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NEST BIOTA AND COMPOSITION OF HOUSEHOLD ANTS IN LAFIA LOCAL GOVERNMENT AREA, NASARAWA STATE

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ABSTRACT: *Household ants are an important group of insect pests because of their close association with man. However, there is less data on their role in the mechanical spread of diseases in the study area. Therefore, this study investigated ant species and the soil microbes in their nest in Lafia Local Government Area of Nasarawa State, Nigeria in August, 2023. A cross-sectional study was carried out in 60 households across three developmental areas using hand-picking methods for ants' collection as well as soil samples collection from available nests which were transferred in sample containers and transported to the laboratory for ants' identification, parasitological analysis and culture. 3,015 ants belonging to five subfamilies, 15 genera and 17 species were collected. The most dominant ant was Brachyponera sennaarensis (21.43%), while Solenopsis spp. was least dominant (0.23%). Of the selected ants screened, none had ecto and endo-parasites. Although three (3) species of soil transmitted helminths were found in the soil analyzed using sedimentation method and the modified Baermann's funnel technique in which Strongyloides starcoralis 16(26.67%) was more prevalent. Ants were also contaminated with (13) species of bacteria of which Escherichia coli was the most frequent (22.63%) pathogenic bacteria. Candida spp. was also recorded in the study. Consequently, Households in the study sites show increasingly high number of ants due to their efficient feeding and nesting activities; this may support the mechanical spread of helminths and soil pathogenic microbes, therefore proper sanitation as well as integrated control measures against ant infestation should be given due consideration.*

KEYWORDS: Household ants, Abundance, Hand picking, Species diversity, Nest soil biota, Lafia.

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INTRODUCTION

A significant class of insect pests in both rural and urban environments are household ant's, due to their close relationship with humans (Economo *et al.,* 2018). Ants (Hymenoptera: Formicidae) are a very ecologically successful group of organisms, having a wide range of habitats for both nesting and foraging across the globe. Ants are social creatures that occupy dense, overcrowded colonies with up to millions of individuals (Agosti, 2000). The organic materials that ants gather as they forage in the area around their massive, stable nests can be concentrated there as waste products, stored food, and inedible debris. This creates an ideal habitat for other soil biota (Diane *et al.,* 1997). Ant nests have fascinating effects on the soil biota, which refers to the diverse community of organisms living in the soil including bacteria, nematodes, helminths, fungi miscellaneous eukaryotes, and microarthropods. Bacteria and fungi typically occur at high densities in ant nest soils (Diane *et al.,* 1997). Ants impact soil biota through scavenging, predation, granivory and omnivory also their nests create microhabitats that support diverse organisms, leading to increased soil richness and abundance (Duarte *et al.,* 2010; Halfen *et al.,* 2011). Like all animals, ants are susceptible to parasitism. They are also superorganisms that share nests; therefore, their parasites experience completely different conditions than those that impact solitary organisms. The majority of ant species' nests are rather stable microhabitats that are likely capable of providing a variety of organism accessibility to easily accessible nourishment as well as some level of shelter from predators as such ants could substantially shape soil properties and nutrient cycling (Hughes, 2012). According to Ashigar and Abdul Hafiz (2020), ants are important arthropod pests associated with human settlement and have a variety of ecological value in many environments. Ants are social insects that can form a variety of parasitic and mutualistic partnerships as well as interactions with other organisms like fungi, protozoa, viruses, bacteria, plants, and animals. They have been shown to represent a potential threat as a result of being carriers of pathogenic microorganisms (Abdul *et al.,* 2016).

Ant foraging activities may be advantageous or damaging, according to earlier studies (Gathalkar & Sen, 2018; Ashigar & Abdul-Hafiz, 2020). Numerous ants invade homes and cause significant direct and indirect damage, including issues with human health, destruction to buildings, and disruption of other organisms. They directly contribute to the transmission of human infections by their presence in the ecosystem (Boursaux-Eude & Gross, 2000; Fonseca *et al.,* 2010). Similar studies by Lima *et al.* (2013) and SyukriahSabtu and Ab Majid (2020) indicated that ant contamination of medical equipment can result in mechanical transmission of diseases, allergies, stings, and bites, as well as food contamination. Numerous ant species from the tropics have already been implicated as pathogenic vectors (Sarwar, 2015). Foraging ants frequently visit kitchens, toilets in homes, bakeries, restaurants, and food manufacturers and the likelihood of infection for people residing in these areas increases as ants forage throughout the home, coming into contact with substrates like floors and pit latrines outside and indoors. From these substrates, the ants may pick up pathogens, which they may then transfer to other clean sites in the house, such as food materials and kitchen utensils used to prepare food (Ashigar & Abdul-Hafiz, 2020). Although ants play a significant part in facilitating the mechanical spread of diseases, research has shown that ants are not well studied in the tropical regions. Additionally, the number of previous research that

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looked at ant nests and other soil organisms such as protozoa, fungi, microarthropod and helminths in the study area is comparatively very low. This study investigated ant's species in the study location, their parasites and pathogens associated with their nests.

MATERIALS AND METHODS

Study Area

The study was carried out in Lafia the state capital of Nasarawa State which is situated in Nigeria's North Central Area. Lafia is located at 8°29'30"N, 8°31'0"E and has a geographical area of 2,737 km. The 2006 census observed that there were 330,712 inhabitants residing there (National Population Commission, 2006).

Study Design and Population

The research was carried out between the months of August to October, 2023. A cross-sectional study was carried out in 60 households across three developmental areas of Lafia Local Government Area of Nasarawa state (i.e. Lafia East, Lafia Central and Lafia North Development Areas) from which samples from 20 households across each sampled site were collected.

