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LABORATORY STUDIES ON TRAIL FOLLOWING BEHAVIOR OF THE TERMIT E*HYPOTERMES OBSCURICEPS* TOWARDS 2-PHENOXYETHANOL

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A B S T R A C T

Hypotermes obscuriceps is the most abundant of termite species found in North-eastern Puducherry. It has been seen to assimilate ligninous waste kept for degradation in the termireactors designed earlier by the authors by the process of termigradation. Termigradation is a termite-based biodegradation process and involves attracting termites towards the ligninous waste in specially designed reactors. Such reactors are kept in pits or aboveground near termite mounds. In order to increase the number of termites that will move towards the feed kept in such termireactors, 2-Phenoxyethanol (2-PE) was explored in the laboratory for making trails that may attract *H. obscuriceps.* Five different concentrations of 2-PE, ranging from 0.1 to 0.0005% were explored and in controlled experiments, the numbers of termites that followed the trails made by these levels of 2-PE as a function of time were determined. It was seen that all the trails that contained 2-PE attracted *H. obscuriceps* and none was toxic to termites for the first 60 minutes.

Keywords: 2-Phenoxyethanol, *Hypotermes obscuriceps,* trail, termites, attractant.

INTRODUCTION

One of the strategies to control termites and other insects has been the use of man-made chemicals to attract the insects in a manner pheromone and other naturally occurring biomolecules do. Once attracted to a spot in this manner the insects can be killed more easily than when they are in a dispersed form. Based on chance observations that termites tend to move down the lines drawn by ball-pen, Becker and Mannesmann (1968) investigated the effectiveness of different ballpoint ink formulations on 55 termite species from 21 genera of 4 families and more than 100 different cultures and groups. It was seen that all species followed the trails formed by the 6 types of ball pen inks that were explored even as the sharpness of the response differed from family to family. In general, Rhinotermitidae and Termitidae reacted to the scents present in the ballpoint ink trails much more strongly than Kalotermitidae and species of *Mastotermes*. The authors attributed the trail following behaviour of termites to the presence of glycol compounds in the ink and showed that different species react with different intensity to glycols of different molecular structure. Even different isomers had a different effect. Since then a number of substrates have been found to attract termites to move up the trails formed by them the summary of all past reports on this subject is presented in Table 1. Additionally, there are patents registered with ergosterol (Henderson *et al.,* 1999), cholesterol, hydroisoandrosterone (Galinis and Strnad, 2000), and 2-naphthalenemethanol (U.S. Pat. No. 5, 63, 298) as trail-eliciting compounds for termites. Chen *et al.,* (1998) investigated the constituents of Papermate brand ball-pens and isolated 2-phenoxyethanol (2-PE) from it as a powerful trail-inducing substance. It was thought that the structural similarity of 2-PE to dodecantreinol, the main compound of the trail pheromone of glycol compounds contained in these formulations of *Coptotermes formosanus* and *Reticulitermes* spp., may be the reason for its appeal to termites. 2-PE has other favourable attributes — it is relatively inexpensive, stable, and does not evaporate too rapidly after LaPorte *et al.,* 2004., LaPorte and Stephens, 2012). The present study reports the effect of 2-PE trails on the termite species *H. obscuriceps.*

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Table 1. Non-pheromone chemicals tested so far in making trails that attract termites.

