The handicap principle and signalling in collaborative systems
Amotz Zahavi

in Sociobiology of Communication: an interdisciplinary perspective

Published in print: 2008 Published Online: Publisher: Oxford University Press
September 2008 DOI: 10.1093/ acprof:oso/9780199216840.003.0001
Item type: chapter

Signalling systems are by nature collaborations, since for a signal to be effective, the receiver has to cooperate with the signaller. The Handicap Principle (HP) ensures the reliability of signals, and is an essential component in all signals. The HP explains why signals evolve their particular patterns, and the relationship of the patterns to the messages encoded in them. The HP is used to understand signalling among Arabian Babblers — the patterns by which they advertise their qualities to mates, rivals, and predators. The HP also explains the altruism of babblers as a selfish investment in advertising prestige. Recent theoretical studies use the HP in interpreting the evolution of chemical signalling among organisms (pheromones) and within multi-cellular organisms (hormones), and the messages encoded in such chemical signals.

Chemical communication and the coordination of social interactions in insects
Patrizia d'Ettorre and Allen J Moore

in Sociobiology of Communication: an interdisciplinary perspective

Published in print: 2008 Published Online: Publisher: Oxford University Press
September 2008 DOI: 10.1093/ acprof:oso/9780199216840.003.0005
Item type: chapter

Effective communication, often involving pheromones, is a fundamental component of social life. Communication requires interactions to be expressed and it is convenient to consider communication within the context of the theory of interacting phenotypes — those phenotypes that have reduced or no meaning outside of a social context. Pheromonal communication will therefore be subject to social selection and indirect
genetic effects and is often highly sophisticated and multifaceted, allowing fine-tuned coordination of messages from senders and receivers. Pheromones can be characterized by nested levels of variation: a multi-component structure in which individual components contain additional source of variation. An integrated understanding of communication by multi-component chemical signals provides insight into the evolution of social signals in general. Insects are ideal model systems to investigate and disentangle the complexity of pheromones and reveal the underestimated potential for reliability that appears to be hidden in chemical signals and their evolutionary stability.

Foraging and Defence Strategies
Anna Dornhaus and Scott Powell

In many habitats, the first animal that a visitor is likely to notice is an ant forager. Ants are model systems for the study of foraging strategies, and have stimulated the development of theories in optimal foraging, central place foraging, risk and robustness, and search algorithms. Differences in diet, as well as differences in habitat structure, competitive environment, and colony size have likely led to the broad diversity of foraging and defence strategies in ants. Many factors affect foraging behaviour at the individual and colony levels, including energy requirements, distance to food resources, and avoidance of mortality. As a taxon, ants employ a range of strategies including morphological, chemical, and behavioural defences during foraging to defend both themselves and any resources they are handling.

General Physiological Principles
Stanley S. Hillman, Philip C. Withers, Robert C. Drewes, and Stanley D. Hillyard

This chapter introduces water and ion budgets along with what is known about their physiological control mechanisms. It delineates both thermal and chemical potential energy budgets for amphibians, and discusses the
respiratory cascade for oxygen and carbon dioxide exchange, providing estimates of the variables involved for both diffusive (lungs and tissues) and convective (ventilation and cardiac transport) processes involved in the exchange of these gasses. The chapter concludes with a discussion of blood volume and the variables that control it.

Avoiding Attack
Graeme D. Ruxton, William L. Allen, Thomas N. Sherratt, and Michael P. Speed
Published in print: 2018 Published Online: September 2018
Item type: book

Avoiding Attack discusses the diversity of mechanisms by which prey avoid predator attacks and explores how such defensive mechanisms have evolved through natural selection. It considers how potential prey avoid detection, how they make themselves unprofitable to attack, how they communicate this status, and how other species have exploited these signals. Using carefully selected examples of camouflage, mimicry, and warning signals drawn from a wide range of species and ecosystems, the authors summarize the latest research into these fascinating adaptations, developing mathematical models where appropriate and making recommendations for future study. This second edition has been extensively rewritten, particularly in the application of modern genetic research techniques which have transformed our recent understanding of adaptations in evolutionary genomics and phylogenetics. The book also employs a more integrated and systematic approach, ensuring that each chapter has a broader focus on the evolutionary and ecological consequences of anti-predator adaptation. The field has grown and developed considerably over the last decade with an explosion of new research literature, making this new edition timely.

