EYE COLOR CHANGES DUE TO PIGMENT MIGRATION IN SOME SPECIES OF HETEROPTERA AND HOMOPTERA

F. W. HOWARD AND BARBARA J. CENTER
University of Florida
Fort Lauderdale Research and Education Center
3205 College Avenue
Fort Lauderdale, FL 33314

F. W. MEAD
Florida State Collection of Arthropods
Bureau of Entomology, DPI, FDACS
P.O. Box 1269, Gainesville, FL 32602

ABSTRACT

Changes in eye color in response to light and darkness were observed in *Trigonotylus doddi* (Distant) (Heteroptera: Miridae), *Saccharosydne saccharivora* Westwood, *Perkinsiella saccharicida* Kirkaldy (Homoptera: Delphacidae), and *Cyarda melichari* Van Duzee (Homoptera: Flatidae). Histological examinations of the eyes of *P. saccharicida* revealed that pigments were condensed in a zone proximal to the crystalline cones when light-adapted, and dispersed distally into the region of the cones when dark-adapted. This adaptation is believed to occur primarily in nocturnal insects or species that are active by day and night. Eye color changes were not observed in 23 additional species of Heteroptera and Homoptera collected in Southern Florida, including *Unerus colonus* (Uhler) (Homoptera: Cicadellidae), which is reported for the first time from the United States.

RESUMEN

Se observaron cambios en el color del ojo como respuesta a la luz o la oscuridad en *Trigonotylus doddi* (Distant) (Heteróptera: Mírida), *Saccharosydne saccharivora* Westwood, *Perkinsiella saccharicida* Kirkaldy (Homóptera: Delphacida) y *Cyarda melichari* Van Duzee (Homóptera: Flátida). Examines histológicos de los ojos de *P. saccharicida* revelaron que los pigmentos fueron condensados en una zona próxima a los conos cristalinos cuando adaptados a la luz, y dispersados distalmente en la región de los conos cuando adaptados a la oscuridad. Se cree que esta adaptacińı primariamente occurre en insectos nocturnos o en especies los cuales son activos día y noche. No se observaron cambios en los colores de los hojos en 23 especies adicionales de Heteroptera y Homoptera colectadas en el sur de Florida, incluyendo *Unerus colonus Uhler (Homoptera: Cicadellidae),* la cual especie se registra por primera vez en los Estados Unidos.

Migration of screening pigments of the compound eye in response to changing light conditions is known in species of various insect orders, including Heteroptera (Bedau 1911) and Homoptera (Howard 1981), and has been explained as follows (Bernhard & Ottoson 1960, Walcott 1975): In the superposition eye, in response to light, a photochemical process takes place which induces the pigments to travel in secondary pigment cells to form a dense band proximal to the crystalline cones, optically isolating each ommatidium. In darkness, the pigments migrate distally in these cells into the cone area, so that light entering any one facet may act on the retinula cells of neighboring ommatidia. By varying the amount of light entering the photoreceptor cells, the screening pigment migration system is analogous to the pupil mechanism of vertebrates (Hoglund

& Struwe 1970, Stravenga & Kuiper 1977). The color of insect eyes is often largely determined by the screening pigments, thus changes in the position of pigments are seen externally as changes in the color of the compound eyes.

Our current interest in this mechanism is that although the color of the eyes is generally not included in taxonomic descriptions of Heteroptera and Homoptera, this character may be useful in field identifications.

Also, since photomechanical changes in the eyes associated with light and dark conditions are more pronounced in nocturnal than diurnal insects (Bernhard & Ottoson 1960, Parker 1932), simple observations for eye color changes as described in this paper can provide clues as to this aspect of an insect's natural history, as was the case with the American palm cixiid, *Myndus crudus* Van Duzee (Howard 1981).

