
PHOTOTAXIC RESPONSE IN THE RHINOCEROS BEETLE (*Oryctes rhinoceros* L.)

By

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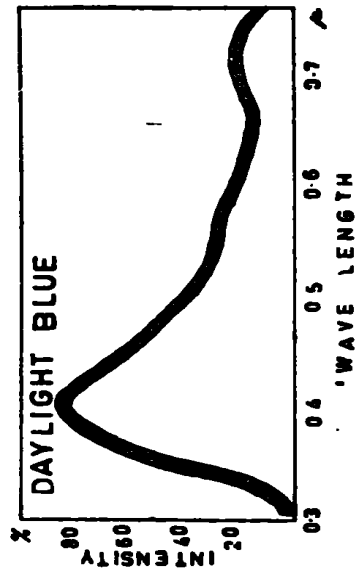
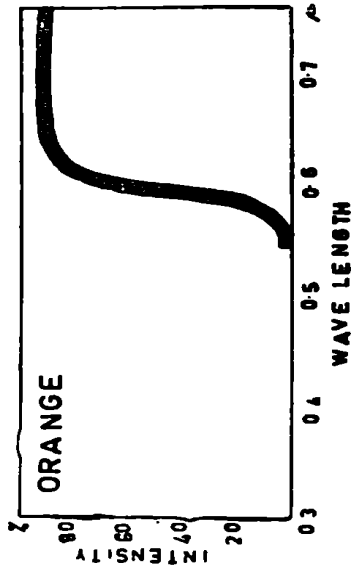
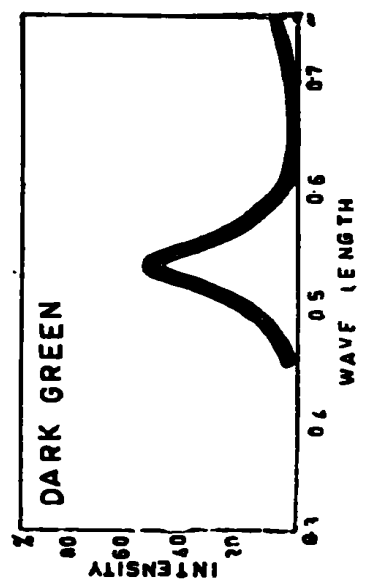
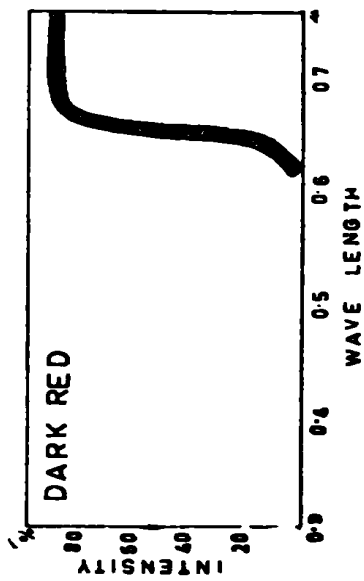
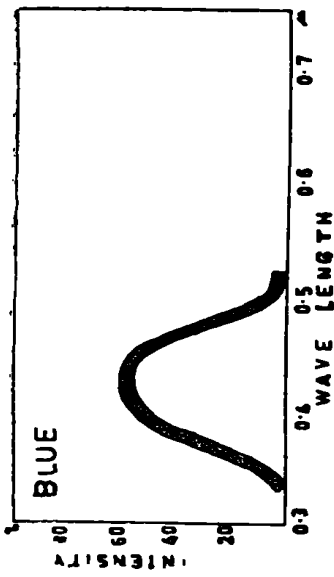
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THE investigation reported herein was designed to determine the response of *Oryctes rhinoceros* L. to light of various wave lengths. It appeared likely that the results would be of value in devising a light trap that would be effective in the control of *Oryctes*. White light was broken up into the following colours by using appropriate filters :—Daylight Blue, Light Red, Orange, Light Green, Dark Blue, Dark Red, Purple, Dark Green, Light Neutral, Day Natural, Yellow.