Sample Collection

An all out hand picking method with hand glove and sterile forcep was used for the collection of ants sample (Anthony *et al.,* 2022), within and around the houses before placing into a sterile container with an appropriate label indicating identification numbers and location of collection. Also, soil samples were collected from available nests in houses where ants samples were collected, the soil on the mold of each respective ant's nest that have been sampled was collected using a clean hand shovel and placed in a small airtight plastic bags before sealing (Pam *et al.* 2019). The specimens were labeled appropriately with identification numbers and location of collection before transporting them to the Zoology Department Laboratory of the Federal University of Lafia, for identification and other analysis.

Samples Processing

Morphological identification of the collected ants' samples was made based on their morphological features. Different sides (head, lateral, and dorsal views) of the ants were studied, and pictures of the ants were taken using an iPhone 11pro camera (Ashigar & Abdul, 2021). Structure and shape of the head, mesosoma, petiolar and post petiolar nodes as well as the gaster was observed using a stereo microscope while comparing with the standard taxonomic keys suggested by Sheela (2008), Fischer *et al.* (2012) and Bolton (2018) and the colored images at the websites (antweb.org bug.org, and antsofafrica.org, respectively) with other relevant literature to identify the samples.

Parasitological analysis of ants sample was done according to the method of Remigiusz *et al*. (2019) with some modifications; a pool of the ant species was placed in a petri dish and washed thoroughly to loosen any parasite that may attach to the body of the ants. The resulting suspensions were filtered into test tubes to separate the ants and were centrifuged at

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3500x for 5 minutes. After loosening the debris plug, the top three layers of suspension were discarded. Specimens obtained from every sample were examined under a microscope (at 10x and 40x magnification). The specimen was further examined by grinding body parts in a mortar with a corresponding amount of water and 0.5 ml of ether, again the resulting suspensions were filtered into test tubes to separate large particles and were centrifuged at 3500x for 5 minutes. Specimens were obtained from every sample and they were examined under a microscope (at 10x and 40x magnification). Soil samples from the nest of the ants were analyzed using the modified Baermann funnel methods to extract the possible soil parasites in the soil sample (Pam *et al.*, 2019). After setting up the apparatus consisting of a retort stand, glass funnel and clipped rubber tubing, trimmed layer cheesecloth the size of the funnel was placed on top of the funnel, so that none of the potentially infective solution will drip over the side of the funnel and contaminate the surrounding bench. The funnel was filled with warm water and 5g of the soil sample was mixed and placed on top of the cheesecloth making sure that it is in contact with the water (Gillespie & Hawkey, 1994; Pam *et al.*, 2019). The apparatus was left to stand for twenty four hours before a portion of the fluid was viewed under the microscope using x10 and x40 objective lenses to check for the presence of parasites. Identification of the parasite was made using standard morphological keys (Center for Disease Control, 2014).

Also soil samples from the nest of the ants were analyzed using a simple sedimentation method. 1g soil was emulsified in 10 ml distilled water and strained through two layers of gauze in a funnel. The filtrate was centrifuged at 2500 (r p m) for 2 minutes. The supernatant is discarded and the sediment is resuspended in 7 ml of formol saline (10%), allowed to stand for 10 minutes the tube was stoppered and shaken vigorously to mix. Then the stopper was removed and centrifuged at 2500 (r p m) for 2 minutes. The tube was allowed to rest in a stand. The plug of debris was detached from the side of the tube with the aid of a glass rod and the liquid was poured off leaving a small amount of formol saline for suspension of the sediment. It was poured on a clean glass slide, covered with coverslip and examined under the microscope after mixing with a drop of iodine (Maisam, 2014).

Bacteriological analysis was done as described by Oliveira *et al.* (2017). After the collection of the ants, pools of 5–10 individuals were sorted by species in the laboratory; the ants were randomly picked from containers using forceps and transferred into sterile dilution bottles containing peptone water. Ten milliliters of sterile normal saline (0.9%) were added to each test tube containing ants and the tubes were thoroughly shaken for 2min to isolate microorganisms from the external surface. Serially diluted (10−3 to 10−7) 0.1ml aliquots were then separately inoculated onto nutrient agar plates and incubated overnight at 37 °C. Bacterial colonies were initially identified by morphological appearance, microscopic examination using staining techniques, and identified further by biochemical test.

Data Analysis

Data obtained was analyzed using Minitap Statistical Software version 21.2. Descriptive statistics were carried out. A p-value of ≤ 0.05 was considered statistically significant.

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RESULT

From the pool of the 51 species of ants across all the selected sites screened for presence of parasites (Table 1), no ecto or endo parasites were recorded in the study. However, prevalence of parasites from the ant nest soil shows that a total of 23(38.33%) parasites were detected across three species which included *Strongyloides spp*, 16(26.67%) followed by *Hookworm spp* with a prevalence of 4(6.67%) while *Ascaris lumbricoides* has the least prevalence with 3(5.00%). Although, the prevalence between parasite species was statistically significant (χ^2 = 13.65, df = 2, p-value = 0.001). The endemicity of the parasites from the soil samples in relation to the sites shows Lafia East had the highest prevalence of 11(55.00%) followed by Lafia Central having the prevalence rate of 7(35.00%) while Lafia North had the least prevalence rate of 5(25.00%). However, the prevalence between nest soil samples in relation to the sites shows no significant differences (χ^2 = 2.435, df = 2, p-value = 0.296).

