EXAMPLES OF SUCCESSFUL PROPOSALS FOR THE ECOLOGICAL AND ENVIRONMENTAL PHYSIOLOGY SERIES (EEPS)

PROPOSAL EXAMPLE #1

Ecological and Environmental Physiology of Vertebrate Embryos, Larvae and Neonates

Roger S. Seymour, University of Adelaide
Peter J. Rombough, Brandon University
Peter B. Frappell, La Trobe University

Rationale

Comparative environmental physiology has focussed on the coordinated and adaptive functions of organ systems in the adult animal. However, the developmental stages of those systems have received much less attention and are sometimes even considered to be inferior to the adult ideal. Physiological differences between embryos, juveniles and adults in the capacity of the systems can introduce unwanted variability into investigations, so work on juveniles is often avoided. This focus of comparative physiology on adult animals can lead to the assumption that the physiology of earlier developmental stages needs not to be particularly well adapted, but only sufficient to keep the animal alive until it reaches reproductive adulthood. However, younger stages of animals may be under as much selective pressure as older ones, and have organ systems that are as fully functional for their requirements and adapted to the conditions of their environments. Only recently have physiologists started to ask questions about the adaptability of embryonic and larval physiological systems, particularly in relation to their environments.

We propose a book dealing with the environmental physiology of vertebrate embryos and larvae to supplement the approaches in the other volumes that are directed mainly at adult animals. In the cases of fish and amphibians, the developmental stages operate effectively as unique organisms, quite different from the adult. Because it might be awkward to deal with these stages in volumes mainly directed at the adult phenotype, it seems useful to assemble the embryonic and larval forms in one volume, that could be cross-referenced with the others as appropriate.

Competition

We are unaware of any other volume that deals directly with the ecological physiology of vertebrate embryos and larvae. One of us (RSS) published an edited book entitled *Respiration and Metabolism of Embryonic Vertebrates* in 1983 (Dr W. Junk Publishers). It dealt with all vertebrates, but was not comparable in scope, because it was mainly restricted to gas exchange and energetics. It was not uniform in style and is now quite dated.

Contents

Summary

I. Introduction

II. General Principles

- Fish
- Amphibians
- Reptiles
- Birds
- Mammals

III. Specific Adaptations to Specific Environments

- Fish
- Amphibians
- Reptiles
- Birds
- Mammals

IV. Techniques/Approaches/Concepts/Applications

- Environmental parameters
- Embryonic parameters
- Models for environmental exchanges
- Embryo culture and model organisms

V. Conclusions and Future Directions

- Summary: current position in the field
- Significance of comparative physiology of embryos
- Future directions: major unanswered questions

The following are proposed ideas of what would be covered in the book, listed under the suggested headings from the series web page.

I. Introduction

This book focuses on the environmental requirements for successful completion of embryonic development of vertebrate animals until they are capable of free-living. The other volumes in this series primarily deal with ecophysiology of adult vertebrates that have evolved within a range of environments, and they consider the physiological and behavioural adaptations for survival. Often unrecognised is the requirement for eggs and embryos to survive in a range of environments and reproductive modes offered to them by the adults. In fact, it is often thought that the evolution of vertebrates has been greatly influenced by the requirements of their embryos, for example the distinction between anamniotes and amniotes, reproduction of amphibians in water and land, and the multiple appearances of viviparity. The roots of many of these distinctions lie in adaptations to the environment. Embryos are also interesting because they have limited scope to adapt to environmental changes, they cannot adaptively adjust their rates of exchange between them and their environments, and they usually have few, if any, options to alter their environments behaviourally.

II. General principles of physiology of vertebrate embryos

It will begin with a description of the comparative embryology of vertebrates to identify the structures in common and to see evolutionary trends. It will distinguish patterns of development between the vertebrate groups and emphasize transitions between egg, embryo and larval phases. It will deal with the common requirements of embryos for energy, nutrients, nitrogen excretion, oxygen, water and temperature, and show in a general way how each group deals with these requirements. It will include the effect of organism size on developmental parameters.

This section will be organised according to phylogeny, because it will reflect the organisation of the rest of the series and make it easier to cross-reference.