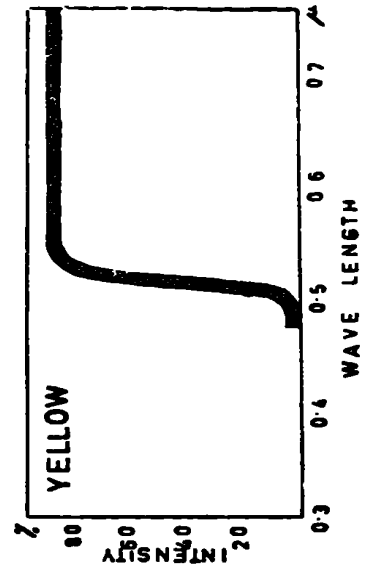
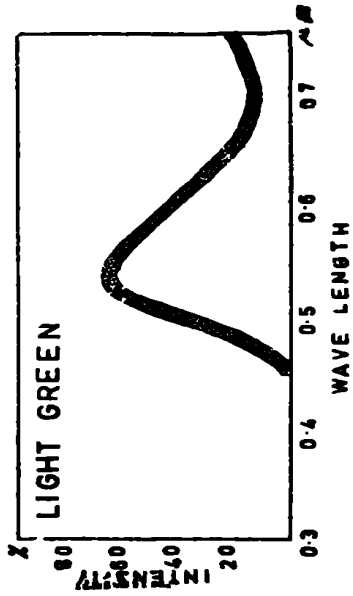
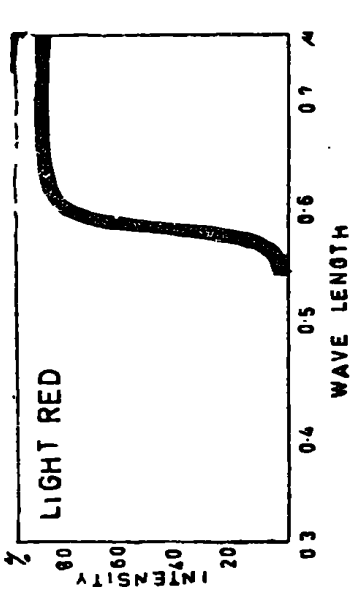
The filters were those supplied by C. Baker of Holborn, Ltd., for use in microscope lamps. The colour transmission curves for the various filters as supplied by the manufacturers are reproduced below. Manufacturers state that "each curve is the mean curve for the type in question." These colours were compared separately with the ground-glass filter which permitted the transmission of white light.

Apparatus :

A box made of $\frac{1}{2}$ in. wood and measuring $21\frac{1}{2}$ in. \times $21\frac{1}{2}$ in. was divided into three compartments by two sloping partitions. The two outer compartments were 9 in. wide at the top and 6 in. wide at the bottom. The sides of the centre compartments were $3\frac{1}{2}$ in. apart at the top and $9\frac{1}{2}$ in. apart at the bottom. The centre compartment sides had two glass panels. Each panel was 14 in. long and 2 in. broad. The sides of the centre compartment were fitted with flaps measuring $1\frac{1}{2}$ in. \times $20\frac{1}{2}$ in., that opened outwards. The lid of the box was made in three sections and was secured by wooden catches. The lids of the outer compartments measured $21\frac{1}{2}$ in. \times $9\frac{1}{2}$ in. and the lid of the centre compartment measured $21\frac{1}{2}$ in. \times $3\frac{1}{2}$ in. On the lids of the outer compartments were two square frames measuring 2 in. \times 2 in. into which the filters fitted.



$\lambda = 10,000 \text{ \AA}$



Colour transmission curves of some of the filters used.

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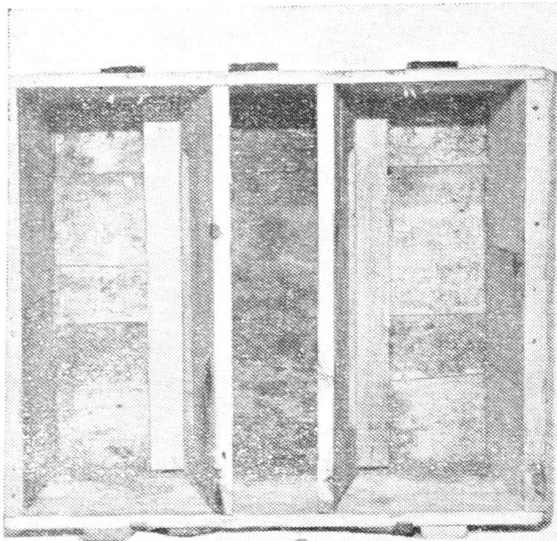


