THE RHINOCEROS BEETLE (*ORYCTES RHINOCEROS L*) IN CEYLON

PART II A — Phototaxic responses of (*Oryctes rhinoceros L*)

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Introduction

It is believed by certain coconut growers that burning at dusk, of rubbish, leaf litter and other debris that is found on and around coconut plantations keeps the number of *Oryctes* down. If this belief is correct then it means that *Oryctes* responds to stimulation by either heat or light or both. If the stimulus is light then it is possible that it may be to a particular portion of the spectrum of white light.

It is however, unlikely that the number of *Oryctes* is kept down by burning litter and rubbish, because there is along with the light emitted during burning a considerable quantity of heat emitted. This heat is carried up as a result of convection. It is likely that there prevails a heat envelope around the burning material. The extent of the limit of this envelope of heat

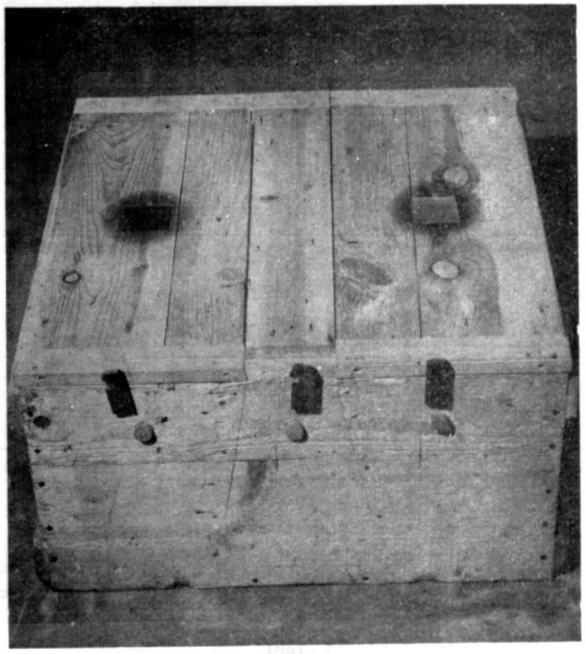

Plate I

The box is shown here with the three sections of the lid in position.

will depend on the air currents prevailing at the time. Therefore it is possible to assume that efficient control of *Oryctes* will not be got because of this envelope of heat surrounding the burning material. However, the observations of the growers that *Oryctes* is attracted to the source of material being burnt has prompted us to look into the other factor that is present when material is burnt. This is light which may be of a particular colour or colours. This paper deals with the colour responses of *Oryctes*. The investigation was carried out with a view to using our findings in a light trap that would be effective in the control of *Oryctes*.

Materials and Methods

2 × 2 inch filters which permitted the break up of white light into its various component colours.

White light was thus broken up into the following colours by using appropriate filters:—

Daylight blue	Dark blue	Light neutral
Light red	Dark red	Day neutral
Orange	Purple	Yellow
Light green	Dark green	

(The filters were 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 "nominal" or mean curve for the type in question.' There are slight variations from melting to melting but every care is taken to keep these small.

COLOUR TRANSMISSION CURVES OF FILTERS SUPPLIED BY C. BAKER OF HOLBORN LTD.