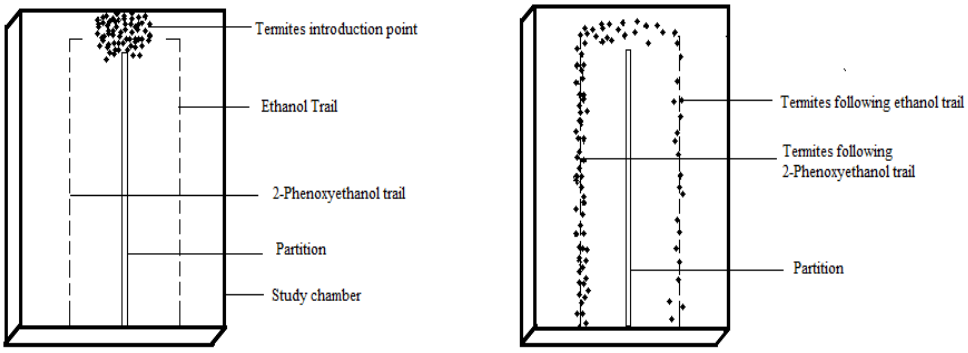
Chemical	Termite genus/species	Concentrations tested	Trail following/attractant	Toxicity	References
Diethyleneglycolmonoethylether, Diethyleneglycolmonobutylether, Ethyleneglycolmonoethylether, Ethyleneglycolmonobutylether, 1,2-propyleneglycol-monobutylether, Isomeric 1,2-Propyleneglycol, 1,3-Propylenglycol, Dipropyleneglycol 1,4-Butyleneglycol	Kalotermitidae, Mastotermitidae, Termopsidae, and Termitidae (55 termite species belonging to 21 genera and 4 families)	Not specified	Diethyleneglycolmonoethylether and di ethyle neglycol butyl ether were effective for almost all termite spp. except for family Kalotermitidae. Isomeric 1,2-Propyleneglycol acted only in very few species. Ethyle neglycol monoethyl ether, Ethyle neglycol mono butyl ether, 1,2-propyleneglycol-monobutylether, Di propyl ene glycol, 1,4-Butyleneglycol were species and group specific.	Not stated	Becker and Mannesmann, 1968
Oil of *Santalums picatum* fractionated to 10cis-(1) and 10 trans-2,6,10-trimethyldodeca-2,6,10-triene	*Nasutitermes*	Not specified	10cis-(1)-2,6,10-trimethyldodeca-2,6,10-triene more effective than 10 trans-2,6,10-trimethyldodeca-2,6,10-triene	Not stated	Birch *et al.,*1970
(Z)-4-phenyl-3-buten-1-ol derivatives	*Coptotermes, Reticulitermes, Schedorhinotermes*	Not specified	Induced trail forming behaviour in three genera	Not stated	Prestwich *et al*, 1984
Amino acids	*C. formosanus* Shiraki	Not specified	Termites consumed significantly more filter paper treated with D-aspartic acid and L- aspartic acid than paper treated with water. Adding L-proline, L-lysine, L-isoleucine to filter paper significantly increased consumption compared with control filter paper.	Not stated	Chen and Henderson., 1996
Extracts of the brown rot fungus *Gloeophyllumtrabeum*	*R. hesperus*	Not specified	The extract assisted worker termites in locating baits.	Not stated	Rust *et al*, 1996
2-phenoxyethanol	*C. formosanus* Shiraki and *Reticulitermessp.*	Four concentrations of 2-phenoxyethanol (0.23, 0.023, 0.0023 and 0.00023) ug/cm were tested.	In 0.00023 ug/cm limited trail-following activity occurred (≤ 30% of termites followed the trails) compared to 0.23 ug/cm, 0.023 ug/cm, and 0.0023 ug/cm (≥ 60% of termites followed the trails).	Not stated	Chen *et al.,*1998
Mixture of sucrose and yeast; urea	*Reticulitermes virginus* and *R. flavipes*	Substrates were drenched with the mixture of sucrose and yeast, or urea	Greater numbers of termites were recruited to the sucrose and yeast chambers than in water drenched chambers.	Not stated	Waller *et al.,*1999
Synthetic dode-3-en-1-ol	*M. annandalei*	Not specified	Induced both orientation and recruitment behaviour effects	Not stated	Peppuy *et al.,* 2001
Carbon dioxide	*Reticulitermes flavipes, R.tibiais, R.virginicus*	5 – 50 mmol/mol	All the species were attracted to CO_2 in laboratory and field tests	Not stated	Bernklau*et al*, 2005
Napthalene	*C. formosanus* Shiraki	10mg/ml to 0.01mg/ml	not elicited trail following behaviour.	Not stated	Cornelius *et al.,* 2005

