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Surface and Subsurface Foraging Activity of Subterranean Sand Termite, *Psammotermes hybostoma*, Desneux (Isoptera: Rhinotermitidae) at El-Fayoum Governorate, Egypt

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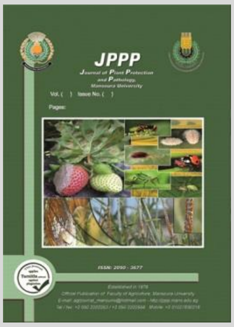

ABSTRACT

Surface and subsurface foraging activity of the subterranean termite, *Psammotermes hybostoma* Desneux (Isoptera: Rhinotermitidae) was examined for one year extended from October 2018 until September 2019 at El-Fayoum district, El-Fayoum governorate, Egypt. The surface foraging activity was estimated using a perforated plastic rectangular box trap, while subsurface foraging activity was determined using a new design column trap (300 cm height, and 7.2 cm diameter). The column trap was divided into five levels with suitable barriers of reinforced cork. Results showed that food consumption, was the lowest during winter (13.23 g./trap/m^2), while it was the highest during spring (76.1 g./trap/m^2). Changes in soil translocation were almost similar to those previously mentioned for food consumption. The highest seasonal means of subsurface food consumption was 1806.92 g./5 column traps during autumn throughout the four levels, while the lowest seasonal means was occurred during spring (1019.15 g./5 column traps). The total annual food consumption increased gradually from 2921.34 g./5 column traps at the first level to 8533.82 g./5 column traps at the fourth one, then it decreased slightly to (7383.22 g./5 column traps) at the fifth level. The total annual number of captured workers increased gradually from the first level (98148 workers/5 column traps) reach the peak at the third level (164178 workers/5 column traps), then it decreased gradually from the fourth level (144636 workers/5 column traps) to the 5th level (107874 workers/5 column traps).

Keywords: subterranean termite, *Psammotermes hybostoma*, surface activity, subsurface activity, traps.

INTRODUCTION

Termites are a group of social insects that belong to order Isoptera. Individuals in each species are differentiated into various morphological forms or castes that live in highly organized societies or colonies (Harris, 1961; Brain, 1978; Rizk and Salman, 1984; El-Sherif, *et al.* 2009 and Abd El-Latif, 2003 and 2013). They are important pests in many countries particularly in the arid tropics and subtropics (Emerson, 1955 and Harris, 1961 and 1967). *Psammotermes hybostoma* Desneux one of subterranean termites that feeds on any wood, sound or decayed, lying on or in contact with the ground (Hafez, 1980). In Egypt, this species occurs chiefly in upper Egypt and it was also collected from Giza, El-Fayoum, Minia, Assuit and Aswan governorates as well as from Kharga, Dakhla and Baharia Oases. It is one of the most economic species causing considerable damage to houses (Kaschef and El-Sherif, 1971 and Ali, 1980). Several scientists were measured surface activity of subterranean termites using various bait materials which are either presented on soil surface or completely or partially buried. These baits were placed sometimes inside a plastic rectangular box trap or covered with plates or surrounded by polyvinyl chloride (P.V.C.) collars (Brain, 1978; Wood, 1978; Abdel Wahab, *et al.* 1983; Salman, *et al.* 1987; El-Sebay, 1991; Ahmed, 1997 and Abd El-Latif, 2003 & 2013). However few studies have been published on subsurface activity. Therefore the present work aim to study the surface and subsurface foraging activity and the relative efficacy of different parameters used for the assessment of foraging activity.

MATERIALS AND METHODS

The surface and subsurface activity of *P. hybostoma* was examined for a year that extended from the 1st of October 2018 until the 30th of September 2019 at El-Lahoun village, El-Fayoum district, El-Fayoum governorate, Egypt. The selected experimental location was heavily infested with *P. hybostoma* and untreated with any termiticides. From this location, area of 35 m^2 was chosen for the study and carefully cleaned from any existing weed or cellulose materials. Thirty-five traps were distributed throughout the experimental area (7 rows × 5 columns) with 1 m distance between each two traps from all directions (Fig. 1). These traps were used to estimate the surface and subsurface activities.

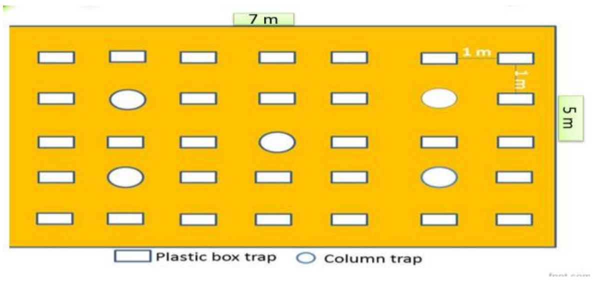

Fig. 1. Design of traps distribution

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1- Surface foraging activity:

Thirty plastic rectangular box traps (Abd El-Latif, 2013) were used for studying surface foraging activity parameters. The trap consists of a plastic rectangular box measuring 25 cm L × 15 cm W × 12 cm H. with plastic lid. The sides of the trap were punctured with 10 holes, each 5 mm in diameter for termite access. Baits consisted of corrugated cardboard paper that was prepared in rolls shape, dried at 105 ºC for 24hr in electric oven. Each trap was provided with 150 g of the previous baits which weighed and then soaked in water until saturation (Fig. 2A). Traps were buried into the soil at 30 cm depth whereas every trap occupied the same position throughout the whole period of the experiment (Fig. 2B). As a half monthly routine, buried traps were carefully removed from the soil with the aid of shovel. All contents of each trap (cardboard rolls remnants and translocated soil by termite workers and termite individuals (Fig. 2C) were put separately in plastic bags. Plastic traps were provided with the same baits and held back in the soil at the same position (Abd El-Latif, 2013). Plastic bags were transferred to the laboratory for examination to determine the percentage of traps visited by the termite species; count and classify the captured termite individuals into different castes (workers, soldier and alates); later, collecting soil particles and cardboard rolls remnants separately and drying them at 105 C° for 24 h in an electric oven, and weighed. Obtained dry weight of soil particles represented translocated soil by termite (Collins and Nutting, 1973 and Abd El-Latif, 2003 & 2013). Dry weight of cardboard rolls before burring the trap into the soil after removing dry weight of cardboard remnants represented food consumption (La Fage *et al.*, 1973; Brain, 1978; El-Sebay, 1991 and Abd El-Latif and Solaiman, 2014).

