so little known and understudied. Increasing public awareness of their role in pest regulation, biodiversity maintenance, and sustainable agriculture is crucial. These wasps offer non-toxic, targeted, and self-sustaining alternatives to chemical pesticides, an urgent need in the face of growing environmental and health concerns. Incorporating parasitoid-based strategies into education, extension services, and conservation policies can foster greater appreciation and protection of these insects. Their presence is often an indicator of healthy ecosystems, while their decline may signal ecological imbalance.

Parasitoid wasps are among the most effective regulators in nature. Continued bioecological research

frequently reveals new host-parasitoid associations and intricate links within food webs. These insights are particularly valuable in agroecological landscapes, where parasitoid communities adapt to changes in cropping patterns, habitat structure, and climate. Through different strategies, they influence populations of herbivores and predators alike, shaping communities across ecosystems. Their evolutionary success, ecological versatility, and practical applications make them central to the functioning and resilience of both wild and cultivated landscapes. As integrative approaches continue to reveal the full spectrum of parasitoid diversity and behaviour, our understanding deepens—not just of these wasps, but of the complex networks that sustain life on Earth. To study, conserve, and apply their potential is infact to work in harmony with nature's own solutions.



Dr. Sheela Ghosh

Masters of Earth: How Ants conquered every corner of our Planet



One of the most fascinating group of insects on earth, the Ants are familiar to all; kids run away from them for the painful bite/sting, mothers consider it as a nuisance in kitchen and the backyard, farmers curse them for bringing the sap sucking pest to their crops. But for researchers, unravelling their behaviour is a very interesting, at the same time a challenging subject.

E.O.Wilson and Bert Holldobler won Pulitzer Prize in 1991 for their book “The Ants” which is a masterpiece depicting every information on Ants.

These tiny creatures having a size of about 1mm to 3-6 cm, they proved that through hard work, unity, division of labour and social organization among the members of the colony, it is easy to establish territory over all parts of the

terrestrial ecosystem. Only ecosystem yet to conquer for Ants is the ice covered poles. Resilience, flexibility to adjust with the resources around and adaptability to temperature fluctuations are key factors for their successful dominance. Ants may be unique in linking themselves to the nature in many roles as predators, preys, scavengers, pollinators, bioturbators, agents of seed dispersing, nutrient recycling and keeping symbiotic association with other arthropods and plants. Some 2000 species of insects (Coleoptera and Hemiptera) and spiders are reported to mimic Ants for defence or food. Ant- plant mutualism is a wonderful phenomenon in which ants protect plants from herbivores and in return, plants provide food and nesting site (domatia). So as

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to attract ants plants produce elaisomes on their seeds, which is a favourite food of ants, there by dispersing seeds through ants.

Ants communicate through a chemical substance called pheromones. Through these chemicals they locate food, make trails to easily move even larger food items to their nests, and also sense the enemies and take precautions accordingly. Through their co-operative social organization, they survive any difficult situations. The ground dwelling ants mostly build nest by excavating soil. The megacities built underground fascinate researchers and commoners alike. Through many studies it is found that they have a tendency to make their own food and their farming resembles that of humans. Leaf cutter ants grow fungus in underground chambers with galleries containing different stages of fungal growth to assure availability of food throughout the year. Such fungi grow in a particular temperature which is apt in the underground galleries. These ants collect huge amount of leaves, cut in to pieces and fill the

different compartments underground, on which they sow the fungal seed, once the leaves turn into humus and the ants regularly de weed it. Queen Ants during their nuptial flight carry a bunch of spores to start a new colony. The same has been seen in case of some ants rearing mealy bugs in their nests, carrying samples of mealy bugs to establish new family. They always maintain cleanliness inside nest, which can be seen in any ant nest if observe them for some time. If we look into the nests in ground we can see the wastes, thrown in a distance in their periphery and regularly a few members keep on doing it, while others carry food to the nest. Inside nest also they keep separate

spaces for food storage, for egg and other activities. All these works are carried out by the workers, which are the sterile females. They are vastly diverse and liberally spread with over 15000 species. Ants are polymorphic and in a colony usually queen, males and workers live, with different duties. Some of the colonies again have different type of workers like soldier, worker minor and worker major. Queen and males engage only in reproduction and new colony founding, whereas the sterile females: the workers are the active members of the colony, carry out all the works from taking care of the queen and young ones to building nests, locating food, collecting and carrying

The pagoda like nests constructed on tall trees by *Crematogaster* ants are very hard, don't break even fall from height and have innumerable chambers with small windows all over with shades.

it to nests and defending the colony from enemies.

Ants have amazing skill in nest architecture too. They build permanent nests in which they stay for years together. How strong the nest built is, that long they live in it. Their nests are mostly protected from fire and rain.

The pagoda like nests constructed on tall trees by *Crematogaster* ants are very hard, don't break even fall from height and have innumerable chambers with small windows all over with shades.

On sensing any disturbance outside, the workers will peep out through those windows to see if there is any threat. These nests are even found unaffected after a fire with live ants along with the brood. Their morphological adaptations also support them to survive in their choice of habitats, as the hypogeic ants are smaller in size, mostly blind and have modified hairs. Predators on ground have strong mandibles to cut and carry materials. Predator ants mostly show a preference for food which is rich in protein.

Some of the common ants are called by names which signify their action. For example *Oecophylla smaragdina* is called Weaver ant, because they weave their nests by sticking leaves together using a secretion from their larvae. *Paratrechina longicornis* are called Longhorn crazy ants where, longhorn refers to their long antenna and they are called crazy ants for their erratic behaviour, *Anoplolepis gracilipes* are called Yellow crazy ants because of their yellow colour and sporadic behaviour when disturbed, *Tapinoma melanocephalum* called Ghost ants because

of they are difficult to spot due to their transparent body colour.

The common weaver ant *Oecophylla smaragdina* is a favourite delicacy for people in India and abroad. Studies on its nutrient content shows it as one of the major source of protein with 18 amino acids, good amount of fibre and lowest carbohydrate.

We know only very little about the life of ants. But what we know are fascinating. They dominate the terrestrial ecosystem with a brain, which is not even visible to us. Still they made us to call them "super organisms".

The common weaver ant *Oecophylla smaragdina* is a favourite delicacy for people in India and abroad. Studies on its nutrient content shows it as one of the major source of protein with 18 amino acids, good amount of fibre and lowest carbohydrate.



Polyrhachis in nest



Nest of *Crematogaster*



Dr. Dipanwita Das

Velvet Armor: The Secret Life of Mutillid Wasps



Velvet ants (family Mutillidae) represent a fascinating group of insects within the order Hymenoptera, suborder Aculeata, and superfamily Vespoidea. Although they superficially resemble ants (family Formicidae), they can be readily distinguished by their non-petiolate abdomen, in contrast to the petiolate abdomen characteristic of true ants. All members of the family Mutillidae are solitary. The common name “velvet ants” refers to the dense covering of setae (hairs) on their bodies, which imparts a velvety appearance.

Velvet ants (family Mutillidae) exhibit pronounced sexual dimorphism. Females are apterous and resemble ants in general appearance, although they can be readily distinguished by the

absence of a petiolate waist and by their dense, velvet-like covering of setae. They possess a powerful sting. In contrast, males are fully winged, lack a functional sting, and resemble wasps in appearance. They possess a typical apocritan mesosoma, whereas in most females the mesosomal sclerites are completely fused. This extreme sexual dimorphism has historically led to the description of numerous

species based on a single sex, making sex association based solely on adult morphology particularly challenging.

Most mutillid species are solitary and range in size from 6 to 30 mm (0.25–1.5 inches). While many species are dark brown or black, others exhibit aposematic coloration with striking hues of red, orange, or yellow. Females are most commonly encountered

The common name “velvet ants” refers to the dense covering of setae (hairs) on their bodies, which imparts a velvety appearance.

in sandy habitats, where they actively search for the subterranean nests of bees and wasps, including both solitary and social species. Males are nectar feeders, and it is presumed that adult females may feed on host nest contents, such as stored provisions or host larvae.

Despite their ecological importance, the biology of most velvet ants remains poorly understood. Mutillids are solitary ectoparasitoids that parasitize the enclosed immature stages of various insect hosts, predominantly within Hymenoptera (e.g., Apidae, Vespidae, Sphecidae, Pompilidae), but also in Diptera, Coleoptera, Lepidoptera, and Blattodea. Globally, the family comprises approximately 4,200 described species, with a distribution concentrated in tropical and arid environments, particularly deserts and sandy regions.

The life history of most species remains inadequately documented, with detailed biological information available for only a few. In general, velvet ants prefer warm, dry habitats with

sandy, loess, or clay-rich soils. Females are typically active during the cooler parts of the day—early morning, late afternoon, and early evening—while avoiding the hottest midday hours by sheltering in cracks or burrowing into soft soil. Their activity period shifts seasonally with daylight changes, with peak surface activity observed between 4 p.m. and 7 p.m. during summer.

Females are often observed running quickly across open ground, frequently pausing to inspect holes and cracks, presumably in search of host nests. They use their antennae in an agitated manner while exploring and can dig effectively using their robust mandibles and spiny legs. Upon locating a suitable host nest, the female may assess the developmental stage of the host larva or pupa with her antennae. If the host is deemed too small, the nest entrance is resealed and another is sought. Otherwise, she uses her sting to paralyze the host and lays a single egg on it. The developing mutillid larva

consumes the immobilized host externally, classifying it as an ectoparasitoid. Larval development typically proceeds through four to five instars, after which the larva spins a cocoon and pupates within it. The complete development from egg to adult may require 4–5 weeks, allowing for multiple generations per year in favorable conditions. However, most temperate species are univoltine, with some females overwintering as adults.

Females of larger species are capable of delivering multiple painful stings, each of which introduces venom into the wound. While the sting is not used for prey capture, it serves primarily in defense and host immobilization. Adult velvet ants are not considered active predators and are presumed to feed primarily on plant-derived materials such as nectar or sap.



Odontomutilla paderua Das & Girish Kumar, 2017 (Female)



Orientilla jabalpurensis Das & Girish Kumar, 2016 (Female)



Phyetopoda discreta (Cameron, 1897) (Male)



Dr. Swetapadma Dash

Giant Water Bug: Guardian of Freshwater Ecosystems



Diplonychus rusticus (Fabricius, 1781), commonly known as the giant water bug, belongs to the family Belostomatidae and is an aquatic insect of remarkable ecological importance. Native to South and Southeast Asia, it thrives in freshwater habitats, especially in ponds, lakes, and marshes with floating vegetation. This often-overlooked insect plays critical roles as a predator, caregiver, and bio-indicator, making it a valuable subject for ecological research and conservation.

A Remarkable Caregiver: Parental Behaviour in *D. rusticus*

Parental care is a rarity in the insect world, *D. rusticus* stands out for its extraordinary reproductive strategy: male parental care. Females lay their eggs on

submerged leaves or directly onto the backs of males, a behaviour that defines this species.

Egg Carrying Behaviour: After oviposition, the male carries the eggs on his back, offering protection and ensuring access to oxygen-rich environments. This brooding behaviour significantly increases the chances of successful hatching.

Evolutionary Benefit: This system allows females to conserve energy for producing future clutches while ensuring higher survival rates for the existing brood. Interestingly, females prefer unmated males, preventing any one male from monopolizing reproduction.

Top Predator: Nature's Pest Controller: As a dominant invertebrate predator,

Parental care is a rarity in the insect world, *D. rusticus* stands out for its extraordinary reproductive strategy: male parental care. Females lay their eggs on submerged leaves or directly onto the backs of males, a behaviour that defines this species.

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Diplonychus rusticus plays a vital role in maintaining balance in aquatic ecosystems. It preys on mosquito larvae, tadpoles, small fish, and various aquatic insects.

Biological Control: Its appetite for mosquito larvae (*Culex* and *Anopheles* spp.) makes it an effective agent for integrated mosquito management, offering a natural alternative to chemical insecticides.

Trophic Regulation: By controlling herbivorous insect populations, it helps maintain nutrient cycling and ecosystem health.

A Living Water Quality Indicator: In recent years, *D. rusticus* has emerged as a bio-indicator species, useful in assessing freshwater health.

Pollution Sensitivity: Though adaptable, it is highly sensitive to pollutants such as heavy metals, pesticides, sewage, and low dissolved oxygen levels. Its disappearance from an area may indicate rising pollution.

Chemical Monitoring: As a top-level predator, it can accumulate toxins in its body, making it a valuable species for long-term pollution monitoring and ecosystem assessments.

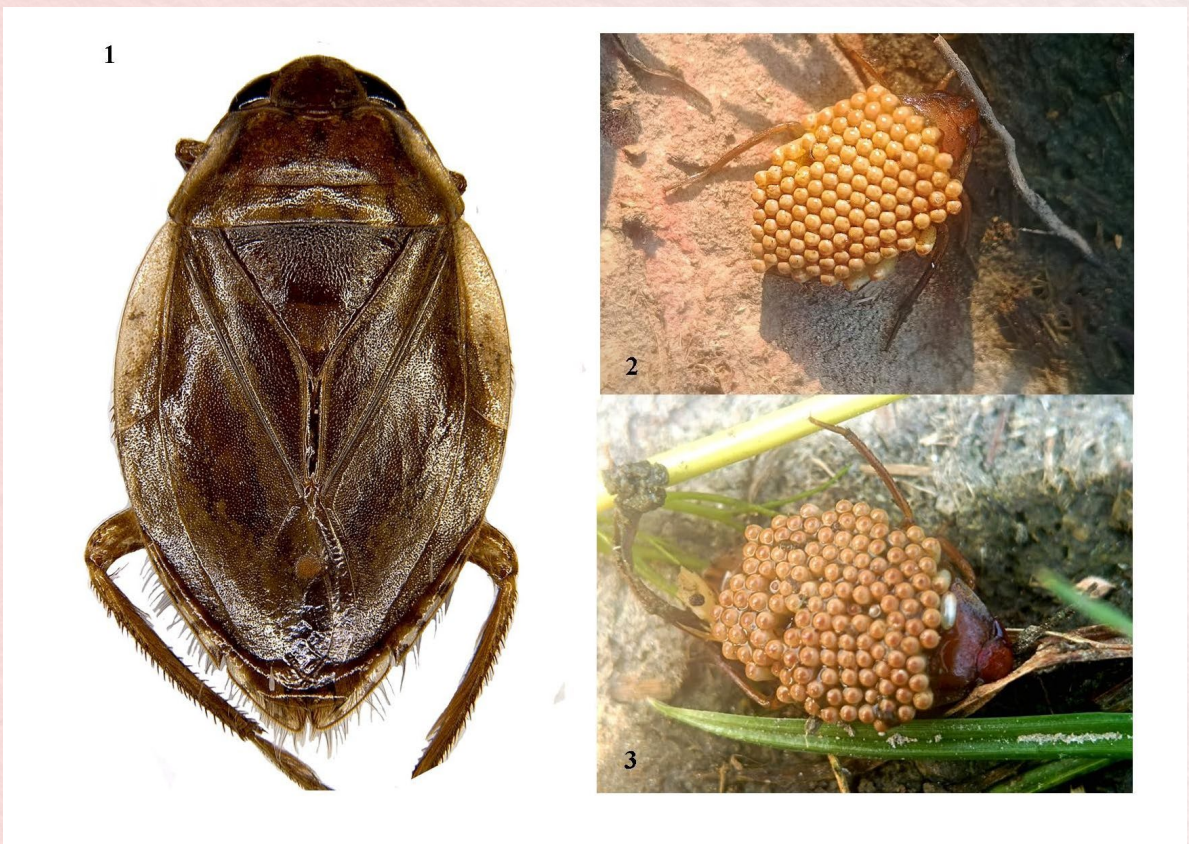
Habitat Preferences and Distribution: *Diplonychus rusticus* prefers clean, oxygen-rich waters with abundant aquatic vegetation. It is commonly found in ponds, lakes, marshes and wetlands, rice paddies with submerged or floating plants.

Its distribution is strongly influenced by water quality, pH, dissolved oxygen, and the absence of high pollutant levels.

Conservation and Research Priorities: In the face of escalating anthropogenic pressures on freshwater systems, preserving species like *D. rusticus* is vital. Its ecological significance spans multiple domains, from pest control and biodiversity to water quality monitoring. To maximize its ecological utility, conducting more regional and ecological studies across India is needed and promoting it as eco-friendly pest control strategies should be encouraged.

A Tiny Insect with a Mighty Role

From carrying its offspring to hunting disease vectors and signalling water pollution, *Diplonychus rusticus* exemplifies how a single insect species can serve as a cornerstone of ecosystem integrity. Protecting this species benefits not only biodiversity but also offers sustainable solutions for public health and environmental monitoring.



Figures 1–3. *Diplonychus rusticus* (Fabricius, 1781). 1. Habitus (Dorsal); 2–3. Parental Care



Mrs. Jennifer Lyngdoh

Water Striders: Skating on Water, Serving Nature



Imagine taking a peaceful walk beside a pond or stream on a quiet day. The water is still, reflecting the sky above. Suddenly, you notice tiny creatures dancing on the surface—skating smoothly, turning effortlessly, as if performing a choreographed ballet on water. These delightful little insects are called water striders. Also known as pond skaters or pond skimmers, these small insects have a fascinating way of life and play an important role in our freshwater ecosystems.

Meet the Skaters of the Water World

Water striders belong to the insect family Gerridae, which is part of the order Hemiptera, often referred to as the “true bugs.” Within the family Gerridae, water striders are placed under the subfamily

Gerrinae. These insects are among the most widespread and well-known semi-aquatic insects. They can be found in almost all types of freshwater habitats—from tiny puddles and ponds to slow-moving rivers and even large lakes.

At first glance, water striders look quite simple, but they have a number of special features that make them uniquely suited to their lifestyle. Their slender, dark

bodies typically range from 8—16 mm in length. They have three pairs of legs, each performing a specific function. The front legs are short and strong, used for grabbing prey. The middle legs act like oars, helping them paddle across the water. The hind legs are the longest, helping them steer and balance as they move.

One of the most amazing things about water striders

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is their ability to “walk” on water. This is possible due to tiny, water-repellent hairs called microsetae on their legs. These microsetae trap air and prevent water from sticking, allowing the insect to stay on the surface without sinking. Combined with their light body weight and long legs that spread their weight evenly, this adaptation makes them perfect surface dwellers.

Life on the Surface: Habitat and Behaviour

Water striders spend almost their entire lives on the water surface. They are usually found in calm or slow-moving water where the surface tension is strong enough to support them. You may see them moving in groups or individually, always alert and agile.

Their movements are fast and graceful. They can skate, jump and even glide quickly to avoid predators or chase prey. If disturbed, they escape by pushing off the surface with their powerful middle legs, much like a speed skater launching across ice.

These insects are also capable of flying. Some species develop wings during

certain seasons, especially when food is scarce or when water bodies dry up. This helps them migrate to better habitats, showing how well adapted they are to environmental changes.

What Do They Eat?

Water striders are carnivorous. They mainly feed on small insects and other invertebrates that fall onto the water surface. Their sharp piercing mouthparts, called a rostrum, allow them to puncture their prey and suck out the body fluids.

Common items on their menu include mosquito larvae, dead insects and even tiny aquatic organisms. By feeding on mosquito larvae and other harmful insects, water striders act as natural pest controllers. In this way, they help reduce the spread of mosquito-borne diseases such as malaria, dengue and chikungunya.

At the same time, water striders themselves are preyed upon by larger animals such as fish, frogs, water birds and dragonfly larvae. This makes them an essential part of the aquatic

food web, transferring energy from small prey to larger predators.

Ecosystem Services: More Than Just Skaters

Water striders may look delicate and playful, but their role in the ecosystem is quite serious. They help maintain ecological balance by keeping insect populations in check. By feeding on dead and decaying insects, they also act as scavengers, cleaning the water surface and contributing to the overall health of aquatic environments.

Water striders serve as bioindicators. Because they are sensitive to pollutants and changes in water chemistry, their presence or absence can tell us a lot about the quality of water in a pond, lake or stream. Scientists often monitor water strider populations to assess the health of freshwater habitats.

When water striders disappear from an area, it can be a warning sign of pollution, habitat degradation or harmful chemical contamination.

