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BIOLOGY
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Orientation of Blowflies (*Calliphoridae*) towards White Light of Various Intensities

by

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Presented by J. KONORSKI on January 3, 1969

Previous studies in this Laboratory showed that the proportion of individuals of a fly population which choose one of two different white light sources in Y-maze did not depend on the relative intensity of light in a simple way. A graph of this correlation for house fly seemed to be a parabola [5], whereas the first experiments with blowfly supported the view that the proportion of flies approaching the stronger light tended towards a maximal value which was 0.60 [7]. The explanation was suggested that the choice observed resulted from two superimposed processes: attraction of sensitive flies proportional to the logarithm of the relative intensity of the lights, and a choice by chance made by insensitive insects, the number of which was proportional to the logarithm of the sum of absolute values of both lights. This mechanism would account for the observed diversity of phototactic reactions of the flies examined, since the differences can be explained as a result of an increasing number of insensitive flies in proportion to the increase in intensity of the standard light. In fact, the rise of the proportion of flies approaching the variable light with the increase of its intensity in relation to the other constant light, called here a standard one, was steeper when the standard amounted to 147 lx than at a standard of 225 lx [5]; the tendency of reaching the maximum being most distinct at a standard light of 900 lx [7].

According to this hypothesis, there should be also a strongly marked difference between the minimal value of the proportion of flies approaching the variable light ($P_{\min}$) at a standard light of low intensity, and its maximal value ($P_{\max}$) at a bright standard light subtracted from one, in particular

$$P_{\min} < (1 - P_{\max}).$$

In order to test this inference from the hypothesis, two series of experiments were performed as an *experimentum crucis*: the one with a dark arm of the maze as a standard, and the other with a dazzle standard light of 28 800 lx.

Material and methods

A mixed population of both sexes of dark-adapted blowfly species *Calliphora erythrocephala* Meig. of the wild strain, differing in age by ±1 day constituted the experimental material for each test. Some additional experiments were performed with *Phormia terrae-novae* R.-D. Generally, 3 to 28-day-old flies were used for all the experiments.

The wooden dark Y-maze was the same as in previous studies [5]. Its arms were 40 cm. long, 10 cm. wide, and 15 cm. high, diverging at an angle of 30°. At the end of each of the arms, an optical glass cover was attached. It allowed the light to penetrate from the respective window in a light-proof box containing lamps with additional equipment which served to produce approximately parallel light beams of the required intensity. The light sources were 50-watt, 12-volt frosted lamps type 26,6696/12 ("Narva", Plauen, Ger. Dem. Rep.), with colour temperature of 3100°K. The illumination was measured in the window of the lamp shelter by means of a luxometer. In the first series of experiment, one arm was dark, in the others — the illumination (e_0) given by the standard light was 28 800 and 900 lx, respectively. The intensity of the variable light (e) was changed in subsequent experiments of one series within the limits from 0 to 28,800 lx, being constant in each experiment. Other conditions and the experimental procedure were the same as in previous contributions.

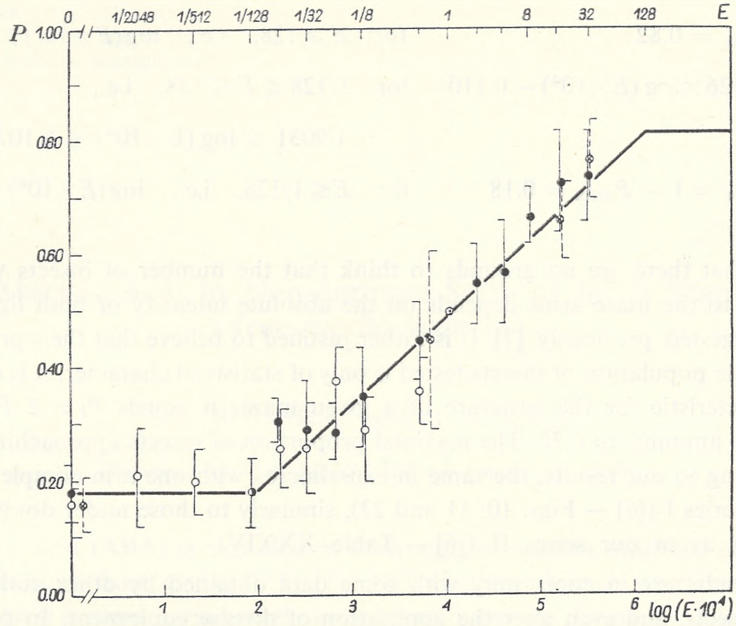
Results

The results of the first series of experiments (standard: 0 lux) are summarized in the Table. They show that the proportion of flies which collect in the illuminated arm of the maze is to a great extent independent of the light intensity, its value (P_{max}) amounting for *Calliphora* to 0.83 (±0.01).

