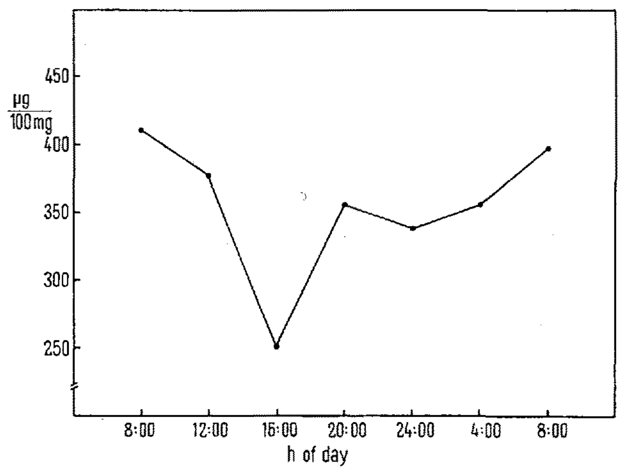
These results indicate that there is a diurnal variation in the adrenal ascorbic acid concentration. It is interesting to note that the depletion of adrenal ascorbic acid occurred at 1600 h, since other investigations have shown that the corticoid level in the blood of the rat[5], and also of the mouse[4], is at its highest at this time. This tends to support the theory that the adrenal ascorbic acid concentration is a good indicator of adrenocortical activity and that it may be of importance in the synthesis and/or release of corticoids[8,11]. From the practical point of view, too, it is useful to know that a reduction of this order occurs in the concentration of adrenal ascorbic acid in the afternoon. As a result, critical experiments by which depletion of adrenal ascorbic acid is induced should, wherever possible, be carried out during the morning.



Daily change in adrenal ascorbic acid concentration of the rat.

The increase in the weight of the adrenals noted at midnight is in conformity with observations that the number of mitoses in the adrenal cortex is highest at this hour[4,7]. Evidently there may be a time lag between adrenocortical activity (indicated by increased corticoid level of the blood and by adrenal ascorbic acid depletion) and cortical hyperplasia (indicated by increased number of mitoses in the cortex and increased adrenal weight).

As for the similarity between the diurnal rhythm of the adrenal cortical function in man and in the rat, a temporal difference is noted. The human adrenal function is at its highest in the morning[1-3]. The fact that the rat is a nocturnal animal has been put forward as an explanation for this difference[4,5].

Previous reports suggest that the nervous system is the site of the regulator primarily responsible for the diurnal cyclicity of adrenocortical activity[12,13].

Zusammenfassung. Der tägliche Rhythmus des Ascorbinsäuregehalts in den Nebennieren von Ratten wurde untersucht. Es wurde beobachtet, dass der Ascorbinsäuregehalt um 16 h nachmittags am geringsten ist. Das absolute Gewicht der Nebennieren wiederum ist in der Nacht gegen 24 h am höchsten. Bei praktischen Arbeiten ist dieser Abfall im Ascorbinsäuregehalt der Nebennieren am Nachmittag zu berücksichtigen.

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Magnetic and Photic Responses in Snails[1]

Since the first report of a magnetic response in the mud snail *Nassarius obsoleta*[2] a number of remarkable characteristics of this orientation reaction have been disclosed[3-5] and demonstrations of its occurrence extended to include *Paramecium*[6], *Planaria*[7], and *Drosophila*[8].

In the snail studies animals were permitted to emerge from a narrow corridor into a symmetrical field which was constant for factors normally regarded as capable of influencing their orientation. Under these conditions mean angle of orientation of the snail paths displayed both solar and lunar variations. This angle could be altered quantitatively by a weak magnetic field in a predictable manner dependent upon direction and magnitude of the horizontal component, hour-angle of sun and moon, and lunar elongation.

More recently the relationship between magnetic and photic responses in snails has been examined. The present paper reports further analysis of some preliminary results which have already been described briefly[9].

Materials and Methods. The apparatus and procedure for obtaining data have been recounted elsewhere[3]. In brief, the amount of turning of snails was measured after 3 cm of free movement following their emergence from a narrow corridor directed magnetic south. The orientation apparatus was situated within a white box which provided the constant light field. This field was made asymmetrical by lining the inside right or left half of the box with mat black cardboard. When the cardboard liner was in place incident illumination in all cases was 150 lux from above, 20 lux from the black side, and 60 lux from the white side.