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A Closer Look at Water Striders in India

India is home to a rich diversity of water striders. According to recent taxonomic studies, there are 21 known species belonging to this group in the country. Some of the commonly recorded species include: *Aquarius adalaidis*, *Gerris thoracicus*, *Limnogonus nitidus*, *Tenagogonus venkataramani*, *Neogerris parvulus*, *Limnometra minuta*, etc.

These species are distributed across different freshwater habitats—ranging from the Himalayan streams to the

wetlands of Assam, the rivers of the Western Ghats to the ponds of Central India. Each species has slightly different habits, sizes or body shapes,

Water striders have also captured the curiosity of scientists and nature lovers alike. Their surface-skating ability has inspired robotic engineers to develop water-walking robots, mimicking the hydrophobic legs of these insects.

but all share the ability to thrive on the water surface. Despite their wide distribution, many of these species are not well studied. Habitat loss due to urbanization, pollution and overuse of pesticides poses serious threats to their populations. There is an urgent need for more research and public awareness about the importance of these small but significant insects.

Cultural and Scientific Curiosity

Water striders have also captured the curiosity of scientists and nature lovers alike. Their surface-skating ability has inspired robotic engineers to develop water-

walking robots, mimicking the hydrophobic legs of these insects.

These bio-inspired machines are being explored for environmental monitoring and search-and-rescue operations in flooded areas.

In traditional culture and folklore, insects like water striders often go unnoticed, yet their movement on water has fascinated children and poets alike. Watching them glide silently across a still pond brings a sense of calm, a reminder of the simple beauty found in nature.

Protecting Our Freshwater Friends

Freshwater ecosystems are among the most threatened habitats on Earth. Pollution, habitat destruction, climate change and invasive species are affecting the delicate balance of life in ponds, lakes, rivers and wetlands. Protecting water striders means protecting the entire aquatic community that depends on clean water.

We can all play a role in protecting water striders and the freshwater ecosystems they depend on. One simple step is to reduce our use of plastic and harmful chemicals, which often find their way into rivers, ponds and lakes, polluting these habitats. Supporting conservation programs that focus on preserving freshwater wetlands can also make a big difference. These habitats are vital not just for water striders but for countless other species as well. Another meaningful way to contribute is by encouraging citizen science initiatives and participating in local biodiversity surveys, which help gather valuable data about insect populations and environmental health. Lastly, teaching children about the importance of insects like water striders can help cultivate a sense of wonder and responsibility for the natural world. Though small and silent, water striders are powerful symbols of balance, adaptation and

the often unseen services that nature quietly provides every day.

In the peaceful waters of our ponds, lakes and rivers, water striders skate with remarkable ease. With their clever adaptations and graceful movements, they bring charm to our freshwater landscapes. But beyond their beauty lies a deeper importance—they are hunters, cleaners, indicators and prey. They connect the surface of the water to the complex web of life below and above.

Let us learn to notice and appreciate these tiny wonders. By understanding and protecting water striders, we protect much more: we protect freshwater life, ecological health, and the magic of nature’s balance.

Common Water striders

*Limnogonus (L) nitidus* (Mayr, 1865)*Limnogonus (L) fossarum fossarum* (Fabricius, 1775)*Neogerris parvulus* (Stal, 1859)

Dr. Kaomud Tyagi

Tiny but Mighty: How Thrips Shape Our World



It was a calm morning in a village in Andhra Pradesh. The sun had just come up over the chilli fields, and the dew-covered leaves looked golden in the light. Farmer Keshav strolled out onto his field and looked at the fields that promised a good crop in the next few weeks. But as he looked at his plants more closely, he saw something strange: small silver streaks on the leaves, edges that curled up, and fruits that were not right. The plants used to be bright and colourful, but now they look pale and tired. A closer look showed the culprits: tiny moving creatures that were hard to see. He contacted the local agricultural scientist in a panic. The scientist replied, "They're back," as he looked at a leaf through a hand lens. "Thrips." He explained to Keshav that

Thrips belong to a group of insects called **Thysanoptera**. Thrips are small (1-2 mm in size), winged insects that are often hard to see with the human eye. They are only about the size of a pinhead, but they have a huge effect on our crops, gardens, and ecosystems.

Thrips are very important to farmers, scientists, and ecologists because they play a role in agriculture, biodiversity, and even the spread of plant diseases. Scientists think that there are many more species that haven't been reported yet, especially in tropical areas. So far, more than 6,000 species of thrips have been described around the world. They had uneven mouthparts that can pierce and suck, which they utilize to break through plant tissues and suck out cell contents. The way that

they eat causes the silvery, stippling, and curling that are seen on plants that are afflicted. Certain kinds of species also eat fungal spores, pollen, or even other small arthropods. Many types of thrips are not harmful and may even be helpful, but a few have gained an adverse image as significant pests in agriculture.

People acknowledge that thrips are harmful for crops. They eat plant tissues and spread viruses like Tomato Spotted Wilt Virus (TSWV), which costs farmers a lot of money in crops including onions, tomatoes, grapes, and chilli. A single infestation can lower yields, change the shape of food, and raise the cost of production. Some thrips, like the **Western Flower Thrips (*Frankliniella occidentalis*)**, ***Thrips palmi***, ***Scirtothrips dorsalis*** etc. are

notorious for spreading deadly plant viruses. In recent years, their numbers and impact have surged due to global trade, greenhouse farming, and warming climates. Some thrips are good and help plants to reproduce in dry areas where bees are sparse. Some eat fungal spores or help break down organic materials, which is good for the health of the soil and the cycling of nutrients. Their presence or absence can even be used to gauge ecosystem health.

A lot of modern entomological research has been done on thrips. Scientists are using DNA barcoding to find out more about how species interact and how they have changed over time. Even if thrips have not received a Nobel Prize yet, the molecular research they have started on how they affect the health of crops is still transforming the way farmers all around the world do things. Science also has trouble with thrips. It is hard to study them since they are little, complex morphology, and cryptic behaviour. Traditional taxonomy, which looks upon external features,

doesn't always work. This is where bioinformatics and DNA barcoding come in. Researchers can tell the difference between thrips species that seem the same under a microscope by looking at a part of the COI gene (cytochrome oxidase I). This has helped find cryptic species, complexes and keep an eye on invasion populations. Knowing what kinds of plants are in a field or greenhouse can help with targeted control. Molecular approaches can also find plants that are infected with viruses early, sometimes even before they show signs of being sick.

It is not easy to get rid of thrips. The best way to deal with pests is through Integrated Pest Management (IPM), which includes regular checks with sticky traps, biological controls like

predatory mites or Orius bugs, careful use of insecticides, and cultural techniques like getting rid of weeds and making sure plants are spaced out correctly. To control thrips in greenhouses, where their numbers can get out of hand, you need to utilize a mix of high hygiene, physical barriers, and plants that are resistant to pests. In India, different types of thrips destroy important crops: *Thrips tabaci* reported on onion and garlic; *Scirtothrips dorsalis* on chili, tea, and mango; *Frankliniella schultzei* as a virus vector on vegetables; *Haplothrips* on groundnut and cotton; *Thrips parvispinus* on chilli.

In the recent years, farmers in Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu and other parts of India have all

In the recent years, farmers in Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu and other parts of India have all faced devastating outbreaks of *Thrips parvispinus* in chilli crops.

faced devastating outbreaks of *Thrips parvispinus* in chilli crops.

This species has completely replaced the *Scirtothrips dorsalis* from chillies. *T. parvispinus* was first reported from India by Zoological Survey of India in 2015 and indicated that it might have entered India from Indonesia.

Indian Council of Agricultural Research and local agricultural universities are working with farmers to develop **region-specific management plans**, conduct **farmer field schools**, and use mobile apps for pest alerts.

Thrips are also valuable to **ecologists** and **climate scientists**. Because they respond rapidly to environmental changes, their presence or absence can serve as a **bioindicator**. Studies in forest ecosystems have used thrips diversity to assess the impact of deforestation, pollution, and climate variability. With global warming, new thrips species are expanding their range. Some tropical thrips are now being reported in temperate countries for the first time. The boundaries of their influence are shifting—and fast.

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Megalurothrips typicus



Dr. Jhikmik Dasgupta

Food For Thought: The Insects!



Have you ever thought how man will get his vast need of food in the coming era? With the rapid increase in human population, access to food resources is likely to become scarce soon. Moreover, due to habitat fragmentation, deforestation, and irresponsible use of insecticides, there has been a sharp decline in the honey bee and bumble bee population worldwide. Bees account for 75% of pollination of major crop plants. Hence, a decline in bee population can directly impact crop production which in turn can cause food scarcity in human population.

Scientists worldwide are now searching for alternate food sources to ensure survival of the human species. Many people have chosen vegan diet for themselves

which excludes all animal products including poultry, eggs, meat, fish, dairy and honey. Some people opt for low carb keto diet consisting primarily of protein and fat. However, in many countries of the world including India, eating insects and arachnids as food has been a custom since ages.

Practice of entomophagy: eating insects as food:

Insects have been viewed as a source of nutrition since ages. The practice of eating these creatures as food have been running across many generations, in many cultures and communities. In India, this practice has been prevalent in the north-east Indian states as well as in some scattered tribal communities of the eastern and southern India. Over

two billion people worldwide have been consuming insects on a regular basis as part of their diet. In some countries like Africa, insects become the primary protein source when there is a scarcity of staple food due to natural calamities. About two thousand edible insects have been reported worldwide which mostly include beetles, bugs, termites, dragonflies, flies, bees & wasps and grasshoppers and locusts. Beetles obviously top the list.

Rich in nutrients:

Filled with major nutrients, insects can easily be alternate animal food sources. Many edible insects are rich in protein, fat, vitamins and minerals and fibre which makes them an important food substitute in the coming days. The nutrient

content in each species, however, varies as per diet, environmental conditions as well as metamorphic stages. The protein in edible insects can easily be digested by humans and contains most of the essential amino acids such as lysine, threonine, tyrosine, phenylalanine and tyrosine.

The average protein content primarily ranges from 35% to 61% amongst edible insects with maximum protein content in crickets and locusts. Moreover, many edible insects are rich in unsaturated fatty acids. Composition of omega-3 polyunsaturated fatty acids in mealworms is almost the same as in fish.

Vitamin concentration is variable among insects. In grasshoppers, there is an increase in the levels of Vitamin A, C, D and E while Vitamin B level is constant across developmental stages. Mineral content amongst edible insects display a wide of variation. Cricket powder, for example, contains high amount of magnesium, copper and zinc. The magnesium content of insects like crickets

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and locusts is quite high while the level of sodium, potassium and calcium is rather low. Termites contain high concentration of iron and zinc. In some cases, the mineral content of insects can be higher than beef. For example, zinc, magnesium and copper content in mealworms and grasshoppers is much higher than in beef. In addition to this, exoskeleton in insects are primarily made of chitin which can serve as fibre for human consumption as it is easily digestible. About 90% dietary fibre can be present in purified chitin. It provides health benefits

in cardiovascular and colon diseases as well as boosts up immune system, reduces cholesterol and promotes wound healing.

Food security for future:

Currently, in the fast-changing world with climate uncertainties, one of the biggest challenges is ensuring an environmentally sustainable food source. The rate of conversion of food into meat in case of insects is much higher than that of poultry and cattle. Moreover, these creatures are easy to rear, hence economic too! Insects also emit comparatively fewer

greenhouse gases and ammonia than cattles and can be reared on organic side streams leading to proper utilization of biowastes. It also requires less land and water for overall maintenance. The nutritional quality of edible insects is often equivalent or superior to those derived from other animal source like birds and cattles. “Construction of insect farms may provide a sustainable means of food for the future. High in calories, rich in protein, and micronutrients, the edible insects has the potential to stop malnutrition and famine across the globe. Potential economic and ecological benefits render insects as

Construction of insect farms may provide a sustainable means of food for the future. High in calories, rich in protein, and micronutrients, the edible insects has the potential to stop malnutrition and famine across the globe. Potential economic and ecological benefits render insects as a major source of food for future.

a major source of food for future.”

About 650 indigenous communities in India consume insects in form of food. In North East Indian states like Nagaland, Assam and Manipur, various edible insects and arachnids are consumed on a regular basis and is sold in open market.

So what about the scenario in India?

Since time immemorial, the practice of eating insects has been prevalent in many parts of India.

About 650 indigenous communities in India consume insects in form of food. In North East Indian states like Nagaland, Assam and Manipur, various edible insects and arachnids are consumed on a regular basis and is sold in open market.

The dreaded Nephila spider!

During my survey in Nagaland, I encountered giant *Nephila* spiders being sold in open market after being dry roasted. It is widely accepted as food and known to taste like pâté. The female of this spider is quite large (larger than a fist) while the male is conspicuously smaller in size. Dressed in orange, black, red and yellow attire, these spiders would scare any common man. However, the people of Nagaland and other Northeast Indian states looked beyond its appearance and understood its value as food.

In other parts of India, such as Odisha, Jharkhand, Chhattisgarh and some parts of West Bengal, the tribal communities often feed on some insects. How and why they chose certain insects as food and not others are yet not known. Probably, through trial and error method, many types of insects were tried previously but due to its taste, smell or harmful effect on health, some insects were chosen and not others. For example, the tangy dish or “chutney” made of red

weaver ant, *Oecophylla smaragdina* has become very famous across the world after its coverage in the National Geographic channel by renowned food blogger Gordon Ramsay in Bastar district of Chhattisgarh. He praised it as the most delicious chutney he had ever had in his life. The red ant chutney is known as “Kai chutney” in Odisha where it is consumed by locals of Mayurbhanj district. It has also received its own GI (Geographical Indication) tag due to its unique taste and texture on Januray, 2024. Its ingredient consists of red weaver ant and its eggs and spices such as ginger, garlic, chillies and salt. The formic acid present in the ant’s body gives it a tangy taste and is a rich source of protein, zinc, calcium, Vitamin B12, magnesium, iron and potassium.

In Manipur, I had encountered silkworm larvae and honey bee larvae being sold like hot cakes in a local market in Churachandpur district. Fleshy and rich in nutrients, there is no doubt that these worms would taste great. In Ukhrul district, I came to

know about the stink bug *Eurostus grossipes* which is eaten as food by the Tangkhul Naga community living there. It emits an obnoxious scent for its defense but its large size and colourful body made it an easy prey for the humans. In Dima Hasao district of Assam, another variety of stink bug *Udonga montana* is eaten after being dried under the sun. It is a rich source of protein and fat and its oil is used in tradition medicine. Being a bamboo pest, they exhibit heavy infestation during the flowering season. Hence, consuming these bugs serve dual purpose, both in protecting bamboo from infestation and also serve as human food.

Besides these, many other insects are eaten across the country, especially amongst the tribal populations. Insects such as giant water bugs, crickets, grasshoppers, termites, mealworm are also eaten as food across various regions of India.

The yucky feeling! I get it!

In recent times, there has been a lot of hype regarding edible insects across the

globe. However, the biggest stumbling block in promoting insects and insect products has been the psychological stigma and disgust attached to insects. While many tribes and communities across the globe have been eating insects as part of their staple diet, it is still uncommon amongst general public. Apathy for accepting insect in the diet of the modern people needs to be changed with evidence, data and demonstration. The insect food industry can then become a very profitable market in the future if focus is given mainly on people who are willing to consume these insects.



Photo of bamboo stink bug (*Udonga montana* Distant 1900 in inset) being sold in local market in Haflong, Dima Hasao district in Assam.



Photo of *Nephila* spiders being fried and sold in a local market in Dimapur district of Nagaland.



Grasshoppers being sold in loose and pickled grasshopper (inset) during Hornbill festival in Nagaland.



Dr. Suranjana Banerjee

Shimmering wings in Peril: Odonates as messengers of climate change in Indian Himalayan Region



Hovering high in the dense fog-draped forests and glacial rivers meandering through heavenly valleys of the Himalayas, a sudden shimmer of emerald green flashes above a crystal-clear sunlit stream. This primitive insect with delicate dazzling wings is no ordinary insect — it's a damselfly or maybe a large, agile dragonfly with huge compound eyes and incredible vision. These glittering aerial hunters, along with their delicate kin, the damselflies, belong to the Order Odonata. Odonates are one of nature's most efficient predators and their name comes from the Greek word 'Odon' meaning tooth. Their sharp teeth found on the underside of their head make them fearsome predatory insects. Odonates appear as mere beautiful insects to the casual onlooker but to a scientist, it's a living

bioindicator, a sensitive sentinel of climate change. Odonates rank among the most primitive flying insects, that originated in the Carboniferous era over 300 million years ago, much before the dinosaurs arrived on planet Earth. Odonates are intricately linked to freshwater ecosystems making them guardians of aquatic realms. The young larval odonates flourish in well oxygenated, clean and unpolluted waters while the adult forms are highly sensitive to changes in air temperature and humidity. In the mystic folds of the Himalayan mountains, these insects thrive in pristine freshwater habitats like cascading rivers, alpine marshlands, rippling streams, and mist-fed wetlands. Odonates are widely recognized as useful tools for biomonitoring

freshwater ecosystems as their sensitivity to temperature, humidity, and water quality makes them excellent bioindicators of freshwater health.

The Himalayas, with its unique rich biodiversity, is particularly susceptible to the impacts of climate change. Increasing temperatures, altered rainfall patterns, melting glaciers and unpredictable monsoons are transforming entire landscapes. As these insects are excellent bioindicators, any changes in their species composition and abundance can often mirror microhabitat transformations such as water temperature and flow linked to climate change. Scientific research supports their role as reliable barometers for monitoring ecological impacts of a warming climate. Studies in the Western

Himalayas indicates that the species assemblage of Odonata in these Himalayan habitats is undergoing noticeable change, with the disappearance of some species and emergence of new ones. For example, a long-term study conducted in the Tirthan River stretch of the Great Himalayan National Park Conservation Area in Himachal Pradesh recorded significant shifts in Odonata species composition over an 18-year period, with many new species recorded and the loss of previously observed species. A study investigating organic terrace rice cultivation in Sikkim state which is nestled in the bosom of Eastern Himalaya, assessed the influence of agricultural practices on Odonata diversity. Odonates depend upon specific habitat parameters such as water quality and temperature for their reproduction and life cycle. Alterations in these environmental factors often driven by climate change can directly affect their population dynamics.

Odonata species once restricted to warmer lowland areas are now being observed at higher elevations, while species adapted to cold

mountain streams are vanishing from these habitats that have either warmed or dried up. Additionally, some species are emerging earlier in the year, potentially unsettling the rhythms of food chains and reproductive cycles. A 2023 survey in Eastern Sikkim and

Arunachal Pradesh recorded range extensions for species like *Calicnemia doonensis* Sangal and Tyagi, 1984 previously restricted to the lower foothills. Meanwhile, high-elevation specialists such as *Anisopleura comes* Hagen, 1880 have become harder to find.

*Anisopleura comes* Hagen, 1880

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the past two decades are under tremendous pressure of undergoing alterations in

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microhabitat parameters, potentially driven by climatic shifts within the Himalayan ecosystem. There are several species of Odonates reported from the Himalayan district of Kalimpong in North Bengal that are highly sensitive to even slight changes in temperature and precipitation. A warming climate can lead to reduced stream flow from glacial retreat or reduced snowmelt. Changes in canopy cover and humidity levels also indicate climatic alterations. If these species begin to disappear or shift their range to higher elevations, it is a clear sign of climatic stress in these ecosystems. For example, *Somatochlora daviesi* Lieftinck, 1977 a high altitudinal dragonfly

found in subalpine or alpine forest streams of Neora Valley National Park in Kalimpong district of West Bengal has narrow temperature and elevation range. The beautiful damselfly *Megalestes irma* Fraser, 1926 found in this National Park prefers shaded, fast-flowing, oxygen-rich hill streams. A decline in the population of *Drepanosticta carmichaeli* Laidlaw, 1915 commonly known as the Indo-Chinese Blue Reedtail reflects reduced stream flow, habitat fragmentation and warming microclimates. A decline in *Vestalis gracilis* (Rambur, 1842) population, a beautiful damselfly found in Kalimpong district of West Bengal can signal reduced forest integrity, stream desiccation, or microhabitat

degradation — all linked to climate shifts. The presence of another Kalimpong Himalayan damselfly *Aristocypha quadrimaculata* (Selys, 1853) or the four spotted stream jewel is a strong indicator of high water quality, so a sudden absence suggests ecosystem imbalance due to climatic or anthropogenic pressures. The damselfly *Anisopleura comes* Hagen, 1880 is a known hill stream specialist and a thermally sensitive species. It relies on the cool microclimate created by forest canopy and high-altitude streams. It thrives in habitats with stable humidity, canopy cover, and stream flow — all of which are vulnerable to climate variations.