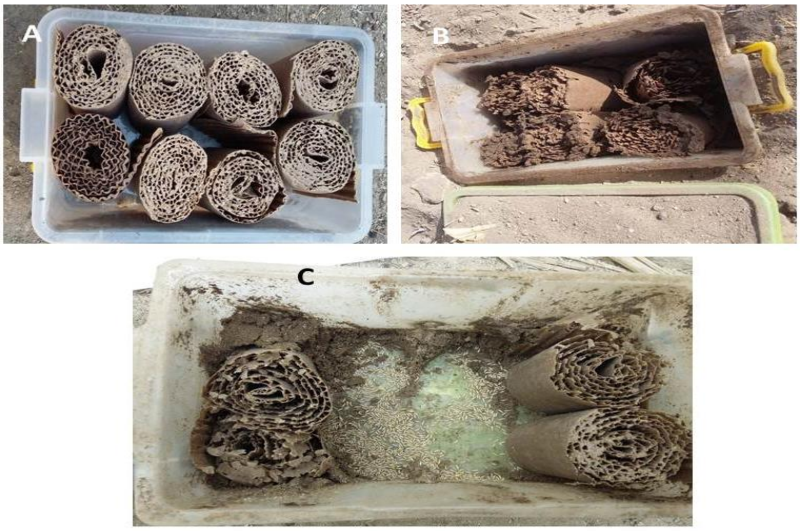

Fig. 2. A) Plastic box trap; B) Trap position; C) Infested trap contents.

2- Subsurface foraging activity:

A cylindrical plastic box column trap (Abd El-Latif and Solaiman, 2014) was used with some modifications in design and height to estimate subsurface foraging activity parameters. This design consisted of cylindrical thermoplastic polymer box column measuring 3 inches (7.2 cm) in diameter and 300 cm in height. This trap was contained 3 main separated parts each measuring 100 cm in height. These parts were connected with together by sleeves and screws, and each part was divided into two divisions with suitable barriers of reinforced cork covered with strips of aluminum foil to prevent completely termite individuals of foraging between both divisions (fig. 3A).

Each column included five levels; the first level length was 30 cm from soil surface to 30 cm depth and represents the surface activity. The other levels measuring 200 cm with 50 cm length for each level. The rest of column (70 cm) was viewed above soil surface to lift it from soil. 5 cylindrical column traps were distributed in the experimental area with 30 plastic rectangular box traps and their numbers were 7, 9, 18, 27 and 29. All levels were filled with a clean roll of corrugated cardboard paper (150 g / level). Before introducing the cardboard rolls into the column trap the formers were dried at 105 C° for 24 h in an electric oven and weighed then soaked in water until saturation. The column trap was buried in a vertical position to the depth of 230 cm into a hole with the aid of an auger on October 1st, 2018 then was covered with soil as shown in (Fig. 3B).

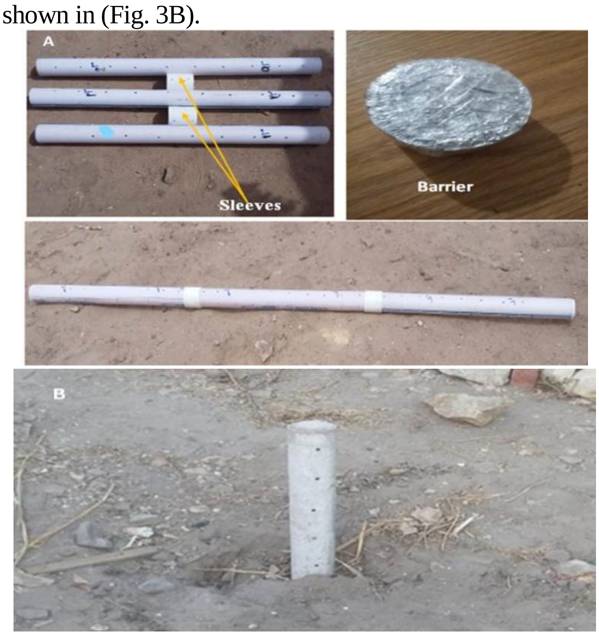

Fig. 3. A) Cylindrical column trap parts; B) Cylindrical column trap position

As a half monthly routine, buried column traps were carefully lifted from the soil, then the cardboard rolls were taken off column and replaced with new ones. Every level's roll and translocated soil were introduced into a separated plastic bag and transferred to the laboratory for examination to estimate subsurface activity at different depths. Rolls and translocated soil were treated as above mentioned in surface activity to determine number of captured termites, caste composition, translocated soil and food consumption.

Statistical analysis:

Simple correlation and regression coefficients were estimated for the relation between foraging activity parameters (number of captured termites, soil translocation and food consumption) and some weather estimates (max., min., and mean temperatures for air and soil and mean RH% using SPSS Statistics version 25.0.

RESULTS AND DISCUSSION

1- Surface foraging activity parameters:

The half monthly and seasonal means of food consumption, soil translocation, percentage of infested traps and number of captured termites at the study location throughout the year of the study are shown in Tables (1 and 2).

