Changes in the levels of acetylcholine and histamine in the rat brain under various conditions

Treatment	Acetylcholine Cerebral hemispheres	Brain stem (μg/g of fresh tissue[a])	Histamine Cerebral hemispheres	Brain stem
Controls	2.88 ± 0.07	3.23 ± 0.07	1.77 ± 0.07	1.89 ± 0.07
Electrical stimulation[b]	1.71 ± 0.06 (−37)	2.05 ± 0.04 (−39)	2.18 ± 0.03 (+23)	2.40 ± 0.02 (+27)
Pysostigmine[b]	3.39 ± 0.03 (+18)	3.91 ± 0.03 (+21)	1.90 ± 0.07[c] (+7)	2.36 ± 0.03 (+29)
Electrical stimulation + Physostigmine	2.20 ± 0.05 (−24)	2.70 ± 0.07 (−17)	3.02 ± 0.04 (+70)	3.50 ± 0.06 (+85)
L-Histidine	2.81 ± 0.08[c] (−3)	3.12 ± 0.05[c] (−4)	2.05 ± 0.03[d] (+16)	2.58 ± 0.03 (+37)
Parathion	4.50 ± 0.08 (+56)	5.92 ± 0.08 (+52)	2.43 ± 0.04[e] (+32)	2.54 ± 0.05[e] (+35)
L-Histidine + Parathion	4.48 ± 0.16 (+55)	5.82 ± 0.18 (+51)	4.05 ± 0.03 (+128)	4.81 ± 0.10 (+153)

[a] Mean ± S.E. for 8 experiments. All values for treated groups are different from controls, $p < 0.001$, except where indicated. In brackets percent change of controls. [b] Different from electrical stimulation + Physostigmine, $p < 0.001$. [c] Not different from controls, $p > 0.05$. [d] Different from controls, $p < 0.01$. [e] Different from L-Histidine + Parathion, $p < 0.001$.

Further details will be published elsewhere as part of a multi-assay technique[13].

Results and discussion. Electrical stimulation induces a depletion of brain acetylcholine, which is accompanied by a concomitant increase of brain histamine in comparison with controls (Table). Acetylcholine depletion, presumably occurring through an accelerated release of the neurohumor from store sites[9–12], might bear a relationship with the increase of histamine. Treatment with cholinesterase inhibitors (physostigmine salicylate, 0.2 mg/kg i.p., 30 min before sacrifice, or an equimolar dose of parathion) induced a significant increase in the levels of both acetylcholine and histamine in the cerebral hemispheres and brain stem of the rat, exception made for histamine in the cerebral hemispheres when physostigmine was employed, where the change was not significant. The latter finding is possibly related to a slower rate of synthesis of histamine in the hemispheres as compared with the brain stem in the various experimental conditions. Free acetylcholine seems to be promoting an increase in the levels of histamine in the brain. Treatment with parathion showed more marked increments of both neurohumors, which is in agreement with its more potent cholinesterase inhibition[14].

Physostigmine plus electrical stimulation (the drug given 25 min before the stimulation) induced a considerably higher rise of histamine than the one found with either treatment alone. The levels of acetylcholine went below those found with physostigmine alone or in the control group, but remained higher than those found with electrical stimulation alone, as if the acetylcholine released during central nervous system stimulation, and accumulated because of cholinesterase inhibition, enhanced in some way to a larger extent the synthesis and/or the accumulation of histamine.

Administration of L-histidine (1000 mg/kg, i.p., 1 h before sacrifice) induced an increase in the histamine levels with no change in the acetylcholine levels. When parathion was administered half an hour after the administration of L-histidine, the combined treatment induced a similar increase in the acetylcholine content to that found with parathion alone; however, the increase in the histamine content was considerably higher than that found with either treatment alone, as if the increased concentration of free acetylcholine were enhancing the synthesis of histamine from L-histidine.

All these findings strongly suggest that the brain acetylcholine released during central nervous system stimulation is triggering a mechanism to accelerate the synthesis of brain histamine in vivo, since it is not likely that histamine might be mobilized from somewhere else in the body[15].

Résumé. Pendant l'excitation du système nerveux central chez le rat, un mécanisme cholinergique augmente l'histamine cérébrale.

H. A. Campos[16] and H. Jurupe

Laboratory of Pharmacology,
University of San Marcos Medical School,
P.O. Box 2694 Lima (Peru), 10 November 1970.

[13] H. Jurupe and H. A. Campos, submitted for publication.
[14] G. B. Koelle, in *The pharmacological Basis of Therapeutics* (Eds. L. S. Goodman and A. Gilman; The Macmillan Comp., New York 1965), chapter 22.
[15] B. N. Halpern, Th. Neven and C. W. M. Wilson, J. Physiol. *147*, 437 (1959).
[16] Present address: Department of Pharmacology, Vargas Medical School, Central University, P.O. Box 6750. Caracas (Venezuela).

Behavioural Aspects of the Extraocular Light Sense of *Urodacus*, a Scorpion

An extraocular light sense has been demonstrated electrophysiologically in the Australian scorpion, *Urodacus*[1]. An indication was also given that the eyes are not necessarily involved in some forms of light dependent behaviour; the present paper continues this line of enquiry.

Urodacus is a nocturnal animal. During the day it withdraws under stones or in its burrow to emerge after sunset and remain active during the first few hours of the night. These two aspects of its behaviour, negative phototaxis and nocturnal activity, were chosen for an assessment of the relative importance of eyes and extraocular light sense.