Vestalis gracilis (Rambur, 1842)



Aristocypha quadrimaculata (Selys, 1853)

The role of Odonates as sentinels of environmental health makes them indispensable in climate change research and ecological monitoring in the Himalayas. Dragonflies of the genera *Crocothemis*, *Orthetrum*, *Trithemis*, *Brachythemis* have been successfully used in climate change studies because they are sensitive to environmental changes and are easy to monitor. Monitoring odonate indicator species gives early warning signs of climate change effects on health of mountain streams, wetlands, and forests. Changes in species distribution, abundance, and phenology help scientists and policymakers track shifting ecosystem functions, habitat degradation and the need for targeted conservation actions.

Conservationists are now urging more long-term monitoring of Odonata as part of climate change research. Citizen science projects and professional faunal surveys are also playing a key role by recognizing the value of Odonata in long-term climate monitoring and sharing observations on platforms like *Odonata of India* and *India Biodiversity Portal*. In the last decade, surveys conducted by the Zoological Survey of

Citizen science projects and professional faunal surveys are also playing a key role by recognizing the value of Odonata in long-term climate monitoring and sharing observations on platforms like *Odonata of India* and *India Biodiversity Portal*.

India and institutions like the Wildlife Institute of India have added numerous species to regional checklists and databases, many of which were previously unrecorded at higher altitudes, clearly indicating signs of climate-induced range expansion.

Odonates, are a diverse group of insects that have shown resilience to climate change by adapting to shifting environmental conditions. This resilience is partly due to their long evolutionary history and ability to colonize various habitats, as well as their climate-driven adaptations like rapid larval development and diapause. Additionally, their flexible life cycles and diverse environmental tolerances allow them to respond to changes in climate.

As we navigate an age of climate change perhaps we might find clarity not in the clouds above, but to the shimmering wings that both dazzle and forewarn. In the Himalayan mountains, where snow fed rivers are lifelines, the health of odonates reveals the health of water systems. These ancient insects may be small but their shimmering wings whisper a story of survival, resilience and warning that the climate is shifting, and with it, the ancient rhythms of the mountains begin to unravel. If we tune in to their silent warnings, we may not only save these fragile insects —we might safeguard entire ecosystems, flowing rivers, living mountain landscapes and the humanity intertwined within.



Dr. Jayita Sengupta

Silent Wings, Vital Work: The Untold Story of Hoverflies



All soldiers do not wear a cape, some come in form of a silent warrior, the untiring heroes especially the non-human ones, who serve effortlessly to provide the necessary ecosystem services often got unnoticed,. Pollination is one such crucial service that need tireless efforts by pollinators across the globe to ensure our food

security over decades. When we think about pollination, the first to come in our mind are insect pollinators. Their unpaid and often overlooked services have contributed to more than 35% of global food production.

According to IPBES Report, 2016, both wild and managed insect pollinators play a globally recognized

role in supporting agriculture, contributing an estimated \$235 billion to \$577 billion annually through crop production.

It is a universal believe that the honey bee is the most adaptable, ubiquitous, and commonly used managed pollinator species. However, global dependence on a single pollinator taxon is increasingly seen as a risky and unsustainable strategy. Recent studies have raised concern over the widespread decline of insect populations, with a global survey reporting that approximately 41% of insect species have declined over the past decade. Among the most affected are bees, dung beetles, and Lepidoptera, which represent key pollinating groups. While honey bees dominate pollination discourse, many

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other insect species—both free-living and wild—also provide essential ecosystem services to agricultural crops. In particular, wild pollinators, beyond the few managed Hymenopteran taxa, have recently been acknowledged for their significant role in enhancing and stabilizing pollination services. Yet, the contribution of non-bee insects to crop pollination remains largely overlooked and underappreciated. One of such forgotten superhero belongs to family Syrphidae under order Diptera and commonly known as Hoverflies or flower flies. Researchers around the world has shown that the hoverflies transmit a good percentile of total pollen carried out by farmland pollinators Across a wide range of habitats—from grassy meadows to snow-covered mountains—hoverflies are ever-present as effective pollinators. These tiny, silent heroes provide essential ecosystem services with both subtlety and significance, often without recognition.

Hoverfly-mediated pollination has been estimated to contribute approximately US\$

300 billion annually to global agriculture.

Moreover, their larvae are aphidophagous, acting as natural pest controllers and thereby offering a twofold benefit to society—pollination and biological pest regulation. A variety of habitats provide suitable conditions for hoverflies and their larvae. The main ecosystems are forest, woodland, marshes, peat lands and bogs, damp grasslands, xerothermic grasslands, gardens and residential area. Due to the limitation of micro habitat speciality of larvae within an ecosystem, all of these ecosystems have their own characteristic hoverfly species. The main habitats inhabited by hoverflies are forest and woodland, Marshes, peat lands and

bogs, Meadows and humid grassland, xerothermic grasslands and rocks, Gardens and residential area. The adult hoverflies are pollen and nectar feeders. They range from slender to robust in body shape and possess excellent flight capabilities. Their pollination efficiency is influenced by several factors, including visual, chemical, and mechanical stimuli, as well as the relationship between body size and mouthpart dimensions. An additional fascinating trait of hoverflies is their ability to exhibit Batesian mimicry—many species closely resemble bees and wasps. In particular, numerous non-polymorphic species within the subfamily Eristalinae display a remarkable resemblance in both body coloration and shape to

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certain Hymenoptera species. In contrast, the Syrphinae group shows a comparatively low degree of mimicry. The reason why so many Eristalinae species have well-defined mimetic models, while so few Syrphinae do, remains unexplained. Worldwide, more than 6,000 species of hoverflies have been reported to date, with 369 species documented from India. Despite their abundance and ecological significance, hoverflies remain an under-researched group in our country. In recent years, citizen science has emerged as a vital component of conservation efforts worldwide, and its integration into hoverfly conservation is both timely and necessary. This initiative should begin at the grassroots level—particularly with farmers—who must be made aware of the crucial role these tiny insects play in sustaining agricultural productivity and ecosystem health. Conservation efforts should extend beyond the scientific community, engaging local populations through awareness and training programs. Encouragingly,

the conservation of hoverflies requires minimal financial resources, making it a feasible and impactful goal even in resource-limited settings. Already in western countries specifically in Europe, initiatives has been taken to conserve these tiny little heroes, the European Red List of Hoverflies, funded by the European Commission, represents the first comprehensive assessment of the extinction risk facing all 892 native hoverfly species across Europe. Conducted using the IUCN Red List Categories and Criteria, this landmark study highlights the alarming finding that 37.2% of these species are currently considered threatened. As part of a broader initiative to emphasize the ecological importance of hoverflies,

the assessment underscores the urgent need for targeted conservation efforts to safeguard this vital yet often overlooked group of pollinators. Countries like India should also undertake similar initiatives, especially given the looming threat of food scarcity driven by a rapidly growing population. Ensuring long-term food security requires not only advancements in agriculture but also the conservation of key pollinators like hoverflies, whose ecological contributions are both vital and often overlooked. To highlight the urgency of conservation, a thought-provoking quote by Joel Salatin captures the prevailing mindset:

The average person is still under the aberrant delusion that food should be somebody

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Now is the time to recognize the true worth of what nature provides and act accordingly—before it is too late. However, this responsibility does not rest solely with policymakers. It is equally important for people at the grassroots level to take part in this movement. The conservation of pollinating insects is no longer a luxury or a subject reserved for high-level international conferences—it is a necessity for the survival of humanity.

As the UN report from October 2010 aptly stated: Not a single bee has ever sent you an invoice, and that is part of the problem. Because most of what comes to us from

nature is free—because it is not invoiced, not priced, not traded in markets—we tend to ignore it.

This sentiment underscores the disconnect between people and the natural

systems—such as pollination—that sustain our food supply, emphasizing the need for greater awareness and responsibility in conserving essential species like hoverflies.

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Marmalade hoverfly: *Episyrphus (Episyrphus) balteatus* (De Geer, 1776)



The Common Drone fly: *Eristalis (Eristalis) tenax* (Linnaeus, 1758)



Dr. Jayita Sengupta

Winged Worries or Unsung Heroes? A Closer Look at Flies



“They may land on filth, but flies carry the weight of ecosystems on their tiny wings.”

When Pandora, driven by ceaseless curiosity, opened her fabled “box,” a swarm of plagues escaped into the world, bringing sorrow and suffering to humankind. These afflictions, borne on invisible wings, emerged like tiny, buzzing flies—stinging her skin and her spirit. In a moment of panic and regret, she slammed the lid shut, trapping inside a single, flickering remnant: hope—the one force capable of healing the wounds unleashed by chaos. Perhaps—just perhaps—what escaped were the tormentors of life: disease-bearing insects, parasitic pests, and crop destroyers. And what remained locked

within were the good flies—those who, though silent and unnoticed, would one day help restore balance and bring comfort to a weary world.

In an age dominated by artificial intelligence, automation, and synthetic solutions, it is easy to overlook the quiet, natural contributors that keep our ecosystems functioning. We live in a time when progress is often measured in lines of code and megabytes, and yet, some of the most essential services for life on Earth come from organisms that work for free, around the clock, without seeking recognition or reward. Among these are the flies of the order Diptera, a group too often regarded with disdain or disgust.

To most people, flies are synonymous with filth—houseflies buzzing around garbage bins or mosquitoes biting at dusk. This narrow perception is rooted in our everyday encounters with a few troublesome species. But this limited view masks the extraordinary diversity, adaptability, and ecological importance of this vast insect order. Diptera encompasses more than 150,000 described species—and many more yet to be discovered—spanning every continent and nearly every habitat imaginable. From the freezing peaks of the Himalayas to the sweltering sands of the Sahara, flies have found a way to survive, thrive, and serve.

These two-winged insects, often dismissed as pests, perform a multitude

of essential ecological functions. Some are pollinators, rivalling bees in their effectiveness, especially in cooler and high-altitude environments. Others are decomposers, breaking down dead matter and returning nutrients to the soil. Some are predators of harmful insects, acting as natural pest control agents. Still others serve as bio indicators, offering clues about the health of aquatic and terrestrial ecosystems. Flies even contribute to fields as diverse as forensic science and medicine. Far from being nature’s villains, many flies are, in fact, among its most indispensable heroes.

To look closer at a fly, then, is not merely to see a nuisance, but to glimpse the elegance of evolution, the resilience of life, and the interconnectedness of all living things. Like the hope that remained in Pandora’s mythical box, flies carry the quiet promise of renewal—proof that even the most misunderstood creatures may hold the keys to healing our planet.

Beyond the realm of bug zappers and mosquito-repellent commercials

lies a world of ecological excellence. Many flies are pollination powerhouses, especially in regions where bees and other Hymenoptera are less effective.

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Other key fly pollinators—such as hoverflies, fruit flies, and bee flies—also play critical roles in supporting agriculture, wild flora, and overall biodiversity.

Flies are not just pollinators—they are Earth’s unsung sanitation workers.

Several families like Asilidae, Sphaeroceridae, Fannidae, Calliphoridae, Sarcophagidae, Muscidae from decomposing organic matter, praying on predators to recycling nutrients in waste systems, they

help maintain ecological balance. Some, from families like Calliphoridae, Sarcophagidae, and Muscidae, even aid in solving crimes—their maggots providing key evidence in forensic investigations. Remarkably, the roots of forensic entomology trace back to 13th-century China: in a murder mystery in “*Collected Cases of Injustice Rectified*” a Chinese book

written in 1247 by Song Ci, where blowflies helped uncover a murder weapon centuries before the fictional brilliance of Sherlock Holmes or Hercule Poirot.

Of course, not all flies are benevolent. Some, such as mosquitoes, houseflies, horseflies, biting midges, and certain crop-damaging species, continue to pose threats to human health and food security. Several dipteran groups hold considerable medical and veterinary significance, while others can be general nuisances when present in large numbers. Certain species, like those in the family Chironomidae, can even trigger allergic reactions through the release of detached body hairs. Families such as Agromyzidae, Cecidomyiidae, and Tephritidae are among the most notorious agricultural pests, capable of causing severe economic losses across a variety of fruits and vegetables. Their impacts include significant declines in production, loss of farmer income, rising rural poverty, and diminished trade in horticultural commodities. In many cases, infestations result in export restrictions or

outright bans—especially in developing countries where agriculture forms a vital part of the economy. These challenges underscore the urgent need for effective surveillance, integrated pest management strategies, and international cooperation in mitigating the threats posed by pestiferous dipteran species.

To study flies, then, is to open a modern Pandora’s Box—one that reveals not just the nuisances we often associate with them, but also the astonishing marvels hidden in plain sight. While some species are undeniably linked to disease, discomfort, and destruction, a deeper look uncovers their vital contributions to ecosystems, agriculture, and even

scientific discovery. Like the enduring symbol of hope that remained in Pandora’s mythic box, flies too hold a quiet, transformative promise. Within their delicate, often-overlooked wings lies the potential to purify our environments through their roles in decomposition and nutrient recycling. They support biodiversity as pollinators in remote and challenging landscapes where few others can thrive. They ensure food security by maintaining the balance of agro ecosystems and, through species like the chocolate midge, make possible the very existence of beloved crops. In forensic science, their life cycles have helped bring justice, and in ecological monitoring, their presence serves as a

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barometer of environmental health.

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recognized as agents of restoration and resilience.

Indeed, to understand flies is to rediscover nature’s ingenuity—and to recognize

that even the smallest, most maligned creatures may carry the weight of life itself on their wings.



Robberfly: Family Asilidae



Mosquito: Family Culicidae



Crane fliy: Family Tipulidae



Mrs. Sk Rehanuma Sulthana

Mollusca: On the Brink of a Silent Extinction

Molluscs constitute the dominant framework of animal diversity on Earth, exhibiting distinct morphological, ecological, and evolutionary complexity. With over 5,000 described species in the country, this invertebrate phylum exhibits critical ecological functions and holds substantial economic importance. Freshwater mussels (e.g. order Unionida) are vital in biofiltration, sediment

stabilization, and nutrient cycling in riverine systems. These bivalves filter out particulate matter, organic debris, and excess nutrients, thus improving water clarity and quality-services that benefit other aquatic life and humans alike. On land, gastropods contribute significantly to soil health. Land snails decompose leaf litter and other organic matter, thereby enriching the soil with essential nutrients.

Their shells, rich in calcium, are also important for soil pH regulation. Indigenous communities in India use certain species of molluscs in traditional medicine, rituals, and even as food. Snail mucin is well known for its regenerative potential, to reduce erythema, itching, and burning pain. They are used many cosmetics. neurophysiological studies.

Despite their significance, molluscs are among the most threatened animal groups. According to the International Union for Conservation of Nature (IUCN), molluscs account for over 40% of recorded invertebrate extinctions. A detailed analysis on endemism of freshwater mollusca available reveals that out of 151 gastropods reported, 73 species are endemic and out of 64 bivalves, 41 species

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causes of mussel extinction many of which are now rampant in Indian river systems. In India, rivers like the Ganga, Godavari, and Narmada are under pressure threatening the delicate lifecycle of Unionid mussels that rely on host fish for larval development and dispersal. Freshwater molluscs are affected by siltation, pesticide runoff, and water pollution from both rural and industrial sectors.

are endemic. Western ghats molluscs exhibit an endemism of 70% and 74% in Andaman nicobar. In India, 9 molluscan species are listed under Schedule I and 15 species under Schedule II of the Wildlife (Protection) Act, 1972, as amended in 2022. It has been reported that of 1,032 species, 638 mollusc species are confirmed extinct, 380 are possibly extinct, and 14 are extinct in the wild, which is more than twice the number recorded by the IUCN Red List.

Habitat destruction, pollution, and hydrological modifications such as damming are the leading

A detailed analysis on endemism of freshwater mollusca available reveals that out of 151 gastropods reported, 73 species are endemic and out of 64 bivalves, 41 species are endemic. Western ghats molluscs exhibit an endemism of 70% and 74% in Andaman nicobar. In India, 9 molluscan species are listed under Schedule I and 15 species under Schedule II of the Wildlife (Protection) Act, 1972, as amended in 2022. It has been reported that of 1,032 species, 638 mollusc species are confirmed extinct, 380 are possibly extinct, and 14 are extinct in the wild, which is more than twice the number recorded by the IUCN Red List.

Researches about the freshwater mussels in China, emphasize how hydrological alterations and catchment degradation critically endanger molluscan populations. The comprehensive review by Sen in detail has shown how habitat conversion, especially in the Western Ghats and Northeastern India, is displacing native land snail populations. Monoculture plantations, urban sprawl, and mining activities have drastically altered or removed the moist evergreen forest patches these gastropods depend on.

The presence of invasive species has further complicated the survival of native molluscs. Non-native gastropods like *Pomacea*

canaliculata outcompete local species and disrupt ecological balance. Likewise, climate change adds another layer of stress, especially through changes in rainfall patterns, droughts, and rising water temperatures. Ocean acidification, though primarily marine, has downstream effects on estuarine molluscs in India's coastal ecosystems.

Despite the severity of these threats, molluscs remain poorly represented in India's conservation planning. They receive disproportionately a small share of conservation attention and funding compared to other higher faunal groups Protected Area networks and biodiversity strategies rarely include molluscan taxa, and

taxonomic expertise on the group is sparse. Researches have highlighted that many land snail species in India remain undescribed or have not been assessed using IUCN criteria. This data deficiency hampers targeted conservation efforts.

To address this, India must invest in comprehensive mollusc biodiversity assessments using both classical taxonomy and modern tools like DNA barcoding and environmental DNA (eDNA). Rapid assessment surveys in biodiversity hotspots such as the Western Ghats, etc could help identify conservation priorities. Species inventory of ecologically important areas is one of the initial step towards the conservation of any species. Habitat protection is paramount for mollusca conservation. Riparian buffer zones, wetland restoration projects, and sustainable agricultural practices can collectively secure habitats for freshwater and terrestrial molluscs. River basin management plans must ensure environmental flow regulations to maintain suitable conditions for

freshwater mussel common in Indian rivers. International studies advocate for a multi-tiered conservation model involving habitat protection, species monitoring, and genetic research to approach applicable to Indian contexts as well. Community participation should be a cornerstone of molluscan conservation. Traditional knowledge of molluscan harvesting practices, seasonal availability, and cultural uses can inform sustainable management. Public engagement through citizen science platforms and education campaigns can elevate awareness. For instance, involving school and college students in gastropod surveys or mussel mapping can foster interest in conservation. China has dismantled 300 out of 357

dams along Chishui river. According to Times of India, 2024; SCMP, 2024, the removal of dams and have reopened migratory routes and restored habitats, benefiting various rare and endemic fish species in the region.

In conclusion, molluscs are not only bioindicators of environmental health but also economic resources and scientific assets. The threats they face are significant

but not insurmountable. By integrating them into mainstream conservation, promoting scientific research, and empowering local communities, India can ensure that these invertebrate species continue to thrive. Our actions today will determine whether future generations inherit rivers and forests still whispering with the slow, silent movement of molluscs.

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Dr. Indu Sharma

River Royals: The Fascinating World of Fishes



Fish (Matsya) is known as the avatar of the “God Vishnu” and first among the Vishnu’s (Dashavatara) ten avatar’s who rescued the first man (Manu) from floods/ threats. Matsya, the fish incarnation of Vishnu is the divine power that ensures the continuation of life on earth. Fishes are recorded firstly (skeletons) around 550 million years ago.

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of Vishnu is the divine power that ensures the continuation of life on earth. Fishes are recorded firstly (skeletons) around 550 million years ago. The first fish in the globe (jawless) evolved

during 530 to 480 million years ago in the Cambrian era. They had evolved jaws during the Silurian period and thrived (Bony fishes) during the Devonian period known as the “Age of Fish”. Fishes are cold-blooded aquatic vertebrates, breathes with the help of gills and swims by fins. They are a heterogeneous assemblage consists mainly of marine and most diverse freshwater fishes.