Among **fish**, this section will cover:

- Incubation environments
  - Early environments
  - Maternal/paternal influences
  - Isolated environments and island biogeography
- Energetics and nutrition
  - Egg size and temperature
- Gas exchange
- Osmotic and ionic balance
- Nitrogen excretion

Among **amphibians**, this section will cover:
- Incubation environments
- Maternal/paternal influences
- Energetics and nutrition
  - Egg size and temperature
- Gas exchange
  - Single eggs
  - Egg masses
- Osmotic and ionic balance
- Nitrogen excretion

Among **reptiles**, this section will cover:
- Incubation environments
- Maternal/paternal influences
- Energetics and nutrition
  - Egg size and temperature
  - Viviparous embryos
- Gas exchange
  - Cleidoic eggs
  - Non-cleidoic eggs
  - Viviparous embryos
- Osmotic and ionic balance
  - Cleidoic eggs
  - Non-cleidoic eggs
  - Viviparous embryos
- Nitrogen excretion

Among **birds**, this section will cover:
- Incubation environments
  - Maternal/paternal influences
  - Physics of nest design
  - Broodpatch heat transfer
- Patterns of development: altricial-precocial
- Energetics and nutrition
  - Egg size and temperature
- Gas exchange
- Osmotic and ionic balance
- Nitrogen excretion

Among **mammals**, this section will cover:
- Patterns of development and prenatal environment
  - Eutherian
  - Marsupial
  - Monotreme
- Post-natal environments
  - Eutherian
  - Marsupial
- Energetics and nutrition
  - Embryo size and temperature
- Gas exchange
- Osmotic and ionic balance
- Nitrogen excretion

III. Specific adaptations to specific environments

With the general adaptations covered in the previous section, this section will focus on the adaptive diversity within each group in response to specific environmental factors. Emphasis will be placed on extreme and unusual environments, and particularly those characteristics of the environment that are relevant to each group.

Fish

- Temperature
- Oxygen
- Salinity
- Acidity
- Light
- Sound
- Buoyancy
- Pressure

Amphibians

- Temperature
- Aquatic eggs
- Terrestrial eggs
- Gastric or pouch brooding
- Salinity
- Acidity
- UV light

Reptiles

- Temperature
- Humidity
- Freezing tolerance
- Transition from oviparity to viviparity
- Placental exchange
- Diapause
- Dinosaur eggs

Birds

- Temperature
- Humidity
- Altitude
- Underground

Mammals

- Temperature
- Altitude
- Aquatic environments
- Marsupial pouch

IV. Techniques/Approaches/Concepts/Applications

This chapter will deal with examples of the kinds of ecophysiological measurements that have been carried out on embryos, including those pertaining to size, respiration, circulation, energy and material content, water balance, and ionic regulation. There will also be a section on environmental parameters including temperature, oxygen availability (pressure and capacitance), carbon dioxide and pH, osmotic and matric tensions, and dissolved substances.

It will also include general models for exchanges of materials between an embryo and its environment, and the concepts of symmorphosis and allometry.

The difficulties involved with working with small, delicate organisms, isolated in protective structures and never in steady states offer serious technological challenges to the physiologist. Even routine procedures for adults, such a blood sampling, electrode attachment or even changing temperature can be lethal. Experimental design is fraught with difficulties because the dynamics of embryonic development offer no baselines. This is probably why most physiological work on embryos has considered the whole animals. Working with embryos has some unique practical advantages over adults. For example, embryos do not need to be fed, watered or cleaned up after.

The use of common laboratory models from fish (zebrafish), amphibian (leopard frogs; clawed frogs), birds (chickens) and mammals (mice, rats) will be highlighted for their availability and extensive background literature. Embryo culture methods will also be referred to. However, model organisms need to be contrasted against the value of the comparative approach and the general applicability to animals in their natural environments. This is particularly appropriate for a book on environmental physiology.

Environmental parameters
- Temperature
- Oxygen availability (pressure and capacitance)
- Carbon dioxide
- pH
- Osmotic and matric tensions
- Dissolved substances

Embryonic parameters
- Size
- Energy content
- Water and salt content
- Gas exchange
- Circulation
- Nitrogen budgets

Models for environmental exchanges
- Diffusion
- Allometry

Embryo culture and model organisms
- fish (zebrafish)
- amphibians (leopard frogs; clawed frogs)
- reptiles (turtles, crocodiles)
- birds (chickens, emus, quail)
- mammals (mice, rats, dunnarts, wallabies)

V. Conclusions and Future Directions

As the name implies, this section (likely a single chapter) draws conclusions and, importantly, suggests future directions in which researchers might profitably turn their attention.

