by boar semen at pH 7.2 to 7.3, by ram semen at pH 7.0 to 7.2; these may be considered optima for these species. At pH levels beyond the limits of those given in Fig. 1 the respiration rates tended to approach that of seminal plasma.[7]

The data given for boar semen consist of results obtained separately with ejacula of 4 boars. They were combined after comparisons had shown that differences in respiration rates of samples from a given animal were as great as those of samples from different animals. The pH ranges of fresh semen of the boar and the ram, given in Fig. 1, are those reported by McKenzie and coworkers.[8, 9]

Conclusions. (1) Hydrogen ion concentrations of the media in which sperm of the boar and ram are suspended definitely influence respiration rates of the sperm. (2) Optimum pH for respiration of boar semen is 7.2 to 7.3, and for ram semen 7.0 to 7.2. (3) As the pH is raised or lowered from the optimum the respiration rate progressively declines. (4) Unit change in pH has significantly less influence on respiration rate of ram sperm than on that of boar sperm. (5) Differences of 0.4 pH unit or more are accompanied by significant differences in respiration rates of boar and ram semen. Conditions for valid comparisons of different samples are presented.

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Retinal Pigment Distribution in Relation to a Diurnal Rhythm in the Compound Eye of Dytiscus.*

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In the higher Malacostracans one manifestation of a persistent diurnal rhythm is the periodic migration of retinal pigment. Therefore, the discovery of a diurnal rhythm in the electrical response from

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[6] Snedecor, George W., *Statistical Methods*, p. 54, Iowa State College Press, Ames, 1940.

[7] Winchester, C. F., and McKenzie, Fred F., PROC. SOC. EXP. BIOL. AND MED., 1941, **46**, 455.

[8] McKenzie, Fred F., Miller, J. C., and Bauguess, L. C., *Mo. Agr. Exp. Sta. Res. Bul.* 279, 1938.

[9] McKenzie, Fred F., and Berliner, Victor, *Mo. Agr. Exp. Sta. Res. Bul.* 265, 1937.

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the eyes of certain beetles (Jahn and Crescitelli[1]) led to the idea that retinal pigment migration might in some manner be concerned with the phenomenon.

More recently it has been demonstrated that the diurnal variation in the compound eyes of the beetle Dytiscus results in two distinct physiological states, called the night phase and the day phase, which are characterized by: (1) differences in wave form of the electrical response; (2) differences in the process of light adaptation; (3) differences in the type of high frequency oscillation obtained from the optic ganglia; (4) differences in the sensitivity threshold to light; and (5) differences in the response to flicker, (Jahn and Wulff[2, 3]). In order to interpret these phenomena, especially the last two, the possible influence of retinal pigment migration must be considered.

The purpose of this investigation was to determine the distribution of the retinal pigment in the compound eye of Dytiscus during the night and during the day and under conditions of extreme light and extreme dark adaptation.

Materials and Methods. Prior to use, specimens of *Dytiscus fasciventris* were kept in aquaria in the laboratory under conditions simulating those of the natural environment.

1. Preparation of dark-adapted animals.

Four animals were placed in an aquarium in a dark room for periods ranging from 15 to 36 hours to insure maximum dark-adaptation. Two animals were removed from this aquarium during the height of the day phase, about 10:00 a.m., and were dropped into a beaker of boiling water. After 10 minutes the beetles were removed from the hot water and decapitated, and their heads were immersed in Bouin's fixative for 24 hours. The material was then prepared for sectioning by a special technic, developed for hard materials by Prof. E. H. Slifer and Mr. T. Tahmisian of this laboratory.

The 2 remaining animals were removed from the aquarium during the height of the night phase, about 11:00 p.m., and treated in the manner described.

2. Preparation of light-adapted animals.

Animals for these experiments were taken from the general aquarium and mounted in a dark chamber so that only one eye was exposed to the stimulating light. The animals were maximally dark-adapted and then exposed to the 10,000 foot-candle light stimulus

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[1] Jahn, T. L., and Crescitelli, F., *Biol. Bul.*, 1940, **78**, 42.

[2] Jahn, T. L., and Wulff, V. J., submitted for publication, 1941.

[3] Jahn, T. L., and Wulff, V. J., submitted for publication, 1941.

for 20 minutes. The beetles were then quickly removed from the chamber, killed and fixed as described. Animals were treated in this manner at the height of the day and night phases.

Results. Comparisons were made of radial sections through the center of the eyes. The results are as follows:

A. The distribution of retinal pigment in the dark-adapted eye.

In the day-phase eye the distal pigment is concentrated markedly toward the corneal ends of the retinulae, as can be seen in Fig. 1, Plate I. This distribution of the distal pigment permits the light to stimulate the photosensory elements over a considerable angular range. The proximal pigment seems to be concentrated on the distal side of

