Animal Physiology - Neurobiology

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Neurobiology of Sensory Systems

Our research focuses on the neurobiology of invertebrate sensory systems. Spiders are our main experimental animals. They have outstanding sensory capabilities which they use for the guidance of elaborate behavior. Our main concern is the animal as an integrated being in its species specific environment. In this sense our research is organismic rather than molecular.

Apart from studying the functional principles underlying various sensory systems we have addressed general questions related to signal recognition and localization, and to the sensory mechanisms of oriented behavior and communication. Particular emphasis has been given to the analysis of complex natural stimuli and their relationship to the fine tuning of the sensory systems. Ultimately, we hope to understand the sensory world which our animals see through their highly selective sensory windows and to gain an insight into the reason for the evolutionary existence of these by studying current ecology and adaptedness.

Our experimental approaches include major technical disciplines of modern neurobiology like electrophysiology and neuroanatomy. We also use advanced equipment to measure, analyze, synthesize and apply complex mechanical, chemical, visual, temperature and humidity stimuli and to record and analyze the animals' behavior both in the field and laboratory.

Current Research Projects

Four current research projects all cluster around sensory biology and deal with different spider sensory systems. About 20 people work in our neurobiology unit. These include postdoctoral associates and visiting scientists from abroad, such as the guests from Japan, Germany, USA, Russia, Ukrainia, Spain, France, Slovenia, and India which we had in the recent past. Our interdisciplinary research on the mechanical senses much profits from the collaboration with engineers and physicists.

(i) Spider webs (FG Barth)

The web of orb weaving spiders is a fascinating natural lightweight structure which serves two main functions: to trap insects and to extend the spider's sensory environment. Our project's main concern is to understand how the architectural and the sensory selective pressures have together shaped this remarkable piece of "engineering". Accordingly, we pursue two complementary approaches, one dealing with the physics of the web and the other with the spread of vibratory signals in the web and the spider's ability to use these for the identification and localization of a signal source.

(ii) Air movement detection (FG Barth)

Many arthropods have fine cuticular hairs with which they detect the slightest movement of air. Wandering spiders use such hairs to detect prey. Our research is directed towards an understanding of the fluid mechanics underlying the hair and air

motion under laboratory and complex natural flow conditions. Our long-term goal is to uncover the ways by which information on complex air movement patterns is gained in the sensory periphery and processed by interneurons.

(iii) Visual sense (A Schmid)

The wandering spider used in our lab has eight highly developed eyes. Recent analyses dealt with the fine structure, the optics, the spectral sensitivities, and the differences between the eye types. Our main present concern is to learn about the importance of visual information in spider behavior and to see how this information interacts with information from other sensory systems. The different roles of the principal and secondary eyes have to be specified. Multimodal sensory interaction will be given particular attention.

(iv) Humidity, temperature, and chemical sense (H Tichy)

We have been able to identify moist, dry and warm cells in a spider electrophysiologically. As is known from meteorology, in layers of air close to the ground humidity and temperature change with frequencies of up to 10 Hz. By examining the effect of such and similar changes on the activity of moist, dry and warm cells we hope to understand the functional properties of this sensory system in its relevant ecological context.

The spider male starts courtship upon touching female silk with his pedipalps. The female somehow adds pheromones to her silk, thus signalling readiness for pairing. We currently try to identify both this pheromone and the male receptor cells responding to it.

Teaching

Our neurobiology group is responsible for a lot of teaching: - Introductory Biology - Zoology (L,3h); - Comparative Animal Physiology (nervous, sensory, behavioral) (L,3h); - Comparative Animal Physiology (nervous, sensory, behavioral) (P,8h) - Neurobiology (P,12h); - The Senses of Man (L,2h); - Seminars, varying topics (neurobiology, arthropods, biomechanics, pollination biology); - Colloquium General Zoology (S,2h).

International Cooperations

Several long-standing international cooperations have been particularly important for our recent work: - Dep't of Aerospace and Mechanical Engineering, University of Arizona at Tucson, USA (J.A.C. Humphrey): fluid mechanics; - Dep't of Biology, Yokohama City University, Japan (E. Eguchi): arthropod visual systems; - Dep't of Engineering, Stuttgart University, Germany (K. Linkwitz): light weight structures; - Arizona Research Laboratory Division of Neurobiology, University of Arizona at Tucson, USA (N. Strausfeld): neuroanatomy; - Institut für Organische Chemie, Universität Hamburg, Germany (St. Schulz): pheromone chemistry; - Dep't of Zoology, University of Stockholm, Sweden (D. Nässel): neuromodulators.

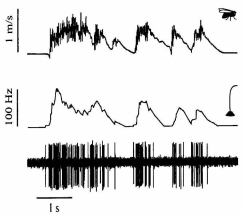

Fig. Response of spider air movement detector (middle and lower trace) to the air flow generated by a flying fly (upper trace)

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