Amphibian Ecotoxicology
Raymond D. Semlitsch and Christine M. Bridges
in Amphibian Declines: The Conservation Status of United States Species
Published in print: 2005 Published Online: March 2012
Item type: chapter

A recent summary of the current state of understanding concerning amphibian population declines indicates that airborne contaminants are important but that “existing test protocols might be inappropriate” to evaluate their influence. This chapter advocates adopting several
approaches, experimental designs, and analyses that will promote a better understanding of the effects that chemicals can have on individuals, populations, and communities. Explicit incorporation of genetic variation into ecotoxicology studies is perhaps the most ignored yet critical factor for understanding the differential susceptibility of populations. Genetic variation, as measured by life history traits or molecular markers, within and among amphibian populations is well established. However, standard procedures for using multiple populations, parents, or full-sibship families of eggs in toxicological tests are seldom utilized. This chapter proposes a hierarchical approach to understanding genetic variation that incorporates individual, population, and geographic variation into experiments. It also shows how the results of ecotoxicology studies may be linked to conservation efforts for amphibians.

Chemical Communication in Giant Pandas
Ronald R. Swaisgood, Donald Lindburg, Angela M. White, Hemin Zhang, and Xiaoping Zhou

in Giant Pandas: Biology and Conservation
Published in print: 2004 Published Online: March 2012
DOI: 10.1525/california/9780520238671.003.0012
Item type: chapter

This chapter reviews the recent studies revealing the role of chemical communication in regulating many giant-panda interactions. The identity of marking individuals, their sex and reproductive condition, and their social rank in the community are examples of the message that a panda may transmit via scent. The data presented highlights the importance of chemical communication to giant pandas, and suggests useful applications of scent in the conservation and management of the species, in both the wild and in captivity. There is a clear role in the application of chemical communication for captive breeding programs. The chapter also notes that scent communication in the giant panda is more complex than the simple monitoring of scent marks deposited in the environment.
This chapter discusses vertebrate chemoreception and focuses on three important chemosensory systems: olfaction, vomeronasal sense, and gustation. It reviews the basics of diffusion and the factors relevant for the spread of biological signal molecules. It also discusses odorants and detection of chemical stimuli.

The Chemical Stimulus and Its Detection
Heather L. Eisthen and Kurt Schwenk

Tetrapods have three chemosensory organs: a gustatory organ, an olfactory organ, and a vomeronasal organ. These chemosensory organs detect sets of chemical stimuli with differing behavioral significance. This chapter discusses the properties of chemical stimuli and identifies which properties are relevant for detection and perception by chemosensory organs. It discusses volatility, solubility, and polarity, and their role in determining which chemosensory organ detects a given stimulus.

Comparative Anatomy and Physiology of Chemical Senses in Amphibians
John O. Reiss and Heather L. Eisthen
This chapter discusses the structure and function of chemosensory systems in amphibians. It first describes the morphology of larval and adult chemosensory organs and their functions in aquatic and terrestrial environment. It then examines the evolution of chemical senses in amphibians that have secondarily adapted to aquatic lifestyle, such as pipid frogs, newts, and typhlonectid caecilians.

**Comparative Anatomy and Physiology of Chemical Senses in Nonavian Aquatic Reptiles**

Kurt Schwenk

in Sensory Evolution on the Threshold: Adaptations in Secondarily Aquatic Vertebrates

Published in print: 2008 Published Online: March 2012
Item type: chapter

This chapter presents a comparative study of the structure and function of chemical senses of nonavian aquatic reptiles such as turtles, crocodylians (crocodiles and alligators), squamates (lizards and snakes), fossil aquatic reptiles (mosasaurs, phytosaurs, and plesiosaurs), and other aquatic mesozoic reptiles. It also examines the functional and evolutionary patterns of chemosensory adaptations to aquatic environments.

