Riassunto. Lo studio cariologico di alcune specie delle famiglie dei Microhylidae, Phrynomeridae, Ranidae e Hyperolidae, le cui relazioni filetiche sono tutt'ora assai discusse, fornisce dati a favore dell'ipotesi di rapporti di parentela tra i Microhylidae (i quali non appaiono cariologicamente primitivi) e i Ranidae, in quanto *Phrynomerus*, che fenotipicamente è assai vicino ai Microhylidae e da vari autori è considerato un membro di questa famiglia, ha un cariotipo assai somigliante a quello dei Ranidae; gli Hyperolidae studiati sono cariologicamente abbastanza differenziati da quest'ultima famiglia.

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Phototactic Choice Between Two White Light Sources of Various Intensity in Blowfly, *Calliphora erythrocephala* Meig.

A group response of freely moving invertebrates to 2 white light sources of varying relative intensities seems to be presently a neglected problem in the study of animal behaviour. We can hardly say whether it has ever been thoroughly studied at all. A single paper on honeybees[1] may be considered the bulk of the literature on the problem. A formula put forward in it:

$$\log R = m \log E + b \qquad (1)$$

(where E is the ratio of the intensity of the variable white light to that of the constant, standard white light, R the ratio of the number of bees attracted by the constant light, m the tangent of the angle of inclination, and b a constant) claimed for about 35 years to describe the fate of insect population in the Y maze under the influence of 2 lights of various intensity. An attempt to verify this hypothesis on house-flies, made recently by the senior author[2], failed to confirm it unequivocally. Those results, however, provided no explanation for another mathematical description of the behaviour of flies.

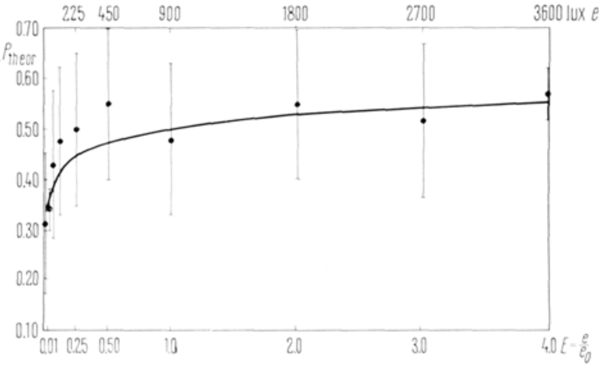
In the light of this, it seems to be justified to present the results obtained by one of us, recently complemented by the senior author, which concern a similar problem in blowflies.

Material and methods. The applied method was the same as in the paper of CHMURZYŃSKI[2]. A mixed population of both sexes of dark-adapted blowflies of the 'wild strain' were allowed to penetrate a wooden Y maze illuminated from the ends of the 2 arms by approximately parallel white light beams coming through water heat-filters from 50 W 12 V C. Zeiss (Jena) bulbs. Intensity of a standard light at the distant end of one arm amounted to 900 lux (e_0), a relative intensity of the other light assumed values, E, within the limits from 1/100 to 4, as presented in the Table; (e are corresponding absolute values of illumination of variable light). After each 10 min run, the lights were switched off, and the flies collected from the ends of the arms, and counted. Then the experiment was resumed. The procedure was repeated until all the flies made choice between the 2 arms of the maze. Each pair of lights was tested at least twice, each time with another group of flies, the mutual position of lights being changed. All the experiments were performed in similar conditions as to the age of flies, the time of day, temperature, humidity, and so on.

Results. The numbers of flies attracted to the experimental lights, n, in all experiments are presented in the Table; N are the numbers of flies used for each test. Respective proportions, P_{exp}, and the ratios, R_{exp}, of the flies approaching the variable light are also given. These data indicate that the greater the difference between intensities of the pair of experimental lights, the less flies enter the darker arm compared with those attracted to the other one.

Discussion. This general tendency is similar to that observed by BERTHOLF[1] in honeybees and by the author[2] in house-flies. However, when compared in details, this correlation (Figure) does not coincide in all these cases. The important feature of our recent results is that at higher intensities of variable light its attractiveness rises only very slowly, unlike this in lower intensities. Thus one can expect that the proportion of flies attracted by the brighter light tends towards a maximal value of about 0.60. Further experiments are needed for a decisive solving of this view. And here is a possible explanation of the mechanism of photic reactions of insect population such as are observed under the condition of choice of 2 white lights of various relative intensities in a Y maze. The assumed mechanism consists of 2 processes independent of each other.

(a) A certain proportion of insect population, P_i, makes choice by chance with the probability of $^1/_2$, independently of relative intensities of lights. This group of 'indifferent'[3] insects, n_i, seems to be directly proportionally correlated with the logarithm of the sum of absolute values of both



Correlation of the proportion ($\pm$ 1.96 σ) of flies approaching variable white light with the relative intensity of it. Further explanations in text.

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[1] L. M. BERTHOLF, J. agric. Res. *42*, 379 (1931).

[2] J. A. CHMURZYŃSKI, Bull. Acad. pol. Sci. Cl. II Sér. Sci. biol. *15*, 415 (1967).

[3] Some of them, however, can be sensitive but they might have entered a 'wrong' arm due to geometrical characteristic of the maze. It will be, of course, a statistically constant proportion (for a given type of maze) which contributes to the parameter a in the formula (2).