FIG. 1

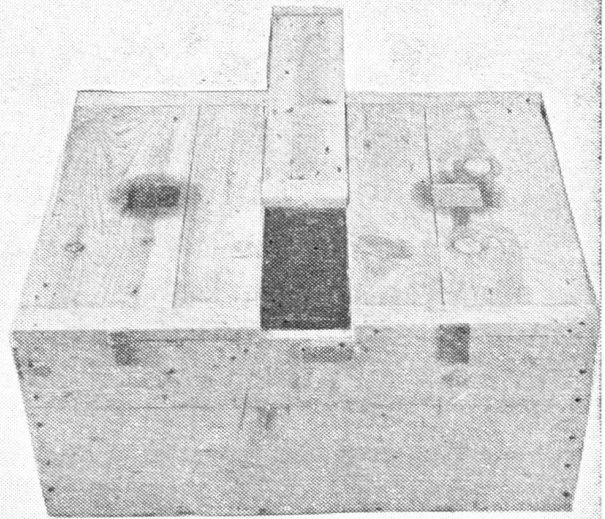


FIG. 2

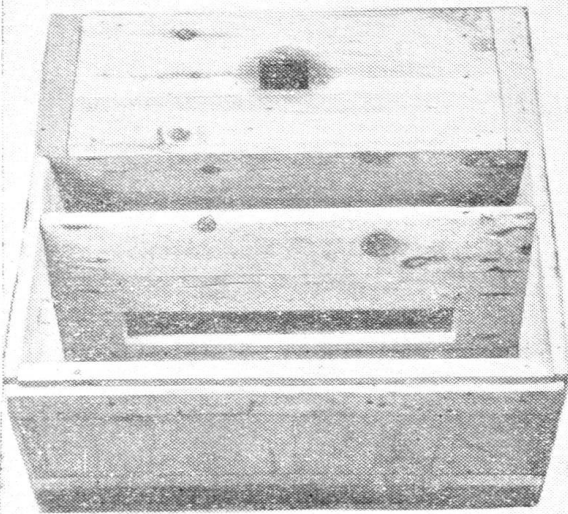


FIG. 3

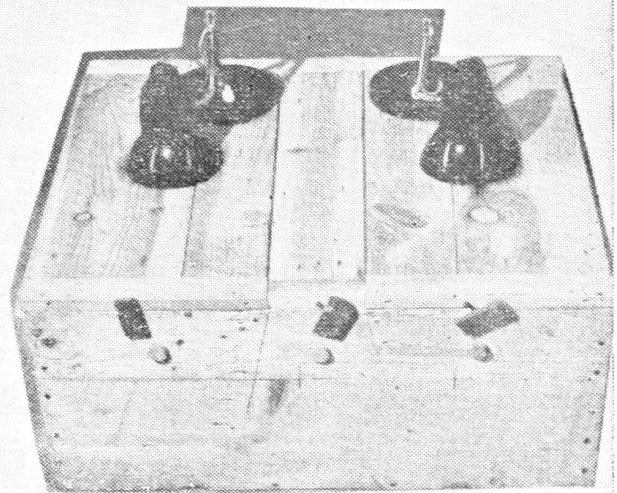


FIG. 4

- (1) Box with lid removed.
- (2) Box with centre section of lid retracted.
- (3) Box with the sections of the lid covering the centre and an outer compartment removed to expose glass pane.
- (4) Box with lamps in position.

Two 40-watt angle-poise lamps were used as sources of light which was directed through the filters, into the two outer compartments. Some of this light passed into the centre compartment through the glass panels.

Procedure :

IN the centre compartment of the apparatus described above, the beetles along with 4 in. pieces of coconut petiole were without any illumination for 72 hours. The feeding material was renewed daily. The lamps were then switched on for 48 hours while the beetles were still confined to the centre compartment. The lamps were then switched off for a further period of 24 hours. Beetles were replaced as necessary. The filters were then placed in position, the checks confining the beetles to the centre compartment were removed, food was introduced into all three compartments, and the lights switched on. The beetles were exposed to the light sources for 24 hours. At the end of this period the number of beetles found in each compartment was counted and their sex noted. For the next 24-hour period the beetles were subjected to complete darkness and were confined to the centre compartment. In this way the beetles were exposed to the various wave lengths for a period of 24 hours, only. A period of total darkness intervened between two successive periods of exposure, and during this period the beetles were confined to the centre compartment.

