

## BIOLOGY

### Ultrasound in Adult Rodents

PRODUCTION of ultrasound by baby rodents has been reported by Zippelius and Schleidt<sup>1</sup> in *Apodemus f. flavicollis* Melchior, *Mus musculus domesticus* Ruddy, and *Microtus a. arvalis* Pallas, and by Noirot<sup>2,3</sup> in baby mice, *Clethrionomys glareolus* Schr., *Mesocricetus auratus* Waterhouse and albino rats. I have now confirmed this phenomenon for the young of *Clethrionomys*, *Mesocricetus* and laboratory rats and mice, and extended it to the young of *Acomys cahirinus* (Desmarest), *Meriones shawi* Rozet, *M. unguiculatus* Milne-Edwards, a species of *Gerbillus*, *Apodemus sylvaticus* (L.), *Mus minutoides* and a species of *Thamnomys*.

In earlier reports ultrasound emission in the species studied ceased on the day on which the eyes opened. I have found, however, that in *Mesocricetus*, *Acomys*, *M. shawi* and laboratory rats ultrasound can be elicited, by handling, after the eyes of the young have opened. In laboratory rats, emission of ultrasound has been followed well into adult life. A continuation of juvenile behaviour due to daily handling can be eliminated, because out of ninety-one adult rats taken at random from normal departmental stock, forty-eight (approx. 53 per cent) produced ultrasound.

Ultrasound was monitored visually on an oscilloscope using a capacitance microphone and wide-band amplifier, and, at the same time, audibly by a "bat detector" as described by Pye and Flinn<sup>4</sup>. Samples of the pulses were recorded directly on magnetic tape. Two distinct types of pulse were produced by these adult rats: "short pulses", of length 30–60 msec at a frequency of about 50 kc/s, were produced by thirty-eight animals when handled; "long pulses" lasting up to 700 msec at about 22 kc/s were produced by twelve animals without handling. Two animals gave both types of pulse.

To elicit short pulses from older rats, they were rolled on their backs and restrained in positions resembling the full submissive posture of rats as described by Grant and MacKintosh<sup>5</sup>. This suggested that ultrasound might be associated with aggressive or submissive responses. To test this, one male rat, previously isolated for 10 days, was introduced into the cage of another, and the actions and postures of the animals, together with the types of pulse produced, were noted for 1 h. Forty different introductions were studied in this way; attacking and fighting occurred in many cases.

Short pulses were heard in every case except one. Long pulses were heard in twenty-six cases and could always be correlated with the long exhalations often shown by the submissive rat. Such abnormal respiration is probably that referred to by Seward<sup>6</sup>. Although the long pulses were initially associated with a submissive or crouch posture<sup>5,7</sup> they were sometimes heard later when the same animal was feeding or cleaning. In only three introductions were long pulses followed by any sort of conflict, actual fighting or boxing. It was difficult to see which animal was producing the short pulses, although sometimes they were synchronous with the head shaking of the aggressive rat as it left the submissive one after typical aggressive postures. Short pulses were often heard during all phases of aggressive behaviour, including fighting, except when the animals were in full aggressive-submissive posture or when one animal was grooming the other. These short pulses were also detected while activities such as feeding, cleaning and sniffing the cage (often occurring as obvious displacement activities) were performed.

In similar conditions of introduction, long and short pulses were detected from male rats (*Rattus norvegicus*) which had been trapped in the wild. No attacking or fighting was seen and in three out of seven introductions both animals remained "frozen" and silent for the whole hour. Short pulses, heard in two other cases, were associ-

ated with one animal approaching and sniffing the other. Long pulses, heard in four cases, were always associated initially with a submissive or crouch posture. One rat produced long pulses for 30 min after the other had been removed.

Many short pulses were detected when male rats were introduced into the cages of lactating or pregnant females, which are noted for increased aggressiveness. In one case these pulses could definitely be associated with the lactating female, for they continued after both her litter and the male had been removed, and were repeatedly obtained by disturbances up to 25 min later.

Short pulses at 50 kc/s were also detected when wild and laboratory males attempted to mount laboratory females or other males. Similar signals were found during intraspecific fighting between adults in *M. shawi*, a species of *Gerbillus* and a species of *Thamnomys* and from a disturbed lactating female *M. unguiculatus* while she thumped one hind foot on the ground. Pulses at 70 kc/s have been heard from mice of Noirot's impure strain, during attempted mounting and sniffing of either sex by males.

These observations suggest that ultrasound plays an important part in the social life of these adult rodents. So far the short pulses seem to be aggressive and the long pulses submissive. Certain aspects of this work including analyses of the ultrasounds and correlation with particular behaviour patterns will be reported in more detail later.

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<sup>1</sup> Zippelius, H. M., and Schleidt, W. M., *Naturwissenschaften*, **43**, 502 (1956).

<sup>2</sup> Noirot, E., *Annls. Soc. r. Zool. Belg.*, **95**, 47 (1965).

<sup>3</sup> Noirot, E., *Anim. Behav.*, **14**, 495 (1966).

<sup>4</sup> Pye, J. D., and Flinn, M., *Ultrasonics*, **2**, 23 (1964).

<sup>5</sup> Grant, E. C., and MacKintosh, J. H., *Behaviour*, **21**, 246 (1963).

<sup>6</sup> Seward, J. P., *J. Comp. Psychol.*, **38**, 175 (1945).

<sup>7</sup> Grant, E. C., *Behaviour*, **21**, 240 (1963).

### Circadian Periodicity of Blood Amino-acids in Adult Men

THE term circadian was introduced by Halberg<sup>1</sup> to describe a recurring sequence of events with a cycle of approximately 24 h, and the present knowledge of human circadian rhythms has been reviewed recently by Mills<sup>2</sup>. The circadian periodicity of a large number of constituents of blood, plasma, and urine has been described. Although a diurnal periodicity of whole blood amino-acids in man, in which concentrations at 2000 h were consistently greater than those at 0800 h on the same day, has been noted in this laboratory<sup>3</sup>, there were insufficient sampling times to establish a circadian pattern. A circadian periodicity of serum amino-acids in growing chickens<sup>4</sup> and whole blood tryptophan in mice<sup>5</sup> has been reported. We report here a circadian periodicity of whole blood and serum amino-acids in healthy adults.

Six healthy male volunteers, aged 20–23 yr, were placed in a hospital ward and subjected to uniform conditions of diet and activity. The subjects were informed of the nature and details of the investigations before they volunteered. Each subject was determined to be in excellent health by a check of his medical history, by a physical examination and by baseline laboratory determinations. Venous blood samples were collected at intervals of 4 h beginning at 0800 h on the day of admission and continued for 5 consecutive days. Amino-acids in 0.006 ml. of whole