It will include an overview of vertebrate evolution emphasizing the constraints of reproductive mode and environment on embryonic characteristics such as egg size, incubation time, and rates of development and differentiation. It will concentrate on the adaptive values for anamniotes of oviposition in air or in water, the transition to the amniote egg and the factors involved with the evolution of viviparity. Patterns of nitrogen excretion will be compared across groups in relation to development in different environments (Needham revisited).

Finally, we will devote a section on the major gaps in knowledge that emerge during the preparation of this book as well as potentially significant areas of future investigation.

- Summary: current position in the field
- Significance of comparative physiology of embryos
- Future directions: major unanswered questions, including:
    - Transitions between embryonic and adult life
    - Embryonic characteristics and fitness
    - Incubation environment and fitness
    - Management of oxygen reactive species
    - Symmorphosis in embryonic development
    - Constraints of reproductive mode
    - Evolutionary bottlenecks among vertebrates

Authors

Roger S. Seymour

EDUCATION:

University of California, Los Angeles. Zoology. 1968-1972 (Ph.D.)
University of California, Riverside. Zoology. 1963-1967 (B.A.)

CURRENT POSITION:

Professor, University of Adelaide, Australia, 2001-present

MAJOR HONORS:

Personal Chair, Department of Environmental Biology, University of Adelaide (2001)

Doctor of Science, University of Adelaide, Studies in Comparative Physiology (1999)

Alexander von Humboldt Foundation Research Fellowship, Max-Planck-Institut für Experimentelle Medizin, Göttingen, West Germany (1985-1986)

RESEARCH INTERESTS:

Quantitative interactions and exchanges between organisms and their environments, with a broadly based comparative and evolutionary approach.

Respiration, metabolism and energetics of vertebrate embryos.

Cardiovascular and respiratory physiology of animals, particularly vertebrates. Emphasis has been placed on the roles of diffusion and convection of respiratory gases in animals in extreme environments, for example, diving and burrowing species.

Comparative thermoregulation of diverse organisms, including plants and insects.

Physiology and biology of archosaurs.

CURRENT RESEARCH:

Respiration in air-breathing fish.

Parallel development of cardiovascular and respiratory systems in vertebrate embryos, testing the hypothesis of symmorphosis.

Energetics, gas exchange and molecular biology of thermogenic plants and the role of floral temperature regulation in pollination ecology.

Validity of solvent tension theory in osmotic phenomena.

RESEARCH SUPPORT:

Australian Research Council. Virtually continuous support for 30 years.

PUBLICATIONS:

Approximately 140 full research papers and reviews. One edited book.

Peter Rombough

(Peter Rombough is currently in the field and unable to submit a complete CV)

EDUCATION

University of British Columbia (BSc)
Dalhousie University (MSc) (PhD)

CURRENT POSITION:

Department of Zoology, Brandon University, Manitoba, Canada

RESEARCH INTERESTS:

Dr. Rombough studies the dissolved requirements of fish, ontogeny of the cardiovascular and respiratory systems in fish, metabolism and energy partitioning in developing fish, the impact of global warming on fish populations and fish aquaculture.

Peter B. Frappell

EDUCATION

Flinders University of South Australia, Adelaide. Zoology. 1986-1990 (Ph.D)
University of Tasmania, Hobart. Zoology. 1981-1985 (B.Sc. Hons)

CURRENT POSITION:

Reader and Associate Professor, Head of Department, 2001 – present

RESEARCH INTERESTS:

Emphasis on a comparative approach to whole animal integrative physiology and physiological adaptation to the environment.

Respiratory, metabolic and thermoregulatory physiology, mainly of vertebrates, and the influence of the environment, particularly oxygen and temperature.

Development of respiratory control in mammals.

Inter- and intra- individual variability in respiratory variables, the effect of environment and genes.

CURRENT RESEARCH:

The interplay between temperature and oxygen level on ventilatory and metabolic responses in neonatal mammalian models (marsupials, KO mice, rats), and the importance of plasticity in the development of respiratory control.

Hypoxic hypothermia and the resetting of the thermal set-point in mammals.

Ecophysiology of daphnids, in particular adaptation/acclimation to low O_2 levels.

Determinants of aerobic capacity in varanid lizards: testing the concept of symmorphosis and influencing factors on the Fick equation for circulation.

