3

The Sensitivity of the Insect Nose: The Example of *Bombyx Mori*

Karl-Ernst Kaissling

Max-Planck-Institut fuer Verhaltensphysiologie. Seewiesen, 82319 Starnberg, Germany
Kaissling@orn.mpg.de

Abstract. The male silkmoth *Bombyx mori* responds behaviourally to bombykol concentrations in air of 3,000 molecules per ml presented at an air speed of 57 cm/s, i.e. the moth is almost as sensitive as a dog. The number of bombykol receptor neurons per antenna is 17,000, about 10,000-fold smaller than olfactory neurons found in dog noses. This high sensitivity is possible due to a very effective capture of odorant molecules and transport to the receptor neurons. The effectiveness of the insect antenna/nose has been determined by using radiolabeled bombykol, counting nerve impulses generated by the receptor neuron, and measuring the behavioural response of the male moth. At the behavioural threshold the neuronal signal/noise discrimination works at the theoretical limit.

3.1 Introduction

For a low olfactory threshold several sensory functions need to be optimized. Odour molecules have to be a) effectively caught by the antenna from the air space, and b) conducted with little loss to the olfactory receptor neurons. c) The odour stimulus has to be most sensitively transduced into nerve impulses, and d) the stimulus-induced impulse firing has to be distinguished from the background of spontaneous impulse discharge from the unstimulated receptor neurons. This paper reviews quantitative work on these items in the male moth of a species which is attracted (i.e. stimulated to walk upwind, Kaissling 1997) by a single chemical pheromone component, (E,Z)-10, 12-hexadecadienol (bombykol) released by the female moth (Butenandt et al. 1959).

3.2 Molecule Capture by the Antenna

To investigate the effectiveness of molecule capture by the antenna we used ^{3}H-labelled bombykol (Kasang 1968; Schneider et al 1968). With a high specific activity of 31.7 Ci/g, or one ^{3}H-atom per four bombykol molecules, about 10^{9} molecules or $4x10^{-13}$ g were required for a measurement in the scintillation counter. The odour source, a 1cm^{2} piece of filter paper (f.p.), had to be loaded with $3x10^{-12}$ g of bombykol in order to induce wing fluttering of some of the moth with a ten-s stimulus. Almost all of the responses occurred within two s. The threshold curve (in % of moths responding within the first two s) covered about 2 decades of stimulus

A. Gutiérrez and S. Marco (Eds.): Biologically Inspired Signal Processing, SCI 188, pp. 45–52.
springerlink.com © Springer-Verlag Berlin Heidelberg 2009

load. Depending on temperature, the time of the day, and the animal origin the 50% threshold was reached at loads between 10^{-11} and 10^{-10} g/f.p. (Kaissling and Priesner 1970).

The fraction of molecules on the filter paper that was released per s, given an airflow of 100 ml/s, was determined with loads of 10^{-8} to 10^{-4} g/f.p. The fraction was 1/60,000 at 10^{-8} and 10^{-7}g/f.p. This value was extrapolated for the load at the behavioural threshold. In our setup the concentration of stimulus molecules decreased on the way from the outlet of the airflow system to the antenna. The fraction of molecules released from the filter paper that was adsorbed on the antenna was 1/150, determined with loads of 10^{-6} g/f.p., or higher.

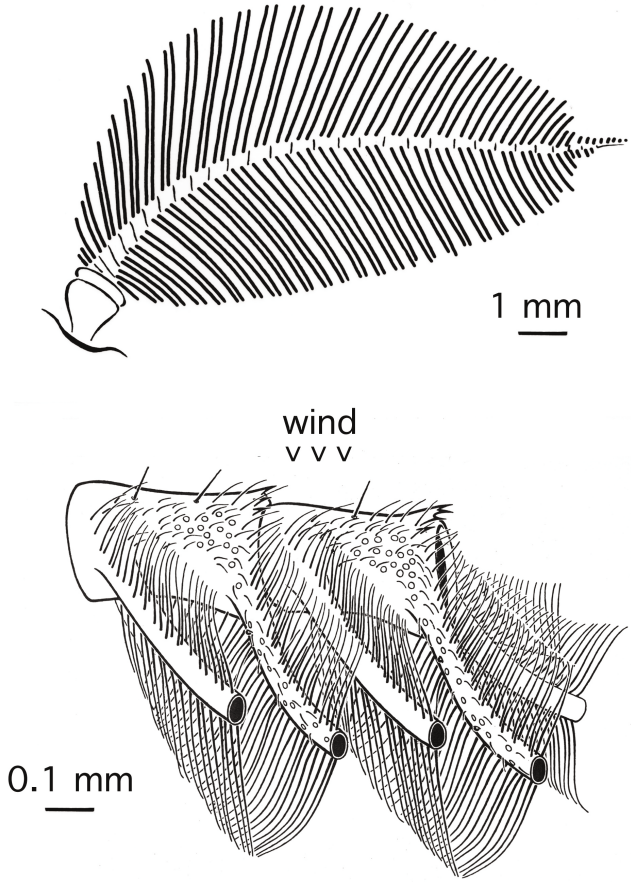

Fig. 3.1. Antenna of the male saturniid moth Antheraea polyphemus. Upper panel: Schematic view of the antenna. Each antennal stem segment has four side branches. Lower panel: Two antennal segments enlarged with different types of sensilla. The numerous, long olfactory hairs contain two or three receptor neurons responding to two or three components of the female pheromone.