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COLOR PHOTOTACTIC RESPONSES
OF AN EYELESS ORIBATID MITE

BY

J. P. Woodring

Dept. of Zoology, L.S.U., Baton Rouge, La.

The test animal, Scheloribates parabilis Woodring, 1965, is a typical higher oribatid. These higher oribatids have heavily sclerotized adults and soft bodied immature stages with no evidence of any kind of external or internal photoreceptors (Woodring and Cook, 1962). Three of the other 4 suborders of mites have species with well developed ocelli, and both the structure and functioning of these eyes have been studied and reviewed by George (1963) and Suski and Naegle (1963). A diffuse dermal light sense in a number of insects is known even for decapitated individuals (Wigglesworth, 1950). Sensitivity to light by eyeless species have been reported in many phyla (Prosser and Brown, 1962), but in those cases studied in detail it appears that slightly specialized neurons are the sensitive structures (Kennedy, 1963). These neural photoreceptors may even contain more than 1 pigment (Kennedy, 1960), and Hama (1961) has shown that lamellar piles similar to those in retinal cells of functional eyes are present in the neural receptor cells of a crayfish ganglion. Aside from the work of Bruno and Kennedy (1962) with Crustacea, and Kennedy (1960) on a lamellibranch, little work has been done on the spectral sensitivity of eyeless animals. This is the first attempt to study the phototactic responses of oribatid mites.

A method was designed that reduced to a minimum the effects of differences of temperature, relative humidity, and food between different light test areas. A piece of Lucite plastic 6 mm in thickness, and 176 by 26 mm, was drilled through with 3 connected holes 12 mm in diameter as per figure 1. This was then pushed slightly, just before setting, into a mixture of 1:9 charcoal: plaster of Paris. The plaster-charcoal hardened into a block 15 mm thick in a 150 mm diameter dish. This provided a physical substrate and maintained, when damp, a relative humidity of about 90% in the test chambers when covered. This large block of plaster-charcoal also absorbed and distributed much heat when wet. Dried, ground

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mushroom was used as food and equal amounts were always maintained in the 3 cells of all test chambers. The mites reproduced and carried on normal activities in the 3 cells, and were checked and counted twice daily.

Except for the U.V. tests, where a commercial U.V. bulb was used, all light was provided by a strong tungsten source regulated by a rheostat. Since the U.V. lamp produced only at restricted voltages, intensity was varied by increased distance from the test chamber. Between the lamp focusing element and the filters there was a continuously running water filter to reduce the heat output of the test beam. With each counting of specimens, the light was checked with a light meter calibrated in foot-candles. The light meter sensing area was reduced to a circle 12 mm in diameter with electrical tape to match the area of a single test cell. The spectral range of transmission above 10% of the 5 Kodak filters used was: U.V. (#18A)- 320 to 390 μ; purple (#35)- 340 to 450 μ; blue (#47)- 410 to 500 μ; green (#58)- 500 to 580 μ; and red (#29)- 610 to 700+ μ. Filters #58 green and especially #35 purple were not completely stable, and the wavelengths produced towards the end of the experiment were probably different than the original. The U.V. filter also transmitted some light above 700 μ, as did both the purple and green filters. The arrangement of lamp, lenses, water filter, mirror (to change horizontal light beam to vertical), and test chamber provided an area of oval illumination 50 x 40 mm. The intensity varied

**FIGURE 1**

![Diagram of test chamber](image)

*Fig. 1.* — Construction of test chamber. A. 3 x 1 glass slide half blacked out. B. Lucite test chamber with 3 interconnecting cells, with a plugable 1.6 mm hole for the thermocouple drilled into 1 cell. C. Side view of chamber embedded in plaster-charcoal. Note the right hand cell here is the dark side (D), and rotation of the covering slide 180° makes the right hand cell the light side (L).
by about 5 f.c. from the center to the outside edge of the spot, but the highest reading was recorded because this fell on the "light test cell" (L). Than in cell L, the center test cell received less intense light in the half towards L, and very no light in the half towards D. The "dark test cell" (D) received no light.

The plastic test chamber (with 3 cells) was covered with a 3 × 1 slide, which was half blacked out as per figure 1A. The inside vertical surfaces of the test cells were also painted black. A colony of *S. parabilis* was started in each test chamber, so that all stages of development were present. If specimens were lost or died due to becoming stuck in moisture on the covering glass slide, new adults were added to the center cell as needed. The test procedure was: remove from light and count the number of adults and immature stages in each cell; record numbers; add food where needed; turn glass slide 180° (so that the cell that was in the light is then in the dark and vice versa); check intensity of test light; return test chamber to the light for half day; remove from light and count; etc.

The results are presented in figures 2 and 3. For example, for 50 f.c. of purple light there was an increase in the L (light side) of 11.5 adult mites from what that cell contained when it was in the dark; in other words, on the average, 11.5 adult mites migrated from either the center cell or the now dark side into the light side. At this 50 f.c. of purple light there was also an average decrease in the now dark side of 6.5 adult mites. The change in the number of adult mites in the L and D sides (after switching and subjecting to the test light for 6-12 hours) was not always equal because the number of mites in the center cell was not considered here, and mites trapped in water (on the slide) and unable to move were not counted. The number of runs at each intensity with each filter was on the average 5-6. Some points represent the average of 12-16 runs.