Rivers of the country are vital aquatic habitats and overwhelmed with rich and diverse fish fauna. India is endowed with extensive network of River System and is categorized into four major groups viz. Himalayan, Deccan, Coastal and Inland drainage. The Himalayan watershed is the source of majority of the major river systems in India. Himalayan

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Rivers (snow fed) are perennial and comprises the Ganges, the Brahmaputra and Indus is the major source of fresh water river system. The Ganges originating from the Gangotri Glacier, is the longest River in India. Brahmaputra River originates from the Tibetan plateau, enters India through Arunachal Pradesh, and is known for its large volume of water. Indus River originates in the Tibetan plateau and enters India through Ladakh and Jammu & Kashmir. The Deccan region comprises rivers Godavari, Krishna, and Cauvery, Narmada and Tapi are primarily rain-fed and drain into the Bay of Bengal and the Arabian Sea. Rivers the Chambal, the Betwa and the Luni situated in the north-west side originates from Aravalli Range. Coastal rivers small in size are

located mainly on the west coast. Some of the inland rivers in Rajasthan drain into the Salt Lake and others after flowing some distance disappear in the desert. Total length of ca of the rivers and main tributaries is 2,7360 km in the country.

There are 1075 fishes are found in freshwater in the country. Among the 42 families of fresh water fishes, four families are richer in diversity i.e. Cyprinidae followed by Nemacheilidae, Sisoridae and Bagaridae and comprises about 90% of total freshwater fishes of India. There are 749 species are endemic to India and high endemism is recorded from Western Ghat and North East.

Fishes constitutes over half of the total number of living vertebrate species of world in small (1%) earth’s aquatic surface. India comprises about 11% (3919 species) of total fish species (37,102) present globally. There are 1075 fishes are found in freshwater in the country. Among the 42 families of fresh water fishes, four families are richer in diversity i.e. Cyprinidae followed by Nemacheilidae, Sisoridae and Bagaridae and comprises about 90% of total freshwater fishes of India. There are 749 species are endemic to India and high endemism

is recorded from Western Ghat and North East. The freshwater fishes are divided as primary, secondary or estuarine as per their habitat. Primary fishes inhabit in their entire life in freshwater and also reproduce in fresh water called potamodromous. The distribution and diversity of fishes is influenced due to ecological condition viz. water temperature, velocity, oxygen. Some of the common genera of freshwater fishes are *Esomus*, *Garra*, *Labeo*, *Puntius*, *Rasbora*, *Salmostoma*, *Schizothorax*, *Tor*, *Amblypharygogodon*, *Barilis*, *Chela*, *Devario*, *Diptychus*, *Botia* and *Lepidocephalichthys*, *Paracanthocobitis*, *Physoschistura*, *Schistura*, *Mystus*, *Bagarius*, *Glyptothorax*, *Glyptosternon* *Clarias*, *Channa* etc. Fishes inhabits in all elevations and habitats from lowest plains to Himalayan and trans Himalayan region up to about 5000 m asl in Ladakh. Mahseer and Snow trout and other hill stream fishes called barbs are found throughout the Himalayan region. Mahseer (Golden Mahseer) is largest fresh water fish in Cyprinidae family. It is known

The distribution and diversity of fishes is influenced due to ecological condition viz. water temperature, velocity, oxygen. Some of the common genera of freshwater fishes are *Esomus*, *Garra*, *Labeo*, *Puntius*, *Rasbora*, *Salmostoma*, *Schizothorax*, *Tor*, *Amblypharygogodon*, *Barilis*, *Chela*, *Devario*, *Diptychus*, *Botia* and *Lepidocephalichthys*, *Paracanthocobitis*, *Physoschistura*, *Schistura*, *Mystus*, *Bagarius*, *Glyptothorax*, *Glyptosternon* *Clarias*, *Channa* etc.

as tiger fish of the river due to its large size, power and its sport qualities. Snow trout is one of important high value indigenous fishes of the hill streams. These fishes are (stenothermal) can tolerate narrow range of temperature fluctuation. There is more diversity in lower to mid altitude as compare to high altitude and trans Himalayan Ecosystem. The less diversity of fishes in Tarans Himalayan is due to their climate,

zoogeographical location, but the fishes found here are rare, unique and mostly endemic to the area. The fish fauna of Trans Himalaya (Ladakh and Spiti) is dominated by the Palaeractic elements and is represented by two families Schizothoracinae and Nemachelidae. Fishes of Genus *Schizothorax* are large size and of the genus *Triplophysa* are small in size and not much commercially important but ecologically

very important. The fishes in the Ladakh region dwells in the streams of glacial of Indus River are well adapted to the area. Water bodies in Ladakh freezes during the winter months and temperature drops down to -70o C and fishes survive deep in bottom to tide over the harsh freezing climatic condition of the area. It is interesting feature that fishes Indu Snow trout (*Ptychobarbus conirostrus*) assemble near hot springs (30- 40oC) in Chungtang near Nyoma along the Indus River. Fishes living in hill streams have developed several unique morphological adaptations to cope up in torrential current of water.

Freshwater fishes are brightly attractive/colourful and colour can be seen only in live fishes as it slowly fades away in the preserved specimens. Colouration in fishes due to two types of the particular pigment cells i.e. *chromatophores* and *iridocytes*. They are arranged in two layers in the skin (dermis) one above and other below the scales. *Chromatophores* produce wide range of colours (black, brown, yellow, red, blue etc.)

and *iridocytes* have silvery and shimmering effect. They are present in different proportion in various species and also varies in different parts of the body in same fish. Mostly large number of Chromatophores (Colour) are present in dorsal side *iridocytes* on the ventral side which give silvery colour ventrally. Body of fishes is covered by various types of scales (Cycloid and Ctenoid) and useful for identification, age and growth of fish.

Fishes have evolved various adaptation that enable them to survive in particular habitats. Scales in the fishes of hill streams are reduced and embedded in the skin and paired fins are thick and flat and pushed outwards and horizontally placed to enabled them to hold with rocks and stones. These fishes possess long, narrow, whip like tail and usually lower lobe of the caudal fin is longer than the upper one are adaption in high altitude fast flowing water. Mouth is generally semicircular and, in some species, jaws are covered with strong horny covering. Barbels are reduced and lips are modified into

sucker ventrally with the help of mouth. Eyes are small in size and pushed upwards and come to close each other (Ventrally) towards upper side. Water is oxygenated in the hill stream fishes so small gill opening enables them to retain water in the brachial chamber for a longer time. There are hydrostatic organs in the hill stream fishes thus the air bladder is reduced in hill stream fishes. The ventral side of the body has grooves and ridges (striated structure) and cushion-like structure on the outer rays of the paired fins are the adaptation in these fishes.

Economic importance to ecosystem and mankind:

Fishes are the excellent indicator of health of aquatic Ecosystem. Their presence, diversity and abundance depict the habitat, ecology and overall health of ecosystem. Fishes are economic important to ecosystem and mankind viz. fish as human food, employment generator, livelihood for people who involved in fishing industry, provider of valuable byproducts. They are vital for maintaining biodiversity

and ecological balance in the ecosystem. Fishes are used as a significant source of food since the time human ancestors appeared on the earth and references are available in Kautilya's as early as in 300 B.C. It is used as food for cattle's known as fish meal, fish manure for fields and most important fishery by-product i.e. fish oil. The oil extracted from the body and liver is known as body oil and liver oil respectively. Various fish species are helpful for biological control as they are larvivorous in habit and feed upon insect larvae and they are introduced in the water and thus helpful to reduce the various insects in the water. Fishes such as Mahseer, trout and Gooch are highly valued for sport fishery and provide recreation to anglers from all over the world. Various fresh water fish's Indian major carps and Chinese carps are widely being exploited for aquaculture practices in India. India is second largest aquaculture fish producer in

the world and contributes about 7% to the global fish production. Aquaculture practices are helpful to raise the socio-economic status, to overcome malnutrition to the people living below poverty line and potential to restock the indigenous species and

conserve threatened species. Various fishes are also used for decoration and known as ornamental fishes. Aquarium is helpful for aesthetic appeal, health benefits etc. Therefore, fishes play a vital role for livelihood and economy of the country.

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Golden Mahseer-*Tor putitora* (Hamilton, 1822)



Green stripe barb-*Puntius vittatus* Day,1865



Blackline rasbora-*Rasbora daniconius* (Hamilton, 1822)



Dr. Archana Bahuguna

My Journey with Turtles: From Toy to Conservation

During my childhood, my father once gifted me a wooden turtle toy—my very first encounter with a turtle, or as we called it, *Kachuga*. The toy had two long strings attached to its back, allowing it to be hung on the wall. I vividly remember how my father hung it up, and I would

eagerly pull the strings, one after the other, making the turtle “walk” up the wall. I found immense joy in this simple play. At that time, I could never have imagined that one day I would be conducting research on turtles.

Turtles and tortoises belong to the order *Testudines* within the class Reptilia. Morphologically, they are easily recognized by their hard, bony or cartilaginous shell—called the carapace—which is a specialized modification of their ribs. They are among the oldest surviving groups of reptiles, having existed on Earth since the time of the dinosaurs, with fossil records dating back approximately 215 million years to the Late Triassic era.

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Globally, turtles display remarkable diversity in shape, color, and pattern. There are 356 known species of turtles and tortoises, distributed across 89 genera and 12 families. Though they are found on every continent except Antarctica, they are absent from Australia. India is home to 29 species of freshwater turtles and tortoises, making it one of the most important countries in Asia for turtle conservation. In fact, India is considered one of the world’s top five turtle biodiversity hotspots, with North and Northeast India recognized as one of the 16 global hotspots for chelonian diversity.

These reptiles have adapted to a variety of habitats—some are fully aquatic, others prefer muddy or freshwater environments, while some are terrestrial or marine, leading semi-pelagic lifestyles. The Indo-Gangetic plains and Terai regions host about 20 species, while Northeast India holds the highest diversity with 25 species.

Freshwater turtles are omnivorous, with diets that vary by species. In the wild, they feed on aquatic

Approximately 50.3% of all known turtle and tortoise species are listed as Threatened (Critically Endangered, Endangered, or Vulnerable) on the IUCN Red List.

plants, fallen fruits, insects (including larvae), snails, worms, crayfish, mussels, and occasionally, dead or injured fish. Despite their ecological importance and ancient lineage, turtles and tortoises are among the most threatened vertebrates on the planet.

Approximately 50.3% of all known turtle and tortoise species are listed as Threatened (Critically Endangered, Endangered, or Vulnerable) on the IUCN Red List. Many of these threatened species are concentrated in Asia. The major threats they face include habitat destruction, pollution, poaching, illegal wildlife trade, and exploitation for food and traditional Chinese medicine. In India alone,

TRAFFIC’s analysis of illegal trade in tortoises and freshwater turtles revealed that 1,11,312 individual animals were trafficked between September 2009 and September 2019. This highlights the urgent need for conservation action and enforcement of wildlife protection laws.

Turtles and tortoises are not only evolutionary marvels but also play vital roles in their ecosystems. Their conservation is not just a national priority but a global imperative. Some carnivorous turtles were released in Ganga to clean it by MoEFCC in 70s during Clean Ganga programme.

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conservation status of each species. However, as in many parts of India, ecological data on turtles in Rajasthan remains limited. Some insights into the biology of *Lissemys punctata* and a few hard-shelled species have emerged from research conducted at Keoladeo National Park (Bharatpur) and along the Chambal River. Unlike other wildlife, turtles are not heavily exploited in Rajasthan. Nonetheless, nomadic and marginalized communities may consume turtles for subsistence. Of concern is the illegal collection of Indian Star Tortoises from arid zones for

Bhupathy and Reena in 2013 reported the presence of 11 species of chelonians in Rajasthan. Among these, 10 are freshwater species and one is terrestrial. The eastern and southern regions of the state, especially the Indo-Gangetic plains and the Chambal River, provide favourable habitats for their survival. The Indian Flapshell Turtle (*Lissemys punctata*) is widely distributed across the state, whereas many hard-shelled species are largely confined to the Chambal River. The authors provided concise information on the

distribution, behaviour, biology, life cycle, and

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trade, necessitating vigilant enforcement by authorities.

Most soft-shelled turtles and selected hard-shelled species are protected under the Indian Wildlife (Protection) Amendment Act, 2006. Some carnivorous species such as *Nilssonina gangetica*, *Lissemys punctata*, and *Chitra indica* play a vital ecological role by maintaining water quality, which is why they were historically released into the Ganga River to help keep it clean and also by Ministry of Forest Environment and Climate Change, India during cleaning of Ganga programmes in 70s. In Indian tradition, turtles are often kept in ponds and wells with the belief that they purify water. In mythology, the turtle—*Kurma*—represents the second avatar of Lord Vishnu and plays a crucial role in the *Samudra Manthan* (churning of the ocean). It symbolizes stability, support, and the safeguarding of the Earth.

To gain deeper insight into this group, I initiated a project titled “Ecological and Molecular Study of Freshwater Turtles from Baanganga in Uttarakhand

to the Ganga in Kanpur”, conducted at the Zoological Survey of India from 2008 to 2011. As part of this work, I carried out local surveys in the Laksar region of Haridwar, particularly around the Sonali and Baanganga rivers.

Observing turtles basking or emerging on riverbanks for nesting was challenging. Many of the surveyed areas were actively used for agriculture, which disturbed turtle habitats. Additionally, deforestation in riparian zones contributes to rising local temperatures.

This change can impact sex ratios in turtles, as temperature-dependent sex determination is a known phenomenon. In crocodiles, higher temperatures lead to more male offspring, while in freshwater turtles, elevated temperatures tend to produce more females—potentially leading to population imbalances and long-term reproductive issues.

One particular incident during a sunny survey day in Laksar remains vivid in my memory. While my team had moved ahead, I was

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searching for turtles alone in an area thick with elephant grass and pebbled terrain. As I stepped forward with my right foot, it suddenly sank nearly three feet deep into a hidden swamp. With a camera and binoculars in hand, I struggled to free myself. I called out for help, and after 10–15 minutes, two of my team members heard me and began searching. The dense elephant grass made it hard for them to locate me, but eventually they reached me, took hold of my equipment, and helped pull me out. I had to leave my shoes behind in the mud and carefully free my leg without applying pressure on the other foot. It was a physically demanding moment but also a reminder of the unpredictable challenges fieldwork can bring.

It was a significant achievement to report *Morenia petersi* (IUCN EN) for the first time from Uttarakhand, along with *Pangshura tentoria circumdata* and *Lissemys punctata andersonii* (IUCN : VU), all listed under Indian Wildlife Protection Act 1972. In 2010, I visited Panchnada,

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Bare in the Etawah district of Uttar Pradesh as part of the same programme. I found the region to be exceptionally rich in turtle biodiversity. Interestingly, this area has a historical association with dacoits.

During our survey, we passed by a temple that was over a hundred years old. The priest there recounted a remarkable story—he showed us a scar from a bullet wound he sustained while sheltering dacoits in the temple from the police. He explained that, during that time, turtles were strictly protected by the dacoits and local communities. Poachers were hesitant to enter the area or

harm the turtles, reflecting a unique form of community-driven conservation. These anecdotes offered fascinating insights into the cultural dimensions of wildlife protection.

After completing the survey in Panchnada, I proceeded to Badaun in Uttar Pradesh. There, I observed that fishermen commonly used fine mesh fishnets, which often trapped and killed turtles unintentionally. Additionally, the local population used mud islands in the river to cultivate vegetables, relying heavily on pesticides to enhance yields. Such practices pose serious threats to freshwater

turtle habitats and need to be strictly regulated or banned.

I submitted recommendations based on my findings to Dr. Savita, Director of the Forest Research Institute in Dehradun. These were included as a one-page note in the *Namami Gange* report, highlighting urgent measures needed for freshwater turtle conservation.

While conducting surveys along the Ganga near Kanpur, I noticed a ritualistic practice involving turtles. People would capture turtles from the river, and then—believing their wishes would be fulfilled—release them back into the water after making a vow. However, this process was harmful, as turtles were

While conducting surveys along the Ganga near Kanpur, I noticed a ritualistic practice involving turtles.

Gange report, highlighting urgent measures needed for freshwater turtle conservation.

first mishandled during capture in fishnets and again during their ritual release. Such practices, though culturally rooted, likely disrupt the turtles’ natural behavior and development.

Freshwater turtles are increasingly threatened by illegal trade, habitat degradation, and the

impacts of climate change—both in India and globally. These pressures make their conservation more urgent than ever. As part of my contribution to their protection, I submitted species-specific gene sequences for eight turtle species from India to the National Center for Biotechnology Information (NCBI). These sequences are now available as references for forensic investigations, ecological studies, and distribution mapping by various agencies and research organizations. Thanks to my father for gifting me a turtle toy and I hope we will be able to maintain the turtle populations and diversity till eternity.



Morenia petersi (Anderson,1879), Indian eyed Turtle (IUCN Endangered), new record for Uttarakhand



Pangshura tentoria circumdata (Gray 1834) , Indian tent turtle , new record for Uttarakhand



Cultivation of vegetables on mud island at Yammuna and Betwa (Hamirpur0



Different technique adopted by locals to catch fish and turtles



Cultivation of sugar cane at the bank of Ganga at Haridwar (Ranjitpur),



Mrs. Supriya Nandy

SUSUNIA: The Lost World



West Bengal, though compact in size, showcases a stunning diversity of natural landscapes—from towering mountains in the north and sprawling plains at its centre to rugged plateaus in the south-west and fertile delta in the south. With its rich mix of forests, flowing rivers, winding canals, and access to the sea, it seems to encompass nearly every terrain imaginable—save for a desert!

The south-western region of West Bengal is marked by distinctive red soil, uneven rocky landscapes, and scattered low and high hills. This terrain is part of the Chotanagpur Plateau that extends from neighboring Jharkhand. On a map, the districts of Purulia, Bankura, Birbhum, Jhargram, West Medinipur, and West Burdwan

The south-western region of West Bengal is marked by distinctive red soil, uneven rocky landscapes, and scattered low and high hills. This terrain is part of the Chotanagpur Plateau that extends from neighboring Jharkhand. On a map, the districts of Purulia, Bankura, Birbhum, Jhargram, West Medinipur, and West Burdwan together shape what is known as Rarh Bengal.

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It is amazing to think, in prehistoric times, this region was home to early hunter-gatherer humans who lived

a nomadic lifestyle, relying on natural resources for survival. In regions like Purulia, Bankura, and West Midnapore, discoveries of scattered stone tools and

artifacts reveal traces of human life dating back to the Palaeolithic era—the earliest chapter of human civilization. Over time, this age of rough, blunt stone implements transitioned into the Neolithic period, marked by tools that were sharper, more sophisticated, and widely adapted for diverse tasks. As humans evolved, they began cultivating selected wild plants and domesticating animals, laying the groundwork for primitive agriculture and animal husbandry. This shift represented a revolutionary stride forward, allowing people to settle rather than constantly migrate in search of food. Eventually, this stability laid the foundation for settled life and mud-built shelters evolved into villages, and over time, paved the way for the rise of cities and more complex societies.

As civilization progressed, people began crafting items from terracotta alongside stone and eventually discovered metals—starting with copper. This ushered in the Chalcolithic era, named from ‘chalco’, meaning copper, marking a pivotal

shift from the Stone Age to the age of metal use.

Small village-based settlements of this period were established along the banks of various rivers like Damodar, Ajay, Kunur, Gandheswari and others. Archaeologists have discovered numerous such sites like Pandurajar Dhibi, Mahishdhal, Mangalkot, and Bharatpur. This vast region has witnessed the continuous advancement of human civilization from that ancient Stone Age to the historical era.

Susunia Hill (23.3951°N, 86.9874°E), located about 10 kilometers north of Chhatna in West Bengal's

Bankura district, is a region rich in both natural beauty and historical significance and popular among visitors and young rock climbers. At the hill's base lies a perennial natural spring, possibly sourced from an artesian well. Adding to its mystique, Susunia holds West Bengal's oldest known ‘rock’ inscription, dating back to the 4th century AD, which documents a donation by King Chandravarman of Dhosagram, a devotee of *Vishnu*, and features an ancient *chakra* (wheel) carving. This blend of adventure, nature, and heritage makes Susunia a unique and culturally treasured destination.

