SVU-IJAS
SVU-International Journal of Agricultural Sciences
Volume 4 Issue (2) pp.: 151-163, 2022
Print ISSN 2636-3801 | Online ISSN 2636-381X
Doi: 10.21608/svuijas.2022.133049.1204

Check for updates

RESEARCH ARTICLE

Influence of the trap's depth and meteorological parameters on population fluctuations of *Psammotermes hypostoma* (Desneux) (Isoptera: Rhinotermitidae) workers

Aly, M.Z.Y., K.S.M. Osman, Elham S.S. Ibrahim and A.M.M. Badawy *

Zoology Department, Faculty of Science, South Valley University, 83523 Qena, Egypt

Abstract

There is a gap in knowledge regarding the impact of trap depths on *Psammotermes hypostoma* (*Desneux)* population variations. The purpose of this study is to investigate the impact of trap depths and some physical parameters on worker population fluctuations. From September 2019 to August 2020, 1300, El-Sebay-modified traps within Poly Vinyl Chloride (P.V.C.) tubes were used at several depths of 10 cm, to 150 cm in Qena City, Egypt. Furthermore, temperatures and relative humidity % were assessed using the Pearson correlation coefficient. The current findings illustrated the highest percentage (34.04%) at 10 cm depth, inversely, the lowest was (7.24%) at 100 cm depth. Interestingly, the 36th week (April) at 50 cm depth had the highest mean number of individuals (234.60 ± 12.9). Although, at 10 cm depth, the lowest mean number of individuals was 0.20 ± 0.20 in the 19th week. On the other hand, result analysis demonstrated that both maximum and minimum temperatures had a substantial positive effect on the worker activity at 10 cm depth where r = 0.333 and 0.318, respectively. However, there was a significant negative effect at 150 cm depth between the maximum, and minimum temperatures. Additionally, RH% had a significant positive effect at 150 cm depth and a negative significant effect at 10 and 50 cm depths, respectively. Thus, it's concluded that the abundance of individuals is inversely proportional to the soil depth furthermore temperature, and directly the relative humidity. So, in the future, this could be a viable result for managing subterranean termites.

Keywords: Meteorological parameters; *Psammotermes hypostoma*; subterranean termites; trap depth.

1. Introduction

Termites are social insects belonging to the Isoptera order. (Ibrahim and Adebote, 2012). Subterranean termites are social insects, which means they work together to care for their young, share resources (food, water, and shelter), have overlapping generations (eggs are laid all year), and have a division of labor, which is defined by the presence of one or more castes, or life forms. (Suiter *et al.*, 2009). During the first or second instar stage, each larva has the potential to become a worker, a soldier, a king, or a queen, and the castes are established during post-embryonic development. Workers have a soft body and hard mouthparts that are designed exclusively for chewing wood. They are both male and female individuals who are functionally infertile and are in charge of the nest's labor. (Pervez, 2018). Worker termites comprise the majority of a colony's population. They've been termed laborers since they do most of the colony's maintenance work. Worker termites perform a variety of duties, including foraging for food, constructing, and repairing colony structures, and caring for other termites. (Suiter *et al.*, 2009). Stakes and blocks of wood are used to evaluate the relative density, caste makeup, and foraging activity of subterranean

***Corresponding author:** **Amr M. M. Badawy**
Email: amr.badawy@sci.svu.edu.eg
Received: April 13, 2022; Accepted: May 15, 2022; Published online: May 16, 2022.

termites. (Jones, 1990), toilet paper rolls (LaFage *et al.*, 1973), corrugated cardboard rolls (LaFage *et al.*, 1983; Mohanny and Ahmed, 2010; Allam *et al.*, 2022). In Saudi Arabia (Badawi *et al.*, 1986) and Egypt at Qena governorate (Mohanny and Ahmed, 2010) such techniques had yielded a favorable outcome. Furthermore, Aly *et al.* (2007) and Abdel-Galil *et al.* (2007) observed a homogeneous relationship between the seasonal oscillation of the sandy termite *P. hypostoma,* and some surrounding biotic factors represented by associated arthropods, particularly insects, as well as abiotic meteorological factors such as surface temperature, soil temperature, relative humidity, and wind velocity in the Dandara temple region of Qena, Egypt, from June 2002 to May 2003. investigated annual changes in subterranean termites using El- Sebay's and cellulose traps in both the field and the laboratory in Qena, Egypt. (Aly *et al.,* 2007; Abdel-Galil *et al.,* 2007; Mohanny and Ahmed, 2010). Subterranean termites are a major problem in the Qena governorate. The purpose of this research is to see how varied trap depths and metrological conditions affect *P. hypostoma* worker population.

2. Materials and methods

2.1. The studied area

An area of about 280 m^2 in Qena Governorate, 610 kilometers south of Cairo in Al-Tuwayrat region, with longitude (32 44.49°) and latitude (26 07.34°).

2.2. Trap used for the experiment

The EL-Sebay modified trap was used to investigate the sand subterranean termites variations. It's made of corrugated cardboard paper and wrapped in a roll shape with a diameter of 5 - 7 cm and a height of 12 cm, with the lower 2 cm left exposed. To keep the moisture in the trap, a polyethylene covering was employed, which was secured with a rubber band. (EL-Sebay, 1991).

2.3. Sampling method

The study area received 25 corrugated cardboard rolls weighing 77.8g each. All sources of cellulose and debris were removed from the study area to avoid nutrients interfering with the applied traps. A randomized complete block design (RCBD) was used in this investigation, which was divided into five blocks (2*2 m) with five replicates and 2m spacing between blocks. Wet traps were inserted into perforated Poly Vinyl Chloride tubes (P.V.C.) and buried in the soil at 10 cm, 30 cm, 50 cm, 100 cm, and 150 cm depths after being wetted and covered with plastic bags. The subterranean termites were attracted to the soil surface by the rolls of corrugated cardboard, which provided cellulose material and humidity. To monitor for foraging activities, traps are left for one week. Every week, the traps are replaced with new ones in the same location, according to **Thabit *et al.*, (2019)**.

2.4. Statistical analysis

1-The annual population fluctuations for subterranean termites are illustrated with Graph Pad-prism 8.0.1 using logarithm plus 1 to avoid the zero numbers of individuals in the results.

2-The effect of the selected meteorological parameters (maximum temperature, minimum temperature, and relative humidity %) on the survival of the subterranean termites, *P. hypostoma*, was estimated based on the Pearson correlation coefficient (correlation "r") using SPSS 25, and then with the Corresponding Canonical Analysis (CCA) test using Canoco for windows 4.5.

3. Results and discussion

3.1. Annual Population fluctuations

Results in Table (1) and Fig (1) illustrated the annual activity of the sand subterranean termite, *P. hypostoma*, workers collecting 25 traps every week from September 2019 to August 2020 in Al-Tuwayrat region, Qena city.

Table 1. The recorded numbers of individuals with percentage for the worker of *P. hypostoma* collected by 1300 traps from September 2019 to August 2020 in Al-Tuwayrat region, Qena city.

