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EDITORIAL:

TWENTY-FIRST CENTURY ZOOLOGY: TRENDS IN ADVANCE RESEARCH AND EDUCATION

The beginning of the science of zoology started with the ancient human civilization when the identification of the beneficial and harmful animals been assessed by the opportunistic animal hunter stone age 'Handy man', *Homo habilis* (approx. 2.4 million years ago) and the hunter hominids, *Homo erectus* (approx. 1.9 million years ago) for their own interest.

The father of Zoological science, philosopher Aristotle (384–322 BCE) first to systematically study and classify animals. His lecture collections such as *"History of Animals* (around 350 BCE)", *"Parts of Animals* (around 350–340 BCE)", and *"Generation of Animals* (around 340–330 BCE)" laid the foundation for the Animal Taxonomy and classification as well as the comparative anatomy and embryological studies in Zoology. He described over 500 animal species, based on their mode of reproduction, habitat, and morphology.

As biodiversity faces unprecedented threats from habitat loss, pollution threats, climate change, and anthropological interference, the integration of modern tools has become essential for both understanding and protecting earth ecosystem. At present, the zoological science has undergone a profound revolution, equipped with the advanced ecological monitoring, behavioral analysis, bioinformatics, and conservation technologies.

Technological Lens on Nature by Ecological and Environmental Monitoring: Remote sensing and Geographic Information Systems (GIS) have revolutionized the ability to visualize and analyze ecosystems. From mapping species habitats to tracing migratory routes and monitoring deforestation, these spatial tools offer real-time insight into ecological dynamics at global scales. Aerial drones equipped with high-resolution cameras are now widely used for habitat mapping and non-invasive monitoring of sensitive wildlife species. Complementing this, environmental DNA (eDNA) has emerged as a powerful, non-invasive tools for detecting organisms from environmental samples like water or soil. It allows scientists to monitor enigmatic or endangered species in nature with remarkable precision.

Environmental Impact Assessment (EIA), Environmental Management Plan (EMP) and even climatic models, once reserved for engineers or meteorologist, are now plays vital role to ecology. Simulation of the projected impacts for global warming on biodiversity, aiding in forecasting range shifts, phenological changes, and extinction risks. Together, these technologies offer a multi-dimensional view for vulnerable ecosystems for future.

Decoding the minds of animals by behavioral and Neuroethological studies: Understanding behavior of animals has now been shifted from labor-intensive field study to video tracking systems. By quantifying movement, interaction, and activity with unprecedented accuracy these modern approaches are invaluable for studies of predator-prey dynamics, social behavior, and mating rituals. In addition to this, neuroimaging techniques such as fMRI (functional Magnetic Resonance Imaging) and calcium imaging allow researchers to observe real-time brain activity in conscious animals. This

technology provides insight into the neurological basis of behavior. Recent use of Artificial Intelligence (AI)-driven behavior recognition algorithms can help in decoding complex behaviors in species like social insects, birds, and mammals, offering scalable insights to the behavioral ecology and ethology.

Blueprint of life through the Bioinformatics and computational zoology: Using the genomic data has opened a new era for the zoosystematics and evolutionary biology Phylogenetic tree construction and sequence alignment help in tracing the phylogenetic relationships among animal species. The tools for the population genetics, viz. BLAST (Basic Local Alignment Search Tool), STRUCTURE (analyzes population genetic structure), and MEGA (Molecular Evolutionary Genetics Analysis) reveal patterns of genetic diversity and adaptation in animals. The proteomics as well as the protein modeling and structural bioinformatics open windows into the molecular architecture of life by linking genotype to the phenotype. At present, Machine learning finds powerful application in identification of animals, prediction of animal behavioral patterns, modeling of species distribution, and assessment of ecosystem health, offering scalable and predictive capabilities that were previously unattainable.

Surveillance towards the survival of species by the conservation technologies: Conservation is no longer limited to the hands on-the-ground efforts. Satellite telemetry, even the scale of across continents and oceans for tracking animal-movements are essential for protecting migratory corridors and breeding sites, Automated acoustic monitoring records and identifies vocal species, such as frogs, bats, and birds, even in remote areas, creating long-term biodiversity soundscapes. The camera traps paired with AI bring safety to work in the silent forests, identifying and counting animals with deep learning techniques. The systems can also detect poaching threats, assess population densities, and even monitor behavior without disturbing the natural environment.

In conclusion, toward a convergent future, by redefining zoological research, the combination of ecology, neuroethology, bioinformatics, and AI is not just enhancing zoological research—it is redefining the future of the subject. By embracing these interdisciplinary tools, better understand the earth biological system, the intricate web of life, respond proactively to environmental crises, and forge a more harmonious coexistence with the natural world can be achieved. The future of zoology lies not only in the field or lab research but also in the in robotics, The Internet of Things (IoT), and in the silent signals of satellites circling above the earth. We hope that new research avenue will be open up for the zoologist to comply with the 5th industrial revolution.

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