Every experiment comprised two series; a series constituted ten snail emergencies in each condition of the following sequence: (1) in the earth's magnetic field into symmetrical illumination, (2) in the earth's magnetic field into asymmetrical illumination black to left and white to right, (3) same illumination as (2) but in a 5-gauss horizontal magnetic field oriented in reverse to the earth's, (4) same as in (1), (5) in the earth's magnetic field with asymmetrical illumination black to right and white to left,

[1] This study was aided by a grant from the National Science Foundation, No. G-15008, and by a contract between the Office of Naval Research, Department of Navy, and Northwestern University No. 1228-03.
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(6) same illumination as (5) but in a 5-gauss horizontal field oriented as in (3). Between July 14 and 22 (1960), eighteen such experiments were performed; six during the mornings, 8 a.m. to 12 m; six during the afternoons, 1:30 to 5 p.m.; and six during the evenings, 6 to 9 p.m. For convenience in the following discussion animals orienting in symmetrical illumination will be referred to as controls.

Results. Several points are evident from the data as they are summarized in Figure 1. First, the average amount of turning in controls varies throughout the day in a manner entirely consistent with the mean daily pattern reported for the summer of 1959, maximum left turning over the noon hour and decreased left turning in the late afternoon and evening. Second, amount of turning in the asymmetrically illuminated fields varies throughout the day in a like manner. However orientations in the two asymmetrical fields, black to left and black to right, are not equivalent in the snails, and for this reason they will be described separately.

Black to left, white to right. The correlation between amount of turning in animals in asymmetrical illumination and amount of turning in controls is much more specific than for three average values for quarters of the day depicted in Figure 1. The relationship extends to within the individual experimental series and is of high statistical significance (Figure 2C). It is notable that the correlation is patent within each of the three groups for quarters of the day and that their combination comprises a homogeneous population. The relationship is not grossly altered when the photic response occurs in the imposed 5-gauss field (Figure 2D).

Black to right, white to left. In Figure 1 it can be seen that differences between turning of the controls and turning in the asymmetrical field are not so uniform as in the previous case. In fact differences for the twelve morning experimental series are significantly less than differences for afternoon and evening series combined, $P < 0.01$. Furthermore the correlation between turning of controls and turning in the asymmetrical field is considerably lower within individual series (Figure 2A). Inspection of the scatter diagram makes it clear that this differential in correlation coefficients cannot be attributed solely to the morning group of values; actually within this group the correlation is much higher than it is among the evening values. However, in Figure 2 B it is seen that the artificial magnetic field conspicuously increases the degree of association. By appropriate correlation methods[10] it can be shown that photic response in the augmented magnetic field correlates significantly higher than photic response in the earth's magnetic field with orientation of controls, $t = 3.06$, $P < 0.01$.

An explanation can be offered for the magnetic effect in the following way. A measure of the consistency of the photic response for individual experiments was got by correlating the average amount of turning in the first experimental series with the average amount of turning under the same condition in the second experimental series. The results of these intra-experiment correlations are depicted in Figure 3. In asymmetrical illumination with black to left consistency is quite high (Figure 3C). There is a suggestion of reduced consistency in the artificial magnetic field (Figure 3D). To the contrary, photic response in asymmetrical illumination with black to right is substantially less consistent within individual experiments than with black to left, $P = 0.015$ (Figure 3A). In the 5-gauss magnetic field the relationship is considerably augmented (Figure 3B). Presumably then, the increase in consistency of response in the 5-gauss field accounts for the increased coefficient of correlation attributed to the magnet in Figure 2B. The intra-experiment correlation coefficient of the controls for black to right was + 0.71 and for black to left, + 0.52.