Food consumption:

This parameter is defined as the actual dry weight of consumed corrugated cardboard/trap/in grams (Abd El-Latif, 2003). As seen from Table (1), food consumption was low in winter and increased gradually during spring until it reached the 1st peak in the 1st half of May with 111 g./trap/m^2, then it decreased gradually during summer to record about 31 g./trap/m^2 in the first half of August, after which it increased progressively during autumn until it reached a 2nd peak of about 89 g/trap/m^2 in the second half of October, food consumption tended to decline to about 23 g./trap/m^2 by the end of autumn.

Concerning the seasonal foraging activity means, as represented by food consumption, was relatively low during winter (13.23 g./trap/m^2), representing 6.7% of the total annual food consumption, while, food consumption was relatively higher during spring (76.1 g./trap/m^2, representing 38.8% of the total annual food consumption). Food consumption is more or less moderate during both summer and autumn; it recorded two distinct peaks; one in the 1st half of May and the other in the second half of October. Several authors assessed the surface foraging activity of different species of subterranean termites depending on the food consumption (Brain, 1978; Ali *et al*., 1982; El-Sebay, 1993; El-Sherif *et al*., 2009; Abd El-Latif, 2013 and Abd El-Latif and Solaiman, 2014).

These results are in agreement with those obtained by Abd El-Latif, 2013 and in partial agreement with those obtained by Ali *et al*., (1982). At the same trend Abd El-Wahab *et al*.,1983 recorded the highest food consumption of *P. hybostoma* at April and August at Kom-ombo Aswan governorate. Salman *et al*., (1987) in the new valley found that foraging level of *P. hybostoma* was high in summer months with three peaks recorded during June, July and September

Soil translocation:

Data in Table (1) refer that the changes in soil translocation were almost similar to those previously mentioned for food consumption. Soil translocation was low during winter, and increased gradually during spring months to record the 1st and highest peak (220 g./trap/m^2) in the first half of May. After that, the activity began to decrease gradually throughout summer months where the translocated soil reached 35 g./trap/m^2 in the 1st half of August, it increased progressively during autumn until it reached the 2nd peak with 144 g./trap/m^2 in the 2nd half of October and declined again to about 28 g./trap/m^2 by the end of autumn. Generally, the highest seasonal means of soil translocation took place during spring (155 g./trap/m^2, represented 46.3 % of the total annual soil translocation) and the lowest seasonal means of soil translocation occurred during winter (about 25 g./trap/m^2, represented 7.4 % of the total annual soil translocation). These results are in agreement with Abd El-Latif, 2013 who stated that the highest mean of soil translocation took place in spring. Also, these results are in partial agreement with El-Bassyoni, 2001 who mentioned that the maximum soil translocation occurred in September and October, while the minimum soil translocation occurred in January. Abd El-Latif, 2003 found that the highest rates took place in summer.

Table 1. Half-monthly and seasonal means of food consumption and soil translocation by *P. hybostoma* at El-Fayoum governorate for one-year extended from October 2018 to September 2019 under field conditions.

Year	Season	Date of inspection	Food consumption (g./trap/m^2)	%	Soil translocation (g./trap/m^2)	%
2018-2019	Winter	15 Dec.	19.45	1.65	35.06	1.75
		31 Dec.	14.65	1.24	16.79	0.84
		15 Jan.	4.50	0.38	11.12	0.55
		31 Jan.	3.84	0.33	8.28	0.41
		15 Feb.	10.58	0.90	19.01	0.95
		28 Feb.	26.36	2.24	57.69	2.87
		Total	79.37	6.75	147.95	7.36
		Mean	13.23		24.66	
	Spring	15 Mar.	33.56	2.85	85.08	4.24
		31 Mar.	56.16	4.77	151.07	7.52
		15 Apr.	77.88	6.62	181.30	9.03
		30 Apr.	96.18	8.17	182.80	9.10
		15 May	110.47	9.39	220.17	10.96
		31 May	82.58	7.02	108.71	5.41
		Total	456.83	38.82	929.13	46.25
		Mean	76.14		154.86	
	Summer	15 June	74.88	6.36	102.63	5.11
		30 June	56.33	4.79	71.19	3.54
		15 July	47.55	4.04	59.71	2.97
		31 July	37.52	3.19	38.20	1.90
		15 Aug.	30.48	2.59	34.79	1.73
		31 Aug.	41.80	3.55	45.41	2.26
		Total	288.56	24.52	351.93	17.52
		Mean	48.09		58.66	
	Autumn	15 Sept.	57.92	4.92	105.14	5.23
		30 Sept.	58.95	5.01	109.57	5.45
		15 Oct.	78.33	6.66	121.06	6.03
		31 Oct.	89.08	7.57	144.40	7.19
		15 Nov.	45.07	3.83	71.28	3.55
		30 Nov.	22.65	1.92	28.38	1.41
		Total	352.00	29.91	579.83	28.86
		Mean	58.67		96.64	
Grand total			1176.76	100.00	2008.85	100.00

The total amount of soil translocation by *P. hybostoma* throughout one year recorded of about 2009 g./trap/m^2. In this respect Abd El-Latif, 2013 estimated the total amount of soil translocation were 464.2-1714.9 g./m^2 by the same species using plastic trap containing 8 rolls. Both food consumption and soil translation rates are the most precise and more quantitatively accurate parameters for the assessment of termite foraging activity. (El-Sherif, *et al*. 2009).

Percentage of infested traps:

The percentage of infested traps is the simplest and easiest parameter, which estimates foraging activity and shows termite damage.

As shown in Table (2), the percentage of infested traps was low throughout winter (17-40 %), while it increased progressively during spring to record the 1st peak (83%) in the 2nd half of April. The percentage decreases gradually during summer (31-71%), after which it trended to increase gradually until it reached the 2nd peak of about 89% in the 2nd half of October.

Table 2. Half-monthly and seasonal numbers of captured termite castes of *P. hybostoma* at El-Fayoum governorate for one year extended from October 2018 to September 2019.