Date	Weeks	Depths									
		10 cm	%	30 cm	%	50 cm	%	100 cm	%	150 cm	%
7\ 09 \ 2019	1	224	1.50	350	5.01	302	3.91	13.0	0.41	0.00	0
14\ 09\ 2019	2	521	3.48	245	3.51	149	1.93	223	7.01	4.00	0.04
21\ 09 \ 2019	3	418	2.80	118	1.69	247	3.19	75.0	2.36	42.0	0.38
28\ 09 \ 2019	4	277	1.85	110	1.58	317	4.10	16.0	0.50	109	0.98
5/10 \ 2019	5	491	3.28	436	6.24	293	3.79	1.00	0.03	30.0	0.27
12/10 \ 2019	6	442	2.96	15.0	0.21	56.0	0.72	65.0	2.04	43.0	0.39
19/10 \ 2019	7	57.0	0.38	9.00	0.13	143	1.85	9.00	0.28	62.0	0.56
26 /10 \ 2019	8	116	0.78	233	3.34	128	1.66	30.0	0.94	39.0	0.35
2 /11 \ 2019	9	52.0	0.35	74.0	1.06	152	1.97	83.0	2.61	73.0	0.66
9/11 \2019	10	126	0.84	46.0	0.66	37.0	0.48	118	3.71	92.0	0.83
16/11 \2019	11	57.0	0.38	68.0	0.97	77.0	1.00	29.0	0.91	130	1.17
23/11 \2019	12	0.00	0.00	334	4.78	103	1.33	53.0	1.67	135	1.22
30/11 \2019	13	162	1.08	175	2.51	219	2.83	84.0	2.64	56.0	0.51
7/12 \2019	14	64.0	0.43	36.0	0.52	47.0	0.61	101	3.18	184	1.66
14/12 \2019	15	0.00	0.00	95.0	1.36	4.00	0.05	74.0	2.33	1036	9.34
21/12 \ 2019	16	104	0.70	61.0	0.87	50.0	0.65	6.00	0.19	306	2.76
28 /12 \ 2019	17	93.0	0.62	1.00	0.01	21.0	0.27	24.0	0.75	158	1.42
4 /1 \ 2020	18	3.00	0.02	12.0	0.17	39.0	0.50	100	3.14	73.0	0.66
11 /1 \ 2020	19	1.00	0.01	11.0	0.16	316	4.09	101	3.18	169	1.52
18 /1 \ 2020	20	122	0.82	71.0	1.02	20.0	0.26	21.0	0.66	255	2.30
25 /1 \ 2020	21	53.0	0.35	14.0	0.20	30.0	0.39	45.0	1.41	274	2.47
1/ 2 \ 2020	22	21.0	0.14	21.0	0.30	36.0	0.47	23.0	0.72	517	4.66
8 / 2 \ 2020	23	14.0	0.09	6.00	0.09	109	1.41	14.0	0.44	301	2.71
15 / 2 \ 2020	24	103	0.69	167	2.39	45.0	0.58	21.0	0.66	181	1.63
22 / 2 \ 2020	25	40.0	0.27	240	3.44	13.0	0.17	89.0	2.80	404	3.64
29 / 2 \ 2020	26	156	1.04	159	2.28	143	1.85	35.0	1.10	142	1.28
7 / 3 \ 2020	27	83.0	0.55	136	1.95	27.0	0.35	127	3.99	314	2.83
14 / 3 \ 2020	28	194	1.30	140	2.00	28.0	0.36	19.0	0.60	441	3.98
21 / 3 \ 2020	29	89.0	0.60	265	3.79	16.0	0.21	11.0	0.35	375	3.38
28 / 3 \ 2020	30	178	1.19	186	2.66	42.0	0.54	89.0	2.80	383	3.45
4 / 4 \ 2020	31	185	1.24	133	1.90	171	2.21	90.0	2.83	681	6.14
11 / 4 \ 2020	32	293	1.96	102	1.46	282	3.65	68.0	2.14	269	2.43
18 / 4 \ 2020	33	378	2.53	7.00	0.10	339	4.38	107	3.36	903	8.14
25 / 4 \ 2020	34	584	3.91	716	10.25	694	8.98	281	8.83	196	1.77
2 / 5 \ 2020	35	869	5.81	55.0	0.79	663	8.58	258	8.11	615	5.55
9 / 5 \ 2020	36	203	1.36	5.00	0.07	1173	15.2	223	7.01	454	4.09
16 / 5 \ 2020	37	1172	7.84	11.0	0.16	342	4.42	64.0	2.01	173	1.56
23 / 5 \ 2020	38	160	1.07	34.0	0.49	24.0	0.31	25.0	0.79	34.0	0.31
30 / 5 \ 2020	39	144	0.96	42.0	0.60	22.0	0.28	2.00	0.06	30.0	0.27
6 / 6 \ 2020	40	307	2.05	69.0	0.99	34.0	0.44	87.0	2.73	104	0.94
13 / 6 \ 2020	41	421	2.82	129	1.85	108	1.40	14.0	0.44	122	1.10
20 / 6 \ 2020	42	532.00	3.56	59.0	0.84	45.0	0.58	12.0	0.38	14.0	0.13
27 / 6 \ 2020	43	911	6.09	0.00	0.00	88.0	1.14	28.0	0.88	247	2.23
4 / 7 \ 2020	44	247	1.65	36.0	0.52	25.0	0.32	41.0	1.29	44.0	0.40
11 / 7 \ 2020	45	421	2.82	13.0	0.19	49.0	0.63	41.0	1.29	378	3.41
18 / 7 \ 2020	46	389	2.60	255	3.65	53.0	0.69	25.0	0.79	96.0	0.87
25 / 7 \ 2020	47	246	1.64	452	6.47	89.0	1.15	52.0	1.63	58.0	0.52
1 /8 \ 2020	48	391	2.61	125	1.79	107	1.38	8.0	0.25	70.0	0.63
8 /8 \ 2020	49	946	6.33	310	4.44	0.00	0.00	17.0	0.53	55.0	0.50
15 /8 \ 2020	50	1148	7.68	202	2.89	108	1.40	3.00	0.09	26.0	0.23
22 /8 \ 2020	51	424	2.84	121	1.73	28.0	0.36	3.00	0.09	85.0	0.77
29 /8 \ 2020	52	323	2.16	273	3.91	78.0	1.01	33.0	1.04	106	0.96
Total	All	14955	34.04	6983	15.89	7731	17.60	3181	7.24	11088	25.24