**Comparative Anatomy and Physiology of Chemical Senses in Aquatic Birds**

Tobin L. Hieronymus

in Sensory Evolution on the Threshold: Adaptations in Secondarily Aquatic Vertebrates

Published in print: 2008 Published Online: March 2012
Item type: chapter

This chapter discusses the physiology and behavioral responses of aquatic birds to chemical stimulants. It presents comparisons of aquatic versus terrestrial chemical sensations in aquatic birds. It focuses on avian olfaction, homing and foraging by olfactory cues, avian chemesthesis, and avian gustation. It also examines evolutionary changes in avian chemical senses using fossil records of basal ornithurines and extinct Pelecaniformes, and comparative analysis.
of extant species of Anseriformes, Pelecaniformes, Procellariformes, Gaviiformes, Sphenisciformes, Charadriiformes, and Podicipediformes.

Comparative Anatomy and Physiology of Chemical Senses in Aquatic Mammals
Henry Pihlström

in Sensory Evolution on the Threshold: Adaptations in Secondarily Aquatic Vertebrates
Published in print: 2008 Published Online: March 2012
DOI: 10.1525/california/9780520252783.003.0007
Item type: chapter

This chapter presents a comparative study of the structure and function of chemical senses in aquatic mammals. It first discusses the chemosensory systems of extant species of Monotremata, Didelphimorphia, Insectivora, Carnivora, Sirenia, Cetacia, Artiodactyla, and Rodentia. It then examines the evolution of chemical senses through a comparative analysis of the olfactory organs of semiaquatic mammals and terrestrial mammals.

Causes
Michael Lannoo

in Malformed Frogs: The Collapse of Aquatic Ecosystems
Published in print: 2008 Published Online: March 2012
DOI: 10.1525/california/9780520255883.003.0005
Item type: chapter

This chapter lists the natural and manmade causes of frog malformations. The natural causes of malformations include wounds from failed predation attempts, fish excrement, extreme tadpole densities, lathyrogens, nutritional deficiencies, ultraviolet-B radiation, diseases, temperature, hereditary factors, and parasites. Several manmade causes of amphibian malformations include acidification, radioactive pollution, ozone depletion, heavy metals, retinoids, agricultural chemicals, and xenobiotics. The chapter also discusses the correlation between morphology and cause of malformation type.
Habitats show great variability in their physical and chemical properties, but even so they support a wide variety of animal species. Fluctuations in environmental temperature, salinity, and oxygen levels are normally accommodated by animals without ill effect, unless the changes are large and challenging. If the environmental changes occurring at the animal's exterior were experienced by the cells and tissues within the animal, they would be badly damaged if it were not for physiological systems that maintain relatively constant conditions in the animal's internal environment. The capacity of animals to recognise perturbations of their physiological systems and then restore them to normal is referred to as homeostasis. Sensory systems inform on events or changes in the environment, and responses such as movement, feeding, reproductive behaviour, or escape are orchestrated by the nervous and endocrine systems.

Reproduction and mating behaviour
Jill Lancaster and Barbara J. Downes

Reproduction is essential for populations to persist and for species to remain extant. Fertilisation is internal in the insects so females typically retain eggs internally, and sperm must be transferred from the male to the female reproductive tract. In aquatic insects, mating typically takes place between adults that are terrestrial in habit. This chapter discusses reproductive events up to, and including mating and egg fertilization, beginning with a brief description of the male and female internal reproductive organs and the formation of eggs and sperm. Some species are ready to mate almost immediately after they emerge as non-feeding adults, whereas others require a period of maturation and may feed during this period. How many offspring each female produces (fecundity) may depend on events during the maturation period and also during the larval stage. Inter-individual communication is very
important in finding a suitable mate and this is discussed in the context of the kind of sensory information communicated, including vision, vibrational signalling, and sound and chemical communication. Once a mate has been located, the pair must copulate to transfer sperm; for most species, the male and female separate immediately after copulation, but mating pairs of a few species, especially the Odonata, remain together in post-copulatory mate guarding. Finally, a few species (primarily Ephemeroptera) have done away with males and mating altogether, and the females reproduce parthenogenetically.