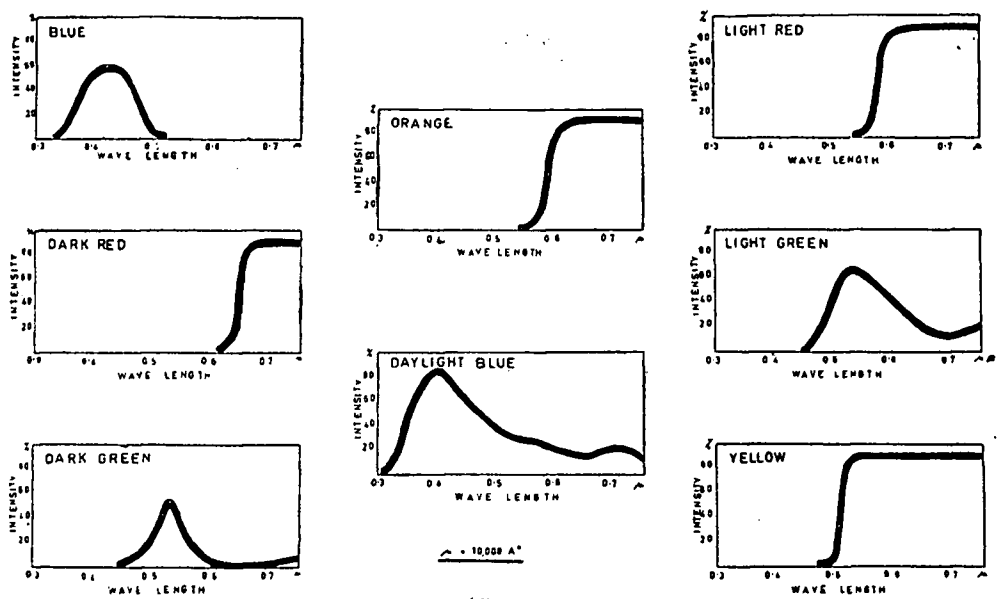

Plate II

Colour transmission curves of some of the filter used. These colours were compared singly with the ground glass filter which permitted the emission of white light. The apparatus and procedure used in the experiment is described below.

Apparatus

The apparatus for the study was designed by the author, and was as follows:—A wooden box made of ½in. wood and measuring 21½" × 21½" was divided into three compartments by two internal partitions, which sloped at an angle. The two outer compartments were of 9 ins. width at the top and 6 ins. at the bottom. The sides of the centre compartments were 3½ ins. apart at top and 9 ½ ins. at the bottom. The centre compartment sides had two panels of window glass. Each panel was 14 ins. long and 2 ins. broad. The oblique height of the panels was 5 ins. from the top and 3 ins. from the bottom.

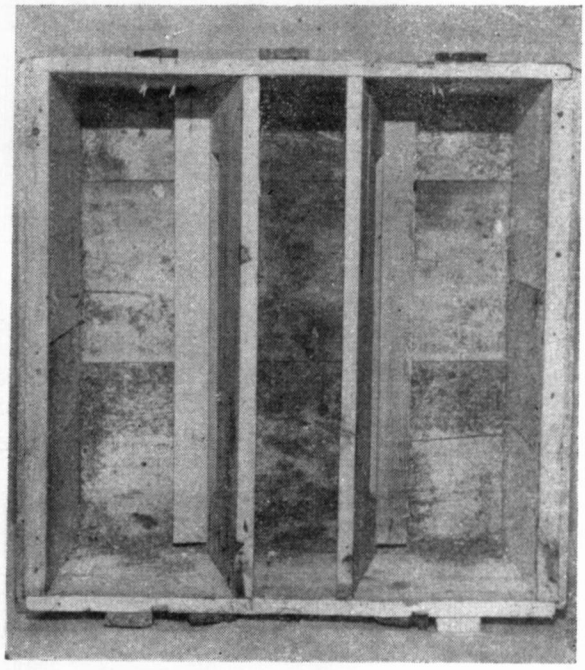

Plate III

The box with the three sections of the lid removed and the bottom flaps on the sides of the inner compartment opened out to show the access that beetles in the centre compartment have to the two outer compartments.

The lower end of the sides of the centre compartment was fitted with moveable flaps 1½ ins. wide and 20½ ins. long. The flaps were so fitted as to permit their movement only in one direction, i.e. from the centre compartment to the outer compartments.

