

Comparative mechanics of filter feeding in *Anas platyrhynchos*, *Anas clypeata* and *Aythya fuligula* (Aves, Anseriformes)

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Summary. The straining of seeds ranging in size from 0.01 to 4.6 mm was investigated in the filtering mechanisms of three anseriform species, *Anas platyrhynchos*, *Anas clypeata*, and *Aythya fuligula*. The morphology of the filtering mechanisms was studied by dissection and from microsections. The kinematic work envelope of the beaks was measured by stereotactic manipulation. The actual beak kinematics were analyzed by calculating the changes of the mouth volume from computer simulations and comparing the results with the amounts of water expelled. The performances of the filter and the water pump were measured with special collection boxes. The influence of the lamellae was estimated by removing them in whole or in part and measuring the performances again. The results show that if the size of the strained seeds increases, the gapes and amplitudes also increase (cf. bill rotations). Beak rotation is elevated for small kernels, even more elevated for slightly larger ones, but depressed for large kernels. However, neither frequencies nor phase shifts change between different moving elements. Simulation of these data by stereotactic manipulation of fresh material and by measuring gape sizes and mesh widths shows that the beak kinematics during straining keep mesh widths and gapes carefully adjusted to the seed size. The pumping and the filtering mechanisms influence each other mutually in setting boundary conditions on mouth kinematics. Beyond a certain kernel size, the necessity for mesh-width control sets a boundary on the increase of the water flow. Conversely, phase shifts, frequency changes and change of lingual amplitudes were restricted by the pumping mechanism. Drastic shortening of either dorsal mandibular or maxillary lamellae in *Anas platyrhynchos* and *Aythya fuligula* does not effect either the filter performances, the pump performances, or the beak kinematics, but these modifications do change the performances in *Anas clypeata*. The usually accepted assumption concerning food sieving was thus verified for *Anas clypeata* and falsified for the other two anseriform species. Therefore, a vortex model in addition to the sieving model, was developed, based on the assumption that local vortices cause inertia of particles so that small kernels are filtered by centrifugation and translation out of the main water flow. Combined effects of sieving and centrifugation occur when

larger kernels are filtered. The kinematics of the filtering mechanism are highly flexible; therefore, a wide tolerance for seed sizes exists. However, the morphology of the filtering mechanism differs in the three species. Testing whether the anseriform filter mechanism is so plastic that the mechanism in each species has developed in such a way that the staple food is gathered most economically has shown that filtering of the staple food does indeed occur at the most efficient levels of maxillary rotation.

A. Introduction

The peculiar mechanisms developed for filter feeding are very attractive for functional and ecological investigation. Most studies on filtering deal with invertebrates. Crome (1985) and Zweers et al. (1977) investigated the Anseriformes. Crome (1985) studied the size of particles filtered by three species of Anseriformes and related thresholds for sieving of randomly sized plankton to the interlamellar distance. Zweers et al. (1977) formulated causal mechanical models for water flow and for the filtering process.

The filter feeding of the Anseriformes received much more attention from the ecological side than from the functional morphological side. Nudds (1983a, b), Pöysä (1983a, b, 1984), Eadie et al. (1979), and Szijj (1965) analyzed the anseriform foraging behavior, but none of these studies focused on the processes in the filtering mechanism itself. Usually a linear relationship was assumed between the diameter of the food kernel filtered and the interlamellar distance; hence a straining hypothesis was adopted. However, this relationship was not tested conclusively. Thomas (1982) showed that no relationship exists between interlamellar distances and sizes of the food gathered from stomachs, whereas Nudds and Bowlby (1984) showed that similar data appear to be correlated. Crome (1985) calculated that the interlamellar distance is not a suitable measure to explain the size of retained particles. The present paper aims to explain the filtering mechanism by a comparative mechanical analysis of three anseriform species: the mallard (*Anas platyrhynchos*), the shoveler (*A. clypeata*), and the tufted duck (*Aythya fuligula*). Such a comparative analysis needs a general model for the cause of water flow through the mouth because the same kinematic patterns of the oral elements serve for pumping water and for filtering food. Water expulsion occurs in the caudal half of the mouth (Zander

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Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes

Gart A. Zweers



Mechanics Of Feeding Of The Mallard *Anas platyrhynchos* L Aves Anseriformes:

Mechanics of Feeding of the Mallard (*Anas platyrhynchos* L. ; Aves, Anseriformes) G. A. Zweers, Anton F. C. Gerritsen, Paula J. van Kranenburg-Voogd, 1977 The Biology of the Avian Respiratory System John N. Maina, 2017-04-28