In the second series, when both arms were illuminated (standard: 28,800 lx) the proportion of flies which approach the variable light (P), as illustrated in the

TABLE

Total number of flies	Variable light			
	Illumination of variable light (lux)	Number of flies approaching variable light	Proportion of flies approaching variable light ±3.36 σ	Ratio of flies approaching variable light
N	e	n	$P=\frac{n}{N}$	$R=\frac{n}{N-n}$
Calliphora erythrocephala Meig.				
504	1	376	0.75 ±0.06	2.94
675	14	541	0.80 ±0.05	4.04
540	56	417	0.77 ±0.06	3.39
1091	225	936	0.86 ±0.04	6.04
706	450	594	0.84 ±0.05	5.30
634	900	518	0.82 ±0.05	4.47
601	14 400	522	0.87 ±0.05	6.61
1343	28 800	1130	0.84 ±0.03	5.59
6094	—	5034	av. 0.83 ±0.01	av. 6.79
Phormia terrae-novae R.-D.				
204	225	180	0.88 ±0.08	7.50
91	450	84	0.92 ±0.10	12.00
573	900	479	0.84 ±0.05	5.10
215	28 800	201	0.93 ±0.06	14.36
1083	—	944	av. 0.87 ±0.03	av. 6.79



Proportion of *Calliphora*-flies approaching variable light *vs.* log. of its intensity. Vertical bars determine the significance intervals for $p = 0.001$. Open circles: II series (standard 28,800 lx). Full circles: III series (standard 900 lx); additional data for *Phormia* — crossed circles

Figure, seems to be a linear function of the logarithm of the relative intensity of light $\left(E = \frac{e}{e_0}\right)$ for the values $1/128 \leqslant E = 1$. Below $E = 1/128$ it assumes a minimal value ($P_{\min}$) of 0.18 ($\pm$0.03), what means that the proportion of flies which approach the brighter light when its $E \geqslant 128$, assumes a maximal value ($P_{\max}$) of 0.82. We obtained the same value (i.e., 0.82$\pm$0.02), when we calculate the proportion of flies approaching the brighter light of relative intensity $E \geqslant 128$ from both series of experiments described above.

To elucidate the problem of the discrepancy between our present findings with blowfly and the previous ones [7], a third series of tests with a standard 900 lx was performed. In this series the experiments from the previous paper [7] were repeated anew with the exception of the one with $E = 4$, i.e., $e = 3600$ lx, with more numerous groups of flies and extension of the tests towards higher illuminations, that is, 7200 lx ($E = 8$), 14,400 lx ($E = 16$), and 28,000 lx ($E = 32$) (higher illuminations were not available). The data obtained agree with the second series of experiments, so that they were used to complete the graph in the Figure. In particular, $P_{\min} = 0.18 \pm 0.04$ (in all the cases, the significance level is $p = 0.001$).

The behaviour of *Phormia* does not differ essentially from that of *Calliphora*.

Discussion

The general trend of the photic behaviour of flies under the double-choice condition, as revealed in the course of the above described experiments, is visualized in the Figure. The graph represents the function:

$$P = \begin{cases} P_{\max} = 0.82 & \text{for} \quad E \geqslant 128, \quad \text{i.e.,} \quad \log(E\times 10^4) \geqslant 6.1072, \\ 0.1526\times\log(E\times 10^4) - 0.1104 & \text{for} \quad 1/128 \leqslant E \leqslant 128, \quad \text{i.e.,} \\ & \quad 1.9031 \leqslant \log(E\times 10^4) \leqslant 6.1072, \\ P_{\min} = 1 - P_{\max} = 0.18 & \text{for} \quad E \leqslant 1/128, \quad \text{i.e.,} \quad \log(E\times 10^4) \leqslant 1.9031. \end{cases}$$

It shows that there are no grounds to think that the number of insects which go by chance to the maze arms depends on the absolute intensity of both lights — as it was suggested previously [7]. It is rather justified to believe that their proportion to the whole population of insects tested is only of statistical character, it is constant, and characteristic for the structure of a given maze; it equals $P_i = 2 \cdot P_{\min}$, and in our case amounts to 0.36. The maximal proportion of insects approaching a light is, according to our results, the same in experiments with one arm completely dark as in our series I ([6] — Figs. 10, 11 and 23), similarly to those under double-choice conditions, as in our series II ([6] — Table XXXIV).

The results are in conformity with some data obtained by other authors with various insects, and even after the application of diverse equipment. In particular, the linear dependence between the logarithm of relative light intensity and the proportion of insects attracted to it, which holds when we disregard the "insensitive" insects, P_i, has been obtained long ago ([1] — Fig. 5; [2] — Fig. 10; [4]).

Similarly, a constant maximal proportion of insects approaching a light ($P_{\max}$) versus darkness has also been recorded [6], although in some cases, when the light was very dim, the proportion of insects increased from the chance level ([3] — Fig. 4, [4] — Figs. 10, 11). In other cases, however, no insects remained at the dim light, or in a dark arm of the maze ($P_{\min}$), owing to a different experimental procedure [4].

The sigmoid shape of the curve in the Figure agrees with the presumption of Brown ([3], p. 212).

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TABLE DES MATIÈRES