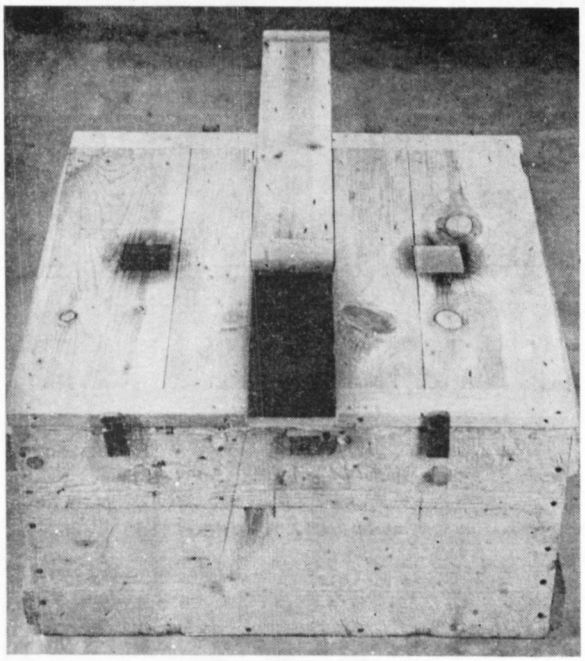

Plate IV

The two sections of the lid fitting the outer compartments in position and a section of the lid fitting the centre compartment partly retracted are shown.

The lid of the box was made in 3 sections. The dimensions of each section corresponding to the dimensions of the compartments at the top, i.e. the lids of the outer compartments measured 21½ ins. by 9½ ins. and the lid of the centre compartment measured 21½ ins. by 3½ ins. When the lid was placed in position it was possible to fasten it securely by means of wooden catches.

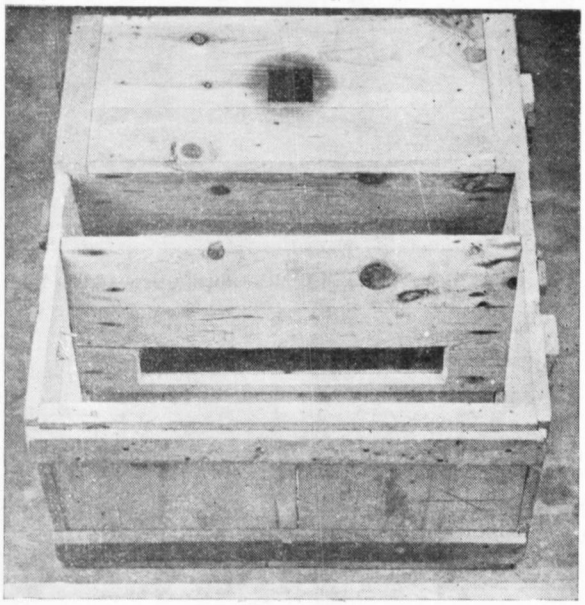

Plate V

Shows a side view of the apparatus with the sections of the lid covering the centre and right outer compartments removed to expose the glass panel 2 ins. × 14 ins.

The lids of the two outer compartment had to be placed in position before it was possible to slide the lid of the centre compartment into position. The lid of the centre compartment was held in position by catches. On each of the upper surface of the lids of the outer compartments were two square frames. The frames were 2 ins. × 2 ins. and into these frames fitted the filters to be tested.

Two angle poise lamps burning 40 watt. clear glass bulbs were used as the sources of light. The beams of light from these lamps were directed through the filters, into the two outer compartments. Some of this light passed into the centre compartment through the glass panels.

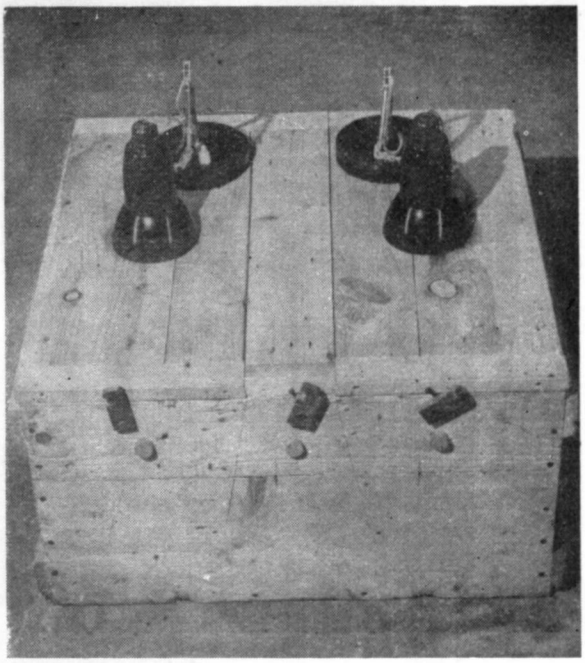

Plate VI

The various sections of the lids and lamps are shown in position during periods of exposure. Beneath the lamps the filters have been placed in their frames.