Year	Season	Date of inspection	No. of captured termite castes/35 traps			% Of infested traps with termites
			Workers	Workers	Workers	
2018-2019	Winter	15 Dec.	2953	73	0	37.1
		31 Dec.	2475	82	0	34.28
		15 Jan.	3261	43	0	17.14
		31 Jan.	2412	36	0	25.7
		15 Feb.	9399	90	0	37.1
		28 Feb.	18416	154	7	40
		Total	38916	478	7	31.89
		Mean	6486	79.67	1.17	
	Spring	15 Mar.	51658	136	2	40
		31 Mar.	17290	135	0	48.57
		15 Apr.	14843	180	0	62.86
		30 Apr.	42607	795	8	82.86
		15 May	29165	890	1	80
		31 May	11846	319	15	68.57
		Total	167409	2455	26	63.81
		Mean	27901.5	409.17	4.33	
	Summer	15 June	50559	616	768	71.43
		30 June	31396	509	148	57.14
		15 July	10023	179	0	40
		31 July	30946	474	280	31.43
		15 Aug.	34910	791	80	34.28
		31 Aug.	38334	570	140	40
		Total	196168	3139	1416	45.71
		Mean	32694.67	523.17	236	
	Autumn	15 Sept.	55544	1314	1	62.86
		30 Sept.	35704	1262	20	62.86
		15 Oct.	119823	708	2	82.86
		31 Oct.	78426	837	0	88.57
		15 Nov.	25418	308	0	54.28
		30 Nov.	22410	159	0	48.57
		Total	337325	4588	23	66.67
		Mean	56220.83	764.67	3.83	
	Grand total		739818	10660	1472	

Number of captured workers:

Data in Table (2), showed that numbers of captured workers/35 traps have five peaks recorded in the 1st half of March (51658/35 traps), in the 2nd half of April (42607/35 traps), in the 2nd half of June (50559/35 traps), in the 1st half of September (55544/35 traps) and the highest peak occurs in the first half of October (119823/35 traps). Number of captured workers was relatively low during winter (38916/35 traps), more or less moderated during both spring (167409/35 traps) and summer (196168/35 traps), while, the highest number occurred during autumn (337325/35 traps). Rizk et al., (1985) stated that the workers of P. hybostoma have two peaks in February /March and August/September. Abd El-Latif, 2013 found that captured workers recorded three peaks per year and the maximum number of P. hybostoma workers occurred during summer.

In this respect El-Bassyoni, 2001 reported that, the Maximum Number of *P. hybostoma* workers occurred during winter, while, the lowest number was found during summer. Abd El-Latif, 2003 indicated that a considerable portion of the total annual number of captured *P. hybostoma* workers took place during the winter season

This parameter is often positively proportional to foraging activity as long as there are remnants of the cardboard rolls in the traps. The result of this parameter is inaccurate when there is no food material, foraging workers move to another trap filling up with cardboard rolls, therefor, the trap used in this investigation containing 8 rolls in order to it is quite suitable for the nutrition requirements of termites during tested period which it was two weeks.

Caste composition:

Data in Table (3) indicated that the vast majority of the trapped individuals were workers, where the total number of P. hybostoma individuals collected from 840 traps throughout the whole period of the current investigation was 751950 individuals of these 739818 (98.39%) were workers, 10660 (1.42 %) were soldiers and 1472 (0.20 %) were alates.

Table 3. Composition of *P. hybostoma* caste captured in the plastic traps at El-Fayoum Governorate during 2018/2019 year.

Caste	No. of captured termite	%
Workers	739818	98.39
Soldiers	10660	1.42
Alates	1472	0.20
Total	751950	

Statistical analysis:

As shown in Table (4), statistically all climatic factors showed highly significant and positive effect on the mean values of food consumption, except RH% which has a significantly negative effect. Concerning soil translocation parameter, all-experimental climatic factors have insignificantly positive effect on the mean values of soil translocation, except that of RH% which was significantly negative. The correlation coefficient between population of termites and all tested climatic factors was insignificantly positive, except that with min. air temperature which was significantly positive and RH% which was insignificantly negative. Also, number of infested traps significantly positive correlated with maximum air temperature and Mean air temperature, while the correlation was insignificantly negative with RH%.

Table 4. Simple correlation (r) and simple regression (b) coefficients for the relationship between some weather factors and the foraging activity parameters of *P. hybostoma* at Fayoum governorate during 2018/2019 year.

Parameters of Foraging Activity	Climatic factors									
	Max. air temp.		Mean air temp.		Min. air temp.		Soil temp.		RH%	
	r	b	r	b	r	b	r	b	r	b
Food consumption	.571**	2.253	0.541**	2.208	0.502*	2.316	0.544**	1.957	-0.589**	-1.638
Soil translocation	0.306	2.397	0.27	2.189	0.222	2.031	0.281	2.004	-0.445*	-2.456
No. of termites	0.381	39.023	0.393	41.66	0.420*	50.3	0.393	36.71	-0.102	-7.366
No. of infested traps	0.427*	1.11	0.405*	1.089	0.392	1.189	0.4	0.949	-0.347	-0.635

** High significance, $p \leq 0.01$. * Significance, $p \leq .05$.

2- Subsurface foraging activity parameters:

Food consumption:

Data in Table (5) indicated that in winter, food consumption was relatively low (437.04 g./5 column traps) at the first level (surface activity), and increased gradually until reached its maximum of about (2697.7 g./5 column traps) at the 5th level. In spring, food consumption was relatively high (1063.74 g./5 column traps) at the 1st level, then it jumped to record its maximum (2512.18 g./5 column traps) at the 2nd level, after that it decreased gradually until reached 953.69 g./5 column traps at the 4th level, then it increased slightly to 1101.92 g./5 column traps at the 5th level. In summer, was very low (155.39 g./5 column traps) at the 1st level compared to other seasons, then it increased progressively from about 2104.1 g./5 column traps at the 2nd level to about 2272.1 g./5 column traps at the 3rd level after which it tended to decline gradually from 1811.46 g./5 column traps at the 4th level to 713.6 g/trap at the 5th level. In autumn, food consumption was very high of about 1265.26 g./5 column traps at the 1st level then tended to increase gradually until it reached its maximum (3246.17 g./5 column traps) at the 4th level. This high was followed by a slight decrease 2870 g./5 column traps at the 5th level.