The white tungsten light intensity in figure 2 is with a #1 B/L neutral density filter in order to get it in the range of the light meter. The test was run without this filter. At intensities below 30 f.c. *S. parabilis* adults do not respond constantly to the light. Above 30 they respond negatively. Ultraviolet light from 15 to 55 f.c. resulted in an increasing negative phototactic response. Red (70 f.c.) and green (40 to 70 f.c.) produce a general negative phototactic response (figure 3). Blue light produces a negative response that seems to decrease with intensity from 50 to 70 f.c. Purple light produces a completely opposite reaction, in that adult mites were positively phototactic from 10 to 70 f.c. intensities. The degree of positive reaction seemed to increase with intensity.

Checks were run periodically by not switching D and L sides, which resulted in very little movement. If for example, the switch resulted in an increase of 12 in the D side, not switching would only produce a further increase of 2 or 3 in the D side. Immature stages were counted, but their responses indicate no correlation with either intensity or color.

Temperature is a critical factor in studying high intensity light phototactic responses. By means of a thermocouple, it was determined that the tempera-
Figs. 2 & 3. — Average change in number of adult mites present after switching (rotating slide 180°) and being subjected to test light for a half day, plotted against intensity in foot-candies (falling on a circle 12 mm in diameter). D — dark side; L — light side.
ture in the L side never exceeded that in the D side by more than 3° C at 60-70 f.c. The small total area and the large moist block of plaster-charcoal helped equalize the temperature. The moist plaster-charcoal was about 3° C above ambient air temperature when kept in the dark for 24 hours. At 20 f.c. without the running water filter the temperature in L increased by 10° C over ambient air + 3° C, but with the water filter the temperature rise was only 1° C. With all colors, and with the water filter, the temperature increase at 60 f.c. was 5° C over ambient air + 3. Even though the overall temperature rose with an increased light intensity, the difference between D and L remained less than 3° C and less than 1° C at intensities below 30 f.c.

Both Wallwork (1960) and Madge (1964) have shown that in the range of 20 to 30° C a difference in temperature as small as 3-5° C will not produce a tactic response in oribatids. Madge further states that mite surface temperature will depend mainly on air temperature, and not, because of their small size (0.6 × 0.4 mm), directly on radiation. He showed for a different species that in the range of 10.5 to 18.5° C, 50 % of the adults took a position in the 12.5 to 13.5° C area; but that in the range of 12.5 to 20.5° C, 50 % took a position in the 15.5 to 16.5° C area. In certain ranges, oribatids are quite temperature sensitive.

It is possible that some of the increased number of responses at higher light intensities could be due to increased heat, except that the response to blue light decreases from 50 to 70 f.c. and the response to purple light is exactly opposite to those of all other colors tested. If temperature were the sole effective factor here, mites should have consistently moved into the D side, or some point between L and D.

Though the vertical migration of oribatids in sod is mostly dependent upon moisture (Shaldybin, 1956) and temperature, the intensities of white light (not the same as sunlight) in figure 2 are comparable to those in nature. In January at 3:00 P.M. on a clear day there registered 30 f.c. (through a B/L #1 neutral density filter) on a circle of 12 mm in diameter in complete shade. In the direct sunlight 50 f.c. was recorded through a #1.3 filter on the same area.

Riha (1957) and others have noted that some adult oribatids have a clear transparent spot in the dark cuticle on the forward end of the hysterosoma (sometimes extending onto the propodosoma), and that there appears to be a light red pigment underneath. Tarras-Wahlberg (1961), working with Diapterobates humeralis (which possesses such a light spot) found evidence of vertical tactic photosensitivity, but not horizontal sensitivity. He (1960) checked the species anatomically and found a large gland lying directly under the clear spot, which he called a Q-organ. He found no pigment, but speculated that this Q-organ was the light sensitive organ though it has no sensory cells or nerve connections. This Q-organ is undoubtedly the salivary gland (which opens by ducts into the buccal cavity) as described by Woodring and Cook (1962). Subsequent work has shown (to be presented elsewhere) that higher oribatid adults all have salivary glands and that all immature stages lack them. It is possible that the salivary gland,
which lies directly over the brain, could function as a focusing mechanism for light. The large vacuolated cells could function as lenses. *Scheloribates parabilis* lacks the clear spot in the cuticle, yet adults respond to light. Immature stages of *S. parabilis*, whose cuticle is thin and transparent all over, lack the salivary glands (Q-organ) and do not respond to light. It is also possible that the contents of the salivary gland act as a filter to screen out certain wavelengths from impinging on the brain. It is believed that the brain of these mites is directly sensitive to light in the adult stage. The adult dorsal brain probably contains modified neurones containing lamellated elements as HAMA (1961) found in the crayfish 6th abdominal ganglion, while the immature stage brain would lack these elements. It is interesting to note that *S. parabilis* is a sod-inhabiting form, and that the adults at times move about on the grass leaves while the immature stages remain burrowing down in the root-layers. Also, those oribatids with clear spots are characteristically arboreal, or at least on low bushes.

**ABSTRACT.**

Oribatid mites lack photoreceptors; yet adults of *Scheloribates parabilis* showed an increasing negative phototactic response to U.V., white, and green light with increased intensity; a decreasing negative phototactic response to blue light with increased intensity; and an increasing positive phototactic response to increasing intensity of purple light. Light and heat relationships are discussed. Correlation is made with the presence of salivary glands in adult oribatids and phototactic responses. Immature stages lack salivary glands and show no response to light.

**REFERENCES CITED**