Summon disks (commercial product)	*C. formosanus* Shiraki	Filter paper disks treated with water extract of summon disks	Consumption of filter paper disks treated with water extract of summon disks was significantly higher than consumption of control filter paper disks.	Not stated	Cornelius and Lax,2005
-phenoxyethanol	*C. formosanus* Shiraki	Three concentrations of 2-phenoxyethanol - 0.041, 0.082, and 0.164% were tested.	In 0.082% 2-PE treated side, total tunnel network length was significantly more extensive compared with control side for both colony A and B. Even residues of 2-PE on pretreated sand with a concentration of 0.082% had higher tunnel length on 16, 17, 18th day compared to control.	Not stated	Fei *et al.,* 2005a
2-phenoxyethanol	*C. formosanus* Shiraki	Six concentrations (0.00023, 0.0023, 0.023, 0.23, 2.3, 23 µg /cm) plus a control (only ethanol) were tested. Six types of 2-PE gradient trails were created. For "increasing-trail" gradients, they were 0.00023-0.0023-0.023-0.23µg/cm, 0.0023-0.023-0.23 2.3 µg/cm, and 0.023-0.23-2.3-23 µg/cm. For "decreasing-trail" gradients, they were 0.23-0.023-0.0023-0.00023 µg/cm, 2.3-0.23-0.023-0.0023 µg/cm, and 23-2.3-0.23-0.023 µg/cm.	Termites responded 100% to the trail at 0.23 µg /cm. Termites travelled significant distance when initial concentration was 0.0023 µg/cm. 0.23 and 2.3 µg/cm significantly increased termite aggregation compared to the control during 3min and 10 min observational time.	Not stated	Fei *et al.*, 2005b
2-phenoxyethanol, acetamiprid, fipronil, and imidacloprid.	*C. formosanus*Shiraki	Two tests were conducted to evaluate the effect of 2-phenoxyethanol as an additive to acetamiprid, fipronil, and imidacloprid on the tunnelling system by the Formosan subterranean termite *Test 1:* In the treated chamber, 0.07% of acetamiprid, fipronil, or imidacloprid and 0.345% of 2-phenoxyethanol were tested. *Test 2:* 0.07% of the	Significantly more search tunnels were constructed in the 2-phenoxyethanol treated side compared with the control side on day 1. With the addition of acetamiprid, the total tunnel network length remained significantly higher in the treated side than that of the control side. Withimidacloprid and fipronil, the total tunnel network length was greater in the treated side than that in the control side, but the differences were not significant. Termite survival rate in the treated chambers was significantly lower than	Not stated	Fei*et al.*, 2005c

		insecticide and 0.345% 2-phenoxyethanol were tested by applying 1.0 ml solutions to sand through the two of the four small access holes. In both the tests control was Double distilled water.	that in the untreated chamber.		
Solvent extracts of intact termite bodies and excised termites	*R. hesperus*	Not specified	Intact termite bodies elicited greater trail-following activity than extracts of excised termites.	Not stated	Grace *et al*, 1995
2-phenoxyethanol	*C. formosanus*Shiraki	Four studies were conducted: attraction and toxicity response on different 2-phenoxyethanol, persistence of 2-phenoxyethanol (0.96% upto 13th week), feeding and survivorship in both- choice test and no-choice test.	Consumption of filter paper treated with 0.12% 2-phenoxyethanol was significantly greater compared to the untreated filter paper. It was an attractant but not toxicant at 0.12 and 0.24 per cent, an attractant and toxicant at > 0.48 per cent and the maximum effect was at 0.96 per cent. 2-Phenoxyethanol at 0.96 per cent attracted 90 per cent of the termite workers to the treated filter paper side, killing 85 per cent of the termites within 48 hours. Residues of 2-Phenoxyethanol on pretreated filter paper remained effective in orienting *C. formosanus* Shiraki workers up to 13 weeks.	2-phenoxy ethanol is toxic at ≥0.36%	Ibrahim *et al.*, 2005

MATERIAL AND METHODS

Ethanol and 2-phenoxyethanol (2-PE) were analytical reagent grade chemicals. Double distilled water was used for rinsing and washing the study chamber. Five concentrations of 2-PE — 0.1%, 0.01, 0.001, 0.005 and 0.0005 % — were used for the study. The apparatus to study the trails of 2-PE consisted of rectangular transparent plastic chambers, 36.5 x 24.5 x 7 cm (Figure 1). Each chamber was divided into two segments by plastic sheets of 32 cm and 7cm in length and height, respectively. Termites were collected from three different sites in Pondicherry University campus representing colonies A, B, and C. For each colony three sets of observations of 100 numbers of termites were taken from the termites picked at random. In the segments of each chamber, trails of 2-PE solution in ethanol, and of ethanol used as a control, were marked on either side of the 'divide' using micropipettes, as shown in Figure 1. In each experiment, 100 individuals of *H. obscuriceps*, comprising of 90 workers and 10 soldiers, were released at the spot shown in Figure 1 so that they could follow either of the trails. The number of termites on each trail, live and dead, were counted once every 15 minutes. The monitoring was continued till all termites in each trail died. A set, in triplicate, without 2-PE/ethanol was kept as control. All the chambers were covered by black coloured high density polyethylene (HDPE) sheet in order to avoid light (which could stress the termites).