Table 5. Half-monthly and seasonal means of food consumption of *P. hybostoma* at different vertical distances of soil surface at El Fayoum governorate, Egypt in 2018/2019 season under field conditions.

Year	Season	Date of inspection	Food consumption g./5 column traps						Grand Total
			Surface	Subsurface activity (SS)					
			L1	L2	L3	L4	L5	SS Total	
2018-2019	Winter	15 Dec.	2	25.64	120	600	600	1345.64	1347.64
		31 Dec.	115.1	162.8	339.36	455	489.4	1446.56	1561.66
		15 Jan.	25	158	236.9	476	600	1470.9	1495.9
		31 Jan.	79.24	99.5	201	391.5	595	1287	1366.24
		15 Feb.	75.7	269	300	300	72.3	941.3	1017
		28 Feb.	140	162	300	300	341	1103	1243
		Total	437.04	876.94	1497.26	2522.5	2697.7	7594.4	8031.44
		Mean	72.84	146.16	249.54	420.42	449.62	1265.73	1338.57
	Spring	15 Mar.	180.74	162	130.53	224.3	289.62	806.45	987.19
		31 Mar.	227.9	431.88	309.1	179.94	312	1232.92	1460.82
		15 Apr.	224.3	483.3	292.3	232.3	242	1249.9	1474.2
		30 Apr.	318.7	450.5	137.8	291.15	176	1055.45	1374.15
		15 May	64.3	385.5	186.6	0	82.3	654.4	718.7
		31 May	47.8	599	490.8	26	0	1115.8	1163.6
		Total	1063.74	2512.18	1547.13	953.69	1101.92	6114.92	7178.66
		Mean	177.29	418.70	257.86	158.95	183.65	1019.15	1196.44
	Summer	15 June	39	352.2	286.4	107	0	745.6	784.6
		30 June	77.2	438	300	86.2	0	824.2	901.4
		15 July	39.1	302	356	289.5	43.6	991.1	1030.2
		31 July	0	395	448	420	180	1443	1443
		15 Aug.	0	269.1	436.7	504.1	303	1512.9	1512.9
		31 Aug.	0	347.8	445	404.66	187	1384.46	1384.46
		Total	155.3	2104.1	2272.1	1811.46	713.6	6901.26	7056.56
		Mean	25.88	350.68	378.68	301.91	118.93	1150.21	1176.09
	Autumn	15 Sept.	32.3	228	641	503.5	260	1632.5	1664.8
		30 Sept.	75.2	68.8	300	261	190	819.8	895
		15 Oct.	426.44	272.91	569.82	502.18	558.58	1903.49	2329.93
		31 Oct.	428.8	322.3	460	555.2	460	1797.5	2226.3
		15 Nov.	238.29	421.73	623.5	676.29	735.82	2457.34	2695.63
		30 Nov.	64.23	386.48	430.8	748	665.6	2230.88	2295.11
		Total	1265.26	1700.22	3025.12	3246.17	2870	10841.51	12106.77
		Mean	210.88	283.37	504.19	541.03	478.33	1806.92	2017.80
	Grand total		2921.34	7193.44	8341.61	8533.82	7383.22	31452.09	34373.43

Concerning the seasonal activity, it was found that the maximum seasonal means of surface food consumption (0-30 cm vertical distance) took place during autumn (210.88 g./5 column traps), followed with spring (177.29 g./5 column traps), while the minimum seasonal means occurred during summer (25.88 g./5 column traps). The maximum seasonal means of subsurface food consumption recorded 1806.92 g./5 column traps during autumn throughout four levels, (from the 2nd to the 5th level), while the minimum seasonal means occurred during spring (1019.15 g./5 column traps). The seasonal means in winter and summer were more or less moderate (1265.73 and 1150.21 g./5 column traps, respectively).

Generally speaking, total seasonal means of surface and subsurface foraging activity, as represented by food consumption was relatively low during summer (1176.09 g./5 column traps) and spring (1196.44 g./5 column traps) and high during autumn (2017.79 g./5 column traps), while it was moderate during winter (1338.57 g./5 column traps). Results are in partial agreement with Abd El-Latif and Solaiman (2014) who stated that the highest rate of food consumption took place during autumn months and the lowest occurred during spring season.

From the surface foraging activity results it is observed that the activity of termite increased during autumn and spring months, while it decreased during winter and summer months. This reduction may be attributed to low temperature during winter and high temperature during summer, whereas termite avoided high temperature of soil surface in summer and moved to deeper levels (2nd,3rd and 4th). In winter also termite avoided low temperature of soil surface and moved to depth 230 cm vertical distance to record the highest activity in the 5th level. It could be concluded that both high and low temperatures resulted in surface forging activity reduction.

The total annual food consumption increased gradually from the first level (2921.34 g./5 column traps) until the fourth one (8533.82 g./5 column traps), then it decreased slightly to (7383.22 g./5 column traps) at the 5th level. These results are in agreement with Abd El-Latif and Solaiman (2014) who stated that food consumption of *p. hybostoma* was relatively low at the 1st level, increased gradually to reach its maximum at the 6th level at 180 cm depth from the soil surface.