Here we report observations of several species of Heteroptera and auchenorrhynchous Homoptera collected near Ft. Lauderdale, Florida to, determine whether their eyes undergo externally visible color changes in response to light and dark conditions. We selected one of the species, the sugarcane planthopper, *Perkinsiella saccharicida* Kirkaldy (Homoptera: Delphacidae), for histological study of this mechanism.

MATERIALS AND METHODS

Live true bugs, leafhoppers, and planthoppers were separated from sweepnet samples or collected by hand from foliage during daylight hours at the Ft. Lauderdale Research and Education Center. They were held in glass vials and the eyes examined under a dissecting microscope in a well-lit laboratory at ca. 25°C. The vials with the insects were then placed in a dark chamber for periods of several hours. They were removed briefly to the light ca. every 10-15 min and examined under a microscope for a change in eye color. Insects which exhibited a change in eye color in response to a dark period were left in the light for 1/2 to several hours and re-examined to determine whether the eye color had returned to its light-adapted condition. These tests were repeated about five times with each insect species.

Pigment migration was studied histologically in the sugarcane planthopper. Twenty sugarcane planthoppers were collected from sugarcane and divided into two groups of 10 each. One group was placed in the dark chamber and the other exposed to light. After an hour, at which time there were pronounced differences in eye color between the two groups, the insects were fixed immediately in Bouin's solution and the compound eyes removed, dehydrated in a tertiary butanol and toluene series (Sass 1958), embedded in paraplast, then sectioned with a microtome at 12 μm. The sections were mounted on microscope slides and the paraffin removed with a xylene bath. Examinations were made with a compound microscope at 100 X. Voucher specimens are in the Florida State Collection of Arthropods or the authors' collections.

RESULTS

Eye color changes were observed in the following species (names followed by the eye color in light-darkness, respectively): Heteroptera, Miridae: *Triognotylus doddi* (Distant), light gray-maroon (Fig 1, a & b); Homoptera, Delphacidae: West Indian canefly, *Saccharosydne saccharivora* Westwood (Delphacidae), yellow-dark purple (intermediate stage-orange); sugarcane planthopper, light gray-dark gray; Homoptera, Flatidae: *Cyarda melichari* Van Duzee, adult, light gray-maroon, nymph, white-dark red.

The changes in eye color were not timed precisely, but it was observed that at the same temperature the change from light to dark adaptation took less than 10 minutes in *T. doddi* and more than 30 minutes in the West Indian canefly.