Design of Experiment :

IN the first series the ground glass filter was placed in the frame on the left-hand side lid, and the coloured filter in the frame on the right-hand side lid. The colour filters were chosen at random.

The sequence was as follows :—

<i>Left-hand side</i>		<i>Right-hand side</i>
Ground glass	vs.	Daylight blue
Ground glass	vs.	Dark blue
Ground glass	vs.	Light neutral
Ground glass	vs.	Light red
Ground glass	vs.	Dark red
Ground glass	vs.	Day neutral
Ground glass	vs.	Orange
Ground glass	vs.	Purple
Ground glass	vs.	Yellow
Ground glass	vs.	Light green
Ground glass	vs.	Dark green

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The same routine was followed in the second series.

The sequence of filters used was as follows :—

<i>Left-hand side</i>		<i>Right-hand side</i>
Ground glass	vs.	Yellow
Ground glass	vs.	Day Neutral
Ground glass	vs.	Dark red
Ground glass	vs.	Light red
Ground glass	vs.	Daylight blue
Ground glass	vs.	Light neutral
Ground glass	vs.	Orange
Ground glass	vs.	Dark blue
Ground glass	vs.	Light green
Ground glass	vs.	Dark green
Ground glass	vs.	Purple

In the two previous series the ground glass filter (standard) was always placed in the left-hand side frame of the lid. In the third series, the ground-glass filter was changed from the left-hand side to the right-hand side with every alternative exposure. The sequence was as follows :—

<i>Left-hand side</i>		<i>Right-hand side</i>
Yellow	vs.	Ground glass
Ground glass	vs.	Day neutral
Dark Red	vs.	Ground glass
Ground glass	vs.	Light red
Daylight blue	vs.	Ground glass
Ground glass	vs.	Light neutral
Orange	vs.	Ground glass
Ground glass	vs.	Dark blue
Light green	vs.	Ground glass
Ground glass	vs.	Dark green
Purple	vs.	Ground glass

Results :

THE results obtained are presented in Table I.

TABLE I

Beetle counts taken in three compartments of the apparatus during the 24-hour period of exposure

<i>Series</i>	<i>Beetles used in Export</i>						<i>Ground glass</i>						<i>Daylight blue</i>					
	<i>Total</i>	<i>Male</i>	<i>Female</i>	<i>Total</i>	<i>Male</i>	<i>Female</i>	<i>Total</i>	<i>Male</i>	<i>Female</i>	<i>Total</i>	<i>Male</i>	<i>Female</i>	<i>Total</i>	<i>Male</i>	<i>Female</i>			
1 ..	39	21	18	18	10	8	11	3	8	11	3	8	11	3	8			
2 ..	13	8	5	6	3	3	6	4	2	6	4	2	6	4	2			
3 ..	12	8	4	2	1	1	4	2	2	4	2	2	4	2	2			
													<i>Dark blue</i>					
1 ..	37	20	17	6	3	3	4	2	2	5	4	1	3	2	1			
2 ..	11	8	3	4	2	2	5	4	1	5	4	1	3	2	1			
3 ..	10	6	4	1	0	1	3	2	1	3	2	1	3	2	1			

TABLE I—(contd.)