Soil translocation (construction activity):

Table (6) shows that the variation of food consumption is correlated with that of soil translocation whereas the relationship was positive and highly significant between food consumption and soil translocation ($r = 0.992^{**}$). In winter, soil translocation was relatively low at the 1st level (679.83 g./5 column traps) and increased gradually until reached its maximum at the 5th level (4919.72 g./5 column traps). In spring, soil translocation was relatively high in the 1st level (1612.62 g./5 column traps), while it sharply increased to record 3915.7 g./5 column traps at the 2nd level followed by decline at the levels 3th and 4th level (2114.47, 810.46). In summer, soil translocation was very low at the 1st level (210.05 g./5 column traps), while it reached to the highest quantity 4338.9 g./5 column traps at the 3rd level. In autumn, the 1st level recorded the highest rate of soil translocation with 2977.38 g./5 column traps compared with the other seasons, while in the same season, it increased to reach its maximum at the 5th level (9434.09 g./5 column traps).

Table 6. Half-monthly and seasonal means of soil translocation rates of *P. hybostoma* at different vertical depth of soil surface at El Fayoum governorate in 2018/2019.

Year	Season	Date of inspection	Soil translocation g./5 column traps						Total
			Surface	Subsurface activity (SS)					
			L1	L2	L3	L4	L5	Ss total	
2018-2019	Winter	15 Dec.	10	43.5	318.3	1055.5	1577.32	2994.62	3004.62
		31 Dec.	183.18	371	583.26	849.66	688.3	2492.22	2675.4
		15 Jan.	31	327	479	758.4	1142	2706.4	2737.4
		31 Jan.	114	103.8	421	642.5	970	2137.3	2251.3
		15 Feb.	92.65	257	385	363	91.5	1096.5	1189.15
		28 Feb.	249	210.95	251	462.38	450.6	1374.93	1623.93
		Total	679.83	1313.25	2437.56	4131.44	4919.72	12801.97	13481.8
		Mean	113.31	218.88	406.26	688.57	819.95	2133.66	2246.97
	Spring	15 Mar.	297.83	210.95	158.17	166.94	367.56	903.62	1201.45
		31 Mar.	409.12	648.25	323.9	125.11	368.38	1465.64	1874.76
		15 Apr.	361.84	620.06	383.6	179	412.92	1595.58	1957.42
		30 Apr.	384.76	520.42	142.6	319.11	209.97	1192.1	1576.86
		15 May	67.5	700.22	267.7	0	107	1074.92	1142.42
		31 May	91.6	1215.8	838.5	20.3	0	2074.6	2166.2
		Total	1612.65	3915.7	2114.47	810.46	1465.83	8306.46	9919.11
		Mean	268.78	652.62	352.41	135.08	244.31	1384.41	1653.19
	Summer	15 June	35.9	441.97	447.76	169.9	0	1059.63	1095.53
		30 June	119.8	861.1	620.5	110	0	1591.6	1711.4
		15 July	54.35	596.9	685.34	454.68	63.34	1800.26	1854.61
		31 July	0	745	962.2	714.2	532	2953.4	2953.4
		15 Aug.	0	388	833	814.59	688.7	2724.29	2724.29
		31 Aug.	0	582.14	790.09	732.67	377.4	2482.3	2482.3
		Total	210.05	3615.11	4338.89	2996.04	1661.44	12611.48	12821.53
		Mean	35.01	602.52	723.15	499.34	276.91	2101.91	2136.92
	Autumn	15 Sept.	55	364.46	1311.61	859.58	534.46	3070.11	3125.11
		30 Sept.	247.28	61.96	511.2	499.2	345.2	1417.56	1664.84
		15 Oct.	986.58	649.97	1382.63	1459.15	1843.49	5335.24	6321.82
		31 Oct.	1038.48	986.36	985.95	1418.85	1618.37	5009.53	6048.01
		15 Nov.	526.8	1348.6	2073.02	1802.48	2630.36	7854.46	8381.26
		30 Nov.	123.24	1031.08	1100.24	1766.11	2462.19	6359.62	6482.86
		Total	2977.38	4442.43	7364.65	7805.37	9434.07	29046.52	32023.9
		Mean	496.23	740.41	1227.44	1300.90	1572.35	4841.09	5337.32
	Grand total		5479.91	13286.49	16255.57	15743.31	17481.06	62766.43	68246.34

Data in Table (6) indicated that, the maximum seasonal means of surface soil translocation took place during autumn (496.23 g./5 column traps) and the minimum seasonal means of soil translocation occurred during summer (35.01 g./5 column traps). Regarding the subsurface soil translocation, it was found that the maximum seasonal means occurred during autumn (4841.09 g./5 column traps) and the minimum seasonal means of soil translocation took place during spring (1384.41 g./5 column traps).

Also, the total seasonal means of subsurface foraging activity, as represented by soil translocation recorded the maximum rates during autumn (4841 g./5 column traps) and the minimum rates during spring (1384.41 g./5 column traps), while they were moderate during both winter and summer. Abd El-Latif and Soliman (2014) stated that the highest construction activity was in autumn and the lowest occurred in spring.

Total annual foraging activity (soil translocation) increased gradually from the 1st level (5479.91 g./5 column traps) until the 3rd level (16255.57 g./5 column traps) then, it slight decreased at the 4th level (15743.31 g./5 column traps) while, the 5th level recorded a maximum quantity of soil translocation (17481.06 g./5 column traps).These result are in agreement with those of Abd El-Latif and Soliman (2014) who reported that the least rate of construction occurred at the 1st level (390.12 g/trap) and the largest was at the 6th level (2427.08 g/trap).

Number of captured workers:

Data in Table (7) showed that in winter, number of captured workers was low at the 1st level (7006 workers/5 column traps), while the maximum number was 46027 workers/5 column traps at the 3rd level. In spring, the maximum number of captured workers was 70289 workers/5 column traps at the 4th level, while it dropped to 40953 workers/5 column traps at the 5th level. In summer, the number of captured workers increased gradually from the lowest rate at the 1st level (11218 workers/5 column traps) to record the maximum number at the 2nd level (36007 workers/5 column traps). In autumn, number of captured workers increased from 34408 workers/5 column traps at the 1st level to reach the maximum population at the 2nd level with 40484 workers/5 column traps, while the lowest number was recorded at the 4th level (18180 workers/5 column traps).