Environmental influences on physiology during development in clones.

RESEARCH SUPPORT:

Australian Research Council

PUBLICATIONS:

50 full research papers and reviews. Two book chapters.

PROSPOSAL EXAMPLE #2

Ecological and Environmental Physiology of Insects

Jon F. Harrison, H. Arthur Woods, Stephen P. Roberts

Rationale

Insects are the most ecologically important multicellular heterotrophs in terrestrial systems, they play critical roles in ecological food webs and remain devastating agricultural and medical pests. In addition, insects are the most diverse group of eukaryotes in terms of species number. Their dominant role among terrestrial heterotrophs arises from a number of key physiological traits, and in particular by the developmental and evolutionary plasticity of these traits. The principal goal of this book will therefore be to present an overview of our current understanding of how the key physiological traits of insects respond to environmental variation.

Three major themes will be developed and used to organize the book. First, we will provide a control theory context to each physiological system: what is known about the sensors, integrators, and effectors for various responses to ecophysiological conditions? A second theme will be an examination of the temporal effects of physiological responses: how do short-term, long-term (developmental plasticity), multigeneration (within population selection) and deep evolutionary (comparisons across species) factors compare? A third major theme will be the consequence of trade-offs: all organisms have limited resources (e.g. materials, energy, brain-power), and compensatory responses to one environmental variable often result in decreased capacities to cope with other conditions.

Another organizational approach that we will take in this book is to begin many of the chapters with a "defining the problem" section. In this section, we will cover what is known about the pathologies that can ensue when compensatory responses to environmental change fail, or do not occur. This is an important issue, often strangely ignored in existing texts of physiological ecology, and we hope to use this section to introduce the functional relevance of the various physiological responses that come later in each chapter.

This book will take a rather broader view of environmental and ecological ecology than has been attempted before. While we include discussion of the classic environmental variables (temperature, water etc.) we will also address other important physiological specializations to niche, including migration, diapause, dietary variation, pathogens and parasitoids. In general, our goal will be to identify provocative patterns and interesting directions for future research rather than provide exhaustive summaries of past work.

We will conclude by discussing how a consideration of the ecological and environmental physiology of insects contributes to broad evolutionary questions with significant human relevance, including understanding the past and possible future effects of global climate change.

Target audience

Graduate students in environmental/ecological physiology and entomology, researchers in evolution/ecology interested in proximate mechanisms, cell/molecular researchers interested in ecology/evolution; researchers working on other taxa looking for comparative data. Given this target audience, and the number of insect physiology texts available, section II will be relatively telegraphic, presenting basic points and differences from vertebrate systems with a few figures and references to review articles and insect physiology texts.

Competing Titles

Insect Physiological Ecology: Mechanisms and Patterns. Steven L. Chown and Sue W. Nicolson. Oxford University Press. 2004. ISBN: 0198515480.

In general, what will set our book apart from the Chown and Nicolson book are the themes of trade-offs, control systems, and a comparison of plastic vs. evolved effects. In addition, we expect to include significantly more molecular/genomic information since there has been a recent explosion of research in this area. Finally we will take a broader view of the environmental physiology of insects, including examination of effects of body size, physiological specialization for behavioral niche (e.g. dispersal vs. sedentary forms) and responses to pathogens and parasites.

Chapter 2 of Chown and Nicolson covers nutritional physiology and ecology. In general, this chapter is organized more like a physiology text, while ours will focus more on the specific environmental “problems” or challenges that insects face. A major theme of this chapter is compensatory feeding. While this is important, we will include coverage of many more types of responses. One issue we have with this chapter is that it repeats the claims of older reviews that most herbivorous insects are nitrogen-limited. We will include a stoichiometric approach and include more recent information that shows that there are other potential limiting nutrients, including phosphate, specific amino acids, and vitamins.

Chapter 3 of Chown and Nicolson covers metabolism and gas exchange. We are not covering this topic *per se*, although some aspects will be addressed in other chapters.

Chapter 4 covers water balance. In general, their chapter is organized more like a classic insect physiology text (eg. mechanisms of ion transport in Malpighian tubules and rectum) while ours will focus on environmental responses.

Chapter 5 concentrates on lethal temperature limits and chapter 6 on thermoregulation. We will have a single chapter that includes both topics. This is probably the area in which our two books will have the most overlap. However, there are a number of topics we plan to highlight that received little attention in their book. One is the topic of thermal performance curves and their evolution. We will also provide more depth on the molecular mechanisms of biochemical acclimation (e.g. transcriptional control of heat shock proteins).