						Inferences from the hypothesis						Experimental results		
Total No. of flies	Illumination of variable light in lux	Relative intensity of variable light		Sum of illumination of both lights in lux		Theoretical proportion of 'indifferent' flies		Theoretical proportion of sensitive flies	Theoretical proportion of sensitive flies attracted to variable light	Theoretical proportion of flies attracted to variable light	Theoretical proportion of flies approaching variable light	No. of flies approaching variable light	Proportion of flies approaching variable light with 95% confidence limits, i.e. ± 1.96 σ	Ratio of flies approaching variable light
N	e	$E = \frac{e}{e_0}$	$\log(E \cdot 10^3)$	$e + e_0$	$\log(e + e_0)$	$P_i = \frac{n_i}{N}$	$\frac{P_i}{2}$	$P_s = \frac{n_s}{N} = 1 - P_i$	$P_a = \frac{n_a}{n_s}$	$P_b = \frac{n_a}{N} = P_a P_s$	$P_{\text{theor}} = \frac{P_i}{2} + P_b$	n	$P_{\exp} = \frac{n}{N}$	$R_{\exp} = \frac{n}{N - n}$
42	9	1/100	1.000	909	2.959	0.64	0.32	0.36	0.01	0.00	0.32	13	0.31 ± 0.14	0.45
698	14	1/64	1.233	914	2.961	0.64	0.32	0.36	0.08	0.03	0.35	239	0.34 ± 0.04	0.52
42	45	1/20	1.699	945	2.975	0.64	0.32	0.36	0.18	0.06	0.38	18	0.43 ± 0.15	0.75
42	113	1/8	2.097	1013	3.006	0.64	0.32	0.36	0.28	0.10	0.42	20	0.48 ± 0.15	0.91
42	225	1/4	2.398	1125	3.041	0.65	0.33	0.35	0.35	0.12	0.45	21	0.50 ± 0.15	1.00
42	450	1/2	2.699	1350	3.130	0.65	0.33	0.35	0.43	0.15	0.48	23	0.55 ± 0.15	1.21
42	900	1	3.000	1800	3.255	0.66	0.33	0.34	0.50	0.17	0.50	20	0.48 ± 0.15	0.91
42	1800	2	3.301	2700	3.431	0.68	0.34	0.32	0.52	0.18	0.52	23	0.55 ± 0.15	1.21
42	2700	3	3.477	3600	3.556	0.69	0.35	0.31	0.54	0.19	0.54	22	0.52 ± 0.15	1.10
361	3600	4	3.602	4500	3.653	0.69	0.35	0.31	0.55	0.20	0.55	205	0.57 ± 0.05	1.31

lights (simultaneously acting on insects at the choice point of the maze!), a proportion of them being:

$$P_i = k \log(e + e_o) + a \qquad (2)$$

(b) The other, sensitive insects, $n_s = N - n_i$, choose the lights probably in a proportional manner to the logarithm of relative intensities of lights, E, as it was supposed in the previous paper[2], viz.:

$$P_a = n \log(E \times 10^3) + c \qquad (3)$$

The hypothesis assumes that it is valid within rather broad, however restricted, limits of values E.

Interference of both processes (i.e. a and b) conduces to the resultant which determines a proportion of all the insects approaching one light, namely:

$$P_{\text{theor}} = \frac{P_i}{2} + P_b\,, \qquad (4)$$

where

$$P_b = P_a\,(1 - P_i),$$

i.e. it denotes the proportion of sensitive individuals attracted to one light to the whole number of insects[4].

If the hypothesis is adequate and, especially, if $P_{\exp}$ really tends towards maximal value (P_{max}) due to the process (a) described by the formula (2), consequently the minimal value of the proportion is

$$P_{min} \neq 1 - P_{max} \qquad (5)$$

and particularly

$$P_{min} < (1 - P_{max}). \qquad (5')$$

This consequence can be tested as an experimentum crucis. Then, if the interpendence (2) is true, there should be a distinct difference between the results obtained with very bright lights, for instance with a standard light, ca. 20,000 lux, and with dim lights, or, even better, with the dark arm of a maze as a standard. It is the aim of the senior author to prove this in his subsequent study.

Zusammenfassung. Die Proportion der Auswahl des variablen Lichtes durch die Population der Schmeissfliege, *Calliphora erythrocephala* Meig. im Labyrinth Y, beim Standard 900 Lux, wächst zusammen mit der relativen Lichtstärke, wobei sie sich bei grösseren Lichtstärken dem Maximalwert von etwa 0.60 zu nähern scheint.

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[4] If we put provisionally $k = 0.077$, $a = 0.412$, $n = 0.245$, $c = -0.235$, and we denote the validity of the formula (3) to the interval $< 1/100, 100 >$, i.e. $< 1.00, 5.00 >$ for $\log(E \cdot 10^3)$, so that our formulae assume the forms:

$$P_i = 0.077 \log(e + e_0) + 0.412 \qquad (2')$$

$$P_a = 0.245 \log(E \cdot 10^3) - 0.235, \qquad (3')$$

we obtain values presented in the Table. (In the Table, n_a means theoretical number of flies attracted to variable light.) Values of P_{theor} calculated in this way evidently coincide well with our experimental results, $P_{\exp}$, and, particularly, a curve in the Figure goes along the points estimated from the formula for P_{theor}. The values assumed serve only as an example of a presumable mechanism of the observed phenomena and do not claim to represent proper relationships.