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But Susunia’s true significance lies in its value to geologists, palaeontologists, and archaeologists. While traces of ancient human civilization exist in nearby regions, Susunia uniquely stands out for yielding rare Pleistocene-era mammal fossils—millions of years old—making it an extraordinary site for studying prehistoric life.

The current geological epoch is the Holocene, which began roughly 11,700 years ago, following the end of Pleistocene. In Earth’s 4.5 billion-year history, this period is a blink in geological time. Life emerged about 3.5 billion years ago, sparking a dynamic journey of evolution. Over the ages, countless plant and animal species have appeared and vanished, shaping the ever-changing tapestry of Earth’s biodiversity.

Major disasters at the end of the Palaeozoic and Mesozoic eras triggered mass extinctions, wiping out numerous species at a time. Yet, evolution persisted as new life forms gradually appeared. With the decline of reptiles and the

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disappearance of dinosaurs, mammals emerged as the most advanced animals and eventually became the dominant life form on Earth—a status they still hold today.

The Pleistocene, at the end of the Coenozoic Era, spanned roughly 2.5 million years and played a crucial role in mammalian evolution. It was a time of repeated Ice Ages—some long, some brief—that drastically reshaped Earth’s climate and geography. Global temperatures plunged, ice spread across continents, and fluctuating

glacial cycles led to rising and falling sea levels. These environmental shifts submerged and revealed landmasses, creating both challenges and opportunities for life to evolve and adapt. During the glacial periods between ice ages, Earth saw the emergence of giant mammals like mammoths, saber-toothed tigers, and woolly rhinoceroses—species many of us recognize. Fossils of mammoths preserved in Siberian ice, offer vivid glimpses into that era. As temperatures dropped, animals migrated in search of

liveable habitats, leading to the wide dispersal of species, though many eventually vanished. By the end of the Pleistocene, modern humans had appeared and managed to endure the harsh climate using their ingenuity—creating fire, crafting clothes from animal hides and seeking refuge in caves. Over time, they spread across the globe. With the end of the last Ice Age, the Earth’s climate settled into a more stable

Between 1959 and 1966, notable archaeological explorations led by the famous archaeologist, late Paresh Chandra Dasgupta uncovered a rich array of evidence in the Susunia Hills region.

state, marking the beginning of the Holocene epoch.

Between 1959 and 1966, notable archaeological explorations led by the famous archaeologist, late Paresh Chandra Dasgupta uncovered a rich array of evidence in the Susunia Hills region. These investigations revealed numerous stone artifacts alongwith a significant collection of fossils. These fossil finds were subsequently analyzed by both the Geological Survey of India and the Zoological Survey of India Both the organizations later carried out further surveys and unearthed even more fossil specimens from the area. Fossils were primarily discovered in areas of Beldanga, Kansara, Shiulibona, Bankajor, Jhikuria, Aduri, Metela, and Babladanga surrounding Susunia Hill. Although

Such animals include the extinct wild species of Siwalik cattle (*Bos namadicus*), the extinct species of buffalo (*Bubalus bubalis var palaendicus*), the extinct Siwalik antelope (*Miotragoceros cf. punjabicus*), the extinct Siwalik porcupine (*Hystrix crassidens*), the extinct Siwalik elephant (*Palaeoxodon namadicus*), the extinct Siwalik horse (*Equus namadicus*). Among these, *Bos namadicus* is the wild ancestor of the cattle, one of the most important domestic species of the Indian subcontinent.

carbon dating was attempted, it proved ineffective because the fossils date back beyond the method’s 40,000-year limit—likely to the late Pleistocene. Most of the fossils belong to mammalian and some to reptilian species, many of which are now extinct or represent ancestral forms of animals living today. Such animals include the extinct wild species of Siwalik cattle (*Bos namadicus*), the extinct species of buffalo (*Bubalus bubalis* var *palaendicus*), the extinct Siwalik antelope (*Miotragoceros* cf. *punjabicus*), the extinct Siwalik porcupine (*Hystrix crassidens*), the extinct Siwalik elephant (*Palaeoxodon namadicus*), the extinct Siwalik horse (*Equus namadicus*). Among these, *Bos namadicus* is the wild ancestor of the cattle, one of the most important domestic species of the Indian subcontinent.

Along with this, fossils of some animals have been found, which are still surviving in the world, even in India, such as the blackbuck (*Antelope cervicapra*), leopard (*Panthera pardus*), swamp deer (*Cervus duvauceli*), nilgai

(*Boselaphus tragocamelus*), terrapin (*Batagur baska*), gharial (*Gavialis gangeticus*), and others. Among these surviving animals, there are

some species those have become completely extinct from the Indian subcontinent long ago, but still continue to exist in other parts of



Some fossils of extinct mammals from Susunia Region, Bankura district, West Bengal preserved in Palaeozoology Division of Zoological Survey of India, Kolkata.

the world, especially in Africa. For example, the lion (*Panthera cf leo*), giraffe (*Giraffa camelopardalis*) and spotted hyena (*Crocota* sp.), which are found only in the African continent, not in India. The fossil of lion found has affinity with African lion. It’s truly astonishing to imagine that majestic creatures like lions and giraffes once roamed the lands of West Bengal.

The extinct Pleistocene mammals, including species now found only in Africa, bear striking similarities to fossil discoveries from the Siwalik Hills—the southernmost stretch of the Himalayas that runs from the Indus to the Brahmaputra. During the Pleistocene, it was a hotspot for mammalian evolution, giving rise to notable species like the elephant and rhinoceros, whose remains are embedded in Siwalik’s rock layers. Fossils also reveal the presence of massive creatures such as Stegodon (an extinct elephant), the saber-toothed cat (*Megantereon falconeri*), a giraffe ancestor (*Sivatherium giganteum*), hippopotamus-like beings

(*Hippopotamodon sivalense*, *Hexaprotodon sivalensis*), the giant tortoise (*Megalocheilus atlas*), and many more. Also the ape or human ancestral species, *Sivapithecus* and *Ramapithecus* are important fossils found here. Several Siwalik species—like the ancient hippopotamus and hyena—eventually migrated across continental land bridges and persisted in Africa, although they vanished from India. During the Ice Ages, certain species also spread into southern India, as evidenced by fossil discoveries in the Narmada Valley and farther south. Remarkably, fossils of these same Siwalik-era animals have also been uncovered in Susunia, dating back to that very period.

It’s likely that towards the end of the Pleistocene, early humans navigated this harsh terrain and crossed paths with the very animals whose fossils now lie buried in the region. Using their survival instincts and tools, they may have hunted these creatures, leaving behind silent traces of that ancient interaction etched in the landscape’s fossil record.

While extreme climatic conditions and habitat loss were major factors in the extinction of large Pleistocene animals, early humans also played a significant role through excessive hunting. Species like mammoths and saber-toothed tigers were targeted for their meat, hides, and other essential resources. Evidence of such communal hunts can be seen in Palaeolithic cave art across Europe, and similar depictions have been found in India’s Bhimbetka caves, offering a glimpse into the survival strategies of prehistoric humans.

In addition to Pleistocene-era fossils, numerous skeletal remains from the more recent Holocene period have been uncovered around Susunia. These sub-fossils, which still retain a significant amount of organic material, haven’t fully fossilized into stone. Archaeological explorations along the banks of rivers like Gandheshwari and Dhankora revealed numerous such bone fragments. These remains suggest that ancient people in the area likely domesticated animals for food and other uses. Notably,

caves on Susunia Hill—such as the one at Bhaluksonda—have yielded bone tools and weapons crafted by these early inhabitants, reflecting their ingenuity and adaptation to their environment. While geologists consider them relatively young, archaeologists and anthropologists regard them as immensely valuable as being several thousand years old. These remains serve as authentic records of evolution and cultural history of human civilization. The Susunia region has preserved an unbroken record of human presence and cultural evolution, spanning from the Palaeolithic through the Mesolithic, Neolithic and Chalcolithic periods into the early historical age.

Even two decades ago, the open fields near Susunia Hills often revealed fragile bone fossils especially when the soil was disturbed for farming or other activities. Though the landscape is changing

due to human expansion, some of these remains may still surface today. The area seems geologically unique, occasionally rising to expose relics from a time long forgotten. Such fossils might be hidden in surrounding regions too, since the prehistoric animals weren't likely confined to one spot.

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It's possible that this land once supported forests or grasslands that helped large species thrive in challenging climates. In essence, the Susunia Hills serve as a powerful testament to both the prehistoric and historical evolution of life.



Dr. Dola Roy

Skeletons of Culture: Decoding History through Fish Bones



Late light glints off tidal flats as a coastal community gathers to clean the catch of that day. Scales flash silver; Knives click against stone; Fires crackle; stories travel farther than smoke. When the meal is over, the bones, vertebrae like glass beads, spines as fine as mustard seeds, jaw parts with teeth no wider than a grain of sand are discarded into ash, pits and shoreline kitchen middens. Centuries pass. Shorelines migrate. Sand becomes stratigraphy. What remains are fragments, splinters of calcium memory, waiting for someone with the patience and tools to listen.

This is what zooarchaeology is all about: the study of animal remains from archaeological contexts to reconstruct past lifeways. Within that broad field, the

zooarchaeology of fishes is both indispensable and notoriously difficult. Without proper reference materials for comparison, these fragments, like thousands of

others from archaeological sites across India, remain enigmas, filed away as simply “fish bone, unidentified.” This scenario repeats across India’s archaeological

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landscape, from Paleolithic shell middens in Tamil Nadu to medieval trading posts in Kerala. India’s 7,500-kilometer coastline harbors some of the world’s richest archaeological evidence of human-marine relationships, yet much of this treasure trove remains locked away by a fundamental problem: the near-absence of comprehensive fish bone reference collections.

The fish remain is considered as the trickiest material an archaeologist will ever face. Fish species diversity is staggering, over 30,000 globally and skeletal architecture varies wildly between lineages. Many archaeological assemblages

preserve only scattered, heavily fragmented elements; in tropical and warm subtropical zones, where biodiversity is extremely high, overlapping bone shapes across genera and species frustrate identifications. Weathering, burning, soil chemistry and differential preservation can erase diagnostic features.

Yet across the entire subcontinent, fewer than a handful of institutions maintain fish osteological collections suitable for archaeological research. The Zoological Survey of India houses some specimens, but these are primarily preserved for taxonomic studies, not archaeological

comparison. Most Indian zooarchaeologists work with makeshift personal collections or spend precious research budgets traveling to international museums in Australia, Europe or North America. The consequences ripple through decades of archaeological research. At Harappan Lothal, fish bones that could illuminate Bronze Age maritime trade remain is generically catalogued. Medieval sites in Kochi and Kollam yield assemblages that might reveal how spice trade intensification affected local fishing practices, but without reference materials, these stories stay untold. Across hundreds of coastal excavations, fish bones accumulate in storage boxes, their secrets preserved but inaccessible.

This taxonomic bottleneck represents a massive loss of archaeological potential. When researchers can only identify remains to broad categories like “marine fish” or “freshwater fish,” they lose the ecological precision that makes archaeological evidence powerful. But when they can distinguish a pomfret from a kingfish,

patterns emerge. Pomfret dominance might suggest near-shore reef exploitation whereas kingfish abundance could indicate deep-water fishing capabilities and sophisticated boat technology. The difference between generic identification and species-level precision is the difference between knowing people ate fish and understanding the entire economic systems, seasonal mobility patterns and technological innovations.

The breakthrough has emerged from an unexpected source: medical imaging technology. High-resolution CT scanners, originally

designed for human diagnostics, prove capable of capturing every ridge, foramen and surface texture of delicate fish bones. Combined with advanced 3D modeling software, these scans create perfect “digital twins” of skeletal elements, specimens that can be rotated, measured and compared without risk of damage. In Australia, the Fishboneviz project has demonstrated the transformative potential of this approach. James Cook University researchers digitized hundreds of Pacific fish specimens, creating the world’s first open-access 3D

fish bone reference collection. Suddenly, archaeologists anywhere can access high-quality comparative materials through a simple web browser.

From a methodological standpoint, digital 3D data integrate seamlessly with emerging analytical pipelines. Machine learning models trained on thousands of annotated bone elements could one day assist in rapid, probabilistic identifications from fragmentary remains—a boon in large assemblages where human time is limited. Automated land marking could standardize morphometric comparisons across labs. Augmented reality applications might let field archaeologists overlay a semi-transparent comparative element atop a freshly recovered fragment for on-site triage. None of this replaces expert judgement; rather, it amplifies it, freeing specialists to spend more time interpreting what identifications mean for past human behaviour.

This type of digital initiatives can revolutionize Indian archaeological scenario completely. Fragmentary

The fish remain is considered as the trickiest materials an archaeologist will ever face. Fish species diversity is staggering, over 30,000 globally and skeletal architecture varies wildly between lineages.

This taxonomic bottleneck represents a massive loss of archaeological potential. When researchers can only identify remains to broad categories like “marine fish” or “freshwater fish,” they lose the ecological precision that makes archaeological evidence powerful.

fish bones from sites like Dholavira could be compared against digital models of Arabian Sea species. Students at universities across India could access the same reference materials that previously required expensive travel to examine. The geographic and institutional barriers that have long constrained Indian zooarchaeology would dissolve. The transformation begins with systematic digitization of modern fish skeletons from Indian waters, species commonly found in archaeological sites. Each bone is first virtually dissected, cleaned of software artifacts and finally annotated with ecological notes and geographic ranges.

The technological advantages prove even more significant than expected. India's tropical climate often leaves archaeological fish bones stained, corroded or partially dissolved. Physical specimens might be too damaged for confident identification but digital models with adjustable lighting and transparency can reveal diagnostic features invisible to the naked eye.

Fish bones work excellently as environmental recorders.

Surface details obscured by mineral deposits in ancient bones become visible when compared against clean digital references. As digital collections grow, their impact multiplies exponentially. Fragments that have puzzled researchers for months can be immediately recognized by colleagues who have encountered similar material from different sites.

Fish bones work excellently as environmental recorders. As we all know, species distributions respond to sea surface temperature, salinity, habitat structure and productivity. A change in species composition at a well-dated archaeological site can therefore mirror environmental transitions like the warming episodes, El Niño–Southern Oscillation variability, reef bleaching intervals and river flow shifts. Where modern fisheries

data extend back only decades, archaeological fish assemblages extend baseline knowledge, revealing whether today's depleted reef actually once supported abundant large carnivores or whether small inshore catches are historically typical. Such long baselines are invaluable for conservation planning, marine protected area design and managing “shifting baseline syndrome”, the gradual lowering of expectations across generations.

In many coastal societies, certain fish species carry ceremonial, clan or status significance. Their appearance in elite burials or feasting deposits can mark political display, alliance building or ritual obligations tied to seasonal migrations of fish shoals. Trade in processed fish, in the form

of dried, salted and smoked actually moved bones (or bone fragments) inland, illuminating exchange corridors between coast and interior. Variation in butchery marks and burn patterns can differentiate household cooking from bulk processing for storage or trade. When taxonomic resolution is high, these subtleties can be seen vividly.

At Harappan Dholavira, the ability to distinguish between local estuarine species and deep-water oceanic fish suggests that Bronze Age residents weren't simply subsistence fishers but participants in sophisticated trade networks. The presence of specific tuna species indicates fishing technology capable of handling Arabian Sea swells, evidence of maritime expertise that connected Indus cities to distant shores. Medieval sites yield even richer narratives. In Kochi, the appearance of Red Sea fish species in 14th-century deposits documents how Arab trading networks brought not just spices and textiles but also preserved fish products across the Indian Ocean. Seasonal

Looking forward, the most exciting work in fish zooarchaeology will likely emerge at the intersection of big comparative datasets, fine-grained chronological control and multi-proxy environmental records.

patterns in catch composition reveal how monsoon cycles shaped fishing calendars, while changes in species diversity through time track the ecological impacts of intensifying commercial exploitation.

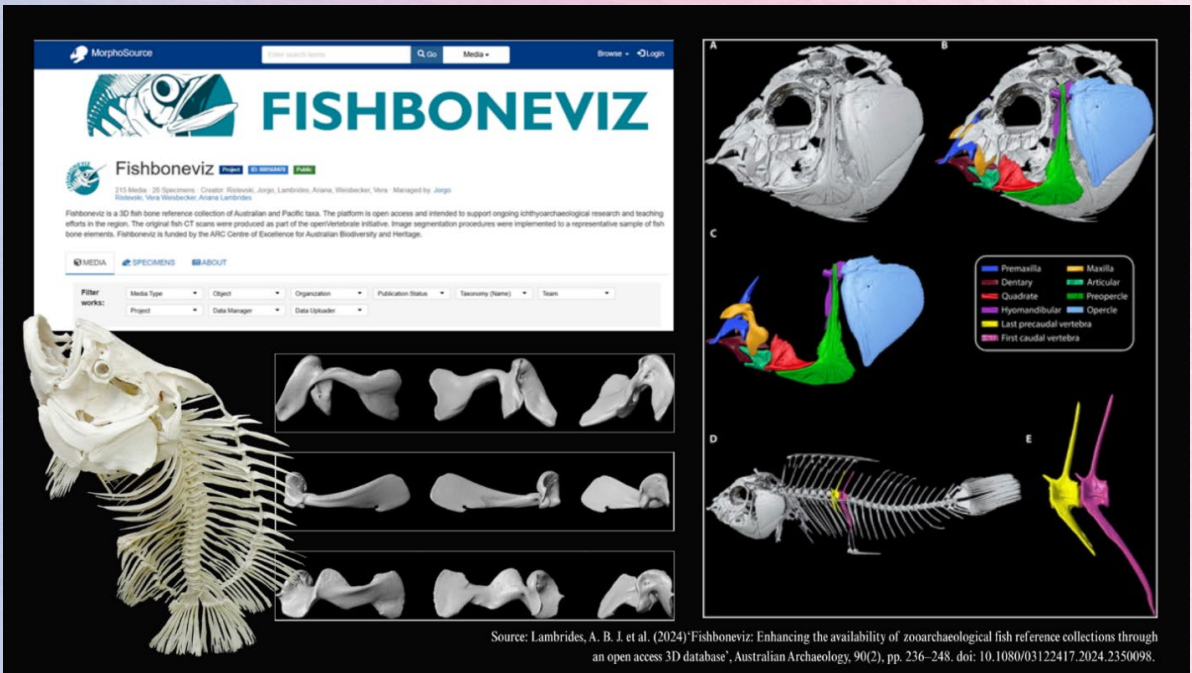
Looking forward, the most exciting work in fish zooarchaeology will likely emerge at the intersection of big comparative datasets, fine-grained chronological control and multi-proxy environmental records. The regional syntheses that combine high-confidence species identifications from digitized reference libraries with stable isotope data tracking marine

productivity swings, otolith sclerochronology revealing capture seasons and ancient DNA (aDNA) signatures can detect past population structure. Layering all these data against palaeoclimate reconstructions and ethnographic analogues and can recover not just what people ate, but how they engineered coastal ecologies, responded to shocks and embedded marine resources in cosmology and community identity over millennia.

In the end, what makes fish zooarchaeology so compelling is the massive scale: the scale of the oceans themselves; the scale of human dependence on aquatic

food; the microscopic scale of the bones that encode this history and now the digital scale at which those bones can be mobilized. When we digitize, annotate and share, we give small things a large reach. The bones tossed aside after an ordinary meal on a long-eroded shoreline can speak into global conversations about sustainability, resilience and heritage.

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Source: Lambrides, A. B. J. et al. (2024) 'Fishboneviz: Enhancing the availability of zooarchaeological fish reference collections through an open access 3D database', Australian Archaeology, 90(2), pp. 236–248. doi: 10.1080/03122417.2024.2350098.



Ms Debashree Dam

The Divine Fossil of Faith - The Shaligram Saga



Fossils have always fascinated me and from my childhood days I was very curious to know about these wonders of the past within which lies the hidden treasures of the bygone era. Dinosaurs have always fascinated us and the first name that comes to every mind when we talk of fossils are the dinosaurs. Fossils are described as the preserved remains of plants and animals usually that which is more than 10,000 years old. Fossil evidence provides a record of how creatures evolved and how the Earth have changed through geological time. Fossils are crucial for reconstructing paleo environments and by studying fossilized remains scientists can infer information about past climates, ecosystems, and geological processes.