The central focus of this book is the avian respiratory system. The authors explain why the respiratory system of modern birds is built the way it is and works the way that it does. Birds have been and continue to attract particular interest to biologists. The more birds are studied the more it is appreciated that the existence of human kind on earth very much depends directly and indirectly on the existence of birds. Regarding the avian respiratory system published works are scattered in biological journals of fields like physiology, behavior, anatomy, morphology, and ecology, while others appear in as far afield as paleontology and geology. The contributors to this book are world renowned experts in their various fields of study. Special attention is given to the evolution, the structure, the function, and the development of the lung-air sac system. Readers will not only discover the origin of birds but will also learn how the respiratory system of theropod dinosaurs worked and may have transformed into the avian one. In addition, the work explores such aspects as swallowing mechanism in birds, the adaptations that have evolved for flight at extreme altitude, and gas exchange in eggs. It is a highly informative and carefully presented work that provides cutting edge scientific insights for readers with an interest in the respiratory biology and the evolution of birds.

A.F.C. Gerritsen [u.] P.J. van Kranenburg-Voogd: *Mechanics of feeding of the mallard *Anas platyrhynchos* L., Aves, Anseriformes* Gart Arie Zweers, A. F. C. Gerritsen, P. J. Kranenburg-Voogd, 1977 The Ecology and Management of Breeding Waterfowl, 1992 Feeding in Domestic Vertebrates V. L. Bels, 2006

Domestication of vertebrates is based on the understanding of the needs of animals in their natural environment. Thus the success of this domestication throughout human history is largely dependant of the knowledge of the animal feeding behaviour. The aim of this volume is to provide advanced students and researchers with a review of current knowledge of feeding in domestic mammals and birds. The book also presents chapters on feeding behaviour in particular species; the scope is wide covering not only ruminants, poultry, and pigs but also more specifically horses, rabbits, and ostrich. Contributors include leading research workers from Europe, USA, Australia, and South Africa.

Chemical Signals in Vertebrates 6 R.L. Doty, Dietland Müller-Schwarze, 2013-11-11

This volume is an up to date treatise of chemosensory vertebrate research performed by over 200 scientists from 22 countries. Importantly, data from over 25 taxa of vertebrates are presented, including those from human beings. Unlike other volumes on this topic, a significant number of the contributions come from leading workers in the former Soviet Union and reflect studies within a wide variety of disciplines including behavior, biochemistry, ecology, endocrinology, genetics, psychophysics, and morphology. Most of the studies described in this volume were presented at the Chemical Signals in Vertebrates VI CSV VI symposium held at the University of Pennsylvania in the summer of 1991. This international symposium was the largest and the most recent of a series of six such symposia, the first of which was held in Saratoga Springs, New York, June 6-9, 1976, and

the last in Oxford England August 8 10 1988 Unlike the previous symposia Chemical Signals in Vertebrates VI lasted a full week reflecting the increased number of participants and the desire of many to present their research findings orally to the group as a whole

Touch and Taste in the Mallard (*Anas platyrhynchos* L.) Herman Berkhoudt, 1980

The Central Nervous System of Vertebrates, Vol. 5/I H. Kuhlenbeck, 1977-11-03 In 1927 Hartwig Kuhlenbeck published a series of lectures on the central nervous system of vertebrates and gave neurobiology its standard reference for decades The present work now complete in 5 volumes represents a monumental expansion of the early lectures

Integration of Feeding Mechanisms in Some Anseriform Birds Johannes Gijsberthus Maria Kooloos, 1986

Feeding in Vertebrates Vincent Bels, Ian Q. Whishaw, 2019-04-23 This book provides students and researchers with reviews of biological questions related to the evolution of feeding by vertebrates in aquatic and terrestrial environments Based on recent technical developments and novel conceptual approaches the book covers functional questions on trophic behavior in nearly all vertebrate groups including jawless fishes The book describes mechanisms and theories for understanding the relationships between feeding structure and feeding behavior Finally the book demonstrates the importance of adopting an integrative approach to the trophic system in order to understand evolutionary mechanisms across the biodiversity of vertebrates

The Origin and Evolution of Birds Alan Feduccia, Professor Alan Feduccia, 1999-01-01 An exploration of all that is known about the origin of birds and of avian flight It draws on fossil evidence and studies of the structure and biochemistry of living birds to present knowledge and data on avian evolution and to propose a new model of this evolutionary process

