GEOTROPIC ORIENTATION OF YOUNG MICE.

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I.

The upward geotropic orientation of young rats can be described by simple mathematical expressions (Crozier and Pincus, 1926, 1926-27, a, b; Pincus, 1926-27). In essence these formulae also apply precisely for the geotropism of invertebrates (Wolf, 1926-27; Crozier and Stier, 1927-28; Wolf and Crozier, 1927-28). It seemed important to repeat with young mice the initial experiments with rats (Crozier and Pincus, 1926-27, a), partly as an independent test of the general results and in further part to investigate objectively certain sources of variation inherent in data obtained as averages from observations upon numerous individuals.

Young mice proved to be not such good material for these experiments as the rats. Their creeping is more irregular, interrupted. The stock used was not of a genetic homogeneity comparable to that of the rats (loc. cit.), having been inbred for but four generations. The extent of average upward orientation on an inclined plane is nevertheless found to be a definite function of the active gravitational component, and the results are, in fact, closely comparable to those earlier secured.

II.

Members of three successive litters (seven individuals) from the same parents were tested from 9 days after birth until the eyes opened. They were allowed to creep upon an inclined board on which was a tightly stretched, close wire mesh, to afford good footing. They were at first observed under red light. In preliminary tests the paths taken were recorded by chalk on the wire mesh and the angle of upward orientation (θ) was measured with a protractor. The mice were dark-adapted before readings were taken.
It was found that the mice would generally move for only short distances before “hesitating” and swinging about a great deal, then continuing again. It was thought that the heat from the red lantern, or the red rays, might disturb the geotropism, and they were accordingly observed in darkness. Small dots of luminous paint were placed in a line on the back of each animal. Sheets of paper, on which were ruled horizontal lines, were pinned at one side of the board. The movements of the mice were recorded with pencil by placing a ruler on the paper parallel to the path of the animal. The ruler had a very slightly luminous edge, which was kept shielded from the mouse. Every upward movement of the mouse of more than about 5 cm. was recorded. The sequence in which the trails were recorded was noted by numbering each path on the paper. From fifteen to thirty readings were taken at a time with each mouse. Where the mouse was brought back to the bottom of the board a new trail was begun. One run up the length of the board would give from two to five readings. The mice were started at the bottom of the board, each time headed downward. The purpose of this was to try to determine any general or progressive sequence in variation of orientation. Record was kept of the ages and hours of experimentation for each individual mouse. Detailed study of the orientation angles as obtained in successive tests showed no systematic effect of fatigue, growth, or training. Values of \( \theta \) gotten by the second method were found to agree well with those secured in the initial experiments under red light. Variability of response seemed definitely increased just before the opening of the eyes.

III.

Over 800 readings were taken with mice from one cage. The results are summarized in Table I. Below an inclination of the board of 20° (\( \alpha \)) there was no definite upward orientation. Above \( \alpha = 20^\circ \) practically all movements were upward. The tilt was gradually increased to 70°. Above 50° there seemed to be no further upward orientation. The precision of orientation, inversely expressed by the probable error, increased with \( \alpha \).

The average angle of orientation, \( \theta \), as an empirical relationship, is directly proportional to the logarithm of the sine of the angle of the creeping plane:

\[
\theta = k \log \sin + C
\]
This relationship is shown in Fig. 1, the points falling almost on a straight line, within the limits of ± 3 times the probable errors of the means, except that above 50° there is no further upward orientation of the mice.

The clarity of this relationship is not so great as with the rats (Crozier and Pincus, 1926–27, a, b), which is undoubtedly due to the lesser uniformity of the material and to the inhomogeneity of the averages resulting from the inclusion of readings from a number of individuals at different times. As was previously pointed out, the

mice do not offer intrinsically as good material. They were not from as uniform a genetic strain, the mode of progression is not so favorable, and data from a number of individuals (seven) were averaged together. Indeed, it was found that a larger number of qualitatively similar readings from later experiments with mice of the same strain, but not litter mates, could be averaged in without materially affecting the results. Furthermore, every movement of the mice was recorded. It is obvious to the observer that at times certain outside influences tend to throw the mouse off its path; slipping on the board,
FIG. 1. Between 20° and 50° inclination of the plane of creeping the limitation of upward orientation of young mice is proportional to the logarithm of the gravitational component. Data (827 readings) in Table I (see text). The plotted bars are centered on the means and the vertical extent = 2 P.E.

FIG. 2. The precision of orientation, as measured by the proportionate scatter of the readings, increases in proportion to log sin α, up to 50°. At higher inclinations mechanical difficulties impede precise orientation, and the variability increases.
running into an obstacle, and the like. Hence the variability of orientation was increased by not discounting certain runs. The precision of the measured angles of orientation may be estimated by the coefficients of variation, taken as the probable errors of the means for the first forty readings expressed as percentages of the means. The P.E. of the mean $\theta$ decreased steadily as $\alpha$ increases. The values of $\text{P.E.}_m/m \times 100$ decrease linearly with log sin $\alpha$, as found with the

![Graph](image)

**Fig. 3.** As previously found for rats, $\cos \theta$ decreases linearly with increase of sin $\alpha$, up to 50°.

rats. Above $\alpha = 50^\circ$ the angle $\theta$ exhibits increased variability, absolutely and proportionately. This is presumably due in large part to mechanical difficulties in maintaining foothold, such that the average value of $\theta$ seems not to be increased above $\alpha = 50^\circ$ (cf. Fig. 2).

Again, as with the rats, $\cos \theta$ decreases linearly as sin $\alpha$ increases. This is made evident in Fig. 3.
SUMMARY.

The geotropic orientation of young mice, on a plane at angles between 20° and 50° to the horizontal, obeys the equations previously found for young rats by Crozier and Pincus (1926–27). When the individuals tested in such experiments are not of the utmost uniformity, the variability of the measured orientations is increased.

CITATIONS.