My journey into the world of fossils began in 2022 when I was transferred to Zoological Survey of India (ZSI), Headquarters, Kolkata from ZSI, Digha, a small coastal town in West Bengal, India. Little did I know that there was a surprise waiting for me in Kolkata. My happiness crossed all boundaries when I came to know that I have been posted to the

fascinating section of Fossils, the Paleozoology Division. My Officer-in-Charge, Dr Supriya Nandy introduced me to all the staff and took me around the Palaeozoology Museum. The moment I entered the Paleozoology Museum I was transported back in time as if I were in a time machine. I was mesmerized seeing the dinosaur egg, the bones of Stegodon, the skull

With intense curiosity I posed my question, “What is this?” I was awestruck when I was told that this black stone is the sacred “Shaligram Shila”, which is revered and worshipped as Lord Vishnu.

of a *Rhinoceros unicornis* Linnaeus from Sundarbans and the prehistoric animal remains of the Indus Valley Civilization. As the tour continued my fascination knew no bounds and then what I saw in front of my eyes was a black stone which caught my attention. With intense curiosity I posed my question, “What is this?” I was awestruck when I was told that this black stone is the sacred “Shaligram Shila”, which is revered and worshipped as Lord Vishnu. I dug deep into finding out facts about the Shaligram from various sources available in the internet in the form of books, papers and research articles on Shaligram stones. From Asia to Europe and from indigenous tradition to ancient empires ammonites have been worshipped and honored for their unique shape, natural beauty and mysterious origin.

The Shaligram, a sacred black stone is found in the waters of the Kali Gandaki River in the Himalayas, Nepal and it holds a revered place in Hindu tradition. The name Shaligram comes from the sacred place called Shalagrama or Shalgram

Kshetra which is a region along the banks of the Kali Gandaki river in Nepal. This river is the only known natural source of the black ammonite fossils that are worshipped as Shaligram Shilas in Hindu

tradition. It is not merely a stone but it is worshipped as a divine embodiment of Lord Vishnu himself. Steeped in mythology and spiritual reverence, the Shaligram connects both science and

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Mythological Significance and facts

When we dive into the pages of **mythology** in the holy scriptures of the Skanda Purana and the Padma Purana, the story of Shaligram begins with a powerful demon king named **Jalandhar**, whose wife **Vrinda** was a fervent worshiper of Lord Vishnu. Her devotion and unshakable chastity granted her husband indomitability. The Gods wanted to fight against Jalandhar and Lord Vishnu assisted the Gods in order to defeat the demon king. Lord Vishnu took the form of Vrinda’s husband and broke her chastity. Upon learning the truth, Vrinda was heartbroken and cursed Vishnu to turn into a stone. As a result of her curse, Lord Vishnu accepted the form of a stone, the Shaligram Shila to reside eternally in the Gandaki River. Vrinda, in turn, immolated herself in grief and from her ashes the Tulsi plant (Holy Basil) was born. Lord Vishnu promised that she would be revered

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and the worship of Shaligram Shila will be incomplete without her presence. Thus, in Hindu rituals, Shaligram Shila is worshipped as Lord Vishnu and Tulsi leaves are offered as offerings. As part of the ritual the Shaligram Shila is bathed in holy water or Panchamrit which consists of milk, curd, ghee, honey and sugar. It is then adorned with sandal paste, flowers and Tulsi leaves. The devotees chant Vishnu Mantra or the Vishnu Sahasra Nama while offering the Tulsi leaves which forms the most important and significant part of the ritual. Worshiping a Shaligram is believed to ward off negative vibes and bring spiritual merit (punya),

protection, prosperity, and moksha (liberation).

Each Shaligram is believed to naturally represent different forms (avatars) of Vishnu, such as Narasimha (the lion-headed form), Varaha (the boar incarnation), Krishna or Rama (personal avatars) and Sudarshan Chakra (the divine discus of Vishnu). Its astonishing that the markings and shapes on the fossils like spirals, chakras, or ridges are not carved but naturally formed and considered manifestations of divine will.

Scientific facts:

Shaligram Shilas are fossilized remains of ancient marine creatures called ammonites. **Ammonites**

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were spiral shelled marine animals belonging to the phylum Mollusca and the class Cephalopoda. They had a coiled external shell similar to that of the modern Nautilus and closely related to Octopus and Squids. The interesting fact about ammonites is that they were born with tiny shells and as they grew they built new chambers onto it. They would move their entire body into a new chamber. They first appeared around 416 million years ago during the Devonian periods and

became extinct about 66 million years ago during the end of the Cretaceous period. From a paleontological perspective, **ammonites** are **vital index fossils** which are used to date geological layers. Their complex suture patterns, coiled shells, and rapid evolutionary changes help scientists map Earth's ancient marine environments. They are very vital in linking the rock layers, determining the age of rock, therefore a good indicator of biostratigraphy.

It leaves us in awe how the marine fossils found their place in river beds in the lofty Himalayas. Geological past tells us that during the Mesozoic era around 200 to 65 million years ago a vast sea called the Tethys sea existed between two huge landmasses of Laurasia and Gondwana. The Himalayan region was once part of the Tethys Sea. The marine Ammonites lived in the Tethys sea and thrived in these tropical marine waters. Significant changes occurred in the Earth's crust and slowly about 55 million years back the Indian plate which was part of Gondwana began to travel upwards and collided with the Eurasian plate. This collision caused the sea bed of the Tethys Sea to be pushed upwards and this gave birth to the highest mountain range in the world, the Himalayas. That is how the ammonite fossils are found in rock layers and river valleys across the Himalayas in Nepal and Northern India.

Global Significance

Throughout South Asia the reveration of the scared fossil ammonites called the Shaligram has been an

integral part of ritual practice. The ritual use of these fossils has become a a significant aspect of pilgrimage and worship in both India and Nepal. The Buddhists interpreted the clockwise spirals of ammonites as a focus for meditation and also as symbols of the eight spoked wheel of dharma. In ancient Greece ammonites were highly revered because their shapes resembled the

tightly coiled Ram's horn which is used to present the Egyptian God, Ammon and it was also found in Ancient Greek currency. In Europe they are commonly called as petrified coiled snakes or serpent stones or snake stones. In China these ammonites were called horn stones, used in traditional medicine in China and also in Chinese culture ammonite fossils are purchased and

kept in homes to ward off negative energies. The ammonites were also referred as Chrysanthemum stones in Japanese texts.

The Zoological Survey of India (ZSI) stands as a proud custodian of India's fossil heritage including the sacred and scientifically significant geological treasures, the ammonite fossil, the Shaligram. Few samples of the ammonite fossils are housed as part of the National Zoological Collection in the Paleozoology Museum, ZSI, Kolkata. With meticulous preservation, research and public outreach ZSI not only safeguards these ancient prehistoric remnants but also educates visitors on the evolution of life, the fossilization process, and India's rich paleontological legacy. ZSI honors both India's biodiversity and its deep cultural connections to the natural world. The ammonites born in the oceans, preserved for millions of years through geological formation and worshipped for millennia establish the fact that science and spirituality coexist. ***The Divine Fossil of Faith, the***

They first appeared around 416 million years ago during the Devonian periods and became extinct about 66 million years ago during the end of the Cretaceous period. From a paleontological perspective, ammonites are vital index fossils which are used to date geological layers. Their complex suture patterns, coiled shells, and rapid evolutionary changes help scientists map Earth's ancient marine environments. They are very vital in linking the rock layers, determining the age of rock, therefore a good indicator of biostratigraphy.

Shaligram remind us that science and spirituality are deeply intertwined in the Indian ethos. **The Shaligram Saga** tells us that when intellect reaches its ultimate boundary, faith takes over. It reminds us that all truth cannot be perceived and understood through analysis some must be accepted and absorbed in silence, in reverence and wonder.



Hoplites sp



Perisaphincles sp

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Dr. Dola Roy

Lost in Time: The story of Indian Dinosaurs



Picture this: A five-year-old girl stands transfixed before a huge Dinosaur skeleton in some museum.

Wide-eyed and breathless, the tiny girl stands before a towering skeleton in a museum. Her tiny hand gripping her mother's fingers as she whispers "**Brontosaurus**". Her eyes shine with wonder as she imagines these giants stomping through ancient forests, their thunderous footsteps shaking the earth.

This is the magic moment which I myself have witnessed countless times. For a few precious years, we all speak fluent dinosaur, rattling off names like *Triceratops* and *Tyrannosaurus rex* (*T. rex*) with the confidence of seasoned scientists. But then something heartbreaking happens,

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the plastic dinosaurs get packed away, the picture books gets replaced by math textbooks and those dreams of discovering new species fade into practical career aspirations.

What makes this transformation particularly tragic in India is that these children are growing up unaware of their own paleontological royalty. While American kids know

that *T. rex* once ruled their ancestral lands, most Indian children have never heard of *Rajasaurus narmadensis*, a horned carnivorous dinosaur that was not only native to India but potentially more formidable than its famous North American cousins.

The story of *Rajasaurus* begins in the dusty rocks of Gujarat's Narmada River valley, where paleontologists unearthed something

extraordinary in 2003. They had found the “prince lizard”, a massive predator with a distinctive horn that had terrorized the Indian subcontinent 70 million years ago. This wasn’t just another dinosaur; it was the proof that India’s prehistoric world was far more diverse and spectacular than anyone had imagined.

But here’s the cruel irony, while children around the world can name dozens of dinosaurs from other continents, India’s own magnificent beasts remain virtually unknown to the very people whose ancestors once shared this land with them. It is as if we have forgotten that once we had kings and queens in our own backyard.

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unique life forms, drifting northward across ancient oceans like some fantastical ark. This was the Indian subcontinent during the Mesozoic era, serving as what

scientists call a “biological ferry”, carrying Gondwanan creatures on an epic journey that would end in a collision so violent that it created the Himalayas.

Along the way, this traveling island preserved an extraordinary fossil record. There was *Barapasaurus tagorei*, discovered in 1975, the first complete dinosaur skeleton from India, a gentle giant whose name means Big-legged lizard. Picture a

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creature weighing 14,000 kilograms, assembled from over 300 bones found in Andhra Pradesh, forever changing our understanding of how these massive plant-eaters evolved.

Then there were the fierce creatures like *Indosuchus* and *Kotasaurus*, that once prowled the Indian landscape, their fossils now providing crucial insights into the final chapter of the dinosaur age (Figure 1). In the Siwalik Hills, paleontologists have uncovered one of the world’s most complete records of mammalian evolution over the past 20 million years, including early elephants, horses and primates that shaped our understanding of how we came to be.

So why don’t Indian children know these stories? The answer lies in a peculiar journey from wonder to indifference that plays out in classrooms across the country. During the primary school years, the fascination burns bright. Children are naturally drawn to dinosaurs because they represent the perfect combination of **familiar and fantastical**, they are animal-like enough to

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understand but impossibly large and mysterious enough to fire the imagination. They offer a safe way to explore concepts of death and deep time that are otherwise too abstract for young minds.

But as these young paleontologists enter middle school, something shifts. Academic pressure intensifies and career counseling begins with a narrow focus on engineering and medicine. Paleontology, if mentioned at all, is dismissed as

“not practical”. The rigid educational system leaves little to no room for subjects that fire the imagination but don’t guarantee job security.

Unlike countries where natural history museums serve as community centers for continued learning, India has a very limited museum infrastructure and that is why children lose contact with their paleontological interests just when they need nurturing most. By high school, most students have

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internalized the message that real science means physics, chemistry and biology, but biology is further reduced to memorizing plant and animal classifications without any evolutionary context.

The tragedy runs deeper than individual career choices. India lacks the infrastructure to nurture young paleontologists even when they exist.

Consider this: despite sitting atop some of the world's most spectacular paleontological treasures, India does not have a single world-class natural history museum comparable to institutions in London, New York or Beijing.

Most science teachers lack training in paleontology or

evolutionary biology. Without passionate educators who can connect fossils to broader concepts of deep time and Earth history, students never develop the intellectual framework necessary to appreciate paleontological research. They learn about rocks and minerals in geology class but never encounter the life forms that inhabited ancient Earth. Moreover, geology is never taught in secondary or higher secondary levels which create a huge gap in interest.

The research infrastructure also tells a similar story. India's paleontological research remains concentrated in a few institutions, which face

chronic funding shortages. The country spends less than 0.7% of GDP on research and development, compared to 2-4% in developed countries and paleontology receives minimal funding compared to other scientific disciplines.

Adding insult to injury, many of India's most significant fossils were shipped to European museums during the colonial period, where they remain today. This means that researchers studying Indian fossils often cannot access specimens collected from their own country, without traveling abroad or relying on international collaborations. This screams a legacy of "parachute science" that continues to impact Indian paleontology.

The bureaucratic challenges are equally frustrating. Complex procedures for fossil collection and research permissions often delay or prevent important discoveries. India's draft geoheritage law has sent "tremors through the research community", with researchers fearing that monopolistic control will increase red tape and infringe on scientific autonomy.

Yet despite these challenges, something remarkable is happening. Recent discoveries continue to reveal new aspects of India's paleontological heritage. The discovery of India's first troodontid dinosaur in 2013 made international headlines, revealing that even small, intelligent dinosaurs inhabited the Indian subcontinent. In 2024, researchers discovered the fossilized remains of *Vasuki indicus*, a colossal snake that slithered through the ancient swamps of Gujarat around 47 million years ago and may have stretched up to 15 meters long, rivaling even the famous *Titanoboa* as one of the largest snakes ever to exist. Ongoing excavations in Gujarat continue to yield spectacular fossils, including new species that are reshaping our understanding of Cretaceous ecosystems.

The Amkhoi Fossil Park in West Bengal demonstrates how research can combine with geotourism, creating economic incentives for fossil preservation and study. Several Indian institutions are developing specialized paleontological programs and international

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collaborations are bringing modern techniques to Indian fossils while training local researchers.

We must remember that the solution is not just about funding or infrastructure—it's about rekindling that sense of wonder that every child feels when they first encounter a dinosaur. Countries like Argentina, Mongolia and Morocco have shown how paleontological tourism can generate substantial revenue while protecting fossil heritage. India's diverse fossil treasures offer similar potential for development that could create employment in fossil preparation, museum curation and interpretive

services while supporting local communities.

The success stories of the United States and China illustrate how sustained investment in museum culture, educational integration and international collaboration can transform a nation's paleontological landscape. What we need is a coordinated action across immediate educational reforms, medium-term research expansion and a long-term vision for global leadership in paleontological science.

Our ancient giants, the *Rajasaurus*, *Barapasaurus* and countless other creatures, hold stories of survival,

adaptation and extinction that are profoundly relevant to current environmental challenges. They are not just fossils; they are time capsules containing lessons about how life responds to changing climates, shifting continents and mass extinctions.

The question isn't whether India possesses significant paleontological treasures, rather we should know that whether we are ready to explore that or not. The fossils are waiting in the rocks of Gujarat, Rajasthan and the Deccan Plateau, ready to inspire future generations and contribute to our understanding of life on Earth. The question is whether we will make the

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necessary investments to unlock these treasures for science, education and national pride.

Yes, indeed the Indian dinosaurs have disappeared twice: first in the great extinction that ended the Cretaceous period 66 million years ago and now again in the collective memory of a nation that has forgotten its own prehistoric royalty.

Yes, indeed the Indian dinosaurs have disappeared twice: first in the great extinction that ended the Cretaceous period 66 million years ago and now again in the collective memory of a nation that has forgotten its own prehistoric royalty.

Perhaps it is time to resurrect them, not from stone and sediment, but from the far more challenging tomb of collective amnesia. The question isn't whether we can bring back the dinosaurs, but whether we can bring back the wonder they once inspired. In a country where

children can name every Bollywood star but not a single Indian dinosaur, the fossil record isn't just about deep time, it's about lost time and the urgent need to reclaim it before another generation grows up believing that all the giants lived somewhere else.

Right now, as you read this article, a five-year-old somewhere is pressed against a museum display case, breath fogging the glass as they stare transfixed at the towering skeleton of a *T. rex*. Their small hands are splayed against the cool surface, eyes wide with wonder, already imagining themselves with a brush in hand, carefully uncovering ancient bones from desert stone. In that moment, a paleontologist is born, not in a classroom or laboratory, but in the electric space between curiosity and possibility. Whether that dream survives to fuel the next generation of paleontologists depends on the choices that we make today. The ancient giants have waited millions of years in the rocks. They can wait a little longer but not forever.

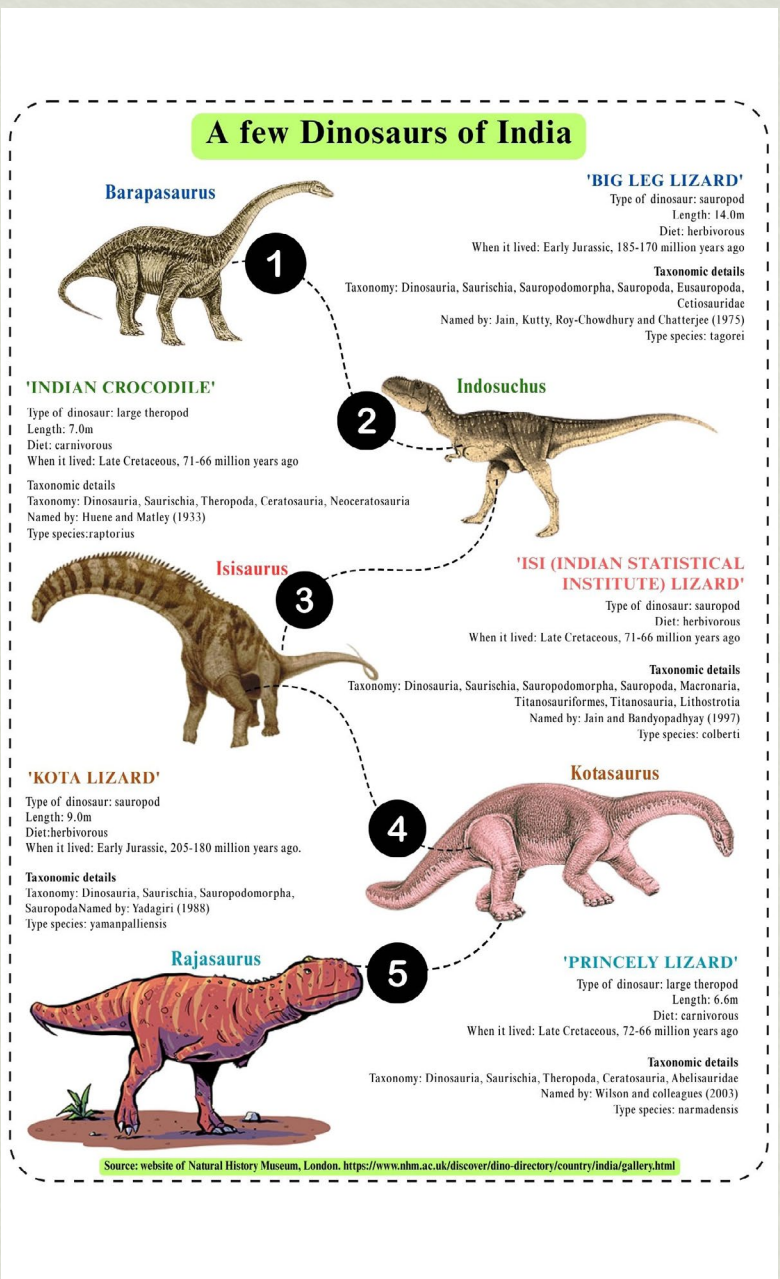


Figure 1: A few Dinosaurs found in India.