Current Catalog National Library of Medicine (U.S.), First multi year cumulation covers six years 1965 70

Ornithology Michael L. Morrison, Amanda D. Rodewald, Gary Voelker, Melanie R. Colón, Jonathan F. Prather, 2018-09-03 The essential text for ornithology courses this book will leave students with a lifelong understanding and appreciation of the biology and ecology of birds Aves the birds is the wildlife group that people most frequently encounter With over 10 000 species worldwide these animals are part of our everyday experience They are also the focus of intense research and their management and conservation is a subject of considerable effort throughout the world But what are the defining attributes that make a bird a bird Aimed at undergraduate and graduate students Ornithology provides a solid modern foundation for understanding the life and development of birds Written by renowned experts from around the globe this comprehensive textbook draws on the latest research to create an innovative learning experience Moving beyond bones muscle and feathers it provides the core information needed to build the bird linking anatomy and physiology with ecology and behavior As it reviews the major orders of birds the book highlights their wide diversity and critically evaluates ornithological concepts and theories Incorporating brief biographies of leaders in the field the text describes their contributions in the context of key historical events in bird science Each chapter ends with a summary of the material covered a discussion of potential management and conservation applications and suggested study questions that will stimulate thought and discussion

Contributors Peter Arcese George E Bentley Lori A Blanc William M Block Alice Boyle Leonard A Brennan Luke K Butler Zac Cheviron Luis M Chiappe Melanie R Col n Caren B Cooper Robert J Cooper Jamie M Cornelius Carlos Martinez Del Rio John Dumbacher Shannon Farrell Maureen Flannery Geoffrey Geupel Patricia Adair Gowaty Thomas P Hahn Ashley M Heers Fritz Hertel Geoffrey E Hill Matthew Johnson Lukas F Keller Dylan C Kesler Pablo Sabat Kirkwood John Klicka Christopher A Lepczyk Ashley M Long Scott R Loss Graham R Martin John M Marzluff Susan B McRae Michael L Morrison Timothy J O Connell Jen C Owen Marco Pavia Jeffrey Podos Lars Pomara Jonathan F Prather Marco Restani Alejandro Rico Guevara Amanda D Rodewald Vanya G Rohwer Matthias Starck Michael W Strohbach S Ma eika P Sullivan Diego Sustaita Kerri T Vierling Gary Voelker Margaret A Voss Jeff R Walters Paige S Warren Elisabeth B Webb Michael S Webster Eric M Wood Robert M Zink Benjamin Zuckerberg

Trophic Interactions Within Aquatic Ecosystems Ahmad Hemami, 2017-09-29

Electricity and Electronics for Renewable Energy Technology An Introduction provides a foundational understanding of electricity and the methods and devices specific to electricity from renewable sources The book begins with a brief explanation of the necessary mathematics and then Addresses the basics of electricity and relationships motors and generators transformers and networks and distribution Tackles the key concepts associated with electronics diodes and transistors switching devices and power converters Covers digital electronics from number systems and logic circuits to encoders and decoders Explores advanced subjects such as reactive power and the operation of a transistor A lab manual and PowerPoint presentation are available with qualifying course adoption Featuring extensive review questions and practice problems at the end of each chapter Electricity and Electronics for Renewable Energy Technology An Introduction instills an essential knowledge of electricity and electronics required for work with renewable energy

Trophic Interactions Within Aquatic Ecosystems Dewey G Meyers, 2019-08-08 First published 1984 The intent of the authors in organizing a AAAS symposium and this subsequent volume was to integrate the findings of aquatic ecologists whose research spans the first three trophic levels algae zooplankton and fish of both marine and freshwater environments Major topics phytoplankton zooplankton fish and community interactions are presented as at least two trophic level associations by scientists who have distinctly differing perspectives The format of papers varies from review to research and was chosen by authors on the basis of suitability to their specific topic