Seasonal means of surface foraging activity (number of captured workers) was low in winter (1167.67 workers/5 column traps) and summer (1869.67 workers/5 column traps) while it was higher in spring and autumn (7586 and 5734.67 workers/5 column traps, respectively).

Table 7. Half-monthly and seasonal numbers of captured workers of *P. hybostoma* at different vertical distance of soil surface at El Fayoum governorate in 2018/2019 under field conditions.

Year	Season	Date of inspection	Number of captured workers/5 column traps					SS Total	Total
			Surface	Subsurface activity (ss)					
			L1	L2	L3	L4	L5		
2018-2019	Winter	15 Dec.	180	19254	7780	20	40	27094	27274
		31 Dec.	70	2302	6812	5380	14227	28721	28791
		15 Jan.	2500	1910	20856	13520	1252	37538	40038
		31 Jan.	3049	350	10547	19380	3409	33686	36735
		15 Feb.	323	2692	12	0	2715	5419	5742
		28 Feb.	884	3796	20	0	6277	10093	10977
		Total	7006	30304	46027	38300	27920	142551	149557
		Mean	1167.67	5050.67	7671.17	6383.33	4653.33	23758.50	24926.17
	Spring	15 Mar.	26500	16658	11536	14937	15608	58739	85239
		31 Mar.	8369	16764	18361	41452	12839	89416	97785
		15 Apr.	1027	2923	11647	6774	3973	25317	26344
		30 Apr.	8820	6521	8293	7076	4967	26857	35677
		15 May	800	7037	500	0	3566	11103	11903
		31 May	0	960	4102	50	0	5112	5112
		Total	45516	50863	54439	70289	40953	216544	262060
		Mean	7586.00	8477.17	9073.17	11714.83	6825.50	36090.67	43676.67
	Summer	15 June	1053	5740	8423	1333	0	15496	16549
		30 June	5346	3529	740	4576	0	8845	14191
		15 July	4819	2170	9952	340	3598	16060	20879
		31 July	0	4670	362	3284	6710	15026	15026
		15 Aug.	0	10940	6054	2721	75	19790	19790
		31 Aug.	0	8958	1560	5613	872	17003	17003
		Total	11218	36007	27091	17867	11255	92220	103438
		Mean	1869.67	6001.17	4515.17	2977.83	1875.83	15370.00	17239.67
	Autumn	15 Sept.	17880	17907	6543	8430	5572	38452	56332
		30 Sept.	9350	5883	240	750	5910	12783	22133
		15 Oct.	2294	3459	7570	1664	3127	15820	18114
		31 Oct.	1591	5011	3128	5074	1390	14603	16194
		15 Nov.	193	422	9530	2162	4044	16158	16351
		30 Nov.	3100	7802	9610	100	7703	25215	28315
		Total	34408	40484	36621	18180	27746	123031	157439
		Mean	5734.67	6747.33	6103.50	3030.00	4624.33	20505.17	26239.83
	Grand total		98148	157658	164178	144636	107874	574346	672494.00

Seasonal means of subsurface foraging activity (number of captured workers) was relatively low in summer (15370 workers/5 column traps), more or less moderate during both winter and autumn (23758.5 and 20505.17 workers/5 column traps respectively), while it was relatively high during spring (36090.67 workers/5 column traps).

Seasonal means of surface and subsurface foraging activity (number of captured workers) in Table (7) results indicated that the lowest numbers of captured workers were during summer (17239.67 workers/5 column traps), while the highest numbers were during spring (43676.6 workers/5 column traps). Seasonal means of captured workers were more or less moderate during both autumn (26239.83 workers/5 column traps) and winter (24926.166 workers/5 column traps).

In this respect Abd El-Latif and Solaiman (2014) reported that the highest numbers of captured workers were in summer and autumn. While, the lowest was in winter.

Concerning the level effect, the total annual number of captured workers increased gradually from the 1st level (98148 workers/5 column traps) until it reached to the peak at the 3rd level (164178 workers/5 column traps), then it decreased gradually from the 4th level (144636 workers/5 column traps) to the 5th level (107874 workers/5 column traps). Abd El-Latif and Solaiman (2014) reported that the least population was captured at the 1st level, while the highest was found at the 5th level.

Number of captured soldiers:

Number of captured soldiers shown in Table (8). In winter, the number of captured soldiers was low at the 1st level (133 individuals/5 column traps), then it increased to 143 soldiers at the 2nd level, after that it decreased gradually to reach its minimum (70 individuals/5 column traps) at the 5th level. In spring, number of captured soldiers was relatively high at the 1st level (413 individuals/5 column traps) compared to the previous season, then it decreased gradually until it reached 129 individuals/5 column traps at the 5th level. In summer, the number of captured soldiers was low (135 individuals/5 column traps) at the 1st level, and raised to 687 soldiers/5 column traps at the 2nd level, after that it decreased gradually until the 5th level (182 individuals/5 column traps). In autumn, the maximum catch of soldiers occurred at the 1st level (679 individuals/5 column traps), then it decreased gradually to record 263 individuals/5 column traps at the 3rd level, after that it increased again gradually to reach 523 individuals /trap at the 5th level.

Surface seasonal means of captured soldiers were relatively low during winter and summer seasons (22.17-22.5 individuals/5 column traps), moderate during spring (68.38 individual/5 column traps), while it was higher during autumn (113.17 individual/5 column traps). Concerning subsurface seasonal means of captured soldiers, the adverse occurred where it was relatively high during summer and autumn (269 and 264.67 individuals/5 column traps, respectively) and it was moderate during spring (185.33 individuals/5 column traps), while it was lower during winter 72.67 individuals/5 column traps.