Ms. Ilona Jacinta
Kharkongor

Life in the Dark

Though many people believe it to be true, a cave is not an isolated hole in the ground inhabited only by bats or hibernating animals. Many animals do hibernate in caves, and caves are bats' favoured roosting place, but life in a cave is extensive, varied and interrelated with life outside. Caves provide a home for many unique and specialized biotas ranging from bacteria and fungi through insects up to larger mammals. This subterranean ecosystem is characterized by abiotic factors crucial to their biocoenosis, the most limiting ones being the perpetual darkness or absence of light, the low or sporadic supply of nutrients and the high levels of humidity. Hence, to survive in such a harsh environment, cave-dwelling forms have

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evolved, morphologically and physiologically, to adapt to these limiting abiotic factors. Cave-dwelling animals are collectively termed *cavernicoles*, and they fall under three broad categories: *trogloxenes*, *troglophiles* and *troglobites*. *Trogloxenes* or 'cave-accidentals' are basically

surface organisms that enter caves for no survival reason. These animals enter caves by 'accident'; being brought/ carried into the cave by flood waters, air current or other animals, including humans. They may use the caves for temporary shelter but do not survive there for long as they cannot establish a population

in such a nutrient-deficient environment. *Troglophiles* or 'cave lovers' are animals that live part or all of their lives in caves, but they exhibit diurnal, seasonal or occasional periodicity in their need to utilize the surface environment for at least one vital function like feeding or reproduction. The Camel-back Crickets and the bats are the most common examples of *troglophiles*. They spend most of their lives inside the caves but need to go outside to the surface for feeding and/or mating. However, *troglobites* or 'true cave-dwellers' are obligatory *cavernicoles*. They complete their entire life cycle inside the cave having established viable and thriving populations within it. They have evolved, both morphologically and physiologically, for life inside the caves. Morphological adaptations include, but are not restricted to, loss of pigmentation, loss of eyes or reduced eyes, enlarged appendages like long sensory antennae and legs that help them 'see' in the dark when in search of food, mates, etc. Physiological adaptations include low metabolic

The biological study of the mysterious and little-known life forms that live and thrive in the deep, dark realms of the caves falls within the ambit of a branch of biology called *Biospeleology*. Though biospeleology began as early as the 1600s in Europe, but it was not till the 1920s that the first ever biological exploration was undertaken in India, despite the existence of numerous caves in the country, particularly in Meghalaya and Chhattisgarh, This pioneering work was carried out by Stanley Kemp and B. R. Chopra of the Zoological Survey of India (ZSI), Calcutta (now Kolkata) in January – February, 1922, when they undertook the first extensive faunal exploration of the Siju Cave of the erstwhile Garo Hills of Assam (now South Garo Hills of Meghalaya). Their 1924 report on the *Fauna of Siju Cave* documented 102 species of various faunal groups found inside the Cave. While 16 of these recorded species are mere troglloxenes that somehow made their way into the Cave, 53 species are trogllophiles occurring in the transition zones of the Cave and the remaining 33 species are believed to be trogllobites restricted to the deeper zones of the 4772 m long Siju Cave.

rate, increased fat storage, efficient food utilization, increased sensitivity, altered longevity, reduced reproduction rate, etc. All these adaptational features help the animal to survive in the cave environment.

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the cave fauna of Meghalaya. While limited or sporadic biospeleological studies continued in other parts of the country, particularly in Chhattisgarh, there was a prolonged lull in Meghalaya. It was not until the 1990s when the Shillong-based Meghalaya Adventurers Association (MAA) started their annual 'Caving in the Abode of Clouds Expedition' that interests in the caves of the State revived. In the following decades, researchers have described about two species of cave fish, a cave spider, an albino cave crab and a cave frog, as new to science. With these additions, the cavernicolous

fauna of the limestone caves of Meghalaya stands at 107 species; with many more awaiting discovery and description. These cave animals are largely endemic to Meghalaya, with some of them being limited to or known to occur in just one or two caves in the regions.

Cavernicolous fauna do play a role in maintaining the ecological balance of the cave ecosystem, with each category of cavernicole doing its part. In the absence of light, primary producers like green plants are entirely absent in the cave ecosystem. So cave animals rely on an allochthonous source of food brought in by the abiotic components of the cave, like air and water. Many cave animals rely on detritus matters carried into the caves by the water and air currents for their nutritional needs, with the troglloxenes like bats further supplementing the nutrient supply by their guano. In fact, caves that harbor bat colonies support a rich diversity of cavernicoles. A plethora of life forms, mostly arthropods, live and thrive in parts of the cave

where there are ample bat guano deposits. The cave fish, the cave shrimps and the guano-loving arthropods cycle the available nutrients, thereby, maintaining the delicate balance of the cave ecosystem.

Cavernicolous fauna also have some economic importance for the local community. Most of the caves in Meghalaya are active river passages supporting sizeable populations of cave fish and cave shrimps,

with some also harbouring colonies of bats in them. Local communities augment their food requirements by fishing in the caves and by trapping bats for food. With many remote villages relying on the underground rivers flowing in the caves for their daily water supply, the aquatic cavernicoles play an additional role as biological indicators. Their continued presence in the aquatic environment of the caves indicates that the



water source is clean and devoid of toxic elements and, therefore, safe for domestic consumption.

It is a well known fact that human activities negatively impact wild life. This impact is felt, not just by the animals that live on the earth's surface, but even by the cave-dwelling life forms. Cave ecosystems are intrinsically linked to the surface environment through air and water. So, changes in the surface environment will, directly or indirectly, the environment of the cave. Activities like changing land use patterns, mining, industrialization, etc. have a great impact on the cavernicoles by the ability of these activities to alter the cave ecosystem. Mining activities, particularly limestone mining and rat-hole coal mining physically destroy caves, in addition to polluting the cave environment through acid mine drainage. Changing land use pattern mainly deforestation for agricultural expansion and urbanization, results in soil erosion, loss of food plants or native vegetation, indiscriminate

use of agro-chemicals like fertilizers, pesticides, etc., contribute to nutrification and pollution of the cave rivers directly or indirectly impacting the cavernicoles. Direct human interference through modification of cave entrances severely alter the stable cave environment by increasing the air flow and causing fluctuations in cave temperature and humidity which, in turn, pose survival risks to the fragile life forms. Small changes in the cave environment will affect the cave organisms and may lead to extinction of those species that cannot adapt to these

sudden changes. Moreover, cave animals, by virtue of their endemism and restricted distribution range are highly vulnerable to becoming extinct if measures are not put in place for protecting the cave habitats. Conservation and sustainability are the buzz words in both social and scientific circles nowadays, having realized the need to protect all life forms on earth for our very own survival. It is high time we learn in harmony with nature, co-exist with all creatures big and small and sustainably use the natural resources at our disposal.

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Dr. Ranjana Bhaskar

The saga of DNA Barcoding

DNA technology has become a powerful tool for species identification, primarily through the sequence analysis of mitochondrial DNA (mtDNA). Compared to nuclear DNA, the mitochondrial genome in vertebrates has been more extensively studied for applications in species identification, phylogenetics, and forensic investigations. A DNA barcode is defined as “a short DNA sequence from the mitochondrial genome that enables easy and reliable for species identification. It’s very similar to how a supermarket scanner uses to identified product a universal product code (UPC) to identify items. Each species has a unique DNA barcode, which can be compared to a reference library to confirm its identity. This

The idea of DNA barcoding was projected by DNA barcoding analysis involves PCR amplification, sequencing, and querying of information from extranuclear genomes, both mitochondrial and chloroplast.

technique is used in various fields, including taxonomy, conservation, and bioprospecting. A 650 bp fragment of the mitochondrial gene cytochrome c oxidase I gene (COI, *cox1*) has gained designation as the barcode region for animals. The idea of DNA barcoding was projected by DNA barcoding

analysis involves PCR amplification, sequencing, and querying of information from extranuclear genomes, both mitochondrial and chloroplast. DNA barcoding sequence has been generated Once from the unknown sample; an algorithm is used to compare unknown sequence with reference

database containing known barcodes from identified samples that makes easy to identify the unknown samples. When biological species is not identified based on morphological characters, DNA sequences are used. DNA barcoding supports to differentiate similar-looking species and identifying damaged or immature specimens. COI shows a greater interspecific variation than the intraspecific variation between many animal taxa. The collection of DNA barcodes can help in the identification of endangered, rare, elusive species by recovering sequences available in public databases such as GeneBank and BOLD Systems. These gene Mito DNA COI regions are chosen because they have conserved region with intraspecific (within species) variation than interspecific (between species) variation, which is known as the “Barcoding Gap”.

Ten reasons to employ DNA Barcoding

- » Works with fragments
- » Works for all stages of life, even at the embryonic age.

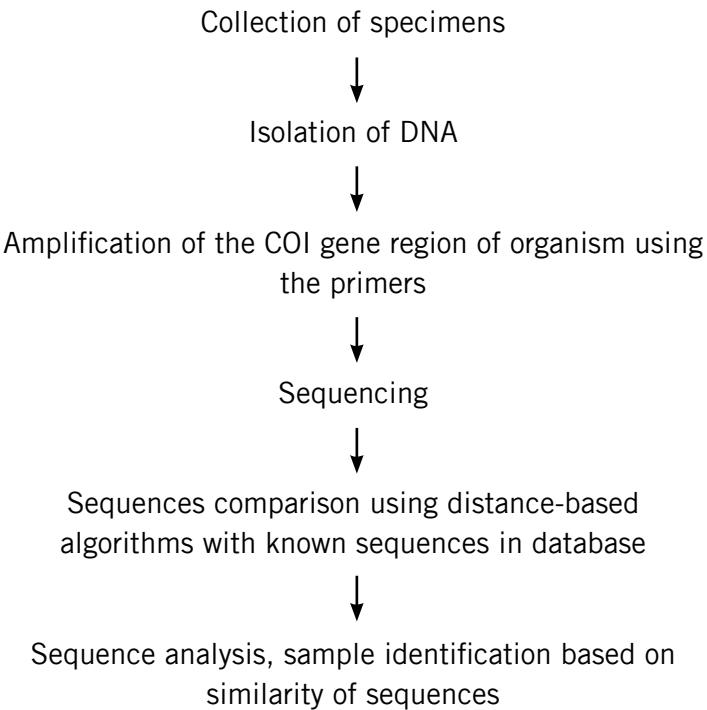
- » Present in all species
- » Reduces ambiguity
- » Makes expertise go further
- » Variable but not too variable but varies between different species
- » We can find an electronic handheld field guide in future, the Life Barcoder
- » New tool in the tree of life
- » Confirms value of collections
- » Standardized among scientists around the world

Procedures/Protocols

The process of DNA barcoding involves two fundamental steps: (1) construction a reference DNA barcode library of known species and (2) matching your generated DNA barcode of an unknown specimen against this library for identification. The first step requires taxonomic scientist to identify the species to make known reference samples to make DNA barcode library. All taxonomists should generate DNA barcodes and deposit verified DNA samples along

with their associated voucher specimens in certified DNA barcode centre. These vouchers then serve as permanent record as DNA barcode for a particular species. Reference DNA barcode library, once complete for the species, then the DNA barcodes generated for the unknown samples are compared to the known barcodes using some type of matching algorithm. There is online search tool, BLAST is a identical tool, provided through GenBank to match between a sequence library and a query sequence. DNA barcodes is not only used for species identification but also for phylogenetic and forensic investigation. This aspect of DNA barcoding has only recently considered among scientists that COI gene is used for animal barcoding.

Outline procedure of the DNA barcode:



1. Specimen Collection/Preservation/Handling

- » Specimens should be preserved in freezing or immersion in ethanol.



- » Don't expose to preservation agents, such as formalin or ethyl acetate, as they can damage DNA
- » Specimens in dried form remains in good condition for DNA isolation for at least a year.
- » Specimens in frozen stage DNA remains stable indefinitely (in cryogenic conditions).
- » Specimens preserved in ethanol for long time often degrades DNA due to acidification. As a result, DNA isolate from specimens as quickly as possible.



2. DNA Extraction/ Purification

Genomic DNA is extracted from specimens. Many DNA isolation commercial kits are available to isolate DNA from a different kind of biological materials. Quality and quantity of DNA isolation may be differed for various DNA kits. The basic steps in DNA isolation from any sample type should meet include: (1) Isolation of DNA from the sample. (2) successful removal

of contaminants, (3) isolation of high purity and quality DNA. (4) high amount of DNA for use in downstream processes.

3. PCR Amplification

Obtained DNA is amplified for the barcode region through the PCR procedure. Typically, 400–800 base pairs, a small fragment of the MtDNA gene is sequenced to obtain the DNA barcode. Amplification of eDNA

material is usually focused on smaller fragment sizes (<200 base pairs), as eDNA is more likely to be fragmented than DNA material from other sources. Many universal primers are available for mammals, insect, fishes, bacteria, plant to amplify DNA barcode.

4. Sequencing

Once the DNA barcode region has been successfully amplified, the next step is to sequence this region using appropriate DNA sequencing methods. A variety of sequencing platforms are available, and technological advancements are progressing rapidly. While Sanger sequencing remains a reliable method, next-generation sequencing (NGS) technologies are increasingly dominating the sequencing landscape due to their higher throughput and scalability. Many platforms such as 454 pyrosequencing is amplifying to recover full-length DNA barcodes of

many specimens. Next-generation sequencing is highly valuable due to its simple protocols, much lower cost per barcode read, faster processing speed, and ability to provide more detailed information.

5. Sequencing analysis

The taxonomic assignment of obtained sequences is achieved by matching of sequences to reference libraries. The BLAST (Basic Local Alignment Search Tool) is widely used to find similar regions by comparing DNA sequences to those in reference databases. If the database contains sequences from the relevant species, the sample can often be identified to the species level. However, if no exact match is found, the sequence may contribute to the creation of a new reference entry. In cases where reference databases are incomplete, identification may only be possible at higher taxonomic levels, such as family or class.

DNA Barcode Databases

Two central DNA barcode databases are widely used. The first is BOLD (Barcode of Life Data Systems), which allows researchers to upload, analyze, and manage barcode data. BOLD is linked to voucher specimen databases through the BARCODE data standard. The second includes GenBank, EMBL, and DDBJ—public repositories maintained by the International Nucleotide Sequence Database Collaboration (INSDC) that store DNA barcode sequences and other genetic data.

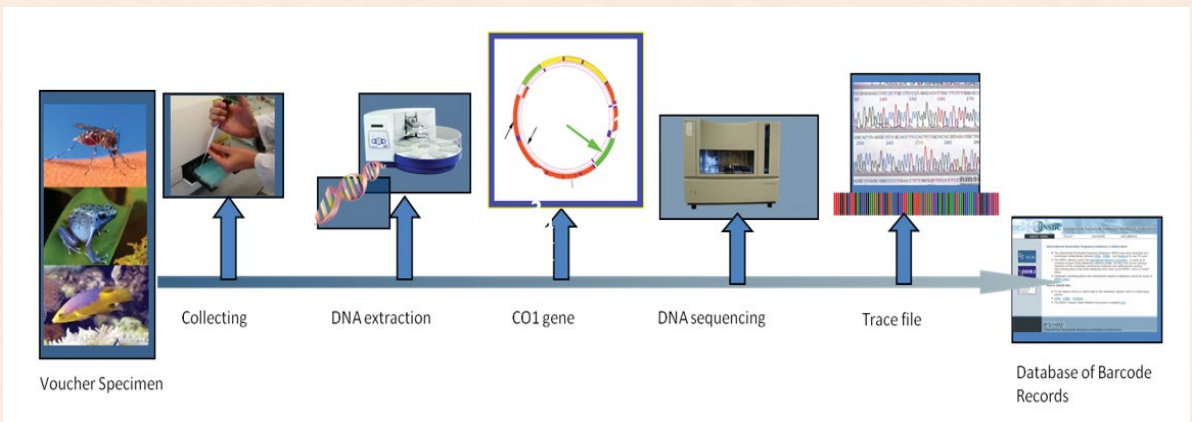
BOLD

The Barcode of Life Data Systems (BOLD) is an online workbench and database that supports the acquisition, analysis, storage and publication of DNA barcode records. By integrating molecular, morphological, and distributional data, BOLD helps bridge a longstanding gap in bioinformatics. Currently, it contains over 4.2 million validated barcode records.

NCBI

The National Center for Biotechnology Information

(NCBI), a division of the U.S. National Library of Medicine at the National Institutes of Health, hosts a wide range of databases relevant to biotechnology and biomedicine, serving as a key resource for bioinformatics tools and services. One of its primary databases, GenBank, stores DNA sequence data. NCBI collaborates with the European Molecular Biology Laboratory (EMBL) and the DNA Data Bank of Japan (DDBJ) as part of the International Nucleotide Sequence Database Collaboration (INSDC), which functions as a permanent public repository for DNA barcode records. To identify unknown samples, nearest-neighbor algorithms are used to compare sample sequences to those in the reference database. The commonly used tool for this process at NCBI is the Basic Local Alignment Search Tool (BLAST), which applies this algorithm to find the closest match between a query sequence and sequences in the database.



Basic steps involved in all DNA Barcoding (Fig. from internet).

Strengths of DNA barcode

- » It is a quick and reliable taxonomic identification tool for situations in which samples are not morphologically identified.
- » This small fragment of gene provides greater efficiency of efforts.
- » Low-cost procedure due to technical advance
- » Potential capacity for high throughput and

- processing large numbers of samples.
- » One reference data is available, can be used by non-specialist.

Applications of DNA barcode

The main use of DNA barcodes is to identify species. It is a valuable tool for taxonomists because barcoding can analyze DNA sequences at all life stages—such as seeds, seedlings, eggs, larvae, mature individuals (fertile or sterile), unisexual species, damaged specimens, gut contents, and fecal samples. Systematists can also use barcode data to measure how consistent their species definitions are by comparing genetic variability. For applied taxonomy, barcoding helps identify regulated

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species, including invasive and endangered ones, and verify the identity and purity of biological products like seafood, herbal medicines, and dietary supplements. Barcoding is also important for discovering biodiversity, as it can highlight species that may be new to science, especially those that are undescribed or cryptic. There are several applications of DNA barcoding.

Identification of species

Short, specific DNA sequences from a standard part of the genome can serve as a DNA barcode to identify species. Molecular methods like this are especially helpful when traditional identification techniques don't work. DNA barcoding is very useful for identifying larvae or small biological samples that usually lack clear physical features, and it also helps link different life stages (such as larval and adult) in many animals.

Detection of invasive species

Alien species can be detected via barcoding. DNA barcoding

is useful for detecting species in places like border control, where quick and accurate identification by appearance can be hard because species look very similar, important features are missing, or experts are not available. Barcoding and metabarcoding can also help check ecosystems for invasive species and tell the difference between invasive and native species that look alike.

Delimiting cryptic species

DNA barcoding allows us to identify hidden or hard-to-see species. It also helps clarify the boundaries between species, especially in groups that are not well studied, have many species, or look very similar. As a result, many hidden species have been discovered using DNA barcoding, which has increased the number of recognized species in many groups.

DNA Barcoding on Forensic Sciences and Conservation of Endangered Species

The accurate identification of plants and animal is equally

important in commercial world as it is to ecologist and taxonomist the accurate identification of plants and animals is equally important. Application of DNA barcoding in the investigations of animal cruelty and poaching and illegal collection and trade of flora and fauna has been increased recently. DNA barcodes forensics broadly said as genetic marker are being used to assure commercial products identification and purity to protect endangered species in illegal trading.

Agriculture Protection

DNA barcoding is a valuable tool for identifying pest species at any life stage, enabling farmers to protect agricultural crops from potential damage. One notable example is the global barcoding initiative, which supports the identification, management, and control of fruit flies. This method offers a rapid, accurate, and cost-effective means of identifying specimens and determining whether they are native, invasive, or require quarantine measures.

Diet analysis and food web application

DNA barcoding is useful in diet analysis, especially when prey cannot be identified by their physical features. It can identify species from small or broken parts. This helps scientists understand food chains by identifying what animals have eaten from stomach contents, and it can also help plant research by identifying roots found in soil layers. There are different ways to collect samples for diet analysis. DNA metabarcoding can be done on stomach contents, feces, saliva, or even whole bodies. In feces or heavily digested stomach contents, it's often hard to tell which tissue belongs to which species, so metabarcoding is used instead. Feces and saliva are non-invasive ways to collect samples, but whole-body analysis usually requires killing the animal. For very small animals, the whole body is often sequenced to study their diet.

Barcoding for food safety

DNA barcoding is a useful tool for checking the quality of food products in today's commercial market. It helps

ensure food traceability, reduce food fraud, and support local and traditional food production. It also plays a role in protecting public health. For example, metabarcoding can identify certain fish, like groupers that cause Ciguatera fish poisoning, even from small leftovers in a meal.

Biomonitoring and ecological assessment

DNA barcoding can help detect endangered species for conservation or identify indicator species that reflect certain environmental conditions. For example, researchers can use DNA barcodes from the cytochrome c oxidase (COI) gene to identify key bioindicator insect species in river monitoring samples. This works best when the barcodes are matched with a locally developed reference library.