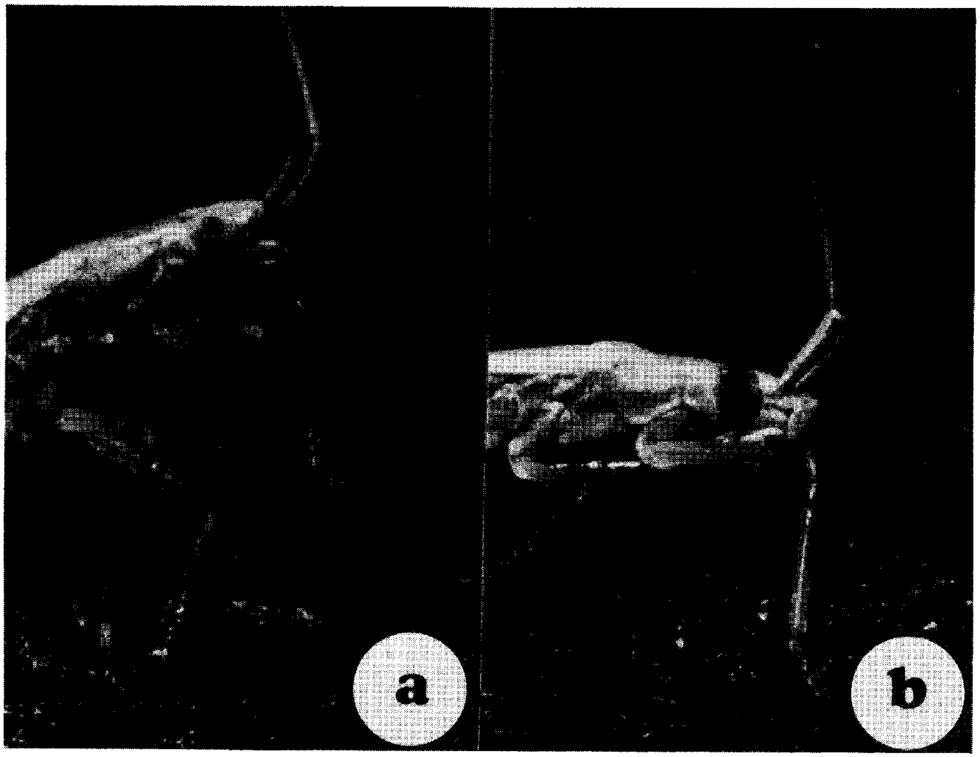

Fig. 1(a). *Trigonotylus doddi* with light-adapted eyes, and (b) dark-adapted eyes.

Examinations of sections of the compound eyes of the sugarcane planthopper showed that the externally visible difference in color between the light- and dark-adapted eyes is related to distal-proximal migration of pigments. When the eye is light-adapted, the pigments are condensed in a zone proximal to the crystalline cones (Fig. 2a). When dark-adapted, the pigments are dispersed into the zone of the crystalline cones (Fig. 2b), and probably because of the greater proximity of pigments to the cuticle, the eye appears darker externally. This is the same kind of mechanism observed previously in the American palm cixiid (Howard 1981), and is undoubtedly similar in the other Heteroptera and Homoptera species in which we observed eye color changes in response to light and darkness.

We were unable to detect color changes in the eyes of 23 other species of Heteroptera and Homoptera that we examined. These included: Heteroptera, Alydidae: *Stenocoris* sp., Pentatomidae: *Mormidea pama* Rolston; Homoptera, Cicadellidae: *Aceratagallia sanguinolenta* (Provancher), *Acinopterus angulatus* Lawson, *Agallia albidula* Uhler, *Balclutha incisa* (Matsamura), *B. hebe* (Kirkaldy), *Chlorotettix rugicollis* Ball, *C. minimus* Baker, *Empoasca* sp., *Graminella villica* (Crumb), *Homalodisca insolita* (Walker), *Hortensia similis* (Walker), *Oncometopia nigricans* (Walker), *Polyamia obtecta* (Osborn & Ball), *Protalebrella brasiliensis* (Baker), *Stragania robusta* (Uhler), *Texananus excultus* (Uhler), *Unerus colonus* (Uhler), *Xerophloea viridis* (F.) Fulgoroidea: *Acanalonia latifrons* (Walker), *Cyrpoptus reineckei* Van Duzee, and *Stobaera concinna* (Stal), all of which were collected in open fields. The 7 specimens of *U. colonus* collected July 12, 1983 at the Ft. Lauderdale Research and Education Center by D. M. Beatty using a sweepnet over mixed vegetation represent the first U.S. record of this neotropical species.