Prevalence of nest soil parasites in relation to ants species (Table 2) shows the nest of *Pheidole spp* has the highests Prevalence rate with 5 (21.74%) positive samples followed by the nest of the Asian needle ants *Brachyponera sennaarensis* with 4 (17.39%) while the nest of *Paratrechina longicornis, Pheidole rugaticep, Tetramorium spp, Odontomachus spp, Tapinoma spp, Crematogaster spp,* and *Monomorium pharaonis* have the prevalence rate of 3(13.04%), 3(13.04%), 2(8.70%), 2(8.70%), 2(8.70%), 1(4.35%), 1(4.35%) respectively. However *Camponotus* spp, *Solenopsis* spp, *Camponotus maculatus, Formica* spp, *Lasius nitidigaster,* and *Monomorium munimum* recorded no nest soil parasites in the study. No significant difference was observed between ants' nest soil χ^2 = 30.957, df = 16, p-value = 0.014 from the study.

A total of 191 bacteria isolates included 13 species was found on the ants species screened in this study. *Escherichia coli* spp. was the pathogenic bacteria most frequent 43(22.63%) of the positive samples (Table 3), followed by *Pseudomonas aeruginosa* with 37(19.47%), *Staphylococuss aureus* 22(11.58%), *Samonella* spp. 20(10.53%), *Proteus* spp. 15(7.89%), *Streptomyces* spp. 13(6.84%), *Enterococuss* spp. 12(6. 32%), *Basillus* spp 11(5.79%), *Micrococuss* spp. 7(3.68%), *Streptococuss* spp. 4(2.11%), *staphylococuss epidermidis* 3(1.58%) while *Klebsiella* spp. and *Shigielia* spp. were the least isolated species found in the study with 2(1.05%) and 1(0.53%) respectively. Based on the Locations sampled Lafia East has the highest prevalence of contamination of the ants 83(43.68%) followed by Lafia North with 58(30.53%) while the least prevalence of contamination of bacteria in ants 49(25.79%) was recorded in Lafia Central development area. The most contaminated ant species (12.11%) was *Pheidole* sp. (Figure 1), the dominant ant species collected in the study followed by *B. sennaarensis* (11. 05%), *Odontomachus* sp. (8.42%), while *P. rugaticep, L.nitidigaster, A. gracilipes, Tetramorium* sp., *Camponotus*sp., *P. longicornis, Tapinoma* sp., *C. maculatus, Crematogaster sp., M. pharaonis, Pse. apache, M. munimum,* showed (7.85%), (7.32%), (6.81%), (6.28%), (6.28%), (5.75%), (5.24%), (5.24%), (4.71%), (4.18%), (3.66%), (2.90%), level of contamination and the least contaminated were *Solenopsis* sp. and *Formica* sp. with (1.57%), respectively.

163 bacteria isolates in 13 species were found in the ants nest soil screened in this study. *Staphylococcus aureus* was the most pathogenic bacteria isolated; 29(17.79%) of the positive

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samples (Table 4) followed by *Proteus* spp. with 25(15.34%), *E. coli* 22(13.50%), *Pseudomonas aeruginosa* with 15(9.20%), *Micrococcus* spp.14(8.59%), *Klebsiella* spp. 14(8.59%), *Enterococcus* spp. 11(6.75%), *Staphylococcus epidermidis* 9(5.52%), *Bacillus* spp. 8(4.91%), *Salmonella* spp. 6(3.68%), *Pseudomonas* spp. 4(2.45%), while both *Enterococcus faecalis* and *Serratia marcescens* were the least isolated species found in the ants nest soil with also the same prevalence of 3(1.84%) respectively. Ants' nest soil in Lafia east was more contaminated 66(40.49%) followed by Lafia north with 51(31.29%) while the least contaminated location was Lafia central with 46(28.22%).

84 fungi isolates which included 6 species were recorded in the ants sample examined; these include *Cadida spp.* (Table 4) which was the most dominant with the prevalence of 33(39.29%) followed by *Aspergillus spp.* with 24(39.29%), *yeast spp.* 11(13.10%), *Aspergillus niger* 7(8.33%), and *Lecanicillium spp.* 5(5.95%), while *Aspergillus flavus* was the least recorded species with 4(4.76%). Lafia east has the highest prevalence of fungi isolates with 34(40.48%) followed by Lafia central 27(32.14%); however Lafia north recorded the least prevalence of fungi species with 23(27.38%). The ant species most contaminated with fungi pathogens is *L.nitidigaster* with (11.90%) (Figure 2), followed by *B. sennaarensis* (10.71%), *Odontomachus sp.* (8.33%), *Pheidole sp.* (8.33%), *A. gracilipes* (8.33%), *P. rugaticep* (7.14%), *Tapinoma sp*. (7.14%), *C. maculatus* (5.59%), *Camponotus sp.* (5.59%), *Crematogaster sp.* (4.76%), *P. longicornis* (4.76%), *Pse. apache* (4.76%), *Tetramorium sp.* (3.57%), *Formica sp.* (2.38%), *M. munimum* (2.38%), *M. pharaonis* (2.38%) and the least contaminated was *Solenopsis sp.* with (1.19%) prevalence.

A total of 69 fungi isolates which included 12 species were recorded in the ants nest soil sample examined, these include *Aspergillus spp.* (Table 4) which was the most prevalent with the prevalence of 14(20.29%) followed by *Cadida spp.* with 10(14.49%), *Yeast spp.* 9(13.04%), *Aspergillus niger* 8(11.59%), *Aspergillus flavus* 6(8.70%), *Altternaria spp.* 5(7.25%), *Cladiosporium spp.* 5(7.25%), *Penicillium spp.* 4(5.80%), *Aspergillus versicolor* 3(4.35%), *Aspergillus fumigatus* 2(2.90%), *Bipolaris spp.* 2(2.90%), while *Lecanicillium spp.* was the least recorded species with 1(1.45%). Lafia central has the highest prevalence of fungi isolates from the ants' nest soil with 32(48.38%) followed by Lafia east 21(30.43%), however Lafia north recorded the least prevalence of fungi isolates with 16(23.19%).

