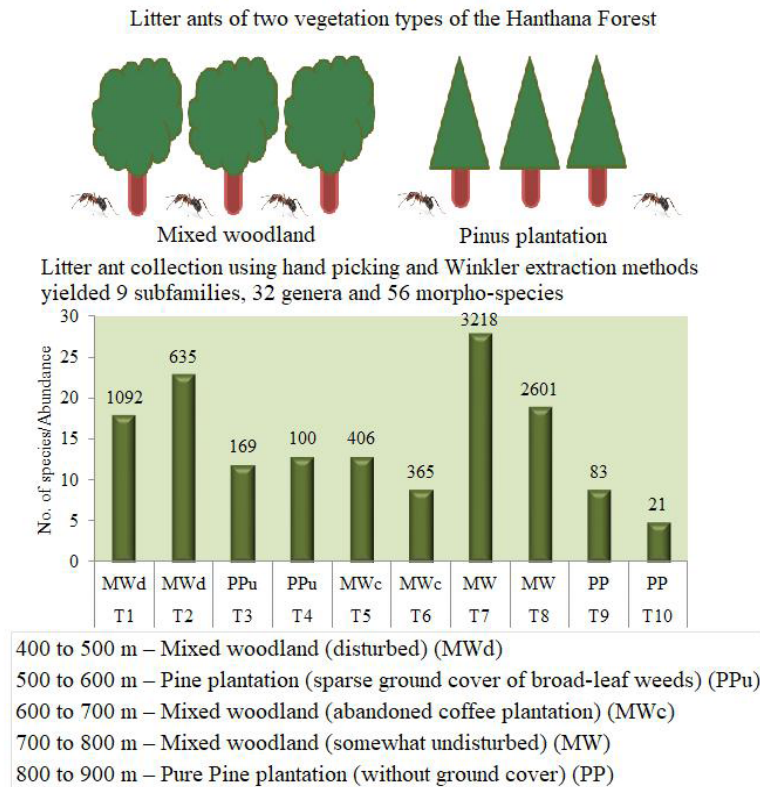


Species assemblages and diversity of litter ants (Hymenoptera: Formicidae) along an altitudinal gradient across two vegetation types in Hanthana Forest in Kandy, Sri Lanka

W.A.I.P. Karunaratne and D.A.G.N.B. Karunarathna



Highlights

- The study yielded 9 subfamilies 32 genera and 56 morpho-species of ants from the two vegetation types.
- Genus *Pheidole* had the highest number of species while *Solenopsis* sp. 1 was the most widely distributed and abundant species.
- The mixed woodlands, regardless of elevation, were richer in ant species than pine plantations.
- The difference in litter ants in Hanthana Forest is possibly due to differences in vegetation types rather than altitude.

SHORT COMMUNICATION

Species assemblages and diversity of litter ants (Hymenoptera: Formicidae) along an altitudinal gradient across two vegetation types in Hanthana Forest in Kandy, Sri Lanka

W.A.I.P. Karunaratne* and D.A.G.N.B. Karunaratna

Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka

Received: 10/10/2019 ; Accepted: 16/05/2020

Abstract: Ants account for 30% of terrestrial biomass and are highly sensitive to environmental variables. Present study investigated the effect of altitude (400-900 m) and vegetation type (mixed woodland and pine plantations in Hanthana forest) on litter ants. Two transects were laid at each of the five 100 m elevation levels. For hand-picking and litter extraction of ants, 1 m² plots were laid at every 20 m intervals along the two sides of each transect. A total of 8689 ants in 9 subfamilies 32 genera and 56 morpho-species were collected. Subfamily Myrmicinae had the highest number of genera (15) and species (26 spp.). Genus *Pheidole* was represented by the highest number of species (5 spp.) while *Solenopsis* sp. 1 was the most widely distributed and abundant (6420 individuals) species. The mixed woodlands, regardless of elevation, were richer in ant species than pine plantations. Permutation test ($\rho=0.30$, $P=3\%$) revealed a weak relationship between ant assemblages and environmental variables. Findings indicated that the difference in litter ant species assemblages and diversity in Hanthana Forest is possibly due to differences in vegetation types rather than altitude.

Keywords: Litter ants; species assemblages; altitudinal gradient; Hanthana forest.

INTRODUCTION

Ants which account for an estimated 30% of terrestrial biomass are the most dominant group of social insects in major habitats around the world saturating a wide range of feeding niches in soil and vegetation. Along with termites, ants are the most important group of insects in tropical rain forests in terms of biomass, number of individuals and ecological impact (Holldobler and Wilson, 1990).