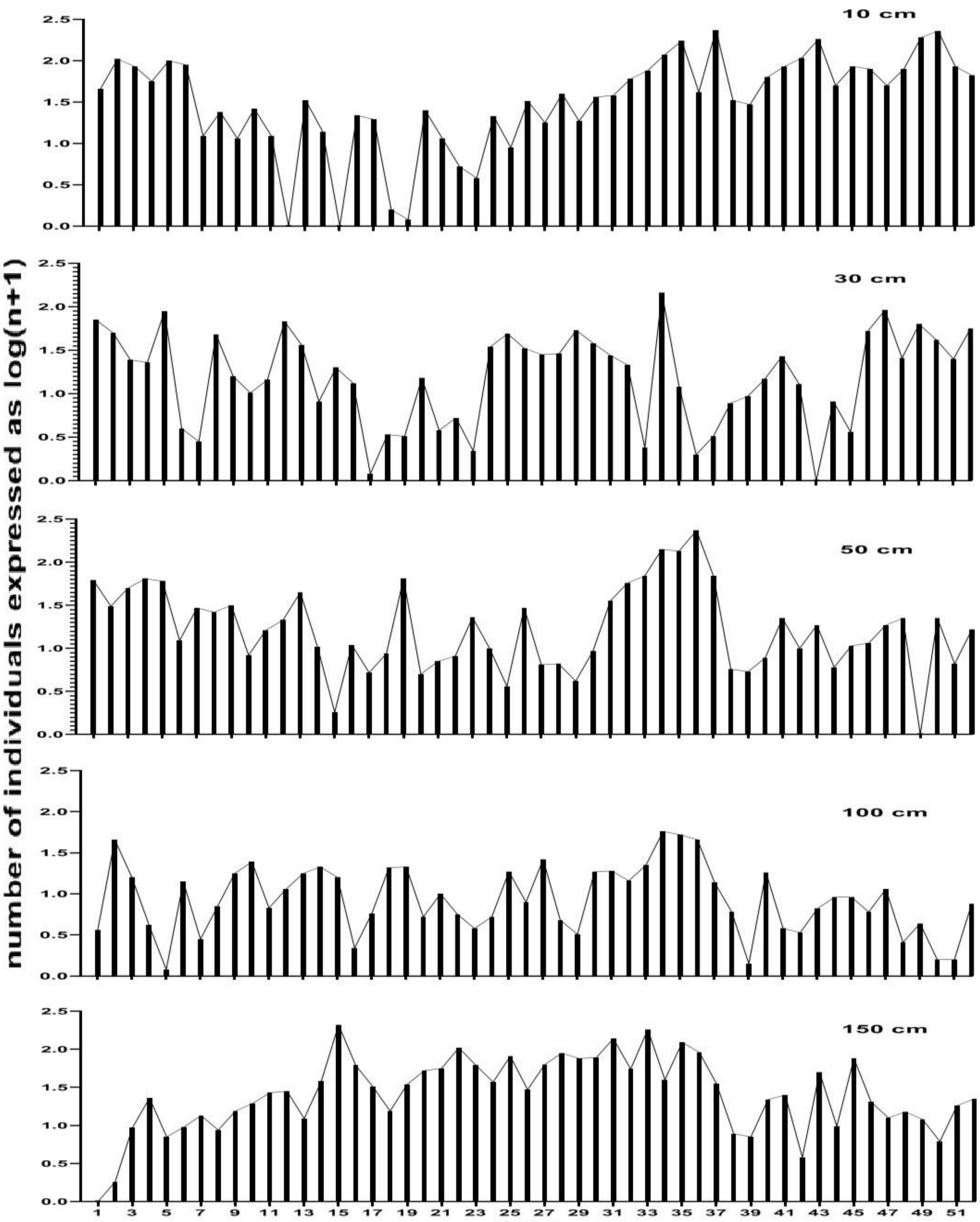

Fig 1. Annual population fluctuations of workers subterranean termite, ***P. hypostoma*** expressed as log(n+1) collected by 1300 traps from September 2019 to August 2020 in Al-Tuwayrat region, Qena city.

The total number of workers recorded over the whole experiment was (43938 individuals). Most workers were found at a depth of 10 cm, with 14955 individuals accounting for 34.04 % of the total. Additionally, the highest numbers of workers were recorded at a depth of 10 cm in week 37th (1172 individuals), representing 7.84%. Moreover, at 50 cm depth, the highest number was recorded in week 36th (1173 individuals), representing 15.17%. On the other hand, the lowest number (1 individual) was reported at a depth of 10 cm in week 19, representing 0.01 %. However, the lowest number was recorded at a 50 cm depth in week 15, (4 individuals), which represented 0.05%. These findings are consistent with those of Abou-Elmagd (2006) and El-Latif (2013), who indicated that the annual 3rd peak of *P. hypostoma* in Qena was observed from April to mid-May, and in El-Fayoum governorate, the 1st annual infested traps with *P. hypostoma* was recorded in May (47.6 %). Moreover, according to El-Bassiouny *et al.* (2015), the largest numbers of A. *ochraceus* workers began to increase gradually from January to May. Moreover, for 30 cm depth, the highest numbers were recorded in the 34th week (716 individuals), which represented 10. 25%. In addition, for100 cm depth, the highest number was recorded in week 34 (281 individuals), representing 8.83%. However, the lowest number was recorded in week 5, where (one individual) represented 0.03%. These findings corroborated those of Abd Elatti (2012), who found that the annual peak of the sand termite *P. hypostoma* in Qena city climbed gradually from January to April, with traps buried at a depth of 30 cm in the soil. In contrast, the maximum number of *P. hypostoma* workers was documented at week 15, (1036 individuals), accounting for 9.34 percent of the total. According to Ahmed (2013) and Evans and Gleeson (2001), the increased numbers of termites collected in Winter can be understood as the recruitment of young foragers into the foraging population during the Winter season, as small instar workers make up a bigger proportion of the foraging population.

3.2. Effect of some meteorological parameters on annual fluctuations of worker of subterranean termite, P. hypostoma

3.2.1. Effect of maximum temperature

Data in Table (2) and Fig (2) illustrated the Pearson correlation coefficient values between the annual fluctuation of subterranean termite, *P. hypostoma,* and meteorological parameters. Results indicated that a significant positive correlation effect at 0.01 level of probability was recorded at 10 cm depth, between maximum temperature and the worker population of the sand subterranean termite, where (r = 0.333). These results suggest that with an increase in maximum temperature, the activity of *P. hypostoma* will increase at this depth. These findings support Kofoid (1934) who observed that temperature influences termite global distributions and local occurrences. Furthermore, Bodine (1973) mentioned that the foraging activity of *Gnathamitermes tubiformans* was highly correlated with temperature. In Islamabad, Sattar and Naeem (2013) found that, a substantial positive association between air temperature and both subterranean termite species, *Odontotermes lokanandi,* and *Microtermes obesi*. Similarly, Pozo-Santiago et al. (2020) reported that temperature and relative humidity percentage have a substantial impact on the survival of the subterranean termite *Coptotermes testaceus*. Reticulitermes termites foraged more during the warmer, drier months, according to Janowiecki and Vargo (2021). However, a significant negative correlation effect at a 0.05 level of probability was recorded at 150 cm depth, between the maximum temperature and the worker population of the sand subterranean termite, (r =-0.141). These findings are consistent with those of Abou-Elmagd (2006), who found that soil temperature had no effect on *P. hypostoma* during the Autumn and Summer seasons. Similarly, El-Bassiouny *et al.* (2015) reported that soil temperature did not affect harvester termites, A. *ochraceus* (Burm), swarming in Sharkia Governorate. Likewise, Thabit *et al.* (2019) found that in the first year of study in the Ismailia governorate, the mean temperature did not affect the foraging activity of A. *ochraceus*.