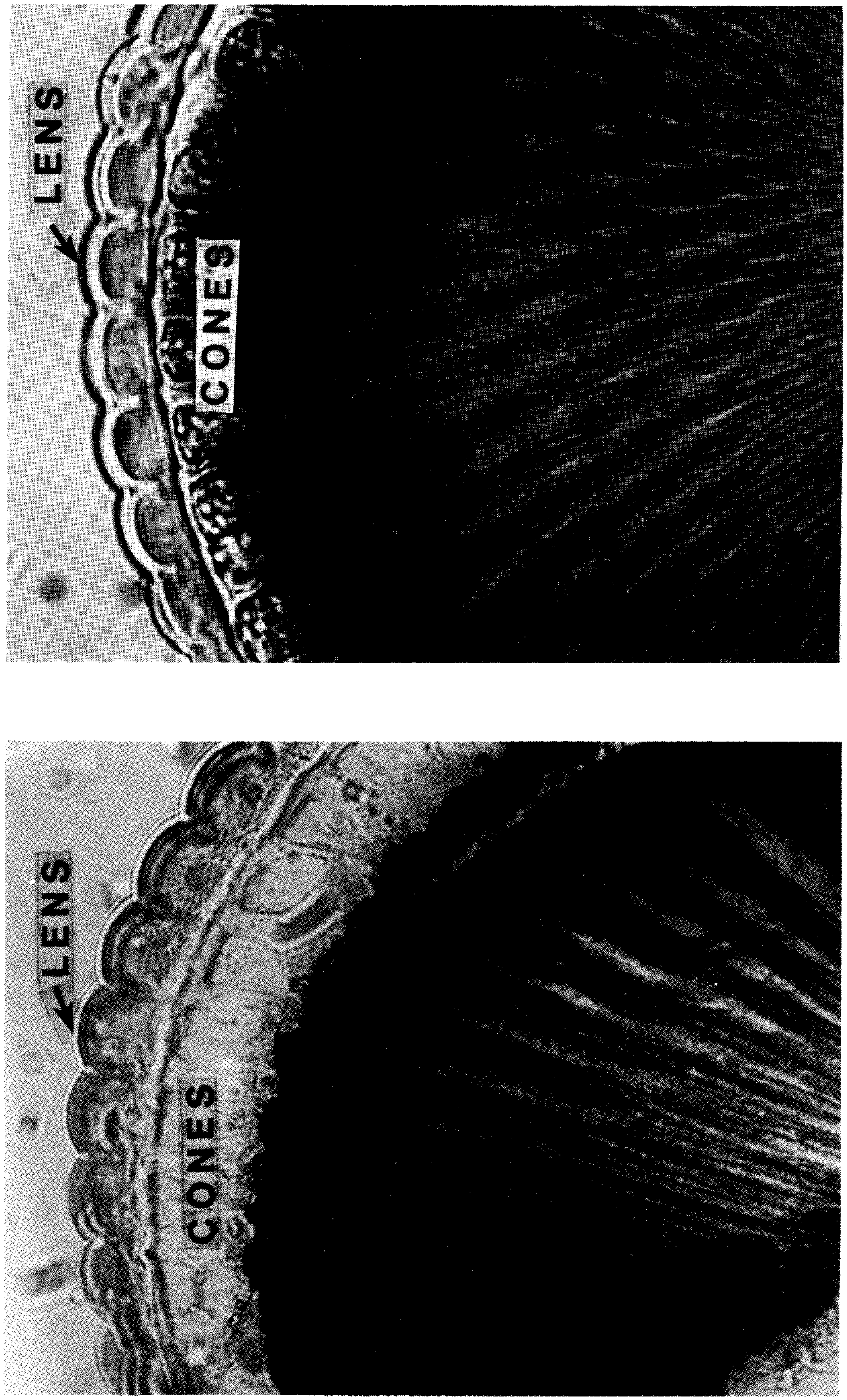

Fig. 2. Long sections of eyes of *Perkinsiella saccharicida*. (a) Light-adapted eye: pigment granules within secondary pigment cells are aggregated into a dense band enclosing ends of cones (b) Dark-adapted eye: pigment granules disperse distally into regions of cones.

The relatively slow migration of distal eye pigments inward in the light and outward in darkness occurs commonly in moths and other nocturnal insects (Bernhard & Ottoson 1960 Parker 1932). The American palm cixiid (Howard 1981), the West Indian canefly (Guagliumi 1953, Metcalfe 1968) and the sugarcane planthopper (Perkins 1903) are all to some degree active both day and night. The bugs and leafhoppers that we observed that did not undergo eye color changes probably are diurnal species with apposition eyes. Taxonomists might note that in Heteroptera and Homoptera in which the externally viewed eye color of the live insects changes in response to light and darkness, the eye color of the dead, dried specimens is generally that of the dark-adapted eye.