(a) (b)

Figure 1. Study chamber (a) spot where termites were introduced (b) general pattern seen on the 2-Phenoxyethanol and ethanol trails.

RESULTS AND DISCUSSION

The pattern in which termites gathered on different replicates at different time intervals in experiment involving 0.1% 2-PE is shown in Table 2. Similar patterns were observed when other concentrations of 2-PE were employed. The findings pertaining to those 2-PE concentrations are summarized in Tables 3 – 7. As may be seen, the 2-PE solutions had, in general 5 – 6 times greater attraction for the termites than plain ethanol. From the outset bulk of the termites went on the 2-PE trail and less than a quarter of them took the ethanol trail. Number of termites were attracted towards 0.1% 2-PE compared to control and other four concentrations of 2-PE (0.01, 0.001, 0.005 and 0.0005%). Paired *t*-test showed that difference in the number of termites attracted towards 2-PE in comparison to ethanol is significant at > 99% confidence level in all the experiments. Within the first fifteen minutes of the observations, more than an average of 65% of the termites were attracted towards 2-PE whereas it was never more than 34% in ethanol. The number of termites attracted by all concentrations of 2-PE reached the maximum in 15 minutes. Subsequently in the trails bearing 0.1%, 0.01%, 0.001%, 0.005% 2-PE, the number reduced with time; whereas in the trail bearing 0.0005%, the number increased with time. In the first 60 minutes, there was a significant ($p<0.05$) reduction in mortality of termites in chambers which had trails of different concentrations of 2-PE and ethanol than in control. As time passed, the mortality in 2PE/ethanol began to rise and then exceeded the mortality in the control chamber. This shows that 2PE is not toxic to termites for the first 60 minutes of exposure. Given that the purpose of laying 2-PE trails is to make termites traverse it towards the feed kept in the termireactors, and that only a few minutes will be needed for the termites to pass through such trails, no toxicity is likely. This indicates that 2-PE can serve as a substance for attracting termites to the termireactors without causing them any harm. There is no past study on the use of 2-PE in attracting *H.obscuriceps* hence it is not possible to compare our findings with any past work on this species. Indeed only two other termite species – *C.formosanus* and *Reticulitermes sp* have been explored earlier for the influence of 2-PE (Table 1) but the concentrations of 2-PE used and the manner of assessing its influence have been different. For example in the experiments of Chen *et al.,* (1998) with *C.formosanus* and *Reticulitermes sp.,* 0.23, 0.023 and 0.0023 µg/cm of 2-PE elicited trail following behaviour in ≥ 60% of termites. In another study conducted by Fei *et al.,* (2005b) on *C.formosanus* the aggregation behaviour of six different concentrations of 2-PE (0.00023, 0.0023, 0.023, 0.23, 2.3, 23 µg/cm) were explored. Of these 0.23, 2.3, 23 µg/cm of 2-PE were seen to induce a 100% response from the termites. As for possible toxicity of 2-PE, a study conducted by Ibrahim *et al.*, (2005) with 0.012, 0.06, 0.12, 0.24, 0.48. 0.96 and 1.92 % concentrations of 2-PE (w/w of filter paper) has revealed that 2-PE is an attractant but not toxicant at 0.12 and 0.24%. In the present study, all the five concentrations of 2-PE (0.1%, 0.01%, 0.001%, 0.005% and 0.0005%) have elicited trail forming behaviour from *Hypotermes obscuriceps* without revealing any toxic effect for the first 60 minutes. These findings show clearly that trails of 2-PE in 0.1% - 0 0005% concentrations can be safely used to attract termites towards termireactors without causing any toxicity to them.

Table 2. The number of termites attracted to 0.1% 2-PE and ethanol, at different timings, from the initial 100 individuals with *H. obscuriceps*: Colony A, B and C.