Table 2. Pearson correlation coefficient of maximum temperature (Max. T.), minimum temperature (Min. T.), and relative humidity (RH%) with sand subterranean termite workers' annual Population fluctuation.

Depths	Max. T.	Min. T.	RH%
10 cm	0.333**	0.318**	-0.293**
30 cm	0.082	0.115	-0.034
50 cm	0.059	0.065	-.128*
100 cm	-0.010	-0.031	0.028
150 cm	- 0.141*	-0.177**	0.148*

*. Correlation is significant at the 0.05 level.
**. Correlation is significant at the 0.01 level.

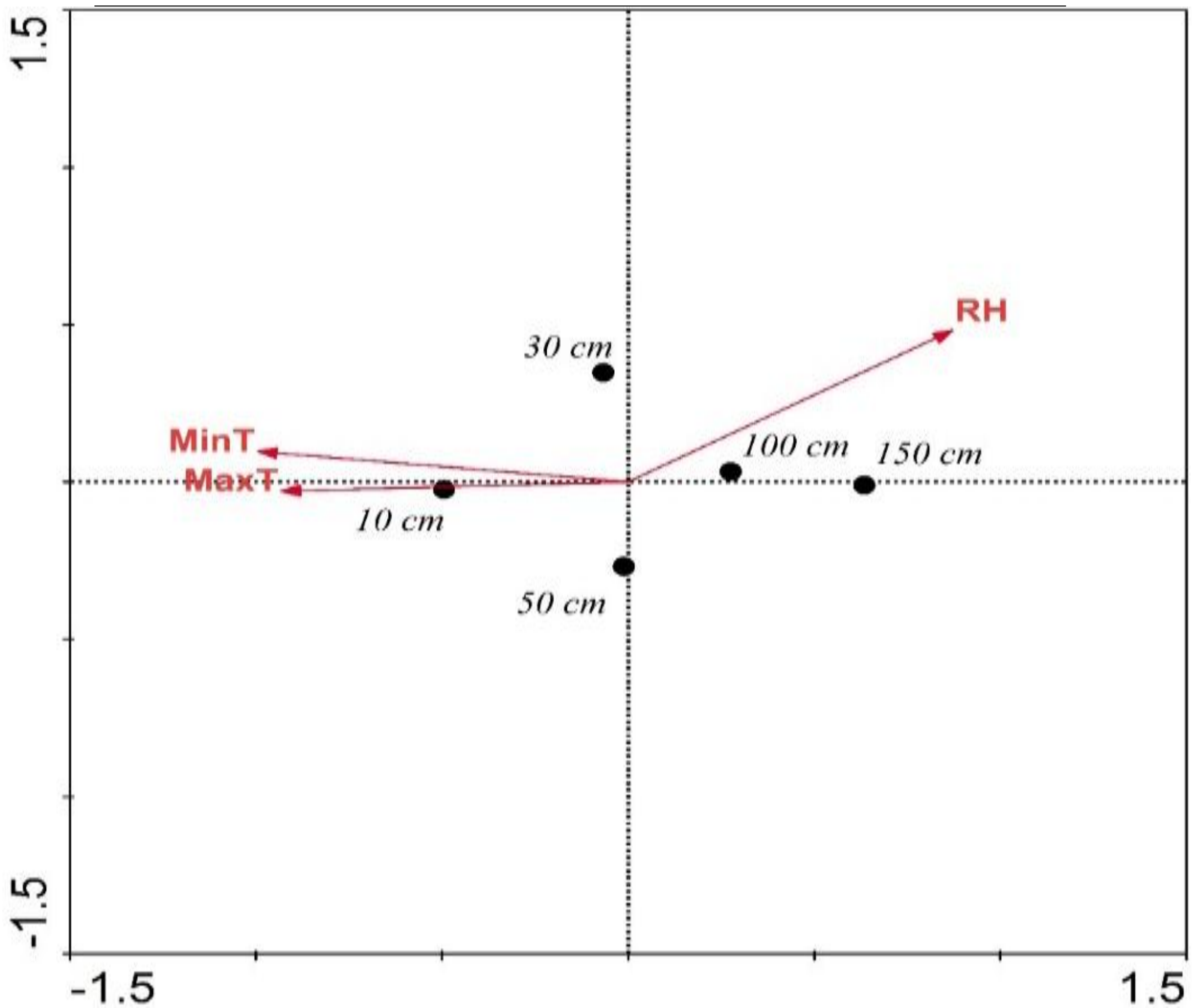

Fig 2. The effect of main weather factors on annual fluctuations of sand subterranean termite workers according to Corresponding Canonical Analysis (CCA). Where Min. T= minimum temperature, Max. T = maximum temperature. RH= relative humidity %.

Additionally, Elsiddig (2019) stated that, as the temperature rises, the damage produced by *Microtermes* spp. termites reduce. Furthermore, termite activity had a substantial negative connection with maximum ambient temperature (r = -0.396) and maximum soil temperature (r = -0.378), according to Avinash and Kumar (2019). On the other hand, an insignificant positive and negative correlation was recorded for 30 cm, 50 cm, and 100 cm depths, which occurred between the max. temperature and the worker population of the sand subterranean termite, where r= 0.082, 0.059, and -0.010, respectively.

3.2.2. Effect of minimum temperature

Results in Table (2) and Fig (2) suggest that the minimum temperature had a significant positive correlation effect (r= 0.318) on the worker population density. These results suggest that with an increase in maximum temperature, the activity of *P. hypostoma* will increase at this depth. These findings are consistent with Salman et al., (1987), who found that the minimum air temperature has the greatest impact on *P. hypostoma* activity. In addition, Haagsma and Rust (1995) found a substantial link between the minimum temperature and the foraging activity of the western subterranean termite, *Reticulitermes hesperus*, in California. Arab *et al.* (2005) stated that the minimum temperature affected the foraging activity of two subterranean termite species, *H. tenuis*, and *C. gestroi*, in Brazil. Furthermore, Cao and Su (2016) found that *Reticulitermes* spp. favored lower temperatures than *Coptotermes* spp. Moreover, a significant negative correlation effect at a 0.01 level of probability was recorded at 150 cm depth, between the minimum temperature and the worker population of the sand subterranean termite, (r = -0.177). Low temperatures restricted the foraging activity of termites of both the desert subterranean termite, *G. perplexus*, and the grass harvesting termite, *T. geminatus*, according to LaFage *et al.* (1976) and Ohiagu (1979), who stated that low temperatures restricted the foraging activity of termites of both the desert subterranean termite, *G. perplexus*, and the grass harvesting termite, *T. geminates*. In addition, El-Bassiouny *et al.* (2015) and Thabit *et al.* (2019) found that soil temperature did not affect *A. ochraceus* foraging activity in the Sharkia and Ismailia Governorates. Termite activity has a substantial negative connection with minimum soil temperature, according to Avinash and Kumar (2019). However, at 30 cm, 50, and 100 cm depths, the Pearson correlation coefficient values obtained from table (2) and Fig (2) demonstrated that an insignificant positive and negative correlation occurred between the min. temperature and the worker population of the sand subterranean termite, where r = 0.115, 0.065, and -0.031, respectively.