The following are more general insect physiology texts that we will cite in Section II.

Insect Physiology and Biochemistry. James L. Nation. CRC Press. 2002. ISBN 0-8493-1181-0

The Insects: Structure and Function. R.F. Chapman. Cambridge University Press. 1998. ISBN 0 521 57890 6

Physiological Systems in Insects. Marc J. Klowden. Academic Press. 2002. ISBN 0-12-416264-9

Contents

I. Introduction

- A. The ecological importance of insects
- B. Insects as models for the study of ecological and physiological adaptation
- C. Insect phylogenetic diversity
  Current phylogenies
  Major taxon-level differences: holo- vs. hemimetabolous insects
- D. Developmental diversity: eggs, larvae, adults
- E. Themes of this book
  - a. Control system theory
  - b. Time-scale of environmental responses (short-term responses, developmental plasticity, evolutionary)
  - c. The integrated organism: trade-offs in physiological systems

II. General Principles of Insect Physiology

- A. Insect neuroendocrine systems
- B. Metabolism
- C. Respiration
- D. Muscles
- E. Digestion
- F. Excretion and ion regulation

III. Responses and Adaptations to Specific Environments and Life Histories

- A. How do insects respond to temperature?
  - a. Defining the problems
  - b. Behavioral responses
  - c. Metabolism and heat production
  - d. Heat exchange with the environment
  - e. Biochemical responses

- B. Maintaining the right amount of water
  - a. Defining the problems
  - b. Responses to dry conditions
  - c. Living in freshwater environments
  - d. Living in brackish and salt-water environments

- C. Obtaining the nutrients for growth
  - a. Defining the problems

b. Responses to low-energy diets
c. Responses to deficiencies in other nutrients: nitrogen, phosphate, vitamins
d. Responses to dietary excess
e. Adaptations to herbivory
f. Digestion by gut fauna communities
g. Coping with plant defenses

D. Maintaining tissue oxygen levels
   a. Defining the problem
   b. Living at high altitudes
   c. Living in hypoxic waters
   d. Preventing hyperoxic stress

E. Polyphenisms for behavioral niche
   a. Specializations for dispersal vs. sedentary forms
   b. Social insect castes
   c. Seasonal polyphenisms and diapause

F. Effects of body size on physiological function
   a. Theoretical scaling effects
   b. Body size effects on insect structure and function
   c. Physiological specializations for large or small size

G. Responses to pathogens and parasitoids
   a. Parasitoids
   b. Viruses
   c. Bacteria

IV. Techniques and Applications

A. Molecular genetic tools in insects
B. Issues with using the comparative method in insects
C. Sources for of key methods

V. Conclusions and Future Directions

A. Predicting results of environmental change
   a. What determines insect range limits?
   b. What determines insect reproductive success in the field?
B. Historical changes in environmental conditions and their effects on insect evolution
C. Responses to insectides
D. Insects as a model system for functional genomics
E. Thematic summaries
   a. Plastic vs. evolved responses
   b. Environmental response and control systems
   c. Trade-offs as a fundamental principle in physiological adaptation

JON F. HARRISON

EDUCATION

University of Toronto: Biology; B.Sc. May, 1978
University of Colorado, Boulder: Environmental, Population and Organismic Biology; Ph.D. December, 1987

PROFESSIONAL EXPERIENCE

1988-1990 Postdoctoral fellow, Dept. of Zoology, University of British Columbia
Jan 1991-Aug 97 Assistant Professor, Dept. of Zoology, Arizona State University
1997-2002 Associate Professor, Dept. of Biology, Arizona State University
August 2002-present Professor, Dept. of Biology, Arizona State University
July 2005-present Associate Director of Facilities, School of Life Sciences

PROFESSIONAL ORGANIZATIONS AND SOCIETIES

American Physiological Society, Entomological Society of America, International Union for the Study of Social Insects, Organization for Tropical Studies, Society for Integrative and Comparative Biology