Time	2-PE										Ethanol										Number of termites attracted towards 2-Phenoxyethanol, compared to control, is significant at confidence level, %
	Number of termites that survived in each replicate									Mean ±SD	Number of termites that survived in each replicate									Mean ±SD	
	1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9		
After 15 min	90	87	95	92	90	84	89	93	90	90.0±3.2	10	13	5	8	10	16	11	7	10	10.0±3.2	99
After 30 min	87	85	92	88	86	81	84	89	84	86.2±3.2	13	15	8	12	14	19	16	11	16	13.8±3.2	99
After 45 min	85	85	88	84	83	77	84	83	82	83.4±3.0	15	15	12	16	17	23	16	17	18	16.6±3.0	99
After 60 min	83	83	84	84	83	77	79	82	74	81.0±3.5	13	13	12	14	17	23	16	18	18	16.0±3.5	99
After 75 min	81	79	79	78	79	73	74	77	69	76.6±3.8	11	12	10	14	15	19	16	18	15	14.4±3.0	99
After 90 min	74	76	72	73	72	67	69	74	62	71.0±4.3	8	10	10	14	12	16	13	15	13	12.3±2.6	99
After 105 min	69	72	66	66	68	65	61	69	59	66.1±4.1	7	9	8	11	9	12	13	15	13	10.8±2.7	99
After 120 min	64	68	63	64	63	61	54	62	53	61.3±4.8	5	7	7	11	9	10	13	15	13	10.0±3.3	99
After 135 min	60	65	59	56	60	55	50	57	48	56.7±5.2	4	6	7	11	9	10	11	11	10	8.8±2.5	99
After 150 min	56	58	57	53	54	51	45	52	43	52.1±5.2	2	3	5	10	7	10	7	8	8	6.7±2.8	99
After 165 min	49	54	52	44	51	48	40	47	38	47.0±5.4	2	3	4	8	7	9	7	8	8	6.2±2.5	99
After 180 min	44	49	45	40	46	43	40	43	34	42.7±4.3	0	3	4	6	7	6	7	8	8	5.4±2.7	99
After 195 min	40	47	41	37	43	36	40	39	29	39.1±5.0	0	2	4	6	5	6	5	6	5	4.3±2.1	99
After 210 min	34	43	36	36	39	31	33	33	24	34.3±5.3	0	1	2	6	4	6	4	6	5	3.8±2.3	99
After 225 min	30	38	33	31	32	28	29	29	19	29.9±5.1	0	1	2	4	2	4	4	6	3	2.9±1.8	99

After 240 min	22	35	25	27	27	24	23	23	17	24.8±4.9	0	1	2	4	2	3	2	3	3	2.2±1.2	99
After 255 min	15	28	21	20	19	19	15	19	14	18.9±4.2	0	0	1	3	2	3	2	2	3	1.8±1.2	99
After 270 min	6	24	16	12	16	17	12	17	14	14.9±4.9	0	0	1	0	0	3	2	2	0	0.9±1.2	99
After 285 min	2	16	10	8	11	11	8	12	11	9.9±3.8	0	0	0	0	0	0	0	0	0	0	–
After 300 min	0	9	7	5	5	7	6	9	7	6.1±2.7	–	–	–	–	–	–	–	–	–	–	–
After 315 min	0	3	5	1	1	5	5	5	3	3.1±2.0	–	–	–	–	–	–	–	–	–	–	–
After 330 min	0	0	0	0	0	2	3	3	0	0.9±1.4	–	–	–	–	–	–	–	–	–	–	–
After 345 min	0	0	0	0	0	0	3	0	0	0.3±1.0	–	–	–	–	–	–	–	–	–	–	–
After 360 min	0	0	0	0	0	0	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–

1, 2 and 3 – Triplicates of Colony A of *H.obscuriceps;* 4, 5 and 6 – Triplicates of Colony B of *H.obscuriceps,* and 7, 8 and 9 – Triplicates of Colony C of *H.obscuriceps.*

Table 3. The number of termites attracted to 0.01% 2-PE and ethanol, at different timings, from the initial 100 individuals with *H. obscuriceps*: Colony A, B and C.