3.2.3. Effect of relative humidity (%)

The Pearson correlation coefficient values were obtained from the table (2) and fig (2), which indicated that the relative humidity (RH%) has a significant positive effect at a 0.05 level of probability at 150 cm depth, where r = 0.148. Moreover, for 30 cm, and 100 cm depths, relative humidity (RH%) has an insignificant negative effect, where (r = -.034, and .028), respectively. These results suggest that the relative humidity had a positive correlation effect on the population density of workers and nymphs of *P. hypostoma*. These results indicate that with an increase in relative humidity, the population density of workers and nymphs of *P. hypostoma* increases in these depths. This may be due to, termites being thin-skinned insects that quickly dry out when exposed to the desiccating effects of wind or dry air (very susceptible to desiccation) because of their soft cuticles with poor water-retaining properties, and thus they require a constant supply of moisture. These observations coincide with the results obtained by Abou Ghadir and khalifa (1982), who mentioned that the *P. hypostoma* infestation was confined to wood rich in moisture at layers near the soil surface, despite the presence of the availability of superficial wood and surface weed vegetation. Moreover, these results agree with those of Sattar and Naeem (2013), as they recorded a positive and significant correlation between relative humidity and the percent workers of *O.*

lokanandi. Moreover, El-Bassiouny *et al.* (2015) mentioned that the highest number of foraged termites, *A. ochraceus*, correlated significantly with relative humidity. Furthermore, Thabit *et al.* (2019) found that the relative humidity percentage has a positive effect on the foraging activity of subterranean termites, *A. ochraceus* (r = 0.509 and 0.585), respectively, in the first year of the study. Also, Pozo-Santiago *et al.* (2020) indicated a significant effect of relative humidity on the survival of subterranean termites, *Coptotermes testaceus* (Isoptera: Rhinotermitidae). However, a significant negative correlation effect at 0.01 and 0.05 levels of probability was recorded at 10 cm, 50 cm depths between the relative humidity and the worker population of the sand subterranean termites, where r = -0.293 and -.128, respectively. These results suggest that the relative humidity harmed the population density of *P. hypostoma*, workers. These results indicate that with an increase in relative humidity, the population density of *P. hypostoma* workers decreases at these depths. These results agree with those of Lewis *et al.* (2011) who demonstrated that humidity did not appear to have a noticeable effect on termite activity. Moreover, Sattar and Naeem (2013) reported that the correlation between the relative humidity and both subterranean termite species, *O. lokanandi* and *M. obesi* in Islamabad was negative and insignificant among both termite species. Furthermore, El-Latif and Solaiman (2014) reported that the effect of RH% was insignificantly negative on the total number of subterranean termites, *P. hypostoma*. Moreover, Hammad (2018) found that a negative correlation was recorded between the relative humidity and the population of subterranean termites, *P. hypostoma*, workers. Moreover, Thabit *et al.* (2019) found that the relative humidity % harms the foraging activity of *A. ochraceus* in the second year of the study. Moreover, for 30 cm, and 100 cm depths, relative humidity percentage has an insignificant negative effect, where r= -.034 and .028, respectively.

3.3. The effect of trap depth on the annual fluctuation of the worker subterranean termite, P. hypostoma

Results in Table (3), Fig (3 and 4), illustrated that the highest mean numbers of individuals found all over the year were 234.60 ±12.92 which was recorded at 50 cm depth, during week 36, on the 9th of May 2020. Inversely, the lowest mean numbers of individuals were 0.20 ± 0.20 and were recorded at 10 cm depth, during week 19, on the 11th of January 2019. Furthermore, statistical analysis demonstrated that there is a significant difference between (10 cm, 30 cm), (10 cm, 50 cm), (10 cm, 100 cm) and (30 cm, 50 cm) and (50 cm, 100 cm), and (100 cm, 150 cm). The results of this study are consistent with those of Abd Elatti (2012), who found extremely significant changes in the mean number of individuals' *P. hybostoma* attracted to different types of traps in different months, despite traps being buried at a depth of 30 cm in the soil. Furthermore, McManamy *et al.* (2008) found a substantial difference in subterranean termites, *Reticulitermes flavipes* (Kollar), when traps placed at a depth of 12 cm in the soil were used.

Table 3. The mean numbers of recorded individuals and ± SE of *P. hypostoma* workers collected by 1300 traps from September 2019 to August 2020 in Al-Tuwayrat region, Qena city, at different trap depths.