Sensory systems—mechano- and chemoreception
Jill Lancaster and Barbara J. Downes

in Aquatic Entomology

Published in print: 2013 Published Online: December 2013
Publisher: Oxford University Press DOI: 10.1093/acprof:oso/9780199573219.003.0007
Item type: chapter

In addition to photoreception, mechanical and chemical signals are major sources of sensory information used by insects and are functionally very important to the autecologies of aquatic insects. Mechanical signals include touch and sound; chemical signals include smell (olfaction) and taste (gustation). In fact, mechanoreception may be the most important source of sensory information for aquatic insects, especially given that poor light penetration in water may limit underwater vision. The sensory organs (sensilla) for mechano- and chemoreception are often small and inconspicuous, but also diverse in structure. This chapter first considers mechanoreception, describing the gross morphology of the major kinds of sensilla, including cuticular receptors (trichoid and campaniform sensilla) and chordotonal organs, and how they work to detect vibrations, waves, and sounds. How aquatic insects use these sensors to perceive their environment and also send mechanical signals to communicate with other insects is discussed in terms of the kinds of signals, including hydrodynamic cues, substrate vibrations and percussion, stridulation, and sounds. Similarly, the discussion of chemoreception first considers the morphology of olfactory and contact chemosensilla and how they work, and then how insects use chemical cues to perceive their environment and to communicate.
Secondary defences
Graeme D. Ruxton, William L. Allen, Thomas N. Sherratt, and Michael P. Speed

in Avoiding Attack: The Evolutionary Ecology of Crypsis, Aposematism, and Mimicry

In this chapter we consider defences that are usually deployed during, or just before, contact between a prey and its predator: so-called ‘secondary’ defences. Secondary defences are found right across the tree of life and therefore come in very many forms, including: 1.) chemical defences; 2.) mechanical defences; and 3.) behavioural defences. Here we review selected examples that provide useful illustrations of the ecological and evolutionary characteristics associated with secondary defences. We discuss costs of secondary defences, placing emphasis on the consequences of such costs, especially as they relate to forms of social interaction. We show also that the acquisition of secondary defences may modify niche, life history, and habitat range of prey animals and review a well-known and significant study of predator-prey co-evolution of defensive toxins of prey and resistance to those toxins in predators. We include a small selection of examples and ideas from the plant and microbe defence literature where we think a broader perspective is helpful. We begin the chapter by considering the evolutionary mechanisms that favour secondary defence evolution.

Orientation and navigation
Hugh Dingle

in Migration: The Biology of Life on the Move

This chapter elucidates the various means that migrants use to find their way. They range from relatively simple orientation to chemical cues to very complex chronobiological interactions between circadian rhythms, sensory inputs, and the brain. Migrants use several cues. They possess the ability to detect magnetic fields and polarized light and have evolved compasses based on these cues and on visible light from the sun and stars. Clock shift experiments demonstrate that migrants can compensate for the movement of celestial bodies across the sky. Cue
conflict experiments demonstrate that migrants use a hierarchy of cues with preferences based on species and situation. Recent neurobiology studies have begun to locate the areas of avian brains specifically functioning in orientation, and biophysical studies suggest that radical pair mechanisms may function in aspects of magnetic field detection. Molecular genetic methods have identified the role of circadian timing genes, for example per, in the ability of the Monarch Butterfly to use a sun compass. The diversity of organisms and their capabilities are discussed throughout.

Research Spotlight: Olfactory Coding In Drosophila Melanogaster
Silke Sachse and Bill S. Hansson

in Structure and Evolution of Invertebrate Nervous Systems
Published in print: 2015 Published Online: March 2016
DOI: 10.1093/acprof:oso/9780199682201.003.0048
Item type: chapter

The chemical senses—taste and smell—are the oldest animal senses. They are characterized by a multidimensional and diverse stimulus space, consisting of many molecules that cannot be classified along any narrow set of dimensions. In the case of the olfactory system, animals detect low molecular weight volatile chemicals (i.e. odorants) with the help of specialized olfactory sensory neurons that express one or a few ligand-binding odorant receptor proteins. Animals cope with the problem of recognizing an extremely large number of different odorants by programming a very large number of functionally different olfactory neurons. Odours activate these neurons and generate characteristic activity patterns across the neuron population, which are relayed to second-order olfactory neurons. The entire available raw information about the animal’s olfactory environment is present in these patterns; however, olfactory information is further processed before it is relayed to higher-order brain centres. Drosophila melanogaster provides an attractive model organism for studying olfaction, as it allows genetic, molecular, and physiological analyses. In recent years, immense progress has been achieved in understanding the olfactory neuronal circuits that underlie the coding and processing of odours in Drosophila. Here, the chapter reviews our present state of knowledge regarding the anatomical architecture of the fly’s olfactory system as well as giving recent insights into the coding strategies of the different neuronal populations involved.