Withdrawal. Animals in half-darkened Petri dishes withdraw from the exposed to the darkened half (Table).

This response is not always immediate, especially when the animals have been handled repeatedly, and the dishes were therefore scored at least 4 h after the animals had been shaken into the exposed half. In a second experiment the median and lateral eyes were painted over with opaque paint; the withdrawal response was not impaired.

This may be due to the extraocular light sense or else to temperature differences in the two halves of the dish. Scorpions are known to have thermoreception, both on behavioural[2] and neurophysiological evidence (personal observations). Since the spectral sensitivity of the extraocular light sense is known[3], the two possibilities can be distinguished by the use of appropriate light filters.

The Petri dishes with the blinded scorpions were so placed under a glass tray that they only received light through a layer of liquid placed in the tray. $CuSO_4$ passes all the wavelengths visible to the receptors (Figure 1) but excludes all infrared. Under these circumstances the withdrawal response still operates (Table). In a complementary experiment a solution of orange G was used which filters out all light visible to the scorpion: the animals now lost all possibility of choice, although the illumination levels had been matched with a thermopile.

Role of extraocular photoreception in the withdrawal response of *Urodacus*

Eyes	Illumination	Side chosen: exposed	shaded
Functional[a]	natural	2	38
Painted[b]	natural	2	30
Painted[c]	blue } matched	10	40
Painted[d]	yellow } energies	22	22

[b, c] $p > 0.1$. [c, d] $p < 0.001$. [b, d] $p < 0.001$.

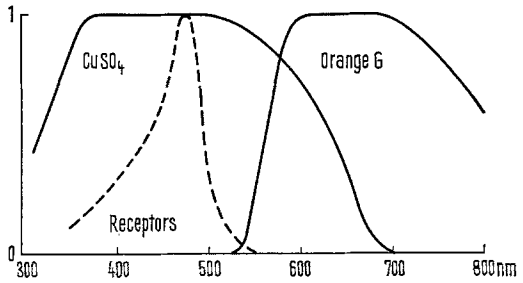

Fig. 1. Transmission spectra of filter solutions and spectral sensitivity of extraocular photoreceptors of *Urodacus*.

The difference in the effects of equal energy blue and yellow lights is only apparent at low intensities. In brighter daylight the animals choose the dark half even under the yellow filter. This may be due to the fact that orange G transmits well up to 2000 nm in the infrared. While the energies were matched with heat-filtered light, the experiments made use of the full range of natural diffuse daylight. Consequently, at higher intensities enough infrared may have reached the animals to enable them to respond. Although the scorpions are sensitive to thermal radiation, this is less effective than visible light of equal energy[1] and may therefore fail as a cue at lower intensities.

Activity. The locomotor activity was recorded by placing the animals in little treadmills and counting the revolutions photoelectrically. The characteristic pattern consists of almost complete inactivity during the day, followed by a burst of activity beginning at sunset and lasting for the first hours of the night. This pattern persists at constant temperatures but fades away after about 3 days in continual darkness.

For our present purpose it is sufficient to consider the onset of activity at dusk (Figure 1). Only the 4 h preceding and those following the transition are plotted; the values for relative activity indicate the number of revolutions compared with the maximum counting capacity of the apparatus. Counts were begun 3 days after the experimental treatment, when it had reached its full effect. Painting the eyes of the scorpions did not result in a pattern similar to that caused by continual darkness. The onset of activity of the blinded animals may be less sudden than that of the controls, but a comparison of the relative activities before and after dark makes the picture clear: untreated animals 0.13 to 0.87; dark animals 0.47 to 0.53; blinded animals 0.19 to 0.81.

Finally, some blinded animals were run under a $CuSO_4$ filter; this did not abolish the activity burst. The nocturnal activity period is therefore not controlled by infrared cues, but by visual ones which, in the absence of functional eyes, can be received by the extraocular light sense.

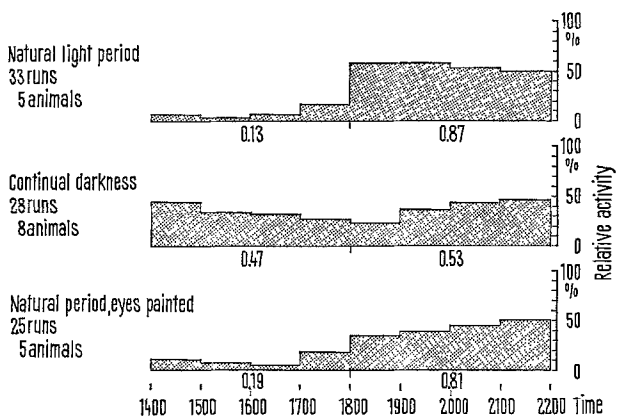

Fig. 2. Actograms of *Urodacus* for 4 h before and 4 h after the onset of normal nocturnal activity.

Zusammenfassung. Nach Ausschaltung der Augen vermag der Skorpion *Urodacus* zwei Formen lichtabhängigen Verhaltens aufrechtzuerhalten (negative Phototaxis und Aktivitätsrhythmus). Dies geschieht mit Hilfe des bereits beschriebenen extraokulären Lichtsinnes.

K. T. ZWICKY

Department of Zoology, University of Western Australia, Nedlands 6009 (Western Australia), 24 October 1969.

[1] K. T. ZWICKY, Life Sci. *7*, 257 (1968).
[2] A. J. ALEXANDER and D. W. EWER, J. Exp. Biol. *35*, 349 (1958).
[3] K. T. ZWICKY, Experientia *26*, 317 (1970).