Table 1: Prevalence of parasites screen from the on the ants and soil samples

Parasites	**Ants**			**Total (%)**	**Nest soil**			**Total (%)**
	LE (n=17)	**LC (n=17)**	**LN (n=17)**	**(n=51)**	**LE (n=20)**	**LC (n=20)**	**LN (n=20)**	**(n=60)**
Hookworm	-	-	-	-	0 (0.00)	2 (10.00)	2 (10.00)	4 (6.67)
Ascaris lumbricoides	-	-	-	-	2 (10.00)	1 (5.00)	0 (0.00)	3 (5.00)
Strongyloides stercoralis	-	-	-	-	9 (45.00)	4 (20.00)	3 (15.00)	16 (26.67)
Total (%)	-	-	-	-	**11 (55.00)**	**7 (35.00)**	**5 (25.00)**	**23 (38.33)**

Between Ants Species Nestχ^2 = 30.957, df = 16, p-value = 0.014

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Key: - indicate absent Location: LE – Lafia east LC – Lafia central LN – Lafia north.

Ants Species	**No. examined**	**Parasites (no +ve)**			**Total (%)**
		Ascaris lumbricoides	***Hookworm***	***Strongyloides stercoralis***	
Monomorium pharaonis	4	-	-	1	1 (4.35)
Pheidole spp	11	1	-	4	5 (21.74)

Table 2: Total number of parasites examined from the nest soil of individual ants species in Lafia LGA

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Paratrechina longicornis	7	1	2	-	3 (13.04)
Camponotus spp	0	-	-	-	0 (0.00)
Solenopsis spp	3	-	-	-	0 (0.00)
B. sennaarensis	8	1	-	3	4 (17.39)
Pheidole rugaticep	6	-	1	2	3 (13.04)
Crematogaster spp	4	-	-	1	1 (4.35)
Camponotus maculatus	0	-	-	-	0 (0.00)
Tetramorium spp	3	-	1	1	2 (8.70)
Formica spp	0	-	-	-	0 (0.00)
Lasius nitidigaster	2	-	-	-	0 (0.00)
Monomorium munimum	3	-	-	-	0 (0.00)
Odontomachus spp	6	-	-	2	2 (8.70)
Tapinoma spp	1	-	-	2	2 (8.70)
Pseudomyrmex apache	2	-	-	-	0 (0.00)
Anoplolepis gracilipes	0	-	-	-	0 (0.00)
Total (%)	**60**	**3(13.04)**	**4(17.39)**	**16(69.56)**	**23 (100)**

Between Ants Species Nest $\chi^2 = 30.957$, df = 16, p-value = 0.014 **Key: - indicate absent**

Table 3: Prevalence of bacteria pathogens isolated from the ants and nest soil sample across locations

Bacteria Pathogens	**ANTS**				**NEST SOIL**			
	LE N0 +ve %	**LC N0 +ve %**	**LN N0 +ve %**	**Total N0+ve%**	**LE N0 +ve %**	**LC N0 +ve %**	**LN N0 +ve %**	**Total N0+ve%**
E. coli	24 (55.81)	7 (16.28)	12 (27.91)	43 (22.63)	11 (50.00)	3 (13.64)	8 (36.36)	22 (13.50)
Proteus spp.	6 (40.00)	4 (26.67)	5 (33.33)	15 (7.89)	12 (48.00)	7 (28.00)	6 (24.00)	25 (15.34)

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Pseudomonas aeruginosa	16 (43.24)	11 (29.73)	10 (27.03)	37 (19.47)	7 (46.67)	3 (20.00)	5 (33.33)	15 (9.20)
Enterococcus spp.	4 (33.33)	3 (25.00)	5 (41.67)	12 (6.32)	3 (27.27)	4 (36.36)	4 (36.36)	11 (6.75)
Bacillus spp.	5 (45.45)	4 (36.36)	2 (18.18)	11 (5.79)	2 (25.00)	4 (50.00)	2 (25.00)	8 (4.91)
Staphylococcus aureus	9 (40.91)	6 (27.27)	7 (31.82)	22 (11.58)	10 (34.48)	7 (24.13)	12 (41.37)	29 (17.79)
Enterococcus faecalis	-	-	-	-	1 (33.33)	2 (66.67)	-	3 (1.84)
Streptomyces spp	5 (38.46)	2 (15.38)	6 (46.15)	13 (6.84)	-	-	-	-
Pseudomonas spp.	-	-	-	-	1 (25.00)	1 (25.00)	2 (50.00)	4 (2.45)
Streptococcus spp.	1 (25.00)	2 (50.00)	1 (25.00)	4 (2.11)	-	-	-	-
Salmonella spp.	8 (40.00)	7 (35.00)	5 (25.00)	20 (10.53)	2 (33.33)	1 (16.67)	3 (50.00)	6 (3.68)
staphylococcus epidermidis	2 (66.67)	-	1 (33.33)	3 (1.58)	4 (44.44)	4 (44.44)	1 (11.11)	9 (5.52)
Micrococcus spp.	4 (50.00)	2 (25.00)	2 (25.00)	8 (4.18)	6 (42.86)s	4 (28.57)	4 (28.57)	14 (8.59)
Shigella spp.	-	-	1 (100.00)	1 (0.53)	-	-	-	-
Serratia marcescens	-	-	-	-	1 (33.33)	2 (66.67)	-	3 (1.84)
Klebsiella spp.	-	1 (50.00)	1 (50.00)	2 (1.05)	5 (35.71)	4 (28.57)	5 (35.71)	14 (8.59)
Total	**84 (43.97)**	**49 (25.65)**	**58 (30.36)**	**191 (100)**	**66 (40.49)**	**46 (28.22)**	**51 (31.29)**	**163 (100)**