Time	Number of termites that survived in each replicate, Mean ±SD		Number of termites attracted towards 2-Phenoxyethanol, compared to control, is significant at confidence level, %
	2 PE	Ethanol	
After 15 min	84.6±6.1	15.4±6.1	99
After 30 min	81.3±4.9	18.7±4.9	99
After 45 min	80.7±3.8	19.3±3.8	99
After 60 min	78.3±3.7	18.3±3.3	99
After 75 min	73.6±4.7	16.0±2.8	99
After 90 min	68.6±4.5	13.7±1.5	99
After 105 min	63.0±4.5	12.9±1.6	99
After 120 min	58.9±4.8	11.9±2.5	99
After 135 min	53.4±4.2	9.2±1.9	99
After 150 min	49.3±5.5	8.9±2.0	99
After 165 min	45.1±5.8	8.4±2.1	99
After 180 min	40.4±6.6	6.4±1.8	99
After 195 min	36.8±6.1	6.1±1.5	99
After 210 min	33.7±8.2	5.6±1.6	99
After 225 min	30.8±9.6	4.3±1.5	99
After 240 min	27.9±8.2	3.3±1.1	99
After 255 min	23.9±7.5	3.0±1.3	99
After 270 min	19.9±6.5	1.1±0.8	99
After 285 min	15.0±5.0	-	—
After 300 min	10.1±4.2	—	—
After 315 min	6.1±3.4	—	—
After 330 min	2.7±2.1	—	—
After 345 min	0.6±0.9	—	—
After 360 min	0.2±0.7	—	—
After 375 min	0	—	—

Table 4. The number of termites attracted to 0.001% 2-PE and ethanol, at different timings, from the initial 100 individuals with *H. obscuriceps*: Colony A, B and C.

Time	Number of termites that survived in each replicate, Mean ±SD		Number of termites attracted towards 2-Phenoxyethanol, compared to control, is significant at confidence level, %
	2 PE	Ethanol	
After 15 min	84.9±7.9	15.1±7.9	99
After 30 min	80.8±6.6	19.2±6.6	99
After 45 min	77.7±5.9	22.0±5.5	99
After 60 min	76.1±6.3	22.0±5.2	99
After 75 min	71.4±6.8	18.4±4.7	99
After 90 min	66.7±6.0	15.3±3.6	99
After 105 min	61.2±5.7	13.9±4.0	99
After 120 min	57.6±5.6	13.1±4.0	99
After 135 min	52.9±4.0	11.0±2.5	99
After 150 min	48.9±4.9	9.9±2.4	99
After 165 min	43.9±4.5	7.8±2.5	99
After 180 min	38.6±4.9	7.4±2.8	99
After 195 min	34.1±5.7	6.7±2.2	99
After 210 min	30.4±7.2	5.1±1.7	99
After 225 min	24.7±7.0	4.1±2.3	99
After 240 min	20.3±7.1	3.3±1.4	99
After 255 min	17.2±5.9	2.0±1.1	99
After 270 min	14.2±5.2	0.9±1.0	99
After 285 min	10.9±4.7	0	—
After 300 min	8.4±4.3	—	—
After 315 min	6.0±3.0	—	—
After 330 min	4.2±2.6	—	—
After 345 min	2.9±1.8	—	—
After 360 min	0.9±1.0	—	—
After 375 min	0	—	—

Table 5. The Number of termites attracted to 0.005 % 2-PE and ethanol, at different timings, from the initial 100 individuals with *H. obscuriceps*: Colony A, B and C.

Time	Number of termites that survived in each replicate, Mean ±SD		Number of termites attracted towards 2-Phenoxyethanol, compared to control, is significant at confidence level, %
	2 PE	Ethanol	
After 15 min	76.6±8.7	23.4±8.7	99
After 30 min	74.6±7.2	25.4±7.2	99
After 45 min	74.1±6.1	25.9±6.1	99
After 60 min	72.4±7.9	24.4±6.9	99
After 75 min	67.9±7.9	21.3±6.9	99
After 90 min	62.4±7.2	17.7±6.0	99
After 105 min	56.6±7.2	15.3±5.4	99
After 120 min	51.7±7.2	13.8±4.5	99
After 135 min	46.8±7.9	11.3±3.4	99
After 150 min	42.0±7.7	9.1±3.2	99
After 165 min	36.9±7.2	7.9±2.5	99
After 180 min	32.6±7.2	6.2±2.4	99
After 195 min	28.1±5.3	5.2±1.9	99
After 210 min	24.4±5.5	4.6±1.5	99
After 225 min	20.6±5.2	3.1±1.5	99
After 240 min	18.4±5.3	2.4±0.9	99
After 255 min	15.8±5.8	1.8±0.8	99
After 270 min	13.7±3.7	0.3±0.5	99
After 285 min	11.0±4.2	0	—
After 300 min	8.2±2.9	—	—
After 315 min	6.1±2.6	—	—
After 330 min	4.6±2.2	—	—
After 345 min	2.9±2.9	—	—
After 360 min	1.1±1.1	—	—
After 375 min	0	—	—

Table 6. The Number of termites attracted to 0.0005 % 2-PE and ethanol, at different timings, from the initial 100 individuals with *H. obscuriceps*: Colony A, B and C.

