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Zoologica Mathematica: Proposing a Formal Mathematical Framework for Zoological Science

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ABSTRACT:
Zoology has historically relied on descriptive, experimental, and statistical approaches to investigate animal form, function, behavior, and ecological interactions. While mathematics is frequently employed as a supporting tool in zoological research, it has seldom been treated as a foundational language for expressing zoological principles. This paper proposes **Zoologica Mathematica**, herein referred to as **Zoothematics**, as a new sub-discipline of zoology that formally integrates mathematical structures into zoological theory. Zoothematics emphasizes the use of geometry, topology, dynamical systems, game theory, graph theory, and quantitative modeling to represent and analyze animal morphology, physiology, behavior, and ecological relationships. Unlike biostatistics or mathematical biology, which primarily apply mathematics post hoc, this proposed field treats mathematical formulation as an intrinsic component of zoological understanding. The paper outlines the conceptual rationale, scope, methodological framework, and potential applications of Zoothematics, positioning it as a foundational step toward predictive, integrative, and theory-driven zoological sciences.

Keywords:
Zoologica Mathematica, Zoothematics, mathematical modelling, biological interactions, differential equations, game theory

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INTRODUCTION

Zoology, is a branch of biological sciences, which focuses upon the scientific study of animals. The field, exclusively deals with the animal morphology, anatomy, physiology, molecular biology, animal behaviour, ecology and many other allied branches.

Zoology as a systematic study has come a long way from its ancient origin. The subject which originated as a systematic study of all the animal forms as classical zoology, over the period time has integrated quite a number of allied fields for the best understanding of the subject and evolved in to modern day zoology. Authors like, Naimah Hussein Mansour and Muhammad A B Abdalnis (2024), have extensively reviewed in their studies, were recent technologies have helped in the refinement and growth of zoology. In their review, they have highlighted that recent advances such as PCR, GIS, digital photography etc have enhanced the understanding of zoology. In recent times, the classical scientific inquiry about the animals, has transformed in to a more advanced and complex discipline. To understand and evaluate this complex physiological mechanism, there is a necessity of introducing advanced and allied branches of science and engineering. In another review by Yelupula Plasi Margaret (2023), where the history and evolution of zoology over a time period have been discussed. According to the author, the subject has undergone significant transformations, since medieval times. From scientific method, to the present-day technologies, such as DNA sequencing, electron microscopy and fields such as bioinformatics, have greatly revolutionized the subject. Museum studies and dissections have long been central to the teaching of zoology. However, growing ethical regulations and heightened animal welfare concerns have resulted in the minimization, and occasionally the elimination, of dissections. Consequently, zoology education has become less hands-on and, for some learners, less engaging. In this context, there is a need to explore alternative approaches that can enhance interest and make the study of zoology more engaging and intellectually stimulating, while ensuring that the discipline remains dynamic and contemporary. One such approach is the integration of mathematical principles to explain and formalize zoological concepts. Similar integrative approaches have been attempted by other scholars. For example, A. K. Gupta (2022) applied mathematical concepts to population ecology, describing immigration and emigration processes using differential equations and employing terms such as *zoo mathematics* and *ecology mathematics*. While such studies demonstrate the applicability of mathematics to zoological problems, they remain limited to specific contexts and do not establish a systematic framework, standardized terminology, or a formally recognized subsidiary discipline. Zoological science has traditionally emphasized descriptive and experimental methodologies to explain animal form, function, and behavior. While these approaches have yielded extensive biological knowledge, they are increasingly challenged by the complexity of modern zoological problems that involve dynamic systems, structural regularities, and multi-scale interactions, which require mathematical knowledge to decipher and anlayze. The absence of standardized terminology, formal scope, and disciplinary identity has limited their broader integration into zoological theory and education. Accordingly, the present paper proposes the development of a sub-discipline of zoology that systematically integrates mathematics, termed **Zoologica Mathematica**, hereafter referred to as **Zoothematics**, envisioned as a new or ancillary branch of zoological science.

THEORETICAL FRAMEWORK AND METHODOLOGY

Nature of the Study: The present work is theoretical and conceptual in nature, aimed at proposing and formalizing a new sub-discipline within zoological science through the systematic integration of mathematical principles. No live animals, experimental organisms, or laboratory materials were used. Instead, the study relies on analytical reasoning, logical synthesis, and interdisciplinary integration of existing zoological knowledge with established mathematical frameworks.

Use of Prior Published Works as Methodological Foundations

The methodological development of Zoothematics is informed by a series of previously published studies by the author, in which mathematical principles were applied to diverse zoological contexts. These works are utilized as methodological exemplars demonstrating the applicability, versatility, and conceptual coherence of mathematical approaches in zoological research.

Three scientific papers, integrating the concepts of mathematics, to anlayze and understand the results have been published which are presented below.

