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THE RELATION BETWEEN THE INTENSITY OF LIGHT AND THE PREFERENCE TO DIFFERENT WAVELENGTHS IN MUSCA DOMESTICA AND LUCILIA SP.

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Abstract. The phototactic choice of some pairs of colored lights by *Musca domestica* and *Lucilia sp.* after a rise in intensity of the non-preferred light in spontaneous responses was studied. In the range of spectrum where no preference in spontaneous responses is noted, the brighter light was chosen after its intensity was increased. It is difficult or even impossible to change the preferences of insects to these lights which are well discriminated in spontaneous reactions after increasing the intensity of the less attractive light.

INTRODUCTION

The problem if the insect in choosing the colored lights follows the hue (wavelength) or the brightness and which of these factors is dominating in the response of insects to monochromatic light, remains yet controversive. Some of the workers (Weiss et al. 1941*ab*, 1943, Weiss 1945, Wagner 1947, Paulov 1957) claim that the response to color cannot be separated from the reaction on brightness because both these components are closely connected with each other.

Paulov (1957) for instance ascertained in his studies on photopositive insects not connected in natural conditions with flowers, that they directed themselves towards the shorter wave of spectrum. He observed this phenomenon also in the house fly which chose the light of a shorter wave in all the experiments.

The studies of many authors (Frisch 1914, Kühn 1927, Ilse 1929, 1949, Kugler 1955, Knoll 1921, Daumer 1956, 1958, Mazokhin-Porshnyakov 1965, Vaidya 1968) permit to postulate the great role of color in the life of insects, especially of those which are connected with colors in natural conditions, i.e. of flower insects.

In the first paper of this series (Zabłocka 1972) the innate preferences to colored lights in *Musca* and *Lucilia* were described. The aim of the present paper is to ascertain whether or not these preferences are based on the choice of a light, which seems to be subjectively brighter for the insect studied, or if they are due to a perception of their hues, i.e. the capability to discriminate radiations of different frequency irrespectively of their intensity. Some attention is given to the study of the responses of these animals to the red light.

MATERIAL AND METHODS

Experiments were carried out on two *Diptera* species: *Musca domestica* and *Lucilia sp.* Young insects were used before their sexual maturity.

Experiments were carried out in the maze described in the previous paper (Zabłocka 1972). Insects were subjected to the simultaneous influence of two monochromatic lights. Prior to the proper experiments, the spontaneous choice of equiquantum lights was observed, then the energy of the non-chosen light was increased and the animals responses to the radiations were tested again. Lights were directed upon the insect so that each of them was shed on different compound eye at the moment of performing the choice. About 300 specimens of *Lucilia* and about 500 of *Musca domestica* were used in each experiment. After the animals were gathered in the containers terminating the arms of the maze, they were anesthetized for a short time and counted in each container separately. Statistical significance has been admitted on the level $p = 0.05$.

RESULTS

Experiment I. The aim of this experiment was to study the response of the animals to several different pairs of colored lights after a rise of intensity of the nonpreferred light in the spontaneous choice.

The responses of *Musca domestica* were studied to 10 pairs of lights when the relative energy of one light from each pair, called the variable light, was gradually increased from 2 to about 10 times. The intensity of illumination was measured in mW/m^2. As is shown at the Fig. 1 and 2 a clear influence of the change of the relative intensity of light to the color preference was noticed in five cases. The significant change of preference evoked by the difference of radiation energy appeared exclusively in the 400–525 nm range of spectrum. The rise in the energy of radiations being one or both beyond the 525 nm wavelength failed to

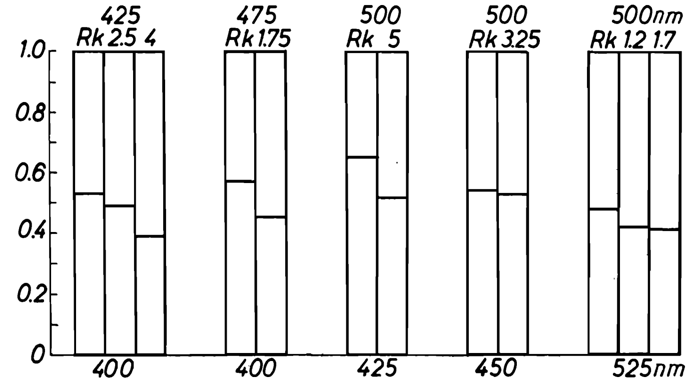

Fig. 1. The influence in the change of relative intensity on the choice of monochromatic lights by *Musca domestica*. Diagrams of experiments in which the changes of preferences after the change of intensity of light were gained. The height of bars columns, the proportions of light choices. The numbers under the diagrams, the wavelengths of standard lights in nanometers. On the top of diagrams, the wavelengths of alternating intensity. *RK*, equiquantum lights in relation to the standard lights. The numbers over the other blocks, the application of the multiplicity of the standard lights intensity.