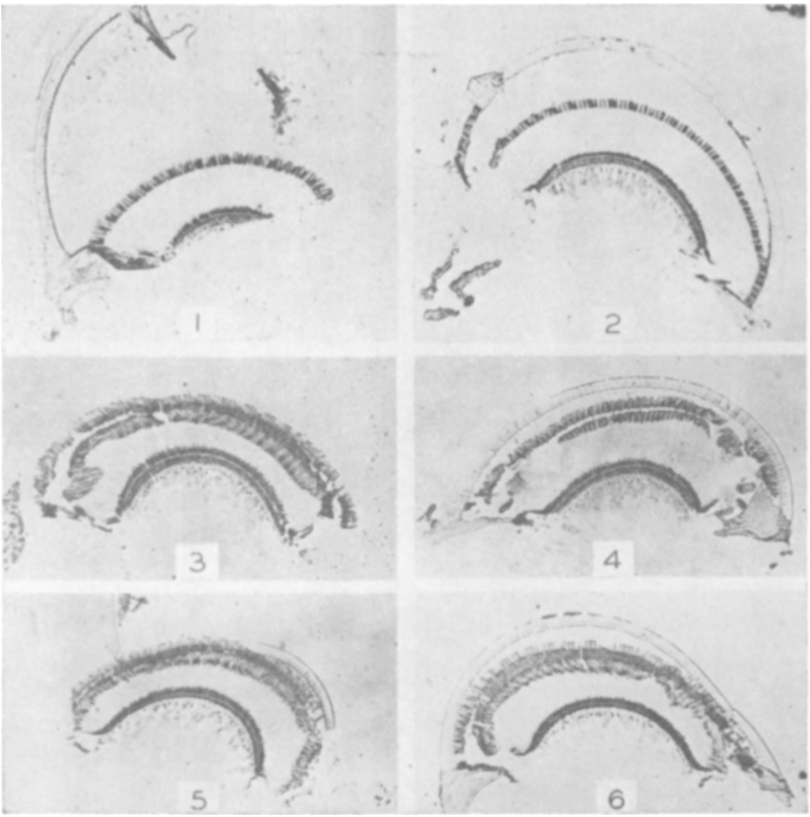

PLATE 1.

Radial sections through the compound eyes of the beetle, *Dytiscus fasciventris*. Fig. 1 and 2, dark-adapted day- and night-phase eyes, respectively. Fig. 3 and 4, right and left light-adapted day-phase eyes, respectively. Fig. 5 and 6, right and left light-adapted night-phase eyes, respectively. In the animals used for Fig. 3 to 5, only the night eye was illuminated. For full detail refer to text.

the basement membrane and dispersed on the proximal side, but the significance of this distribution is not known.

In the night phase the distribution of the pigment in the dark-adapted eye is precisely the same as that for the day phase (Fig. 2, Plate I).

B. Distribution of the pigment in the light-adapted eye.

In the light-adapted day-phase eye (Figs. 3 and 4, Plate I) the distal pigment is considerably more widely dispersed than in the dark-adapted eye, so that the distal half of the retinulae is sheathed with the dark pigment. This means that the light which stimulates the sensory elements must strike the ommatidia perpendicularly or nearly so. Most of that light which strikes at an angle will be absorbed by the distal pigment. The obvious result of this is to lower the subjective intensity of the stimulating light. The proximal pigment is concentrated on both sides of the basement membrane, and the meaning of this distribution is not obvious. The distribution of pigment is the same for both the right and left eye, although only one eye was stimulated by light. This indicates that the nervous or neuro-humoral systems are involved in pigment migration.

In the light-adapted night-phase eye (Figs. 5 and 6, Plate I) the distribution of the pigment is identical with that in the light-adapted day-phase eye. The distribution in both right and left eyes is the same, although only one eye was illuminated.

Discussion. It is quite apparent, in view of the facts just mentioned, that migration of retinal pigment is totally unrelated to the physiological diurnal rhythm present in the eyes of Dytiscus. Hence, the peculiarities of visual function, by which this diurnal rhythm is identified, must have their origin in the physiological mechanism responsible for visual phenomena. This conclusion is supported by the fact that in the crayfish, which has a diurnal cycle of pigment migration, there is apparently no diurnal change in the electroretinogram (Jahn and Crescitelli[1]).

Thus, the fact that the dark-adapted night-phase eye has an intensity threshold 1000 times lower than the dark-adapted day-phase eye (Jahn and Wulff[2]) attains considerable significance. At present the only reasonable explanation seems to be that the concentration of photosensitive materials is greater in the dark-adapted night-phase eye than in the dark-adapted day-phase eye. These sensitivity relationships are not true for the partially light-adapted eye, which has an intensity threshold about the same during the day and night phase, and the maximally light-adapted eye, where the sensitivity relations are totally reversed (Jahn and Wulff[2, 3]). This may then be interpreted as meaning that the process of light adaptation is more pronounced in the night-phase eye, resulting in a lower concentration of photosensitive materials than is present in the day-phase eye light-adapted to the same extent. Why this difference in the effect of light should exist must be left to future investigation. The differences in response to flicker, described elsewhere (Jahn and Wulff[3]), can be explained in a similar manner.

The usual migration of proximal and distal retinal pigment under the influence of light is sufficiently well known not to require further discussion (Parker[4]).

Conclusions. 1. The distribution of retinal pigment is similar in the dark-adapted day-phase and dark-adapted night-phase eyes. 2. The distribution of retinal pigment is similar in the light-adapted day-phase and light-adapted night-phase eyes, as well as in the illuminated and non-illuminated eyes of the same animal. 3. The diurnal variations in visual function, described elsewhere, are, therefore, independent of retinal pigment migration and originate in the physiological mechanism of the visual process.

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Influence of a Visual Diurnal Rhythm on Flicker Response Contours of Dytiscus.*

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A physiological diurnal rhythm is present in the compound eye of the predaceous diving beetle, *Dytiscus fasciventris.* This diurnal rhythm results in two distinct functional states of the eye which are referred to as the night phase and the day phase. These physiological states may be identified by several characteristics which are enumerated elsewhere (Jahn and Wulff[1, 2]).

The measurement of subjective flicker fusion frequency at various intensities of stimulating light has proven to be an excellent index of the physiological state of photoreceptors. The purpose of this

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[4] Parker, G. H., *Ergebn. der Biol.*, 1932, **9**, 239.

* Aided by a grant from the Rockefeller Foundation for Work in Cellular Physiology.

[1] Jahn, T. L., and Wulff, V. J., submitted for publication, 1941.

[2] Jahn, T. L., and Wulff, V. J., submitted for publication, 1941.