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What is This?
NOISE AS AN ENVIRONMENTAL PROBLEM IN THE ANIMAL HOUSE

by

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SUMMARY

Audiogenic seizures, changes in parameters of the stress syndrome, and disturbance of acoustic communication in rodents are discussed as possible harmful effects of noise and evaluated in regard to standards published in Germany for man. These standards are insufficient to protect laboratory animals from ultrasound, to which rodents are very sensitive. Neither do they give sufficient protection for many experiments, since some physiological parameters of the stress syndrome may be influenced by levels of noise less than that regarded as acceptable for man.

Great efforts are made in laboratory animal science to achieve a high degree of standardisation of genetics, nutrition, and microbiological environment. Temperature, humidity, and light—as parts of the physical environment—are more or less well standardized, but little attention has been paid to noise.

This review of literature is intended to help evaluate the noise environment of laboratory rodents, and the need for and usefulness of standardisation. The standards for noise that are observed in the construction of laboratories and animal houses are compared to the bio-acoustic peculiarities of laboratory rodents.

The only relevant standards available in the FRG are the critical values for noise at places of work published by the Union of German Engineers (Verein Deutscher Ingenieure, 1960). These recommendations aim at the protection of man from the harmful effects of noise, a danger one is well aware of (Beranek, 1966; Cohen, 1968; Jansen, 1971; Klosterkötter & Gono, 1971). They allow a constant level of perceived noise of 70 (DIN) phon in offices and comparable work places, and they declare 90 phon as the highest tolerable constant loudness level during many kinds of work. Higher levels may be tolerated, but only for short periods.
The Verein Deutscher Ingenieure (1960) refers to 'loudness-level' as the physical property that makes noise dangerous, and say nothing about tolerable frequencies. Generally the higher the frequencies the more dangerous the noise (Wisner 1967). It is open to doubt whether observance of the values recommended for man is sufficient to protect laboratory animals. Rodents have quite a different spectrum of audible sounds (mouse and rat 30 000 Hz), with maximum sensitivity at frequencies which are inaudible to man (Heffner, Heffner & Masterston, 1971; Miller, 1970; Heffner, van Oeveren & Masterston, 1971; Ralls, 1967; Gould & Morgan, 1941; Berlin, 1963; Gourevitch & Hack, 1966; Schleidt, 1952; Sewell, 1968). Man can perceive frequencies from 18-18 000 Hz, the frequencies from 400-4800 Hz being important for speech (Wisner, 1967). Rodents not only produce sounds we can hear, they also produce and hear frequencies which are inaudible to us, perceiving sounds up to 80 000 Hz. The ability to perceive ultrasound widens the spectrum of noise which could be noxious to frequencies we hardly ever think of.

Fig. 1 shows the different threshold curves of man and Mus musculus. Comparison makes clear the difficulties of evaluating the influence of noise on man and animal, which are increased by the fact that acoustic signals can trigger off psychosomatic reactions in rodents. Rodents, especially rats, have an intense sound communication system (Sewell, 1968; Anderson, 1954) where background noise is an important factor (Tembrok, 1968). The acoustic background in the animal house is very different from that against which the communication system evolved.

It is known that in order to be perceived by a rat a pure tone accompanied by background noise must be louder than if without one (Irwin, 1970). A noisy background can presumably disturb the acoustic communication of the rat in the same way that a noisy surrounding disturbs a telephone call (Beranec, 1966; Verein Deutscher Ingenieure, 1960).

The rat possesses a set of acoustic signals (mainly ultrasonic) which are exactly defined in frequency and duration (Sewell, 1967; Sewell, 1970), and which seem to be of importance in its social life. Infant rats and mice produce sounds that make the mother come and fetch them back to the nest. These sounds also block the aggressiveness of the mother towards animals outside the nest (Noirot, 1966; Allin & Banks, 1972), and are widely used in the demonstration of dominance and submission (Sales, 1972). A signal of 22 kHz and 700 ms duration expresses the wish to avoid contact and confrontation, and may be associated with a submissive attitude. Male rats also utter this signal during the refractory period following ejaculation (Barfield & Geyer, 1972). Many encounters between rats of different social rank are...
Fig. 1. Threshold curves of audibility for man (a)* and Mus musculus (b)†. For clarity a linear rather than the usual logarithmic scale has been used for the abscissa.


avoided by uttering appropriate signals, so making social life much easier for the animals (Sales, 1972).

HARMFUL EFFECTS OF NOISE ON LABORATORY RODENTS

Among the harmful effects of noise on man, hearing loss has received the greatest attention. In laboratory animals, neuro-endocrinologic disturbances are of much greater importance and must be considered first in the evaluation of a noise background. The most important disturbances of that kind are audiogenic seizures and alteration of parameters of the stress syndrome.
Audiogenic seizures

The phenomenon of audiogenic seizures in mice is well known, although there seems to be no published report of their incidence at loudness levels below the values defined by the Verein Deutscher Ingenieure (1960). The occasional sharp, loud noise may provoke, or may work as primer for, such seizures (Iturrian & Fink, 1968; Lane-Petter, 1963; Henry, 1967).