evoke changes in preference after increasing the energy of one of the lights even 12 or 13 times. As illustrated in Fig. 3, *Lucilia* similarly to the house fly reacts to the change of light intensity only in the range of 400–525 nm.

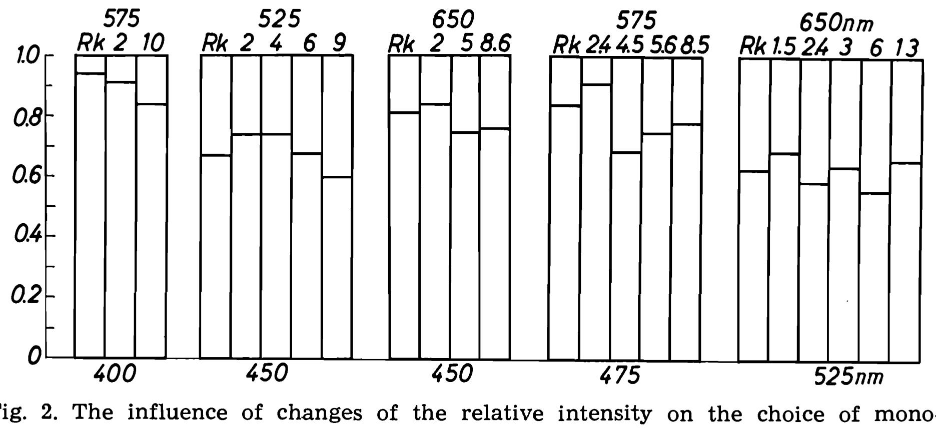

Fig. 2. The influence of changes of the relative intensity on the choice of monochromatic lights by *Musca domestica*. Diagrams of experiments in which the changes of light intensities did not influence the proportion of choice. Denotation as in Fig. 1.

Experiment II. In this experiment, the responses of *Musca domestica* to two equal monochromatic equiquantum lights and after the change of intensity of one of them was proved. These experiments were carried

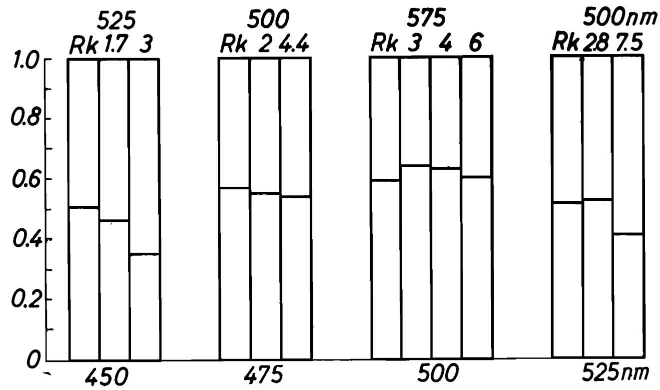

Fig. 3 Influence of change of relative intensity on the choice of monochromatic lights by *Lucilia sp.* Denotations as in Fig. 1.

out on the long and short wave ranges of spectrum. The results are presented on Fig. 4. As follows from this experiment, even a slight change of intensity of one light from the pair of radiations of the same wavelength, is sufficient to evoke the direction of the insect towards the brighter light. J. Chmurzyński (unpublished data) ascertained in experiments with white lights of different intensity that in the house fly the proportion of choice of light of changed intensity depends approximately on the logarithm of its intensity related to standard one, within the limits of relative intensities from 1 to 16. Over this value, the reaction of flies to the variable light does not increase.

Experiment III. In this experiment, the response of insects to the red light was studied. According to Mazokhin-Porshnyakov (1960), the house fly reacts to the red light only at a high brightness. He explains this by the rapid adaptation to darkness of the receptor acting in the long-wave part of spectrum.