Conclusions. The correlation between orientation to asymmetrical illumination and concomitant orientation in symmetrical illumination is of some consequence in the

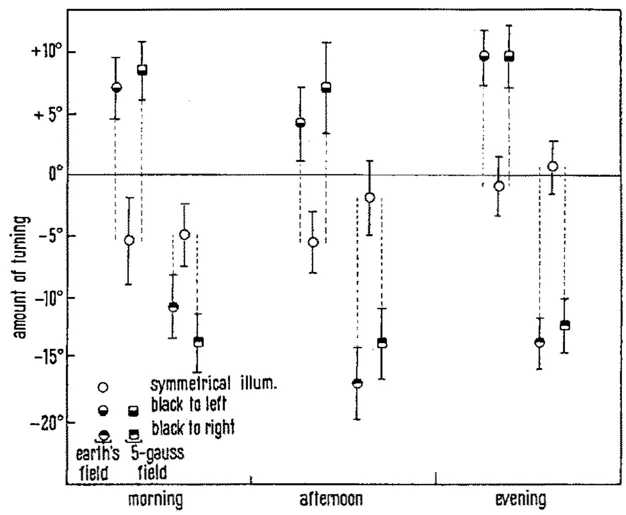

Fig. 1. Summary of results for three quarters of the day. Each point represents 120 individual orientations. Dashed lines associate experimentals with their controls. Standard errors are indicated.

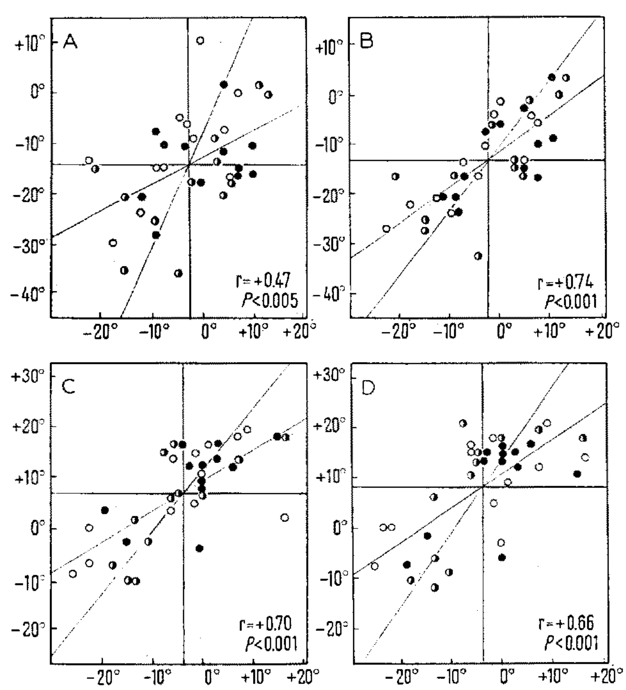

Fig. 2. Relationships of amount of turning in the asymmetrically illuminated field (ordinate) to amount of turning in the symmetrically illuminated field (abscissa). A. In earth's magnetic field, black to right. B. In 5-gauss magnetic field, black to right. C. In earth's magnetic field, black to left. D. In 5-gauss magnetic field, black to left. Open circles are morning experiments; half circles, afternoon; closed circles, evening.

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orientation reactions of the snails. It reveals that whatever factors are regulating the orientation of snails in a constant field participate most significantly in the photic response of the organisms. It has been suggested earlier that the snail orientational response might involve a compass reaction to the fixed directional component of the experimental light source. More recent studies, however, using planarians and eliminating all horizontal directional light cues[7] and further studies with snails involving only compass-direction changes[11] have indicated that a simple compass response to light does not adequately account for the phenomenon. The role of the regulating factors may be so great as to bring about what appear to be qualitative differences in the light response. For example, in Figure 2C within the range of data presented there are controls at all three times of day turning so strongly negatively that the turning of animals associated with them in the asymmetrical field is apparently a *negative* phototaxis. Furthermore, the ability to account for 50% of the variance in the orientation of snails in asymmetrical light (Figure 2C) in terms of orientation of controls clearly points up the methodological value of having a reference, or base line, such as is provided by the controls in these experiments.

It is also evident from this analysis that phototaxis in *Nassarius* may be remarkably asymmetrical. Roles of physiological asymmetries in various photic responses of animals have been recognized for a number of years[12]. In *Nassarius* the asymmetry is of a labile nature and can be significantly altered by a weak magnetic field. This relationship is currently under investigation.