Piezo Channels , 2017-07-17 Piezo Channels Volume 79 the latest volume in the Current Topics in Membranes series provides the necessary membrane research to assist readers in discovering the current state of a particular field and future directions New chapters in the updated volume include A Tour de Force The Discovery Properties and Function of Piezo Channels Piezo1 Channels in Vascular Development and the Sensing of Shear Stress the Origin of the Force The Force From Lipids Principle Applied to Piezo Channels Genetic Diseases of PIEZO1 and PIEZO2 Dysfunction and The Structural Basis for Sensing by the Piezo1 Protein Users of this series will find an up to date presentation of the current knowledge in the field of Piezo Channels Written by leading experts in the field Contains original

material both textual and illustrative that make it a very relevant reference Presented in a very comprehensive manner Ideal reference for both researchers in the field and general readers who will find this book to be relevant and up to date The Feeding System of the Pigeon (Columba livia L.) Gart A. Zweers,1982-03-01 Anthropocentricity and pragmatism seem to be the main reasons why pigeons have served as the black boxes of so many psychologists and neurobehaviorists during the past decade Anthropocentricity because at first glance pigeons show several striking features which bear a beautiful similarity to human systems in respects such as drinking bipedality territoriality and apparently easy pursual of individual interests Pragmatism because of the suspected lesser complexity of the pigeon's system which enables them to serve as good paradigms for human systems For example the visually guided grasping system of the beak could be used as a model for the visually guided grasping system of the tips of the thumb and forefinger in humans personal communication Zeigler Other pragmatic reasons are the low cost of breeding these birds their easy adaptation to experimental conditions and their obvious capacity for learning and remembering Although a closer and more critical examination largely undermines the anthropomorphic arguments this has not diminished interest in the pigeon In many studies on sensorimotor and motivational processes of hunger thirst and learning pecking and drinking behavior serve as the systems on which the outcome of different black box systems is measured Clear examples of this application are found in McFarland 1964 1965 Dawkins 1966 Dawkins and Dawkins 1973 Goodman and Schein 1974 Machliss 1977 and Zeigler Levitt and Levine 1980 *Convergent Evolution* Vincent L. Bels,Anthony P. Russell,2023-03-01 This volume presents a series of case studies at different levels of inclusivity of how organisms exhibit functional convergence as a key evolutionary mechanism resulting in responses to similar environmental constraints in mechanically similar ways The contributors to this volume have selected and documented cases of convergent evolution of form and function that are perceived to be driven by environmental abiotic and or biotic challenges that fall within their areas of expertise Collectively these chapters explore this phenomenon across a broad phylogenetic spectrum The sequence of chapters follows the organizational principle of increasing phylogenetic inclusivity rather than the clustering of chapters by perceived similarity of the phenotypic features or biomechanical challenges being considered This is done to maintain focus on the evolutionary phenomenon that is the primary subject matter of the book thereby providing a basis for discussion among the readership about what is necessary and sufficient to justify the recognition of functional convergence All chapters stress the need for integrative approaches for the elucidation of both pattern and process as they relate to convergence at various taxonomic levels **The Skull, Volume 3** James Hanken,Brian K. Hall,1993-07 In this authoritative three volume reference work leading researchers bring together current work to provide a comprehensive analysis of the comparative morphology development evolution and functional biology of the skull *Feeding* Kurt Schwenk,2000-08-03 As the first four legged vertebrates called tetrapods crept up along the shores of ancient primordial seas feeding was among the most paramount of their concerns Looking back into the mists of

evolutionary time fish like ancestors can be seen transformed by natural selection and other evolutionary pressures into animals with feeding habitats as varied as an anteater and a whale From frog to pheasant and salamander to snake every lineage of tetrapods has evolved unique feeding anatomy and behavior Similarities in widely divergent tetrapods vividly illustrate their shared common ancestry At the same time numerous differences between and among tetrapods document the power and majesty that comprises organismal evolutionary history Feeding is a detailed survey of the varied ways that land vertebrates acquire food The functional anatomy and the control of complex and dynamic structural components are recurrent themes of this volume Luminaries in the discipline of feeding biology have joined forces to create a book certain to stimulate future studies of animal anatomy and behavior

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Table of Contents Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes

1. Understanding the eBook Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - The Rise of Digital Reading Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Advantages of eBooks Over Traditional Books
2. Identifying Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - User-Friendly Interface
4. Exploring eBook Recommendations from Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Personalized Recommendations
 - Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes User Reviews and Ratings
 - Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes and Bestseller Lists
5. Accessing Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes Free and Paid eBooks
 - Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes Public Domain eBooks

- Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes eBook Subscription Services
- Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes Budget-Friendly Options
- 6. Navigating Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes eBook Formats
 - ePub, PDF, MOBI, and More
 - Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes Compatibility with Devices
 - Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Highlighting and Note-Taking Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Interactive Elements Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
- 8. Staying Engaged with Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
- 9. Balancing eBooks and Physical Books Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Setting Reading Goals Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Fact-Checking eBook Content of Mechanics Of Feeding Of The Mallard Anas Platyrhynchos L Aves Anseriformes
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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