1. Modeling the Effect of Starvation on Phospholipid Content in *Anabas testudineus* (Climbing Perch) Bloch: An Integration Approach (2024)
   Volume 40, Number 2, *Bio-Science Research Bulletin*
2. Zoological Evidence for Pythagorean Theorem in Animal Morphological Design was published in *International Journal of*

Zoological Investigations Vol. 11, No. 1, 760-765(2025)

3. Game Theory in Urban Birds: A Nash Equilibrium Analysis Using
Crows and Pigeons, Volume 41, Number 2 *Bio-Science Research Bulletin*

RESULTS

The present study yields a set of conceptual and structural outcomes that collectively support the feasibility of establishing **Zoologica Mathematica (Zoothematics)** as a formal sub-discipline of zoological science.
Firstly, the study provides a clear theoretical definition and disciplinary identity for Zoothematics, distinguishing it from isolated applications of mathematics in biology.

Secondly, a set of core mathematical domains relevant to zoological inquiry is identified, including geometry, calculus, probability theory, and game theory. These domains align naturally with key zoological themes such as morphology, physiology, population dynamics, and behavior.

Thirdly, the applicability of these mathematical tools across diverse zoological domains is demonstrated through representative studies (Table 1), including previously published works by the author and related interdisciplinary research.
Collectively, these studies establish methodological consistency and conceptual feasibility. Finally, the results indicate that Zoothematics provides a unifying framework capable of integrating theoretical modeling with traditional zoological perspectives, thereby expanding the analytical depth and pedagogical appeal of the discipline.

Table 1:

S. No.	Mathematical Framework	Zoological Domain	Conceptual Application	Representative Study	Contribution to Zoothematics
1	Euclidean Geometry (Pythagorean theorem)	Morphology & Functional Anatomy	Spatial relationships and proportionality in biological structures	Padmavathi Sriram *et.al*, 2025	Demonstrates geometry in the morphology of animal organization
2	Integral Calculus	Physiology & Biochemistry	Quantification of cumulative biological variables	Padmavathi Sriram (2024)	Establishes calculus as a tool for biological measurement
3	Game Theory	Animal Behavior & Ecology	Strategy optimization and interaction dynamics	Padmavathi Sriram and Y. Sunila Kumari (2026)	Introduces formal decision-making models in behavioral studies

DISCUSSION

The proposal of Zoothematics reflects a broader shift in biological sciences toward integration, formalization, and predictive modeling. By embedding mathematical structures within zoological theory, this field has the potential to transform zoology from a predominantly descriptive discipline into a more predictive and unifying science. Zoothematics does not seek to replace traditional zoological methods but to complement them by providing a formal language capable of expressing biological regularities. This approach aligns with historical precedents in science, where disciplines such as biophysics and systems biology emerged through similar theoretical consolidation. The decline in traditional hands-on approaches such as extensive dissections and museum-based studies has reduced experiential engagement in zoology education. In this context, Zoothematics offers an alternative pathway to stimulate analytical thinking and conceptual engagement without ethical or logistical constraints. The integration of mathematical reasoning introduces problem-solving, modeling, and logical interpretation into zoology curricula, thereby revitalizing the discipline and aligning it with contemporary interdisciplinary education trends. In this context, it is pertinent to cite earlier scholarly contributions that highlight the relevance of mathematical approaches in biological sciences. Notably, Nijhout *et al.* (2015) provided a comprehensive review of the application of mathematical modeling to elucidate complex biological phenomena. The authors emphasized that mathematical models are particularly valuable for enhancing conceptual understanding and systematic investigation of intricate biological interactions, including metabolic networks, gene regulatory systems, and organism–environment interactions. Their work underscores the broader utility of mathematical frameworks in biology, thereby supporting the rationale for extending such approaches into zoological science through a structured and formalized framework. Similarly, Allman and Rhodes (2003) advocated the application of mathematical concepts, particularly differential equations, to predict and analyze a range of biological phenomena, including population growth, disease spread, and enzyme kinetics. Their work highlights the capacity of mathematical modeling to capture the dynamic and ever-changing nature of complex biological systems, demonstrating that such phenomena can be systematically described, analyzed, and understood through rigorous quantitative frameworks. In another review by Kaznessis (2011), the author, emphasizes the need of application of appropriate mathematical concepts and models to explain intricate biological interactions. Similarly, authors like Hemant Pandey and Badri Vishal Padamwar (2019), in their review have also highlighted the importance of mathematical reasoning and different application of various deterministic, stochastic, and hybrid models to understand major fields of biology such as neuroscience, epidemiology, population dynamics etc.

Based on these studies and observations, it can be argued that integrating zoology with mathematics is both appropriate and justified. As the discipline continues to advance, there is a growing need for the emergence of newer sub-disciplines that can address complex biological phenomena using quantitative and analytical approaches. Additionally, the gradual decline in hands-on laboratory work poses a serious risk, as it may lead to stagnation of the subject and eventual loss of relevance. In such a scenario, zoology risks being overlooked or forgotten. Therefore, the development of **Zoothematics** may be viewed as a timely and necessary initiative to revitalize zoological science. By introducing mathematical rigor and predictive frameworks into zoological research, Zoothematics has the potential to preserve, strengthen, and restore the intellectual vitality and relevance of the discipline.

CONCLUSION

In conclusion it may be said that taken together, these considerations support the recognition of Zoothematics as a coherent and forward, looking sub-discipline capable of enriching both zoological research and mathematics. As a foundational proposal, this work has limitations, including the absence of explicit mathematical models and empirical case studies. Future research may focus on developing specific equations, simulations, and experimental validations to strengthen the field's applicability.

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