Date	Depth/ weeks	10 cm Mean	±SE	30 cm Mean	±SE	50 cm Mean	±SE	100 cm Mean	±SE	150 cm Mean	±SE
7\ 09 \ 2019	1	44.8	18.5	70.0	12.3	60.4	6.25	2.60	2.60	0.00	0.00
14\ 09\ 2019	2	104.2	27.1	49.0	24.6	29.8	3.69	44.6	11.3	0.80	0.80
21\ 09 \ 2019	3	83.6	35.2	23.6	15.3	49.4	5.94	15.0	7.22	8.40	0.40
28\ 09 \ 2019	4	55.4	22.7	22.0	13.7	63.4	6.07	3.20	3.20	21.8	3.80
5/10 \ 2019	5	98.2	16.3	87.2	27.2	58.6	5.23	0.20	0.20	6.00	1.00
12/10 \ 2019	6	88.4	19.0	3.00	3.00	11.2	7.31	13.0	11.6	8.60	1.33
19/10 \ 2019	7	11.4	10.4	1.80	1.80	28.6	4.79	1.80	1.20	12.4	1.19
26 /10 \ 2019	8	23.2	10.6	46.6	19.3	25.6	25.6	6.00	3.79	7.80	1.41
2 /11 \ 2019	9	10.4	7.11	14.8	6.49	30.4	18.6	16.6	14.9	14.6	2.17
9/11 \2019	10	25.2	21.7	9.20	5.31	7.40	7.40	23.6	16.9	18.4	1.27
16/11 \2019	11	11.4	11.4	13.6	13.6	15.4	10.9	5.80	4.15	26.0	3.72
23/11 \2019	12	0.00	0.00	66.8	16.8	20.6	12.8	10.6	6.81	27.0	3.93
30/11 \2019	13	32.4	8.12	35.0	5.00	43.8	11.7	16.8	9.55	11.2	1.27
7/12 \2019	14	12.8	9.33	7.20	7.20	9.40	6.76	20.2	11.2	36.8	5.60
14/12 \2019	15	0.00	0.00	19.0	7.30	0.80	0.80	14.8	11.2	207	20.2
21/12 \ 2019	16	20.8	2.80	12.2	8.77	10.0	7.38	1.20	0.58	61.2	14.4
28 /12 \ 2019	17	18.6	18.6	0.20	0.20	4.20	2.58	4.80	4.80	31.6	7.44
4 /1 \ 2020	18	0.60	0.60	2.40	2.16	7.80	5.20	20.0	17.4	14.6	6.10
11 /1 \ 2020	19	0.20	0.20	2.20	1.96	63.2	9.10	20.2	14.8	33.8	3.22
18 /1 \ 2020	20	24.4	16.4	14.2	2.99	4.00	3.52	4.20	3.29	51.0	8.03
25 /1 \ 2020	21	10.6	9.87	2.80	2.80	6.00	5.28	9.00	3.73	54.8	8.34
1/ 2 \ 2020	22	4.20	3.10	4.20	4.20	7.20	6.71	4.60	3.31	103	19.9
8 / 2 \ 2020	23	2.80	2.13	1.20	1.20	21.8	14.0	2.80	2.33	60.2	6.40
15 / 2 \ 2020	24	20.6	15.5	33.4	13.9	9.00	5.69	4.20	3.04	36.2	10.2
22 / 2 \ 2020	25	8.00	5.67	48.0	11.8	2.60	1.69	17.8	14.6	80.8	22.7
29 / 2 \ 2020	26	31.2	8.43	31.8	6.90	28.6	17.3	7.00	3.27	28.4	6.28
7 / 3 \ 2020	27	16.6	2.44	27.2	4.31	5.40	3.17	25.4	13.9	62.8	14.3
14 / 3 \ 2020	28	38.8	5.50	28.0	5.88	5.60	2.48	3.80	2.33	88.2	19.0
21 / 3 \ 2020	29	17.8	7.74	53.0	6.4	3.20	1.96	2.20	1.56	75.0	12.6
28 / 3 \ 2020	30	35.6	6.49	37.2	10.7	8.40	8.40	17.8	14.7	76.6	10.8
4 / 4 \ 2020	31	37.0	2.54	26.6	15.6	34.2	20.4	18.0	18.0	136	37.1
11 / 4 \ 2020	32	58.6	8.57	20.4	13.3	56.4	33.6	13.6	12.4	53.8	27.3
18 / 4 \ 2020	33	75.6	3.61	1.40	1.40	67.8	21.6	21.4	21.4	181	30.0
25 / 4 \ 2020	34	103	2.00	143	29.3	139	24.3	56.2	56.2	39.2	21.3
2 / 5 \ 2020	35	174	33.7	11.0	11.0	133	27.1	51.6	31.3	123	32.0
9 / 5 \ 2020	36	40.6	16.7	1.00	1.00	235	12.9	44.6	43.1	91.0	25.0
16 / 5 \ 2020	37	234	19.5	2.20	1.96	68.4	42.8	12.8	9.25	34.6	4.90
23 / 5 \ 2020	38	32.0	10.9	6.80	4.58	4.80	4.32	5.00	3.69	6.80	1.06
30 / 5 \ 2020	39	28.8	2.81	8.40	6.79	4.40	3.44	0.40	0.40	6.00	0.85
6 / 6 \ 2020	40	61.4	16.2	13.8	6.93	6.80	3.76	17.4	10.9	20.8	3.38
13 / 6 \ 2020	41	84.2	14.7	25.8	12.0	21.6	10.4	2.80	2.13	24.4	4.89
20 / 6 \ 2020	42	106	34.4	11.8	7.05	9.00	6.00	2.40	1.60	2.80	1.83
27 / 6 \ 2020	43	182	23.0	0.00	0.00	17.6	10.2	5.60	5.60	49.4	13.0
4 / 7 \ 2020	44	49.4	11.9	7.20	4.50	5.00	3.52	8.20	5.22	8.80	1.10
11 / 7 \ 2020	45	84.2	16.2	2.60	1.6	9.80	9.80	8.20	6.20	75.6	4.35
18 / 7 \ 2020	46	77.8	20.1	51.0	14.9	10.6	10.6	5.00	5.00	19.2	8.43
25 / 7 \ 2020	47	49.2	12.4	90.4	19.1	17.8	16.6	10.4	9.67	11.6	6.49
1 /8 \ 2020	48	78.2	11.6	25.0	13.6	21.4	12.9	1.60	1.17	14.0	8.19
8 /8 \ 2020	49	189	31.4	62.0	13.8	0.00	0.00	3.40	3.16	11.0	7.42
15 /8 \ 2020	50	230	36.1	40.4	20.3	21.6	20.1	0.60	0.40	5.20	3.76
22 /8 \ 2020	51	84.8	23.5	24.2	10.7	5.60	3.56	0.60	0.60	17.0	12.1
29 /8 \ 2020	52	64.6	9.86	54.6	15.1	15.6	9.57	6.60	4.40	21.2	6.72

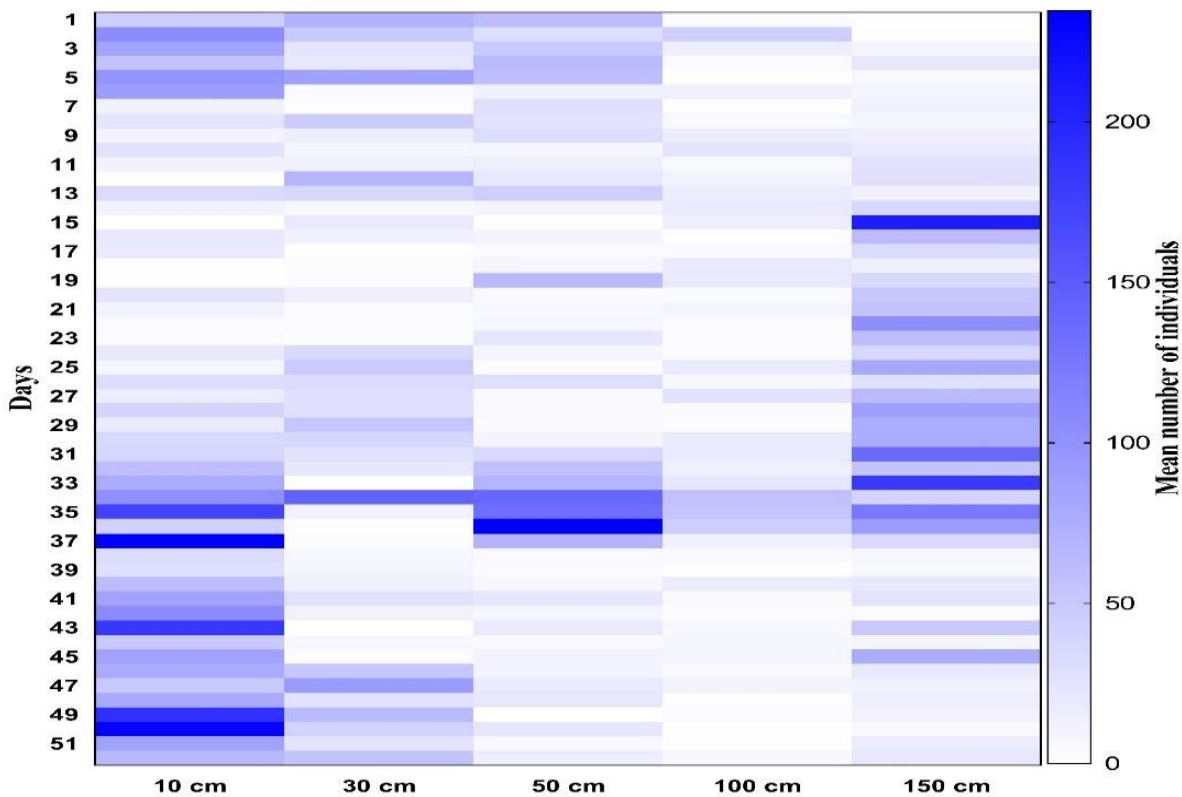

Fig 3. The mean numbers of recorded individuals and of *P. hypostoma* workers collected by 1300 traps from September 2019 to August 2020 in Al-Tuwayrat region, Qena city, at different trap depths. (Heat map conducted with Graph Pad-prism 8.0.1).