SELECTED SCIENTIFIC OFFICES AND SERVICES

Organizer: 21st International Entomological Congress Symposium on "Spiracular mechanisms: ultrastructure and physiology" (Brazil, 2000)
Program Officer, Division of Comparative Physiology and Biochemistry, Society for Integrative and Comparative Biology (2000-2003)
Co-Organizer (with Stefan Hetz and Timothy Bradley): 22nd International Entomological Congress Symposium on "O_2, H_2O and oxygen radicals in insects: understanding the balance", (Brisbane, 2004)
Organizing Committee Member, Comparative Physiology 2006: Integrating Diversity (American Physiological Society)
Panel Member, NSF Ecological and Evolutionary Physiology Panel (2000, 2005)
Panel Member, NSF Integrative Physiology Panel (2005)

HONORS AND AWARDS

2005	Elected Fellow, American Association for the Advancement of Sciences
2005	Nominated for "Last Lecture Series" for outstanding teaching by ASU students (Co-Curricular Programs)
2002	Nominated for Dean's Distinguished Teaching Award, College of Liberal Arts and Sciences, Arizona State University
1998	Nominated for Outstanding Advising Award, College of Liberal Arts and Sciences, Arizona State University
1990	Scholander Award, American Physiological Society

THESIS ADVISOR: Todd T. Gleeson

POSTDOCTORAL ADVISOR: John E. Phillips

GRADUATE SUPERVISION (* = current)
Brenda Rascón*, Sydella Blatch*, Joanna Henry*, Steven Roberts (currently Associate Professor, Univ. of Nevada, Las Vegas), Scott Kirkton (PDF at Univ. of California, San Diego), Kendra Greenlee (PDF at Baylor College of Medicine), Marc Perkins (currently Asst. Prof. at Orange County Community College), Melanie Frazier (currently Ph.D. student at the Univ. of Washington)

POSTDOCTORAL SUPERVISION (* = current)
Patricia Ashby (currently Assist. Prof., Scottsdale Community College), Cornelis J. Klok*, H. Arthur Woods (Asst. Prof. Univ. of Montana, Missoula)

SOME RECENT PUBLICATIONS

Rascón, B. and J.F. Harrison. 2005. Atmospheric oxygen effects on metabolic rate and lift production of tethered flying locusts. Journal of Insect Physiology 51:1193-1199.

Kirkton, S.D., Nsika, J. and J.F. Harrison. 2005. Ontogenetic effects on aerobic and anaerobic metabolism during jumping in the American locust, *Schistocerca americana* Journal of Experimental Biology 208:3003-3012.

Harrison, J.F., J.J. LaFreniere, K.J. Greenlee. 2005. Ontogeny of tracheal dimensions and gas exchange capacities in the grasshopper, *Schistocerca americana.* Comparative Biochemistry and Physiology 141:372-380.

Greenlee, J.F and J.F. Harrison. 2005. Respiratory changes throughout ontogeny in the tobacco hornworm caterpillar, *Manduca sexta.* Journal of Experimental Biology 208:1385-1392.

Harrison, J.F., O.R. Taylor and H.G. Hall. 2005. The flight physiology of reproductives of Africanized, European and hybrid honey bees (*Apis mellifera*). Physiological and Biochemical Zoology 78:153-162.

Hartung, D.K., S.D. Kirkton and J.F. Harrison. 2004. Ontogeny of tracheal system structure: a light and electon-microscopy study of the metathoracic femur of the American locust, *Schistocerca americana*. J. Morphology 262:800-812.

Greenlee, K. and J.F. Harrison. 2004. Development of respiratory function in the American locust, *Schistocerca americana*. I. Across-instar effects. J. Exp. Biol. 207: 497-508.

Harrison, J.F. 2003. Respiratory Systems. Pages 1002-1007 in: “Encyclopedia of Insects”. Editors, V.H. Resh and R. Carde, Academic Press, San Diego.

Woods, H.A., M.C. Perkins, J.J. Elser and J.F. Harrison. 2002. Absorption and storage of phosphorus by larval *Manduca sexta*. J. Insect Physiology 48, 555-564.

Bustami, H.P., J.F. Harrison and R. Hustert. 2002. Evidence for oxygen and carbon dioxide receptors in the CNS of insects which influence ventilation. Compar. Biochem. Physiol. A 133 (3), 595-604.

Woods, H.A. and J.F. Harrison. 2002. Interpreting rejections of the beneficial acclimation hypothesis: when is physiological plasticity adaptive? Evolution 56(9), 1863-1866.

Harrison, J.F. Insect acid-base physiology. 2001. Annual Review of Entomology 46:221-250.