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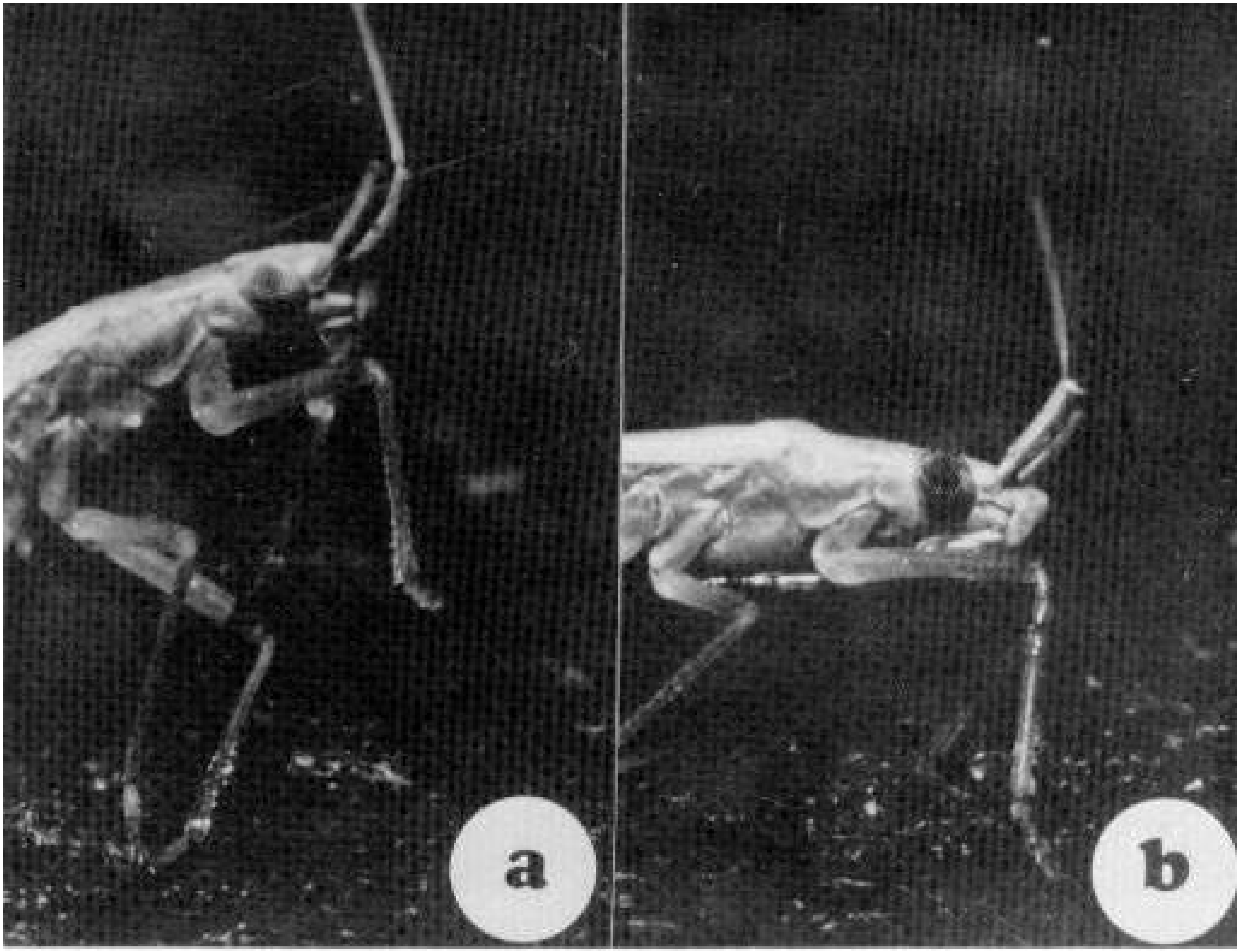