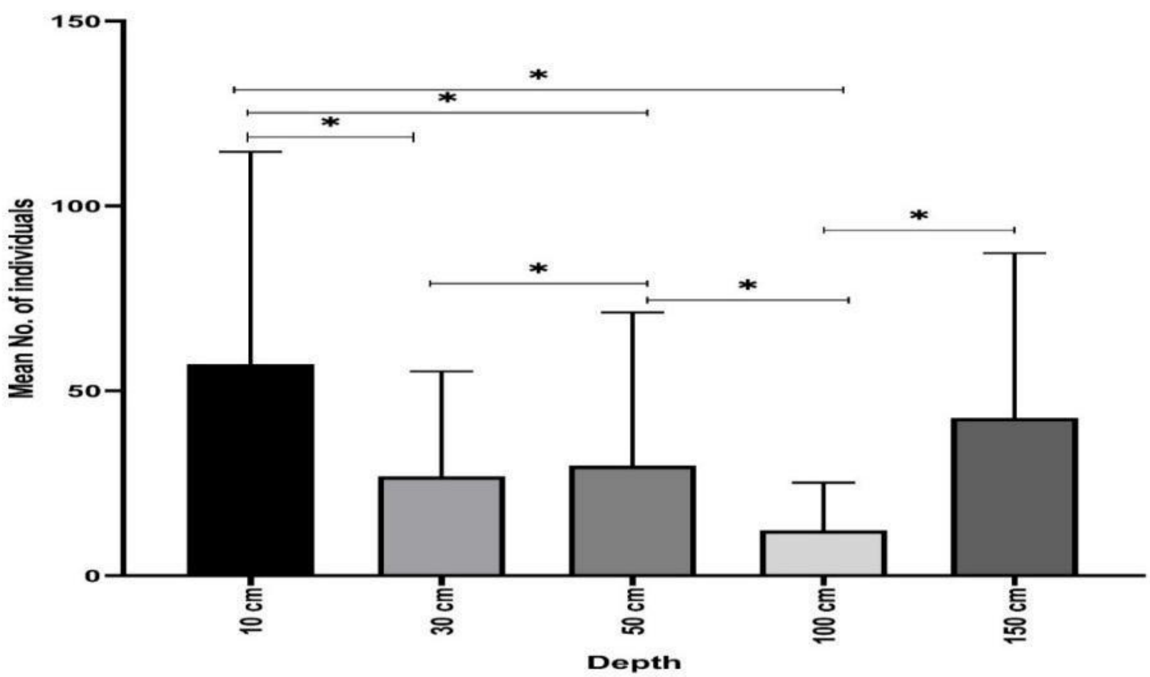

Fig 4. The mean numbers of collected individuals and of *P. hypostoma* workers collected by 1300 traps from September 2019 to August 2020 in Al-Tuwayrat region, Qena city, at different trap depths. and ± standard error (SE). ***** The mean difference is significant at the 0.05 level**.**

4. Conclusion

The current investigation on the trap's depth found that the abundance of individuals is inversely proportional to the soil depth furthermore temperature and directly to the relative humidity of the ambient soil. Thereby, in the future, this could be a viable method for managing subterranean termites.

Authors' Contributions
All authors contributed to this research.

Funding
There is no funding for this research.

Institutional Review Board Statement
All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement
Data presented in this study are available at fair request from the respective author.

Ethics Approval and Consent to Participate
This work carried out at the plant protection department and followed all the department instructions.

Consent for Publication
Not applicable.

Conflicts of Interest
The authors declare no conflict of interest.

5. References

Abd Elatti, Z.S. (2012). *'Studies on the biological control of subterranean termites, Psammotermes hypostoma (Isoptera: Rhinotermitidae) and their population fluctuation in Qena city',* M.Sc. Thesis. Faculty of Science. South Valley University, pp. 64-76.

Abd El- Latif, N.A. (2013). 'Foraging activity parameters of the sand subterranean termite, *Psammotermes hypostoma* Desneux (Isoptera: Rhinotermitidae) and its Associated fungus *Metarhizium Anisopliae* under the field conditions at El-Fayoum Governorate, Egypt' *Egyptian Journal of Crop Protection*, 8(2), pp. 8-20.

Abd El-Latif, N.A., Solaiman, R.H.A. (2014). 'Foraging activity of the subterranean sand termite, *Psammotermes hypostoma* (Desneux) and its associated fungus *Metarhizium anisopliae* under natural environmental conditions in El-Fayoum Governorate, Egypt', *Egyptian Journal of Biological Pest Control*, 24 (2), pp. 321-328.

Abdel-Galil, A.F., Aly, M.Z.Y., Osman, K.S.M., Abou-El-Magd, S.M. (2007). 'Harmony of seasonal abundance of *Psammoptermes hybostoma* Desneux population (Isoptera: rhinotermitidae) with some ambient environmental biotic and abiotic factors', *Journal of the Egyptian German Society of Zoology.*, 52(E), 93.

Abou-Elmagd, S.M. (2006). *'Ecological studies on termites (Isoptera) and associated arthropods at Qena Governorate',* M.Sc. Thesis. Faculty of Science. South Valley University, 33, 95.

Abou Ghadir, M.F., Khalifa, M.E. (1982). 'Desert termite foraging populations and their relation to superficial wood and soil environment', *Assiut Journal of Agricultural Sciences*, 13(3), pp. 79-86.

Ahmed, H.M. (2013). 'Delineate of foraging territories and estimate the densities of colonies of sand subterranean termite *Psammotermes hypostoma* (Desneux) in Aswan', *Alexandria Journal of Agricultural Research*, 58(1), pp. 19- 27.

Allam, R. O. H., Badawy, A. M. M., & Ali, M. A. (2022). Green synthesized silver nanoparticles for controlling subterranean termites, *Psammotermes hypostoma* (Desn.)', *SVU-International Journal of Agricultural Sciences*, 4(1), pp. 135-143.

Aly, M.Z.Y., Abdel-Galil, A.F., Osman, K.S.M., Abou-El-Magd, S.M. (2007). 'Possible association between food consumption by *Psammotermes hybostoma* (Isoptera: Rhinotermitidae) in the field and laboratory with annual population fluctuations', *Journal of the Egyptian German Society of Zoology.*, 52(E), 78.