Procedure

Into the centre compartment of the apparatus described above, the beetles along with 4 inch pieces of coconut petiole were introduced. The sexes of beetles were noted. The beetles were confined to this compartment without any illumination for a period of 72 hours. The feeding materials were renewed daily. The lamps were then switched on for a period of 48 hours while the beetle were still confined to the centre compartment. The lamps were then switched off for a further period of 24 hours. Any replacements of beetles that was necessary in order to maintain the beetle numbers was carried out. 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 were counted and their sex noted. For the next 25 hour period the beetles were subjected to complete darkness and

were confined to the centre compartment. The beetles were thus exposed to the various coloured lights 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. Renewal of food was done daily irrespective of whether the beetles were or were not exposed to light.

Design of Experiment

First replicate.—In this series the ground glass filter was placed in the frame on the left-hand side. The coloured filter in the frame on the right-hand side. No predetermined sequence for use of colour filters was employed. The colour filters were chosen at random for use in all replicates.

The sequence followed in the first replicate was as follows:

Left-hand Side		*Right-hand Side*
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

Second replicate.—The sequence of filters used were as follows:

Left-hand Side		*Right-hand Side*
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

Third replicate.—In this replicate a further factor of randomisation was used. In the two previous replicates the ground glass filter (standard) was always placed in the left-hand frame of the lid. In this replicate the ground glass filter was changed from the left-hand side to the right-hand side with every alternate exposure. The exposure was as follows:

Left-hand Side		*Right-hand Side*
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 tabulated below in Table I.

TABLE I

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

Experiment	*Beetle used in expt.*			*Ground glass*			*Daylight blue*		
	Total	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*	*Male*	*Female*
1 ..	39	21	18	18	10	8	11	3	8
2 ..	13	8	5	6	3	3	6	4	2
3 ..	12	8	4	2	1	1	4	2	2
							Dark Blue		
1 ..	37	20	17	6	3	3	4	2	2
2 ..	11	8	3	4	2	2	5	4	1
3 ..	10	6	4	1	0	1	3	2	1
							Light Neutral		
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
							Light Red		
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
							Dark Red		
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
							Day Neutral		
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
							Orange		
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
							Purple		
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
							Yellow		
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
							Light Green		
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
							Dark Green		
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

Analysis of the Results

The factor subjected to statistical treatment was the percentage of beetles attracted to the different colours. Although some colours were split up into components such as light and dark, for purposes of analysis, the factors were combined.

TABLE II

Percentage of beetles attracted to the different colours

Colour	*Replicate* 1		*Replicate* 2		*Replicate* 3	
	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

The data was transformed into 'natural sines' in order to ensure 'Normality of distribution'. This was done because the percentages are based on small numbers.

Table III gives the transformed data which was subsequently statistically analysed.

TABLE III

Percentage of beetles attracted to different colours transformed into 'natural sines +'

Colour	*Replicate* 1		*Replicate* 2		*Replicate* 3	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
Blue ..	7	16	30	22	17	22
Neutral (light and day) ..	14	17	13	24	19	15
Red ..	25	32	34	28	36	51
Green ..	0	22	18	12	11	30
Orange ..	39	36	0	20	8	0
Purple ..	0	18	30	37	30	89
Yellow ..	0	24	0	24	17	53

+ Units are in degrees.

TABLE IV

Analysis of Variance

Source	*D.F.*	*S.S.*	*M.S.*	*F.*
Replicates ..	2	887	444	2.08
Main effects				
Colour ..	6	2,469	412	1.93
Sex ..	1	1,349	1,349	6.33 +
Interactions				
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 V

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 VI

Sex Means

Sex	*Mean*	
	Sine	% +
Male ..	16.6	28.6
Female ..	27.9	46.8

+ Re-transformed.