Time	Number of termites that survived in each replicate, Mean ±SD		Number of termites attracted towards 2-Phenoxyethanol, compared to control, is significant at confidence level, %
	2 PE	Ethanol	
After 15 min	65.7±9.1	34.3±9.1	99
After 30 min	68.2±7.1	31.8±7.1	99
After 45 min	70.8±5.7	29.2±5.7	99
After 60 min	71.3±5.0	28.0±6.0	99
After 75 min	67.0±4.4	25.4±6.5	99
After 90 min	61.9±4.6	22.4±6.2	99
After 105 min	56.9±4.4	20.0±5.7	99
After 120 min	51.8±4.2	17.7±5.7	99
After 135 min	47.4±4.7	15.9±6.3	99
After 150 min	43.2±4.6	14.4±6.1	99
After 165 min	38.7±4.1	12.1±5.5	99
After 180 min	34.0±2.9	10.6±4.8	99
After 195 min	30.0±2.5	9.0±4.7	99
After 210 min	26.8±3.9	7.0±3.7	99
After 225 min	23.1±3.9	4.9±2.5	99
After 240 min	20.0±3.5	3.1±1.8	99
After 255 min	17.6±2.6	1.6±1.0	99
After 270 min	15.2±2.7	0	—
After 285 min	12.8±2.7	—	—
After 300 min	10.8±1.6	—	—
After 315 min	9.8±2.0	—	—
After 330 min	7.2±2.2	—	—
After 345 min	6.0±2.2	—	—
After 360 min	3.7±2.1	—	—
After 375 min	2.4±1.5	—	—
After 390 min	1.4±1.9	—	—
After 405 min	0.3±0.6	—	—
After 420 min	0	—	—

Table 7. The number of termites alive at different times compared to the initial population of 100 individuals of *H. obscuriceps*.

Time	Number of termites that survived in each replicate			Mean ±SD
	1	2	3	
After 15 min	98	99	97	98.0±1.0
After 30 min	94	99	94	95.7±2.9
After 45 min	91	93	91	91.7±1.2
After 60 min	88	90	85	87.7±2.5
After 75 min	85	88	85	86.0±1.7
After 90 min	82	86	82	83.3±2.3
After 105 min	79	82	78	79.7±2.1
After 120 min	77	80	75	77.3±2.5
After 135 min	74	76	70	73.3±3.1
After 150 min	69	74	70	71.0±2.6
After 165 min	67	70	67	68.0±1.7
After 180 min	64	66	64	64.7±1.2
After 195 min	61	61	59	60.3±1.2
After 210 min	57	55	59	57.0±2.0
After 225 min	53	52	56	53.7±2.1
After 240 min	48	46	50	48.0±2.0
After 255 min	45	40	48	44.3±4.0
After 270 min	43	37	46	42.0±4.6
After 285 min	40	32	41	37.7±4.9
After 300 min	37	26	37	33.3±6.4
After 315 min	35	23	34	30.7±6.7
After 330 min	32	20	29	27.0±6.2
After 345 min	29	18	26	24.3±5.7
After 360 min	26	18	21	21.7±4.0
After 375 min	23	17	18	19.3±3.2
After 390 min	20	15	17	17.3±2.5
After 405 min	17	13	15	15.0±2.0
After 420 min	14	10	12	12.0±2.0
After 450 min	10	8	9	9.0±1.0
After 465 min	6	0	7	4.3±3.8
After 480 min	0	0	4	1.3±2.3
After 495 min	0	0	0	0

CONCLUSION

In the present study, all the five concentrations of 2-Phenoxyethanol (0.1%, 0.01%, 0.001%, 0.005% and 0.0005%) elicited trail forming behaviour on *H.obscuriceps.* In the first 60 minutes, there was less mortality of termites in chambers which had trails of different concentrations of 2-PE and ethanol than in control. Hence the study revealed that 2-PE can serve as an attractant for the initial 60 minutes of exposure, after which it becomes toxic to termites.

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