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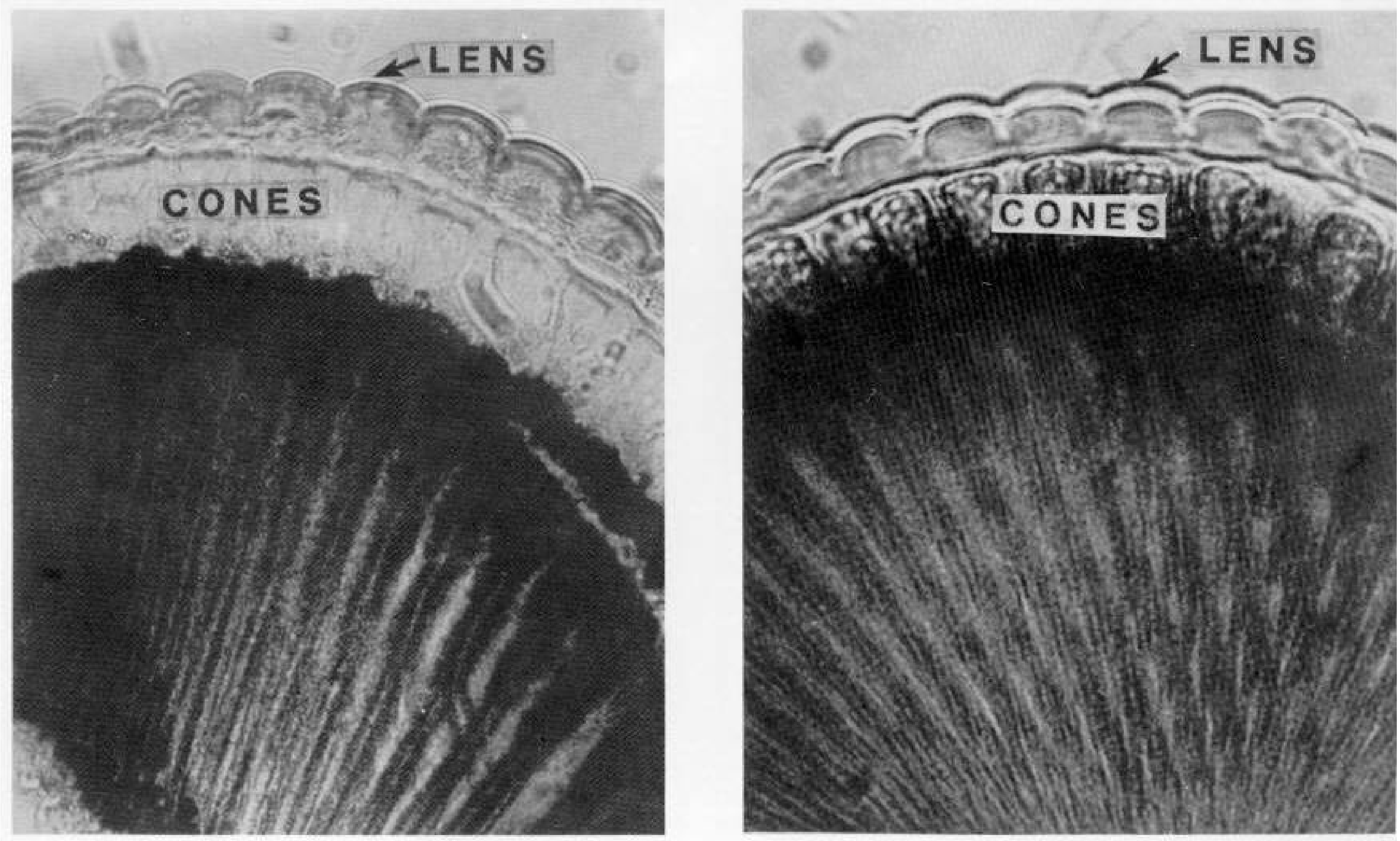
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