Beetle counts taken in three compartments of the apparatus during the 24-hour period of exposure—*contd.*

Series	Beetles used in Export			Ground glass			Daylight blue		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
							<i>Light Neutral</i>		
1 ..	32	15	17	15	5	10	6	3	3
2 ..	15	8	7	6	4	2	5	2	3
3 ..	14	8	6	1	1	0	6	4	2
							<i>Light Red</i>		
1 ..	29	14	15	12	4	8	13	6	7
2 ..	14	9	5	5	3	2	8	5	3
3 ..	11	7	4	2	1	1	7	4	3
							<i>Dark Red</i>		
1 ..	24	12	12	8	4	4	12	5	7
2 ..	15	9	6	4	3	1	7	5	2
3 ..	15	10	5	3	3	0	10	6	4
							<i>Day Neutral</i>		
1 ..	24	7	17	4	2	2	9	2	7
2 ..	15	5	10	5	0	5	5	1	4
3 ..	13	7	6	7	4	3	2	1	1
							<i>Orange</i>		
1 ..	20	8	12	8	3	5	11	5	6
2 ..	12	9	3	7	5	2	1	0	1
3 ..	12	7	5	5	2	3	1	1	0
							<i>Purple</i>		
1 ..	25	9	16	5	1	4	5	0	5
2 ..	11	6	5	3	2	1	6	3	3
3 ..	6	4	2	0	0	0	4	2	2
							<i>Yellow</i>		
1 ..	18	8	10	8	3	5	4	0	4
2 ..	15	5	10	4	1	3	4	0	4
3 ..	12	7	5	3	2	1	6	2	4
							<i>Light Green</i>		
1 ..	18	6	12	8	2	6	4	0	4
2 ..	12	8	4	6	2	4	4	4	0
3 ..	9	6	3	3	2	1	1	1	0
							<i>Dark Green</i>		
1 ..	16	6	10	6	5	1	4	0	4
2 ..	13	8	5	5	2	3	3	1	2
3 ..	8	5	3	1	1	0	4	1	3

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Percentages of beetles attracted by various colours are given in Table 2. The data after transformation to the inverse sine scale appropriate to a binomial distribution have been subjected to an analysis of variance.

TABLE II
Percentage of beetles attracted to the different colours

Colour	Replicate I		Replicate II		Replicate III	
	Males	Females	Males	Females	Males	Females
Blue ..	12.2	28.1	50.0	36.7	29.2	37.5
Neutral (light and day)	24.3	29.4	22.5	41.4	32.2	25.0
Red ..	42.3	52.5	55.6	46.7	58.6	77.5
Green ..	0.0	36.7	31.3	20.0	18.4	50.0
Orange ..	62.5	50.0	0.0	33.3	14.3	0.0
Purple ..	0.0	31.3	50.0	60.0	50.0	100.0
Yellow ..	0.0	40.0	0.0	40.0	28.6	80.0

TABLE III
Analysis of Variance of Transformed Data ($\theta = \text{Sin}^{-1} \sqrt{P}$)

Source	..	..	D. F.	S. S.	M. S.	F.
Replicates	..	..	2	887	444	2.08
<i>Main effects:</i>						
Colour	..	..	6	2,469	412	1.93
Sex	..	..	1	1,349	1,349	6.33*
<i>Interactions:</i>						
Colour and Sex	..	..	6	1,274	212	—
Error	..	..	26	5,537	213	—
Total			41	11,516	—	—

S.E. of mean ± 5.958
 S. E. of difference between 2 treatments means = ± 4.214 .
 Critical difference = 8.7.

TABLE IV
Treatment means

Colour	Mean	
	Sine	%*
Red ..	34.3	56.4
Purple ..	34.0	55.9
Yellow ..	19.7	33.7
Blue ..	19.0	32.6
Neutral (light and day)	17.0	29.2
Orange ..	16.2	27.9
Green ..	15.5	26.7

*Re-transformed.

TABLE V
Sex means

<i>Sex</i>		<i>Mean</i>			
		<i>Sine</i>		<i>%*</i>	
Male	16.6	..	28.6
Female	27.9	..	46.8

*Re-transformed.

Conclusions :

THE following conclusions stem from the statistical analysis :—

- (i) The red and purple coloured beams are significantly better than the other colours. The red is relatively more reliable than purple because the purple is based on a fewer number of beetles.
- (ii) There is no significant difference between red and purple.
- (iii) Yellow, blue, neutral (light and day), orange and green did not differ significantly among themselves.
- (iv) Sex difference highly significant, i.e., females are more attracted to all colours.
- (v) Sex \times colour interaction is not significant. This means that there is no sex bias towards a particular colour or colours.

Acknowledgments :

THANKS are due to Mr. V. Abeywardene for the statistical analysis of the results and to Mr. D. B. Hettiaratchi for the photographs.