Harrison, J.F. and S.P. Roberts. Flight respiration and energetics. 2000. Annual Review of Physiology 62:179-205.

Harrison, J.F. 1998. An introduction to “Responses of terrestrial arthropods to variation in the thermal and hydric environment: molecular, organismal and evolutionary approaches” American Zoologist 38:413-417.

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Education

1998 Ph.D. University of Washington, Department of Zoology (Joel G. Kingsolver)

1991-1992 Research associate at Hopkins Marine Station, Pacific Grove, CA (Dennis A. Powers)

1991 B.S. in Biology at Stanford University (Carol L. Boggs)

Professional Experience

2006 - Assistant Professor, Division of Biological Sciences, Univ. of Montana

2001-2006 Research scientist and lecturer in the School of Biological Sciences (Section of Integrative Biology) at the University of Texas at Austin.

2000-2001 Postdoctoral research associate, Biological stoichiometry; advisors: Drs. Jon F. Harrison and James J. Elser.

1998-2000 Postdoctoral Fellow with the Center for Insect Science, Dept. of Biology, Arizona State University, Postdoctoral advisor: Dr. Jon F. Harrison

Research interests: Insect physiology, physiological acclimation and plasticity, temperature and oxygen biology, gas exchange, ecological and evolutionary physiology of reproductive structures

Grants

2002 – 2003 NSF 'QEIB: Gas exchange across insect eggshells' IBN-0213087, $53,000.

2005 - 2008 Co-PI with Dr. Amy Moran (UNC-Chapel Hill) NSF: 'Collaborative Research: Effects of oxygen and temperature on egg mass function of Southern Ocean marine invertebrates.' My part $US 238,000; total amount $532,000.

2005 – 2006 Co-PI with Dr. Mary Poteet (UT-Austin). Barton Springs/Edwards Aquifer Conservation District (Austin): 'Physiological and behavioral responses of a *Eurycea sosorum* to variation in levels of dissolved oxygen and conductivity.' $123,000.

5 Recent Refereed Publications (28 total)

Zrubek, B & HA Woods (in press). Insect eggs exert rapid control over an oxygen-water tradeoff. Proceedings of the Royal Society B. doi:10.1098/rspb.2005.3374

Woods HA, RT Bonnecaze, B Zrubek (2005) Oxygen and water flux across eggshells of *Manduca sexta*. Journal of Experimental Biology 208, 1297-1308.

Woods, HA and RI Hill (2004) Temperature-dependent oxygen limitation in insect eggs. Journal of Experimental Biology, 207, 2267 - 2276.

Woods, HA, W Makino, J Cotner, S Hobbie, JF Harrison, K Acharya, and JJ Elser (2003) Temperature and the chemical composition of poikilothermic organisms. Functional Ecology 17, 237-245.

Woods, HA and JF Harrison (2002) Interpreting rejections of the beneficial acclimation hypothesis: when is physiological plasticity adaptive? Evolution 56, 1863 – 1866.

STEPHEN PAUL ROBERTS

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EDUCATION:

1998-99 Postdoctoral Research, the University of Chicago: Organismal Biology and Anatomy
1993-98 Ph.D., Arizona State University, Tempe: Biology
1990-92 M.S., Illinois State University, Normal: Biological Sciences
1988-90 B.S., Illinois State University, Normal: Biological Sciences

REPRESENTATIVE PUBLICATIONS:

1. Altshuler, D.L., W.B. Dickson, J.T. Vance, **S.P. Roberts** and M.H. Dickinson. 2005. Short amplitude, high frequency wing strokes determine the aerodynamics of honeybee flight. *Proceedings of the National Academy of Science* 102:18213-18218.
2. Sinclair, B. J. and **S. P. Roberts**. 2005. Acclimation, shock and hardening in the cold. *The Journal of Thermal Biology* 30:557-562.
3. **Roberts, S. P.** and M. M. Elekonich. 2005. Muscle biochemistry and the ontogeny of flight capacity during behavioral development in the honey bee *Apis mellifera*. *The Journal of Experimental Biology* 208:4193-4198.
4. Guadagnoli, J. A., A. M. Braun, **S. P. Roberts** and C. L. Reiber. 2005. Environment influences hemoglobin subunit structure in the branchiopod crustacean *Triops longicaudatus*. *The Journal of Experimental Biology* 208:3543-3551.
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