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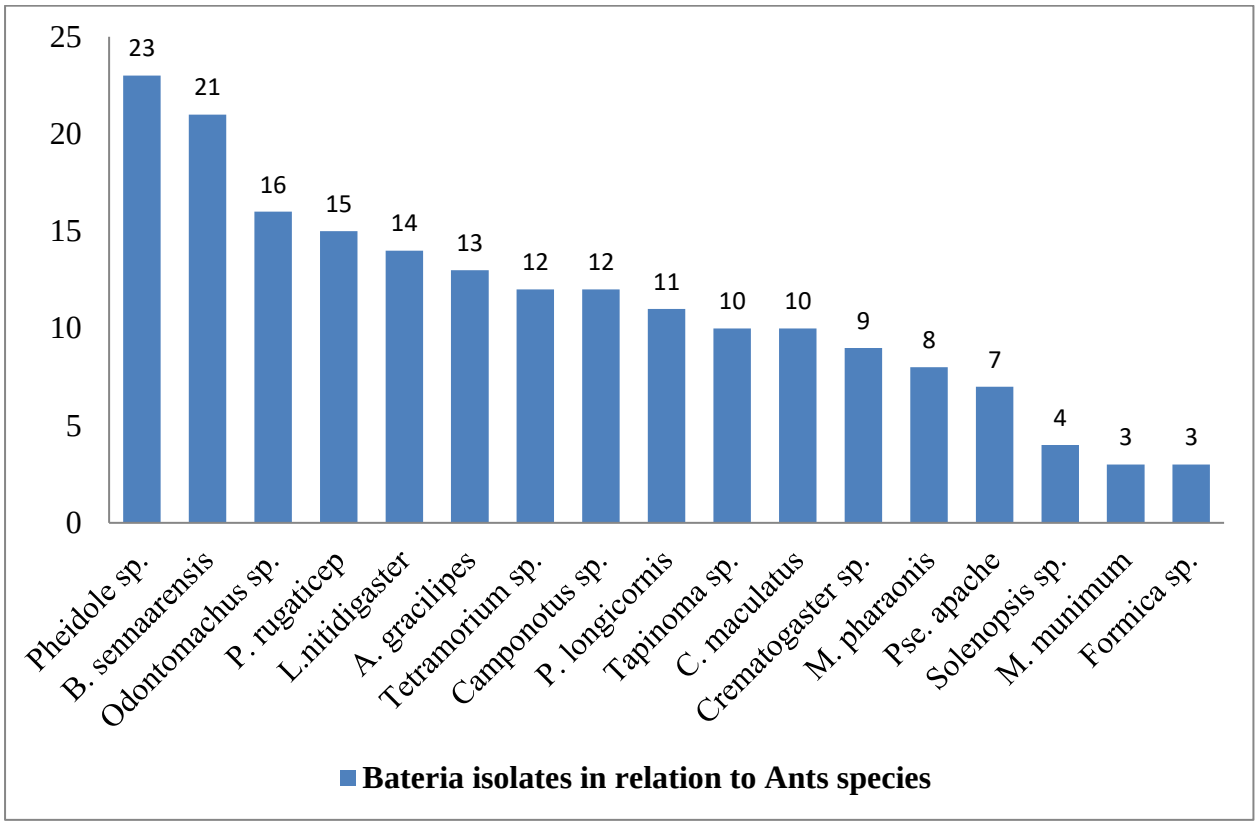

Figure 1: Prevalence of bacterial pathogens in relation to ants species

Table 4: Prevalence of Fungi pathogens isolated from the Ants and Nest soil sample across locations.

Fungi Pathogens	ANTS				NEST SOIL			
	LEN0 +ve %	LCN0 +ve %	LNN0 +ve %	Total N0+ve %	LEN0 +ve %	LCN0 +ve %	LNN0 +ve %	Total N0+ve %
Aspergillus spp.	9(37.50)	6(25.00)	9(37.50)	24(28.57)	3 (21.43)	7 (50.00)	4 (28.57)	14 (20.29)
Candida spp.	15(45.45)	11(33.33)	7(21.21)	33(39.29)	1 (10.00)	5 (50.00)	4 (40.00)	10 (14.49)
Yeast spp.	4(36.36)	3(27.27)	4(36.36)	11(13.10)	3 (33.33)	5 (50.56)	1 (11.11)	9(13.04)
Aspergillus niger	3(42.86)	4(57.14)	-	7(8.33)	1 (12.50)	4 (50.00)	3 (37.50)	8(11.59)

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Aspergillus flavus	1(25.00)	1(25.00)	2(50.00)	4(4.76)	2 (33.33)	4 (66.67)	-	6(8.70)
Alternaria spp.	-	-	-	-	1 (20.00)	3 (60.00)	1 (20.00)	5 (7.25)
*Cladiosporium*sp p.	-	-	-	-	4 (80.00)	1 (20.00)	-	5 (7.25)
Penicillium spp.	-	-	-	-	3 (75.00)	1 (25.00)	-	4 (5.80)
Aspergillus versicolor	-	-	-	-	1 (33.33)	1 (33.33)	1 (33.33)	3 (4.35)
Aspergillus fumigatus	-	-	-	-	1 (50.00)	-	1 (50.00)	2 (2.90)
Bipolaris spp.	-	-	-	-	1 (50.00)	-	1 (50.00)	2 (2.90)
Lecanicillium spp.	2(40.00)	2(40.00)	1(20.00)	5(5.95)	-	1 (100.00)	-	1 (1.45)
Total	**34(40.48)**	**27(32.14)**	**23(27.38)**	**84(100)**	**21(30.43)**	**32 (46.38)**	**16 (23.19)**	**69 (100.00)**