Some mouse strains or strain sublines (DBA/2J, C57, AKR, BALB, CBA, and others) are particularly susceptible to such seizures (Lehmann, 1971; Fuller, Easler & Smith, 1950; Henry & Bowmann, 1969, 1970). In these animals noise can provoke all stages of the syndrome—wild running, clonic seizures, tonic seizures, death—or it can sensitize the animals for audiogenic seizures. This priming is only effective during certain periods of life, and can also operate in mouse strains or sublines that have no disposition towards audiogenic seizures. In animals with an inherited disposition the danger of spontaneous seizures decreases with age (Takahashi, Tanaha, & Yamauchi, 1969). Such animals may not be susceptible to acoustic priming during the first weeks of life, but with decreasing occurrence of spontaneous seizures priming becomes effective—in DBA/2J mice at the age of 4 weeks (Henry & Bowmann, 1969).

Henry, Thompson & Bowmann (1971), working in the range 5-17 kHz, 110 dB, 60s, showed that higher frequencies are more likely to cause seizures. It is of interest that exposure to high frequencies also increases the susceptibility to low ones (Henry & Bowmann, 1969).

The production of occasional high-frequency noise in animal houses and laboratories is not uncommon—repair work, cage-washing and other machines, metal items knocking together, etc. Where the noise stress is continuous, susceptibility to seizures decreases (Takahashi et al., 1969).

The rat is also susceptible to audiogenic seizures (Bevan, Hard & Seal, 1951; Wada & Asakura, 1970).

Alteration of parameters of the stress syndrome

The stress reaction triggered off by noise is of greater importance to the experimenter, and noise-stress is recognised as a good model for studies on the adaptative response pattern (Hrubés & Benés, 1965).

The reaction of parameters of the stress syndrome on noise have been frequently recorded (Henkin & Knigge, 1963; Anthony, Ackermann & Lloyd, 1959; Thalken, 1971; Takemaro, 1966; Miyui, 1968; Pushkina & Svadkovskaya, 1967; Hrubés & Bénes, 1965; Jonek, Stanosek, Kranze & Wacławczyk, 1965). The noise level in animal houses and laboratories is, at least occasionally, sufficient to act as a stressor.
The adrenal stress-response to noise has 2 aspects, the medullary adrenaline and noradrenaline responses involving circulatory alterations and metabolic responses (catabolism of glycogen and a rise in the level of the free fatty acids), and the anabolic effect of the cortical hormones on liver glycogen and its side effects (ascorbic acid levels in the adrenals, eosinopenia, liver glycogen deposition). These effects are linked in the stress-response pattern, but subdivision might help to give an answer to the problem of adaptation to noise stimuli. Not all human beings are equally sensitive to noise, but whether sensitive or tolerant, alterations in the circulation occur on exposure to noise, alterations that closely resemble the effects of adrenaline (Lehmann & Tamm, 1956; Fuchs-Schmuck & Vogel, 1970). They are pronounced after exposure to noise of more than 80dB, but minor alterations can be observed at sound pressures as low as 55dB. No adaptation to noise is observed when such parameters are investigated (Jansen, 1961, 1971), although the steroid response does show adaptation (Anthony et al., 1959).

Parameters that are linked to the adaptative response pattern are clearly influenced by noise. For example, in the rat a sudden rise in sound pressure from 60 to 70 dB(20-4800 Hz) caused a decrease in circulating eosinophils of 50%, and a rise from 60 to 93dB was followed by a drop in the eosinophil count of 65%. After 1 h the number of cells had risen but was still only 70% of the control value (Geber, Anderson & van Dyne, 1966).

Apart from these stress reactions to loudness-levels that are readily tolerated by man at his place of work, louder noise, even when short in duration, can cause enormous alterations. After 28 weeks of 95dB at 500-5000 Hz for 2 × 5 min per day, changes in the behaviour of rats, mainly a pronounced aggressiveness, were observed. In several cases the noise induced seizures. The most surprising findings were cortical and subcortical lesions that were in 60% of all cases classified as grave (Nitschkoff, Kriwitzkaja & Gnüchtel, 1967).

CONCLUSIONS

It is obvious that the DIN standards on noise mentioned above are not sufficient to overcome the hazards to animals and to experiments that may arise from uncontrolled background noise. The standards do not, of course, take into account the bioacoustic peculiarities of laboratory rodents. We know that sudden noise of more than 70 DIN phon can be tolerated by men at work, but it can act as a stressor and might even trigger audiogenic seizures in laboratory animals. The repeated induction of stress reactions can be important in many experiments, in most cases contributing to non-specific disturbances of metabolic parameters. Since animal houses and laboratories have many uncontrolled noise sources, and rodents are so sensitive to noise, it is surprising that there is so little definite information about the
full significance of noise in the housing of laboratory animals. Its effects on
breeding performance and general well-being should perhaps not be over-
estimated, since mice and rats have been bred successfully in laboratories for
many years. But it may be that selection has eliminated animals that were
especially sensitive to noise.
Since doubling the intensity of a noise causes an augmentation of the
loudness level of 3 phon the disturbing effect of sudden noise can be greatly
reduced by a constant background noise. In some animal houses loudspeakers
playing music or ‘white noise’ are used for this purpose. This is justified
because changes in the background noise are more dangerous than a constant
noise level, but there is no information about the effect of such an unphysio-
logical noise background on the acoustic communication of rodents. Since
the usefulness of an artificial noise background is limited by the frequencies
and loudness level of the noise we want to cover, it would seem advisable to
define and measure them first.

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