DNA barcoding is a useful genetic-based marker in terms of identifying unknown specimens or species. DNA barcoding has wide range of applications in taxonomy, evolutionary study, phylogeographic analysis, processed food identification

and species complex identification. Although several gene markers have been suggested, more intensive work is needed to verify whether DNA barcodes can successfully provide accurate identification across all taxa and species with hybridization. It is predicated that if DNA barcodes will discover a recognition of new species. However, DNA barcodes should not be used as the whole sole criterion for description of new species, it requires analysis of diverse data, including morphology, behaviour and ecology, as well as genetics. DNA metabarcoding is used with new sequencing technologies (NGS) to study the genes in complex environmental samples. It helps us understand evolution and biodiversity better. In basic research, DNA barcodes are widely used in fields like taxonomy, ecology, evolution, and biogeography. They are also useful in many other areas such as controlling pests, protecting endangered species, preserving natural resources, monitoring water quality and identifying medicinal plants. I have barcoded

314 species, including 5 new species, and submitted 103 species to NCBI for the first time. I also use the COI gene as a valuable tool for identifying Indian rhesus macaques (*Macaca mulatta*) and understanding their genetic relationships with other macaque species. I analyzed 47 sequences of Indian rhesus macaques alongside 120 sequences of the genus *Macaca* to see the genetic relationship. Indian macaques form a polyphyletic assemblage, comprising two potential lineages: one from Northern India and the other from Eastern India.

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Robotics and AI: A New Era in Wildlife Protection



The primary objective of wildlife conservation is to preserve animals, the environment, and both human and wildlife ecosystems, a goal that has been established by many governmental and private sectors.

Wildlife conservation plays an important role in maintaining biodiversity, protecting ecosystems, and preserving natural habitats. The primary objective of wildlife conservation is to preserve animals, the environment, and both human and wildlife ecosystems, a goal that has been established by many governmental and private sectors.

Biodiversity contributes to the ecosystems, where many species provide services like pollination, pest control, and seed dispersal that are vital for human survival and economic activity. Studies show that a larger number of animals and birds have become extinct in the past two decades due to both natural and human activities.

1. Threats and challenges in wildlife conservation

Climate change can impact wildlife conservation by affecting animals' habitats, ecosystems, changes in animal behaviour, and species distribution that lead to nutritional deficiency, competition among species for food and shelter in extreme winters. One of the threats to wildlife conservation is the occurrence of invasive species that cause changes in ecological balance by competing with native species. Both flora and fauna will be affected by invasive species as they alter their ecosystem, health, and economic well-being. Additionally, the illegal trading and poaching of endemic species and animals are sold as exotic pets or used for traditional medications.

Various challenges in conserving wildlife include biodiversity and ecosystems, mainly due to human activities, changes in the environment, political gaps, and socioeconomic factors. These factors influence the habitat loss, climate change and fragmented landscape, which leads to loss of genetic diversity, population separation or isolated populations.

2. Human-wildlife conflict

Now a day, biodiversity has been facing various threats, resulting in significant losses due to human development. The rapid expansion of urban areas led to the degradation of ecosystems and Animal-Human Conflicts (AHC). These conflicts cause risks to both wildlife—particularly large animals and primates—and human livelihoods such as agriculture and crops. According to the World Wildlife Fund reports, over 60% of worldwide populations are adversely affected by human activity. To resolve to these issues, scientists have innovated advance technologies such as artificial intelligence,

robotics, sensors, and data analytics to support nature. These progressive tools can help policymakers and conservationists in protection wildlife and their habitats. The various applications of such advance technologies is a promising future for wildlife conservation. Monitoring and detecting wildlife in remote area or isolated regions are remains challenging manually. However, exact identification of endangered species is gradually possible through advance technological tools, aligning

with modern conservation goals.

3. Advanced Technologies in Conservation

Using technology in wildlife conservation will help in tracking endangered species in their natural habitate, collection of important data, follow their migration methods, and find possible threats. This information supports better conservation planning. The technological advancements incorporated into wildlife

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conservation have broadened the understanding, which is centred on protecting nature and offers a concept to management decisions for the preservation of all species. Digital methods have made it easier to deal with complications like loss of habitats, pollution, and climate change. They also help researcher to gather and study data about wildlife conservation. By combining information both information where people live with where animals live, researchers can learn more about poaching methods or patterns. This makes it easier to monitor and manage animal populations and how they change over time. Technology like social media and internet services play an important role in raising awareness about environmental problems and supports communication network between people and protected areas to prevent harmful happenings. Using these digital tools, Scientist can improve the well-being of both wildlife and people. Artificial intelligence (AI) can also make a big difference in wildlife monitoring by helping process data faster, collect information automatically,

AI (Artificial intelligence) is an advance technology that can think and work like humans. It can think, understand patterns, solve problems and make decisions correctly. AI has developed one of the most widely used in recent time, and exciting technologies because it can handle complex issues.

and predict future risks. It can also be used to listen for sounds made by endangered animals.

AI in wildlife conservation

AI (Artificial intelligence) is an advance technology that can think and work like humans. It can think, understand patterns, solve problems and make decisions correctly. AI has developed one of the most widely used in recent time, and exciting technologies because it can handle complex issues. It comprises many tools, such as robots, computer, machine learning

and language understanding. These advanced systems are developing rapidly and are now affecting many parts of our daily lives. AI tools can also be useful for tracing and studying wildlife and their environments, especially as climate and environmental conditions change. Some common AI methods include machine learning (ML), neural networks (NN), support vector machines (SVM), deep learning (DL) and reinforcement learning (RL). These are all attached with computer to teach AI how to learn. Physical examples

Machine intelligence differs from human and other organisms in that it is artificially generated and operates in terms of nature. The introduction of AI in wildlife conservation provides a solution to many of the challenges posed by traditional methods of monitoring. The monitoring of biodiversity is approached by conservationists using machine learning algorithms that are capable of analysing camera trap images at speeds significantly faster than humans, allowing them to spot individual animals, identify species, and count populations. AI has also demonstrated important value in forestalling future conservation challenges, with models.

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Robotics in wildlife conservation

Robotics is a field of technology that designs and builds machines that can perform several tasks and functions. Robots will resemble the potential of humans to show the same actions. The domains of industrial environmental science, agriculture, and service robots are also subject to this observation. Among the various types of service robots are humanoid, medical, undersea, field, rehabilitation, and construction robots. Larger data conversion from various characteristics to a central location for processing became standard with the advanced technology. Traditional monitoring

has a lot of limitations, including being restricted to isolated areas, being time-consuming, requiring intensive data gathering, and having limited spatial coverage. Environmental measurements are taken using a range of sensors, which lowers costs and prevents human error, and helps collect data with higher resolution. Robots are being used in conservation efforts as AI-driven technology to assist a variety of field operations, including wildlife detection,

habitat monitoring, and data collection. These robotic systems are usually mobile, two-wheeled machines with movable mechanisms that may be operated remotely via wireless interfaces to carry out a variety of tasks in tough terrain. To monitor habitat conditions, evaluate vegetation cover, and identify the impacts of natural stress such as drought, temperature extremes, salinity, pollution, and flooding, robots can be set with high-resolution cameras and environmental

sensors. Furthermore, Robots are also helping in detect diseases that affect plants and animals by studying ecosystems closely. In remote or hard-to-reach in forest areas, they can collect water and soil samples. It will help scientists to check important physical and chemical features of the environment to make sure it is healthy enough to support key or endangered species.



Google photo

4. Tools in Artificial Intelligence

» Machine learning (ML)

Machine learning (ML) is a subfield of artificial intelligence (AI), allows computers to learn from data and enhance their performance without categorical task programming. ML includes unsupervised learning, supervised learning and reinforcement learning and all other kinds of algorithms. Various studies highlight the importance of machine learning in conserving biodiversity. Shivaprakash highlighted the machine learning (ML) as an important tool for protecting endangered species and their ecosystems. Furthermore, Sipper and Moore revealed that ML systems are capable of analysing millions of data points in real time, allowing for the unprecedentedly efficient prediction of species movements, population dynamics, and possible conservation risks. The analysis of data from sources like satellite imaging, camera traps, and audio sensors is one important use of machine learning in this discipline.

» Deep learning (DL)

Deep learning (DL), an also subdivision of artificial intelligence (AI) and machine learning (ML), has an important tool in computer science and intelligent systems lately. While ML emphasizes on learning from data to create estimated models, and AI mostly refers to the imitation of human intelligence in machines, DL is an area where scientist can process huge datasets using multi-layered artificial neural networks and, more recently evolved to deep neural networks (DNNs), which consist of multiple hidden layers capable of extracting complex patterns from high-dimensional data. In the field of wildlife conservation. DL has shown great potential in automating habitat assessment, species detection, and population control. Processing ultra-high-resolution imagery for ecological purposes, such as tracking vegetation cover, invasive species expansion, and wildlife presence or movement, is increasingly being done using DL techniques.

» Sensors in wildlife conservation

Sensor data suggests a range of viewpoints for observing wildlife, keeping an eye on numbers, and understanding behaviour. Sensors produce a different of data kinds, such as soundscapes, images, and psychological data. They can be stationary or mobile, and used to record changes in habitats or landscapes over time (satellites, drones), monitor activities in a specific area (camera traps, acoustic sensors), or gather data on people or species of interest (bio-loggers, drones). Stationary sensors are long-term, close-range, constant monitoring that can be either signal-based (audio) or image-based, like camera traps, recorders. Predator-prey interaction, species identification, and behaviour analysis are collected in high progressive resolution. The number of species recorded depends on the location and time of the sensor.

» Camera traps

Camera traps are important tools in modern wildlife conservation because they offer a non-invasive, effective, and scalable way to monitor biodiversity and habitats. These devices use motion sensors and automatic cameras to take photos and videos of animals, including those that are active at night or hard to spot. Since camera traps don't require

much presence of human, they reduce disturbance to wildlife and improve the quality of data. They are especially useful when it placed near the animal's availability of such as pathways, breeding sites, or migration routes. The images collected from camera traps will help in identification of individual animals, estimate population sizes, and study animal health and behavior.

» Bioacoustics sensors

There is another tool besides image-based systems is using sensors based bioacoustic, which depend on microphones and hydrophones to study vocal animals and their surroundings. Passive acoustic monitoring (PAM), which uses networks of these sensors, is becoming more useful for conservation in land, water, and ocean environments. PAM is detecting sounds from all directions, works well in different weather and lighting conditions although things like wind can affect it, and is often low-priced for collecting detailed data across large areas and long periods.



Google photo



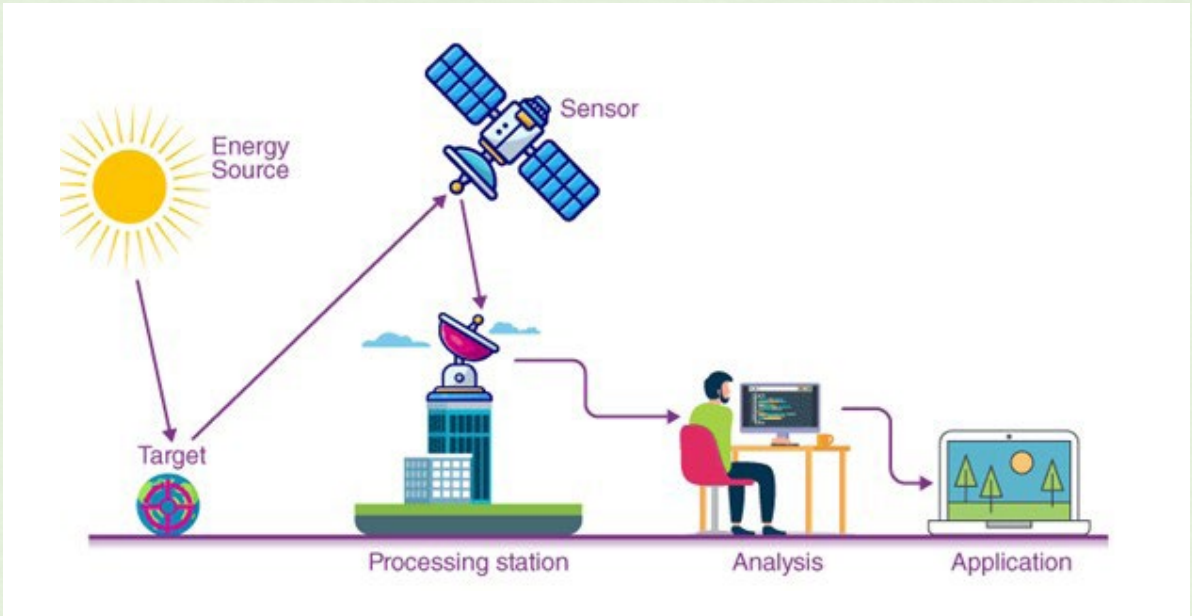
Google photo

» **Remote sensing**

Remote sensing is used in wildlife conservation to track animals, map wild areas, and collect detailed location data. Tools like drones, satellites, and other aerial platforms allow scientists to study species and ecosystems without being in the field. This helps provide a broad view of the landscape and

biodiversity. Satellite data is especially useful for covering large areas while reducing disturbance to animals. Although free public satellite images often aren't detailed enough to see individual animals, medium-resolution images (10–30 meters per pixel) can still support habitat and ecosystem studies. Remote sensing data includes image bands

beyond what the human eye can see, offering high image quality and wide coverage—but it needs more research to be fully used. While these advanced bands (multi- and hyperspectral) are already useful in plant studies, they haven't yet been widely applied in animal research, where they could improve how habitats are identified.



Google photo-mechanism of Remote sensing

5. Tools in Robotics

» **Aerial Robotics (Drones)**

Drones, also known as unmanned aerial systems (UAS) or an aerial robot are a powerful tools for collecting high-resolution data over

large and hard-to-reach areas. These flexible devices are increasingly used in tracking wildlife, monitoring air quality, checking forest

health and studying coastal regions. Drones have become very useful for researchers and conservationists because they can safely and quickly

collect all information. Drones are often more effective due to reach in difficult locations in the forest and hilly areas and provide clear aerial images.

With special cameras and sensors, it can take photos and videos from high up, helping scientists monitor animal populations, tracking migration patterns. Drones

is coming now in different types based on their size, battery life, range, and what they can carr).



Google photo- Aerial Robotics (Drones)

» **Terrestrial robots**

land-based robots or Terrestrial robots is becoming valuable tools in wildlife conservation. They are a better another traditional observation methods by using advanced navigation systems to move in different habitats and collect high-resolution data. These robots are helping

in monitor animal behaviour, population changes, and habitat conditions without disturbing the wildlife. This allows for more accurate and continuous data collection. Terrestrial robots also helping in addressing problems like habitat loss, species extinction, and the effects of climate change on biodiversity.

» **Autonomous ground vehicles (AGVs)**

Autonomous ground vehicles (AGVs) are wheeled robots that can move all around the natural environments without human control. Using technologies like GPS, computer vision and LiDAR, they can travel in forests, grasslands, and

wetlands, avoiding obstacles and finding the best paths. These are very useful for tracking animals, studying habitats and checking nests. Subsequently they can work for long aeras with little human presence, they help reduce disturbance to wildlife. The also have some time, like sound recorders, thermal cameras, and environmental sensors, to support wildlife research and conservation efforts.

» **Walking robots**

Another robot called walking robots is useful in observation of animals' movement, and is designed to walk over rough and uneven ground while staying balanced. Their ability to reach those areas which are hard-to-reach places like dense forests and rocky areas. These robots use advanced designs and control systems to copy the way insects, mammals, and other animals walk, helping them stay stable in tricky environments. Sensors in these robots are so strong that they can detect obstacles, avoid things like rocks, roots, and fallen trees. This lets them keep working in remote areas that are hard

for people to reach. Walking robots help researchers study wildlife by collecting data,

and are consistent, ideal for long-term monitoring in tough conditions.



Google photo- walking robots

Underwater Vehicle-Manipulator System (UVMS)

An Underwater Vehicle-Manipulator System (UVMS) is a robot that combines an underwater vehicle—either controlled by remote or autonomous—with robotic arms. This moves underwater and performs complex activities. People are using this in many areas, such as marine research, underwater repairs, deep-sea exploration, archaeology, and defense. These systems have sensors like cameras, sonar, IMUs, and force sensors to help in taking samples, inspecting equipment, picking up objects and making repairs. Although many challenges like poor visibility and limited communication exist, UVMS greatly improves our ability to work underwater. Advanced controls, including force sensing, visual guidance, and AI-powered systems, help ensure safe and precise interactions with the underwater environment.

6. Application of AI and Robotics in Wildlife Conservation

Monitoring Animal Populations: Monitoring of wild animals is important for protecting wildlife, but traditional methods can be slow and not always correct. AI and Robotics is helping in Monitoring wildlife. For example, AI is helping images to identify different species and spot invasive ones. It also uses machine learning to improve monitoring. In places where taking photos is hard, AI and robot can take image and listen to animal sounds to identify them, which works well in areas with a lot of activity.

Species Distribution: AI can help in predict climate change occurrence in wildlife and its effects on species distribution by evaluating various factors such as habitat necessities, climate conditions, and geographic problems. This insight enables the implementation of active conservation approaches that are modified to address the specific needs of species in danger.

Species Distribution: AI can help predict in climate change affects where different species live. It does this by looking at things like habitat needs, weather conditions, and location challenges. This information will help in better conservation plans that focus on the specific needs of species at risk.

Poaching Prediction: AI can analyze poaching data to find out when and where poaching is most likely to happen. By incorporating elements like weather, human population density, and past poaching cases. This can help in conservationists take action and improve efforts to stop poaching.

Wildlife Corridor Mapping: AI and robot can help in finding the wildlife path, called wildlife corridors, that connect separated habitats. These corridors help animals movement and share gene flow, which is especially important during climate change.

The future of animal conservation, AI, robotics, and associated sensors are

creating a powerful new toolkit for protecting wildlife and ecosystems. AI can monitor number of camera trap and acoustic sensor data to identify species, detect poaching and study behavior or deforestation in real time. Automated drones and robots—airborne, underwater or— ground-based, can safely reach and gather data in places people can't, even in extreme environments.

Technologies like robotic pollinators (e.g. RoboBees), seed-planting rovers, and biohybrid robots help restore habitats and support species that are declining. The combination of AI, robotics, and the Internet of Things signals the beginning of a new development in digital conservation ecosystems. This technological integration promises significant advancements in

active conservation strategies and real-time monitoring of ecosystems. Technology aimed at building capacity are vital to empower local conservationists and communities with the necessary skills to effectively utilise these technologies. AI and robotics extend beyond mere advanced tools; they serve as transformative agents for innovation in wildlife conservation.

Notes

Notes

Dedicated to the first women Director of ZSI, Dr. Dhriti Banerjee

JOURNEY FROM 'I' to 'WE'

Celebrating this journey from I to WE
We salute to you, our role model
Confidence sparkling in your eyes
One in a million aiming to reach the skies.

Beauty blended with intelligence
Making you the invincible.
True to your name 'Dhriti'
You are courage and strength.

You dare to embrace your foes
Shunning their negative lanes
You show them the path to positivity
Bringing out the best of their creativity.

You follow the path of righteousness
Empathy and compassion your very nature.
Turning every problem into a challenge
You gulp the tears silently putting forward your brightest smile.

You play diverse roles with utter perfection
From a daughter to a friend, a mother showering so much affection,
Professionally you are at the helm of affairs
Solving all problems with smile, skill and dares.

With you as source of energy
Your team always works in synergy
Conferred with awards and accolades
You are a dynamic scientist, the Lady of the flies.

This is the story of 'I' to 'We'
It all began when she was a young girl
Her Papa used to say, 'Dream the impossible and work hard'
Success will touch you in decades to come.

The day has finally dawned
Success, name and fame is all yours today
We salute to your unconquerable power
Your remarkable journey from I to we
From Glorious 100 women scientists of ZSI
To the top 100 Powerful Women in India.

Our prayers to the Almighty
May your success graph soar high and mighty
From the power of 100 in India to the world
This journey of 'I' to 'we' will broaden its boundary

You will remain the UNSTOPPABLE
For generations to come
The first women Director of ZSI
The one and only Dhriti Banerjee.

MS. Debashree Dam