Soil-inhabiting ants play a considerable role in mineralization processes because of their extensive digging activity. Hence, they are highly sensitive and respond rapidly to environmental changes (Van der Woude *et al.*, 1997). Silva *et al.*, (2017) found that litter ants do not reflect the holistic picture of arthropod diversity and assemblages in leaf litter, but the quality of the habitat for the survival of all litter arthropods. Gunawardene *et al.*, (2012) found that ant assemblages respond to plant structure at ground level rather than to tree species diversity in a lowland dipterocarp-dominated forest in Sri Lanka. According to Thuenis *et al.*, (2005) ant species distributions were related to the quality and weight of leaf litter. However, limited

studies have been conducted to investigate the diversity and species assemblages of ants along an altitudinal gradient (Samson *et al.*, 1997; Bruhal *et al.*, 1999; Bharti, 2008) that encompasses different climatic conditions and vegetation structure. In Sri Lanka, though ant species composition in many habitat types has been established, the effect of altitudinal gradient on ant species assemblages has not been explored. Therefore, the present study was conducted to investigate the effect of altitude and forest type on species assemblages and diversity of litter ants in Hanthana Forest in Kandy, Sri Lanka.

MATERIALS AND METHODS

Study Site

Hanthana Mountain Range which ranges in elevation from 500 m – 1200 m encompassing different vegetation types lies in the Kandy District in central Sri Lanka (Latitude/longitude: 07°16'11"N 80°37'47"E). The study sites were demarcated along an elevation gradient to include two vegetation types; mixed woodland and pine plantations along an elevation gradient ranging from 400 m to 900 m. Study sites were selected within each 100 m elevation level to incorporate five different sub-elevation levels as given below.

400 to 500 m – Mixed woodland (disturbed) (MWd)

500 to 600 m – Pine plantation (with sparse ground cover of broad-leaf weeds) (PPu)

600 to 700 m – Mixed woodland (an abandoned coffee plantation) (MWc)

700 to 800 m – Mixed woodland (somewhat undisturbed) (MW)

800 to 900 m – Pure Pine plantation (without ground cover of weeds) (PP)

Sampling of litter ants

A 100 m line transect was laid down within each vegetation type perpendicular to the slope. Ants were collected using two methods, i.e., Winkler extraction (Bestelmeyer *et al.*, 2000) and hand picking. One square meter quadrates were laid at every 20 m interval on both sides along each transect. Litter in 1 m² quadrates laid at every 20 m interval

*Corresponding Author's Email: inokap@pdn.ac.lk

 <https://orcid.org/0000-0002-1483-9494>



along one side of each transect was collected for Winkler extraction. Collected litter samples were sieved to remove larger litter particles and the rest was collected into a cloth bag to carry into the laboratory for ant extraction. Along the other side of each transect at every 20 m interval, 1 m² quadrat was thoroughly examined for the presence of litter ants. Small quantities of litter at a time was collected and placed on a white tray to examine and collect ants using forceps. Ants from each quadrat were preserved in 70% alcohol and stored in labeled vials.

This procedure was conducted twice at each of the five 100 m elevation level for a period of one year from 2011-2012. A total of 10 transects were laid at 10 places of the five elevation levels to sample ants in the Hanthana Forest during the present study.

Identification of ants

Three to four representative specimens of each morpho-species were card mounted to make a reference collection and the rest were stored in 90% ethanol. Ants were identified up to the subfamily, genus and morpho-species using taxonomic keys, descriptions (Bolton, 1994; Bingham, 1903), and the reference collection lodged in the Department of Zoology, University of Peradeniya.

Determining whether parameters and ground cover characteristics

At each site, air temperature (°C), relative humidity (RH) and light intensity at five points along each transect were measured using Kestrel 3500 pocket weather meter. Ground cover characteristics were quantified by estimating the percentage coverage by bare ground, leaf litter, large rocks, and plant stems in a 1 m² quadrat. Estimations were made in five quadrates along each transect and averaged.

Statistical Analysis

Data on number of ant species and individuals with respect to vegetation type, altitude, weather parameters and ground cover characteristics were analyzed using Primer v6 software. Diversity of ants in different vegetation types and elevation levels were calculated using species richness (Margalef diversity index, Simpson dominance), and evenness indices (Simpson evenness index). Cluster analysis was performed to check the similarity of ant assemblages among the different study sites. A relate test was performed for ant species matrix and environmental and litter parameter matrix using Euclidean distance. A permutation test (Relate test) was applied to the matching coefficient ρ (Rho) between the ant abundance matrix and site characteristics matrix which were independently derived and have sample labels which can be matched up.

Two-sample *t*-test was carried to test any difference between the ants collected from hand picking method and Winkler extraction method using Minitab 14.

RESULTS AND DISCUSSION

A total of 8689 specimens of ants belonging to 9 subfamilies, 32 genera and 56 morpho-species were found along an elevation gradient ranging from 400 m to 900 m in the Hanthana Forest (Table 1). This accounts for ~26%

out of 215 species in 64 genera (Dias and Rajapaksa, 2016) recorded in Sri Lanka. Five subfamilies contained only a single genus and a species. Subfamily Myrmicinae included the highest number of ant genera (15) and species followed by Ponerinae (7 and 15 respectively) (Table 1). According to Dias *et al.* (2012), Myrmecinae, Ponerinae and Formicinae are the most common three subfamilies account for 75% of generic diversity and 80% of the species diversity in Sri Lanka.