Arab, A., Costa-Leonardo, A.M., Casarin, F.E., de Camargo Guaraldo, A., Chaves, R.C. (2005). ‘Foraging activity and demographic patterns of two termite species (Isoptera: Rhinotermitidae) living in urban landscapes in southeastern Brazil’, *European Journal of Entomology,* 102(4), pp. 691.

Avinash, T.G., Kumar, N.G. (2019). ‘Pest status and seasonal activity of termites in relation to abiotic factors in different field crops’, *Journal of Entomology and Zoology Studies,* 7(1), pp. 1235-1239.

Badawi, A., Faregalla, A.A., Dabbour, A., Mostafa, S.A.S. (1986). *‘Studies on the termite’s problem in Saudi Arabia’,* Science Research Division, King Abdel-Aziz University: Jeddah, Saudi Arabia, pp. 99-105.

Bodine, M.C. (1973). *‘The impact of the termite Gnathamitermes tubiformans on rangeland herbage dynamics’,* Ph. D. Thesis. Texas Tech University, 39.

Cao, R., Su, N.Y. (2016). ‘Temperature preferences of four subterranean termite species (Isoptera: Rhinotermitidae) and temperature-dependent survivorship and wood-consumption rate’, *Annals of the Entomological Society of America,* 109(1), pp. 64-71.

El-Bassiouny, A.R., Ahmed, H.M., Abol-Maaty, S.M. (2015). ‘Study on swarming and colony structure of harvester termite, *Anacanthotermes ochraceus* (BURM)’, *Journal of Plant Protection and Pathology,* 6(11), pp. 1613-1621.

El-Sebay, Y. (1991). *‘A modified El-Sebay trap for subterranean termites’,* Fourth Arab Congress of Plant Protection, pp. 245-247.

Elsiddig, F.I. (2019). ‘Effect of ambient temperature and relative humidity on foraging activity of termite *Microtermes thoracalis* (Isoptera: Macrotermitinae) in Sinnar State, Sudan’, *Nile Journal for Agricultural Sciences,* 4(02), pp. 48-60.

Evans, T.A., Gleeson, P.V. (2001). ‘Seasonal and daily activity patterns of subterranean, wood-eating termite foragers’, *Australian Journal of Zoology,* 49(3), pp. 311-321.

Haagsma, K.A., Rust, M.K. (1995). ‘Colony size estimates, foraging trends, and physiological characteristics of the western subterranean termite (Isoptera: Rhinotermitidae)’, *Environmental Entomology,* 24(6), pp. 1520-1528.

Hammad, M.S. (2018). *‘Efficiency of some pesticides and their alternatives against termites under Qena Governorate conditions’,* M.Sc. Thesis. Faculty of Agriculture. South Valley University, pp. 65-114.

Ibrahim, B.U., Adebote, D.A. (2012). ‘Appraisal of the economic activities of termites: A review’, *Bayero Journal of Pure and Applied sciences,* 5(1), pp. 84-89.

Janowiecki, M., Vargo, E.L. (2021). ‘Seasonal activity, spatial distribution, and physiological limits of subterranean termites *(Reticulitermes Species)* in an East Texas Forest’, *Insects,* 12(2), pp. 86.

Jones, S.C. (1990). ‘Colony size of the desert subterranean termite *Heterotermes aureus* (Isoptera: Rhinotermitidae)’, *The Southwestern Naturalist,* pp. 285-291.

Kofoid, C.A. (1934). *‘Climatic factors affecting the local occurrence of termites and their geographical distribution. Termites and termite control’,* University of California Press, Berkeley, CA, pp. 13-21.

LaFage, J.P., Haverty, M.I., Nutting, W.L. (1976). ‘Environmental factors correlated with the foraging behavior of a desert subterranean termite, *Gnathamitermes perplexus* (Isoptera: Termitidae)’, *Sociobiology,* 2(2), pp. 155-167.

LaFage, J.P., Nutting, W.L., Haverty, M.I. (1973). ‘Desert subterranean termites: a method for studying foraging behavior’, *Environmental Entomology,* 2(5), pp. 954-956.

LaFage, J.P., Su, N.Y., Jones, M.J., Esenther, G.R. (1983). ‘A rapid method for collecting large numbers of subterranean termites from wood', *1, 2. Sociobiology,* 7(3), pp. 305-309.

Lewis, V., Leighton, S., Tabuchi, R., Haverty, M. (2011). 'Seasonal and daily patterns in activity of the western drywood termite, Incisitermes minor (Hagen)', *Insects,* 2(4), pp. 555-563.

McManamy, K., Koehler, P.G., Branscome, D.D., Pereira, R.M. (2008). 'Wood moisture content affects the survival of eastern subterranean termites (Isoptera: Rhinotermitidae), under saturated relative humidity conditions', Sociobiology, 52(1), pp. 145-156.

Mohanny, K.M., Ahmed, H.M. (2010). 'Field studies on the foraging populations and caste composition of sand subterranean termite *Psammotermes hypostoma* (Desneux) in El-Konooz Region, Qena Governorate', *Journal of Plant Protection and Pathology,* 1(7), pp. 479-484.

Ohiagu, C.E. (1979). 'A quantitative study of seasonal foraging by the grass harvesting termite, *Trinervitermes geminatus* (Wasmann), (Isoptera: Nasutitermitinae) in southern Guinea savanna, Moka, Nigeria', *Oecologia,* 40(2), pp. 179-188.

Pervez, A. (2018). 'Termite biology and social behaviour', In *Termites and sustainable management* (pp. 119-143). Springer, Cham.

Pozo-Santiago, C.O., Pérez-De La Cruz, M., Torres-De la Cruz, M., De La Cruz-Pérez, A., Capello-García, S., Hernández-Gallegos, M.A., Velázquez-Martínez, J. R. (2020). 'Survival of *Coptotermes testaceus* (Isoptera: Rhinotermitidae) to environmental conditions (relative humidity and temperature) and preference to different substrates', *Sociobiology,* 67(3), pp. 425-432.

Salman, A.G., Morsy, A.A., Sayed, A.A. (1987). 'Foraging activity of the sand termite *Psammotermes hypostoma* (Desneux) in the New Valley, Egypt', *Assuit, Journal of Agriculture Science,* 18 (4), pp. 84-90.

Sattar, A., Naeem, M. (2013). 'Impact of environmental factors on the population dynamics, density, and foraging activities of *Odontotermes lokanandi* and *Microtermes obesi* in Islamabad, 2(1), pp. 1-7.

Suiter, D.R., Jones, S.C., Forschler, B.T. (2009). 'Biology of subterranean termites in the eastern united states', *Bulletin,* 1209, pp. 1-8.

Thabit, A. Th., Abdel Wahed, M.S., Ahmed, H.M. (2019). 'Field studies on foraging activity and cast composition of subterranean termite, *Anacanthotermes Ochraceus* (Burm.) at Al-Qassasin Region, Ismailia Governorate', *Journal of Environmental Science,* 47(1), pp. 77-97.