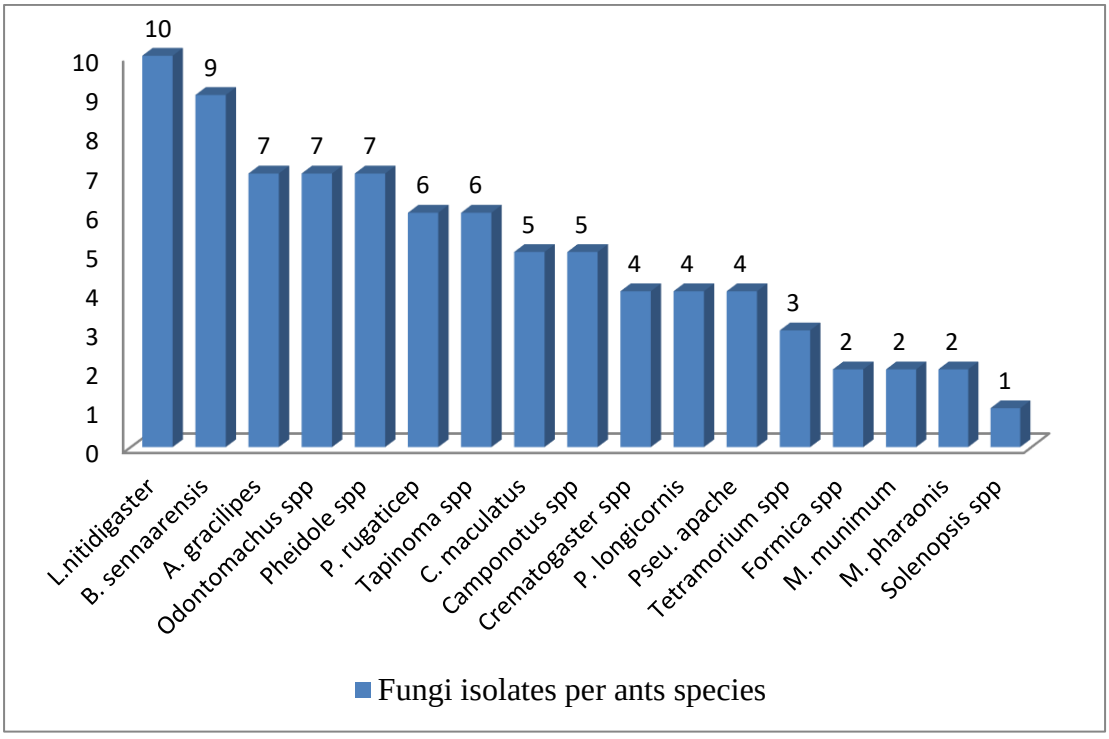

Figure 2: Prevalence of fungi pathogens in relation to ants species

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DISCUSSION

The problems associated with ants in homes and their frequency have been the subject of research, but little is known about the pathogens these insects bring into homes and the possible harm they could cause to the residents in the current study area. An overall total of 3,015 ants were collected from this study, comprising 17 species of ants belonging to 5 subfamilies (Myrmicinae, Dolichoderinae, Formicinae, Ponerinae and Pseudomyrmicinae). The result is similar to the work of Thyssen *et al.* (2004) who investigated the role of insects (Blattodea, Diptera, and Hymenoptera) as possible mechanical vectors of helminths in the domiciliary and peri domiciliary environment while it differs with Villani *et al.* (2008) whose study demonstrated the capacity of common household ants species in carrying pathogens like nematodes and protists. In their study, workers of *Camponotus rufipes* which is a large ant when compared to the others and bears hairs over the body surface had higher incidence of pseudo-infection as such their results showed that size influences the transportation of pathogens for facilitating adhesion of the parasites. The ant species collected for this study may not have been contaminated with parasite cysts or eggs at the time of collection, and the majority of species encountered are not as large and hairy as the *Camponotus rufipes* investigated in the study of Villani *et al.* (2008). These factors could account for the results obtained from this study. Additionally, parasites are opportunistic organisms that require the ideal place, time, and factors that will aid them to attach to their host.

However, ant nest soil was found to be contaminated by three (3) species of parasites which included *Strongyloides stercoralis, Hookworm spp* and *Ascaris lumbricoides.* ***Strongyloides stercoralis*** 16 (26.67%) was the most prevalence in the soil and number of features account for this high prevalence including a ubiquitous distribution, the high number of eggs produced per parasite, the durability of eggs under a variety of environmental conditions, and poor socioeconomic status that facilitate its spread (Dahal *et al.* 2019). *Strongyloides stercoralis* has been linked to so many infections that affect both humans and animals because of its free life cycle in soil (Arora, 2009). Edema *et al.* (2022) reported a prevalence of 12.0% of *Strongyloides stercoralis* infection in Ogoja Local Government Area, Cross River State while from Dadin Kowa Jos, Plateau State, Nigeria Dahal *et al.* (2019) reported a prevalence of 1.5%. An important factor contributing to the high degree of parasite contamination 23 (38.33%) of ant nests found in this study is the ants' tendency to collect and preserve invertebrate corpses, such as cockroaches, which are known to be carriers of pathogens. A previous study has also observed *Brachyponera spp.* Scavenging on dead cockroaches and other organisms. Also, the Asian needle ant has increasingly been found pilfering food from school cafeterias and residential kitchens which can increase the likelihood of food contamination (Rice & Waldvogel, 2017). Therefore, the biological contact between ants and the invertebrate carcasses of some carriers of food borne illnesses may result in facilitating the spread of mechanically transmitted human pathogenic infections (Ashigar & Abdul Hafiz, 2020). In addition, workers' ants engaged in foraging were observed in this study to transport animal droppings into human settlement through window sills in houses. These actions could potentially contribute to the transmission of mechanically transmitted human pathogenic infections. Human and animal waste that may harbor stages of these soil parasites could be carried into the nest by these ants. Furthermore the nests of *Pheidole species* in this study were shown to host more soil parasites than those of other ant species (Table 2). This conclusion is consistent with the findings of Ashigar and Ab Maji (2020), who discovered a high abundance of *Pheidole species* preying on the American