Statistical Findings

From the above analysis we have the following findings:

(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 x colour interaction is not significant. This means that there is no sex bias towards a particular colour or colours.

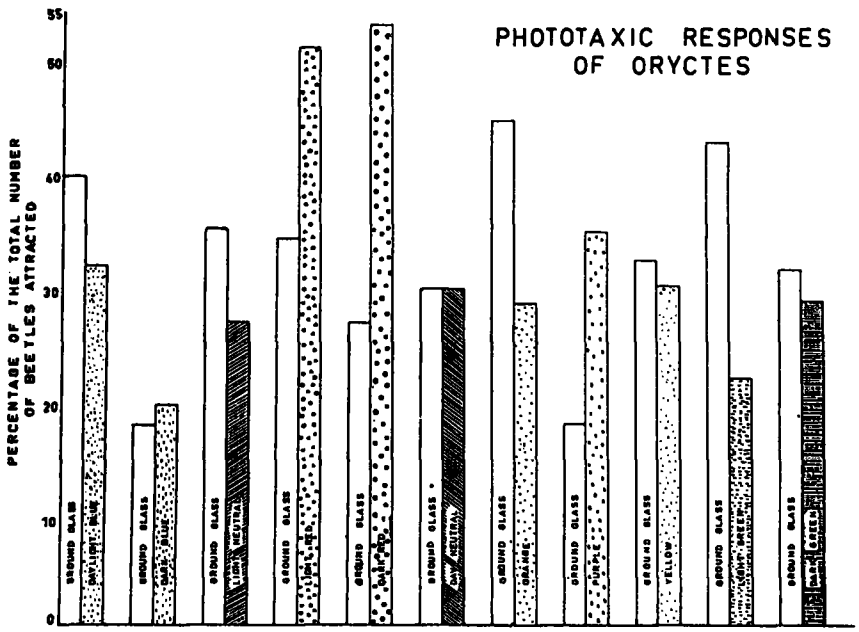

Plate VII

The responses obtained with the various filters in the three replicates of the experiment.

Discussion

The apparatus was simple and effective for the purpose it was to be used. The heat generated by the lamps during the 24 hour exposure period was checked prior to setting up of the experiment by placing two maxima and minima thermometers in each of the outer compartments. There was only a 3°C rise in temperature during the whole period of exposure. Thus it will be seen that the experimental insects were not subjected to any great temperature stresses.

There were no deaths resulting from thermal effects. Deaths that occurred appeared to be due to natural causes. The number of beetles during the experimental period fluctuated widely as will be seen from the figures in Table I. When deaths occurred replacements were made.

By providing food in all three compartments of the apparatus the response to food was standardised. The food comprised of pieces of leaf petiole 4 ins. long and 1 in. square. A piece of petiole was provided for each beetle to feed on.

The design of the apparatus was such that the panels on the sides of the centre compartments permitted a narrow strip of light to enter into this compartment. When the lamps were switched on, the two strips of light that came into the centre compartment were separated by a zone which did not permit the light that diffused through the two panels, to mix. In this way the different beams of light that entered the centre compartment were kept separate. Since the light source did not diffuse into the other, the beetles were not subjected to differential optical stimulation unless they crossed over from one side of the centre compartment to the other side.

Although no particular accepted experimental design was employed, 'randomness' was incorporated into the experiment and this lent the experiment to statistical analysis. Each colour filter was used once and in no preconceived order. This precaution was taken to avoid introduction of any bias.

In the third replicate a further precaution was taken by selecting at random the compartment in which the colour filter was placed. For all intents and purposes randomisation has been incorporated into the experiment.

A 24 hour period was allowed between two successive periods of exposure. This period was interposed in order to permit the reactions of the beetles to return to normal, prior to being subjected to the next exposure.

In all 2 colours were used, among them being dark and light shades of certain colours. The analysis was restricted only to the main colours, and to do so the dark and light shades were combined. This gave 7 main colours for analysis.

Summary

(i) *Oryctes* is attracted to red and purple light.
(ii) Females are attracted to light more than males.
(iii) There is no sex x colour interaction.

Acknowledgements

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