Surface and subsurface mean of captured soldiers recorded the highest rate during autumn (378 individuals/5 column traps) and lowest rate during winter (95 individuals/5 column traps).

On the other hand, total annual number of captured soldiers reached the highest rate at the 2nd levels (1625 individuals/5 column traps) while, it decreased to record the lowest (904 individuals/5 column traps) at the 5th level. Abd El-Latif and Solaiman (2014) reported that number of the soldiers was 13.4 individuals/trap in winter and 23.8 individuals/trap in summer.

Table 8. Half-monthly seasonal numbers of captured soldiers of *P. hybostoma* at different vertical depth of soil surface at El Fayoum governorate in 2018/2019.

Year	Season	Date of inspection	No. of captured soldiers/5 column traps					Ss total	Total
			Surface	Subsurface activity (ss)					
			L1	L2	L3	L4	L5		
2018-2019	Winter	15 Dec.	18	53	30	2	9	94	112
		31 Dec.	8	10	53	26	11	100	108
		15 Jan.	39	32	28	19	12	91	130
		31 Jan.	19	7	15	46	7	75	94
		15 Feb.	21	16	2	0	10	28	49
		28 Feb.	28	25	2	0	21	48	76
		Total	133	143	130	93	70	436	569
		Mean	22.17	23.83	21.67	15.50	11.67	72.67	94.83
	Spring	15 Mar.	58	34	26	44	19	123	181
		31 Mar.	59	73	53	71	27	224	283
		15 Apr.	27	20	63	39	34	156	183
		30 Apr.	248	23	53	132	18	226	474
		15 May	21	153	31	0	31	215	236
		31 May	0	33	131	4	0	168	168
		Total	413	336	357	290	129	1112	1525
		Mean	68.83	56.00	59.50	48.33	21.50	185.33	254.17
	Summer	15 June	17	42	24	13	0	79	96
		30 June	75	82	25	87	0	194	269
		15 July	43	28	95	17	27	167	210
		31 July	0	93	18	62	87	260	260
		15 Aug.	0	221	126	81	20	448	448
		31 Aug.	0	221	63	134	48	466	466
		Total	135	687	351	394	182	1614	1749
		Mean	22.50	114.50	58.50	65.67	30.33	269.00	291.50
	Autumn	15 Sept.	270	141	103	243	227	714	984
		30 Sept.	339	112	20	29	140	301	640
		15 Oct.	2	60	18	8	26	112	114
		31 Oct.	24	49	15	25	14	103	127
		15 Nov.	17	7	40	36	23	106	123
		30 Nov.	27	90	67	2	93	252	279
		Total	679	459	263	343	523	1588	2267
		Mean	113.17	76.50	43.83	57.17	87.17	264.67	377.83
	Grand total		1360	1625	1101	1120	904	4750	6110.00

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نشاط السروح السطحى وتحت السطحى للنمل الأبيض تحت أرضى نمل الرمال *Psammotermes hybostoma* Desneux (Isoptera: Rhinotermitidae) فى محافظة الفيوم ، مصر

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الملخص

تم تقدير نشاط السروح السطحي وتحت السطحي للنمل الأبيض تحت الأرضى.*Psammotermes hybostoma* Desneux (Isoptera: Rhinotermitidae) لمدة عام واحد من أكتوبر ٢٠١٨ حتى سبتمبر ٢٠١٩ فى محافظة الفيوم ، مصر. تم تقدير نشاط السروح السطحي باستخدام مصيدة بلاستيكية مثقبة مستطيلة الشكل ، بينما تم استخدام مصيدة عمود ذات تصميم جديد (ارتفاع ٣٠٠ سم ، وقطر ٧,٢ سم) لتقدير نشاط السروح تحت السطحى ، تم تقسيم مصيدة العمود إلى خمسة مستويات مع حواجز مناسبة من الفلين المضغوط والمقوى بشرائح من الألومنيوم. وقد أظهرت النتائج أن نشاط السروح (الإستهلاك الغذائي) كان منخفضًا نسبيًا خلال فصل الشتاء (١٣,٢٣ جم/مصيدة/م٢) ، بينما كان استهلاك الغذاء أعلى نسبيًا خلال فصل الربيع (٧٦,١ جم/مصيدة/م٢). وكانت التغيرات في نقل التربة مماثلة تقريبًا للإستهلاك الغذائى. وسجلت أعلى المتوسطات الموسمية لإستهلاك الغذاء تحت السطحي ١٨٠٦,٩٢ جم/٥ مصائد أعمدة خلال فصل الخريف خلال المستويات الأربعة ، بينما سجلت أدنى المتوسطات الموسمية خلال فصل الربيع (١٠١٩,١٥ جم/٥ مصائد أعمدة). وارتفع إجمالي الاستهلاك السنوي للغذاء تدريجياً من ٢٩٢١,٣٤ جم/مصيدة في المستوى الأول إلى ٨٥٣٣,٨٢ جم/٥ مصائد أعمدة في المستوى الرابع ، ثم انخفض بشكل طفيف إلى (٧٣٨٣,٢٢ جم/٥ مصائد أعمدة) عند المستوى الخامس. كانت معدلات التربة المنقولة مشابهه لمعدلات الاستهلاك الغذائى. كما ارتفع العدد الإجمالي السنوي للشغالات الممسوكة بالمصائد تدريجياً من المستوى الأول (٩٨١٤٨ شغالة/٥ مصائد أعمدة) حتى وصل إلى الذروة في المستوى الثالث (١٦٤١٧٨ شغالة/٥ مصائد أعمدة) ، ثم انخفض تدريجياً من المستوى الرابع (١٤٤٦٣٦ شغالة/٥ مصائد أعمدة) حتى المستوى الخامس (١٠٧٨٧٤ شغالة/٥ مصائد أعمدة).