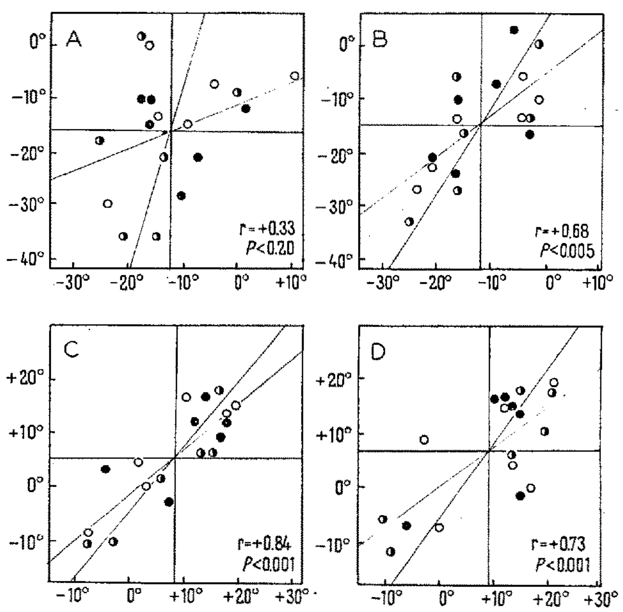

Fig. 3. Consistency of photic response measured by intra-experiment correlations. Ordinate is average of first ten runs; abscissa, average of second ten runs. A. In earth's magnetic field, black to right. B. In 5-gauss magnetic field, black to right. C. In earth's magnetic field, black to left. D. In 5-gauss magnetic field, black to left. Symbols are same as in Figure 2.

Zusammenfassung. Das Ausmass, in dem sich die Schnecke *Nassarius obsoleta* asymmetrischem Licht zuwendet, ist einer früher beschriebenen Orientierungsreaktion übergeordnet, die selbst bei symmetrischer Beleuchtung eintritt. Ausserdem lässt diese Lichtreaktion eine physiologische Asymmetrie erkennen, die durch ein schwaches magnetisches Feld geändert werden kann.

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Form und Zellzahl der akustischen Nervenzentren in der Medulla oblongata von Eulen (*Striges*)

Von der Annahme ausgehend, dass die Ausbildung eines nervösen Zentrums in Beziehung zu den darin ablaufenden Prozessen steht, wurden die Kerngebiete im Einstrahlungsbereich des Hörnerven von Eulen untersucht. Der untere Teil der Hörbahn von Vögeln besteht aus dem primären Ggl. cochleare, den sekundären Nucl. magnocellularis und Nucl. angularis sowie dem tertiären Nucl. laminaris. Der letztgenannte Kern wird von den Nuclei magnocellulares beider Seiten mit Fasern versorgt. Ventral von den genannten Zentren liegt der Nucl. olivarius superior, an den vermutlich sowohl sekundäre wie tertiäre Fasern herantreten[1-5].

Insgesamt wurden 12 Gehirne von 5 Eulenarten histologisch verarbeitet und zum Vergleich auch mehrere Singvogel-Gehirne herangezogen (Tabelle). Nach Serienschnitten von 10 bis 20 μ wurde die Anzahl der akustischen Nervenzellen bestimmt und 30fach vergrösserte Modelle hergestellt. Auf Grund von Kontrollen wird ein Zählfehler von $\pm$ 15% angenommen.

Schon äusserlich lässt das Einstrahlungsgebiet des Hörnerven vor und unter den Kleinhirnschenkeln bei den Eulen eine stärkere Anschwellung als bei tagaktiven Vögeln erkennen, durch die der 4. Ventrikel eingeengt wird. In Schnitten zeigt sich die starke Ausprägung des dorso-lateral die «Ecke» der Medulla formenden Nucl. angularis, der eine ventrale Längsfalte bildet (Figur). Etwas caudal von diesem Kern tritt auch der Nucl. magnocellularis dorsal an die Aussenkante der Medulla heran und zieht dann schräg nach rostro-medial. Seine Hauptmasse liegt im caudalen Abschnitt der Längenerstreckung, umgekehrt wie beim Nucl. angularis. Innerhalb des Nucl. magnocellularis wird ein lateraler und medialer Teil durch Grösse und Anfärbbarkeit der Zellen unterschieden.

Auch der Nucl. laminaris ist bei allen Eulenarten sehr umfangreich; die Ausbildung lässt Unterschiede innerhalb der Ordnung erkennen. Bei *Athene* und *Bubo*, die schon in der Dämmerung aktiv werden, liegen die Verhältnisse noch ähnlich wie bei den untersuchten *Oscines*. So finden wir am lateralen Rande der caudalen Kernhälfte eine

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