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Cockroach (*P. americana*), a well-known vector of parasites. *Pheidole species* were also found to be capable of both collecting corpses and effectively infiltrating the nests of other competing ants (Dejean *et al.*, 2007). According to Ashigar and Ab Maji (2020), the foraging activity of *Pheidole species* on *P. americana*, an ideal carrier of several pathogenic microorganisms due to the filthy nature of its breeding habits and feeding mechanism, can be a source of great concern. Because *Periplaneta americana* harbored more species of pathogens than other cockroach species (Pai *et al.*, 2003) and the foraging activity of ants on them can be an unnoticed medium of dissemination of diseases causing pathogens in human societies, particularly during an outbreak of diseases such as cholera.

Of the ants screened for prevalence of bacteria in this study, a total of 191 isolates belonging to 13 species were obtained (Table 3), which include *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Salmonella* spp., *Proteus* spp., *Streptomyces* spp., *Enterococcus* spp., *Bacillus* spp., *Micrococcus spp.*, *Streptococcus spp.*, *Staphylococcus epidermidis*, *Klebsiella* spp. and *Shigella* spp. These species identified are of medical significance as they can cause severe diarrhea and abdominal distress as reported by Alharbi *et al*. (2019). The findings are in accordance with the study of Silva *et al.* (2014), Ogba *et al.* (2017), Leckranee *et al.* (2018), and Ashigar and Ab Maji (2020) who also reported contamination of ants with these bacteria species in their studies. *Escherichia coli* was the pathogenic bacteria most frequent 43(22.63%) of the positive samples, this is similar to the findings 75(30.0%) of Ogba *et al.* (2017) in Calabar Nigeria, and its different from the work of Maximo *et al.* (2014) in Brazil, where *Bacillus spp*. 45.7% and *Listeria spp*. (10%) were the most prevalent and the work of Leonardo *et al.* (2020) also in Eastern Amazon Brazil who reported *Pseudomonas aeruginosa* as the most pathogenic bacteria most frequently isolated comprising 10.9% of the positive samples. The difference in the types of isolates observed from these various studies may be due to geographical differences. *Escherichia coli* has been reported to be a bacterium which constantly causes urinary tract infections (Hespanhol *et al.*, 2017). In a similar study, the result was elevated, because 18% belonging to this species were isolated from ants (Simothy *et al.*, 2018). *Pseudomonas aeruginosa* is the second most isolated bacteria in this study, with 37(19.47%). These bacteria are described as widespread and one of the primary etiological agents that cause hospital infections. This bacterium has caused the majority of hospital pneumonia, venous, and bladder catheterization infections (Máximo *et al.*, 2014; Alves *et al.*, 2017). Other bacterial species isolated in this present study are *Staphylococuss aureus* 22(11.58%), *Salmonella* spp. 20(10.53%), *Proteus* spp. 15(7.89%), *Streptomyces* spp. 13(6.84%), *Enterococcus.* 12(6. 32%), *Bacillus spp* 11(5.79%), *Micrococcus spp.* 7(3.68%), *Streptococcus spp.*4(2.11%), *staphylococcus epidermidis* 3(1.58%), however *Klebsiella spp.* and *Shigella* spp are the least prevalent species of bacteria isolated in this study 2(1.05%) and 1(0.53%) which is even lower than the findings of Silva *et al.* (2014) who presented a low frequency of *Klebsiella* sp. (2%).

Klebsiella sp. is a pathogen that has successfully colonized the nosocomial environment. It is a bacterium that is extremely hazardous to newborns and those receiving extensive treatment, particularly the variant that produces carbapenemases. Although *Staphylococuss aureus* was the most pathogenic bacteria isolated 29(17.79%) from the 163 bacteria isolates of ants nest soil, among which are other 12 species (Table 3), *Proteus spp.* with 25(15.34%), *E. coli* 22(13.50%), *Pseudomonas aeruginosa* with 15(9.20%), *Micrococuss*spp. 14(8.59%), *Klebsiella spp.* 14(8.59%), *Enterococuss* spp. 11(6.75%), *Staphylococuss epidermidis* 9(5.52%), *Basillus* spp. 8(4.91%), *Samonella* spp. 6(3.68%), *Pseudomonas* spp., 4(2.45%),

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while both *Enterococcus faecalis* and *Serratia marcescens* were the least isolated species found in the ants nest soil with also the same prevalence of 3(1.84) respectively. *Staphylococuss aureus* found in this study have been reported by Lestari *et al.* (2019) to be a pathogen that can survive in inanimate surfaces during long periods, which increases the possibility of infection in certain individuals. It is also considered the most frequent pathogen in the hospital environment with elevated virulence. While research done in São Luis - Maranhão reported 12.4% isolates of the bacteria *S. aureus* (Lima *et al.*, 2013), which is less when compared to the result obtained in this study. 11 of the isolated bacteria species identified in the ants nest soil were also found to contaminate the ants species screened in this study however two of the bacteria species *Enterococcus faecalis* and *Serratia marcescens* were not isolated from the ants species in this study. Furthermore, there is a positive correlation between the number of pathogens on ants collected and the nest soil microbes isolated in the study. Therefore proper sensitization on the role of ants in the epidemiology of diseases as well as the use of effective methods to combat ant infestation in the locality should be encouraged.