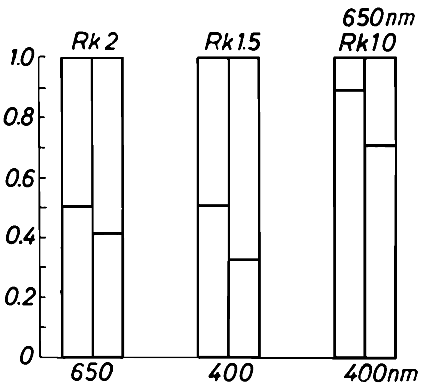

Fig. 4. The influence of change of relative intensity on the choice of monochromatic lights by *Musca domestica*. Diagrams of experiments in which the monochromatic lights of an equal wavelength and varying intensity were applied. On the right hand, the control test in which both extreme lights were used. Denotations as in Fig. 1.

One arm of the maze was illuminated by the light $\lambda = 650$ nm with an intensity of 0.4 W/m², the other arm was dark. The flies went into the containers of the maze in an almost equal number. Subsequently the intensity of the red light was risen three times and a significant choice of the lightened container was gained.

It became evident that *Lucilia* was more sensitive to long-wave radiation than the house fly. *Musca* reacted to the light $\lambda = 650$ nm only by high energy of radiation. *Lucilia* still responded to the radiation of 675 nm and the intensity of 444 mW/m², i.e. an equiquantum light, when compared to all others applied in Experiments I and II.

In a similar experiment with the violet light ($\lambda = 400$ nm), *Lucilia* chose the lightened arm in 98%.

DISCUSSION

A series of experiments with a variable intensity of light was carried out in order to investigate the mutual influence of action of wavelength and intensity or brightness on insect choice. As follows from literature (Weiss et al. 1941*ab*, Weiss 1943), the light intensities may be chosen in such a manner that two any radiations are equal thier attractiveness. In experiments of the present study, lights were chosen so that either both or one of them (beyond the range of 525 nm) lied within the reach of the twilight receptor. It becomes evident that for lights lying in the region between 400 and 525 nm, an inconsiderable rise of intensity — in several cases for only twice — is sufficient for evoking the change of preference. If however one of the lights is beyond the range of 525 nm, the rise of intensity, even for 12 times, fails to evoke any difference in the rections to those lights. Consequently it may be ascertained that in the region of 400–525 nm the light intensity plays a considerable role and the choice of lights by the insect is ruled by the brightness because this factor, in this case, acts more strongly than the hue.

If however, the lights studied are in the regions well discriminated, i.e. if one of them is beyond the range of 525 nm towards the long-wave part of the spectrum, then the hue of a colored light is dominating and the rise of the radiation energy even for 12 times is not sufficient to change the animal's reaction. Mazokhin-Porshnyakov (1966) stated — that two lights, each of them lying in regions of action of two different receptors, cannot be equaled energetically so that they would be indistinguishable for the insect. Consequently, if the view of Mazokhin-Porshnyakov is to be accepted, the regularity should be explained so that in the working range of one receptor, brightness is the dominating factor controlling the choice of lights, whereas in the region of action of two receptors — where the distinction of colors is effective — their hue (i.e. the wavelength of radiation) in decisive.

The influence of the change of light intensity on the animal reaction depends consequently on the wavelength of radiation. For some of them, no difference in the insect reaction was observed even after the application of considerable changes of light energy. It could be hardly postulated that lack of the subjective feeling of brightness differences of given monochromatic radiations could account for such an addity. In other words, it seems that the tenfold or twelvefold rise of radiation energy changes the brightness of this light in such a distinct manner that, according to the results of J. Chmurzyński (unpublished data), it should influence the tactic reaction of the insect — if the brightness plays in it a decisively dominating role. Chmurzyński stated in his studies on the house fly reactions to the white light of different intensities related to the standard, that the maximal preference appears already after a 16-times increase of the relative intensity of light. Thus after a tenfold and thirteenfold increase of light intensity, the choice of brighter light should not be much lower, if the brightness was the only factor acting upon the choice. However, since the change of light intensity fails to evoke the change of preference, or of any reactions of insects to the presented colors — the influence of the hue on the choice of colored lights seems to be proved.

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