Eighty-four (84) fungi isolates which included 6 species were recorded in the ants sample examined. These include *Candida sp.* (Table 4) which was the most dominant with the prevalence of 33(39.29%) followed by *Aspergillus spp.* with 24(39.29%), *yeast spp.* 11(13.10%), *Aspergillus niger* 7(8.33%), and *Lecanicillium spp.* 5(5.95%), while *Aspergillus flavus* was the least recorded species with 4(4.76%). The dominance of the fungi *candida spp*. in this study is similar to the findings of Ogba *et al.* (2017) in Calabar who also identified the fungi 25(10.0%) in their work on The Public Health Importance of the Association between *Camponotus consobrinus* and Potential Bacterial Pathogens in Human Dwellings. Similarly, to the work of Leckranee *et al.* (2018) and De Zarzuela *et al.* (2005) in residential kitchens and bathrooms, out of 137 ants, 66(48.2%) were contaminated with fungi. de Castro (2015) also conducted a meta-analysis of studies assessing the association between ants and microorganisms and determined that 38% of investigations reported association with fungi. Silva *et al.* (2005) further reported presence of toxigenic molds such as *Aspergillus spp.* on edible insects. Even the potential for transmission of fungi by ants has been demonstrated (Silva *et al.*, 2005). The result obtained from this study differs from the work of Aquino *et al.* (2013) who reported *Aspergillus spp.* as the most common fungal species associated with the ant workers. Same for Mosayebi *et al.* (2017) who in his study isolated *Aspergillus fumigatus* (16.2%), *Aspergillus flavus* (16.2%), *Candida albicans* (16.2%), *Mucor spp.* (8.1%), *Penicillium spp.* (8.1%), *Alternaria spp.* (8.1%), *Aspergillus niger* (5.4%), *Rhizopus spp.* (5.4%), and *Cladosporium spp.* (5.4%). Three of the fungi species identified in their study were also encountered in this present study. These organisms reportedly produce numerous small and light spores that remain longer in the air compared to other fungal with heavier spores (Vonberg & Gastmeier, 2006). It is suggested that these organisms have longer survivability when they adapt to the different types of condition of the items commonly used in the environment. *Aspergillus flavus* was the least recorded species with 4 (4.76%). This pathogen has been reported by Asghar *et al.* (2011) as a human pathogen in hospitalized patients, infective spores may contain aflatoxins (84–200 µg aflatoxin/g) which are potential agents of lung cancer in indoor environments. Also *Aspergillus spp*. was the most dominant fungi pathogen of the 12 fungi species isolated from the ant nest soil (Table 4) with the prevalence of 14(20.29%) followed by *Candida spp*. with 10(14.49%), *yeast sp.* 9(13. 04%), *Aspergillus niger* 8(11.59%), *Aspergillus flavus* 6(8.70%), *Alternaria spp.* 5(7.25%), *Cladosporium spp.* 5(7.25%), *Penicillium spp* 4(5.80%),

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Aspergillus versicolor 3(4.35%), *Aspergillus fumigatus* 2(2.90%), and *Bipolaris spp.* 2(2.90%) while *Lecanicillium spp.* was the least recorded species with 1(1.45%).

The result obtained from this study concurs with the report from Aquino *et al.* (2013) who reported *Aspergillus sp*. as the most common fungal species associated with the ant workers but differs with work of Mosayebi *et al.* (2017) who in their study isolated *Aspergillus fumigatus* (16.2%) as the most dominant ant species. *Aspergillus spp.* generally resides in soil and serves a great source of infectious, air-borne spores are continuously released into the atmosphere. Aspergillus spores are important not only for initiating allergic reactions (rhinitis, asthma, and sinusitis) and superficial to deadly deep mycoses in various hosts such as mammals, birds, and even sea fans but also for their potential to harbor life-threatening mycotoxins (Asghar *et al.*, 2011). *Candida spp*. was the second most prevalent fungi species from the ant nest soil; however, the fungi was the most dominant species found to contaminate the ants in the study which shows the potential of the ants in picking these pathogens from their surrounding environment. Although (6) species which include *Altternaria spp., Cladosporium spp., Penicillium spp., Aspergillus versicolor, Aspergillus fumigatus* and *Bipolaris spp.* were not isolated from the ants species, *Lecanicillium spp*. was the least prevalent species from both the ants and the soil. Finally, *Aspergillus sp.* detected in this study have been reported by Sham *et al.* (2021) to produce numerous small and light spores that remain longer in the air compared to other fungal with heavier spores and as such these organisms have longer survivability when they adapt to the different types of condition of the items commonly used in an environment which may be a great source of contamination to the ants as the move about foraging for food their by aiding in the distribution of this species from their nest to other clean sites in the environment.

CONCLUSION

Although no parasite was recorded from the ant species examined. Ants' nest soil revealed a high prevalence of parasitic contamination. Furthermore, the ants in the study area were also contaminated with microbial pathogens which are of medical and public health importance because of the presence of ants in homes, as poor sanitation of environments may increase the likelihood of parasite, bacterial and fungi colonization of environmental surface which increases the tendency of ants to become mechanical vectors of these pathogens as a result of their foraging lifestyle. Therefore, proper sanitation as well as integrated control measures against ant infestation should be given due consideration.

Conflicts of Interest: The authors declare no conflict of interest

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