Seventeen genera of ants contained only a single species while nine genera contained two species (Figure 1). The most species rich genus, *Pheidole* was represented by five species and *Solenopsis* sp. 1 was the most widely distributed and abundant species of which 6420 individuals were recorded. This was abundant in mixed woodland habitats but completely absent in the pure pine plantation. According to Uys (2012), dominant species can vary in different forest types because these species dependent on habitat conditions, micro climate, food sources and competition.

The monotypic genus *Dorylus* (Dorylinae), a subterranean army ant of the subfamily Dorylinae, was also recorded in the present study. This was represented by a single specimen and is known to be a very rare subfamily not discovered even in an extensive study conducted in Sinharaja Forest Reserve by Gunawardene *et al.*, (2008). However, the present study failed to spot the Sri Lankan relict ant, *Aneuretus simony*, a twig nesting species recorded by Wilson *et al.* (1956) from Peradeniya and Kandy. Karunaratna and Karunaratne (2013) recorded this species from a wet zone forest, Moraella and an intermediate zone forest in Knuckles Forest Reserve.

Figure 1 gives the accumulation of ant species by the two collecting methods. Accordingly, Winkler extraction method yielded a larger number of species compared to hand picking method. Number of ant species significantly differed ($p=0.002$) between the two collecting methods while genera was not significant ($p=0.079$). According to Bestelmeyer *et al.*, (2000), hand collection is often difficult to standardize as samples collected are influenced by the skill and efficiency of the collectors. Furthermore, these species accumulation curves did not reach a plateau (Figure 1 indicating that the study sites were under sampled. Majority of the genera recorded during the present study contained a single or two species. Therefore, there is a possibility of recording more species if sampling was continued throughout the year. However, even in larger studies, it is impossible and impractical to completely capture all the species in a hyper-diverse taxon like ants, especially in tropical forests (Longino and Colwell, 1997).

According to Table 2, the forest types with the highest number of species were mixed woodland (MW) at 700 – 800 m elevation and the disturbed mixed woodland (MWd) at 400 – 500 m elevation. Compared to these two sites, the number of ant species was low in the mixed woodland, which is an abandoned coffee plantation (MWc) at 600 – 700 m elevation. Only a few species of ants were encountered from the pure pine (PP) plantation compared to the pine plantation with sparse ground cover

Table 1: Subfamily, Genera and the number of morpho-species of ants collected from the Hanthana Forest Reserve.

Subfamily (No. G/M-spp.)	Genus	No. of Morpho-species
Amblyoponinae (1/1)	<i>Amblyopone</i>	01
Cerapahyinae (1/1)	<i>Cerapachys</i>	01
Dorylinae (1/1)	<i>Dorylus</i>	01
Dolichoderinae (2/5)	<i>Tapinoma</i>	02
	<i>Technomermex</i>	03
Formicinae (3/4)	<i>Acropyga</i>	01
	<i>Anoplolepis</i>	02
	<i>Paratrechina</i>	01
Leptanillinae (1/1)	<i>Leptanilla</i>	01
Myrmicinae (15/26)	<i>Cataulacus</i>	01
	<i>Indomyrma</i>	01
	<i>Meranoplus</i>	03
	<i>Myrmecina</i>	01
	<i>Kartidris</i>	01
	<i>Oligomyrmex</i>	02
	<i>Pheidole</i>	05
	<i>Pheidologeton</i>	01
	<i>Ponera</i>	02
	<i>Quadristuma</i>	02
	<i>Recurvidris</i>	01
	<i>Solenopsis</i>	02
	<i>Strumigenys</i>	01
	<i>Tetramorium</i>	02
	<i>Wasmania</i>	01
Ponerinae (7/15)	<i>Anochetus</i>	02
	<i>Cardiocondyla</i>	01
	<i>Diacamma</i>	01
	<i>Hypoponera</i>	01
	<i>Leptogenys</i>	04
	<i>Odontomachus</i>	03
	<i>Pachycondyla</i>	03
Pseudomyrmicinae (1/1)	<i>Tetraoponera</i>	02
Total: 09	32	56

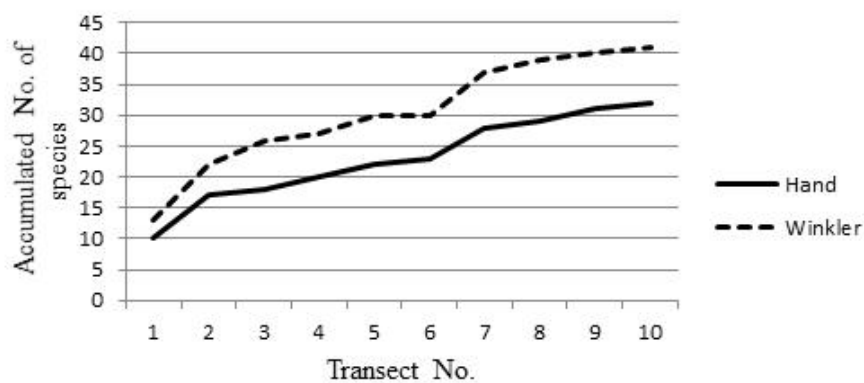
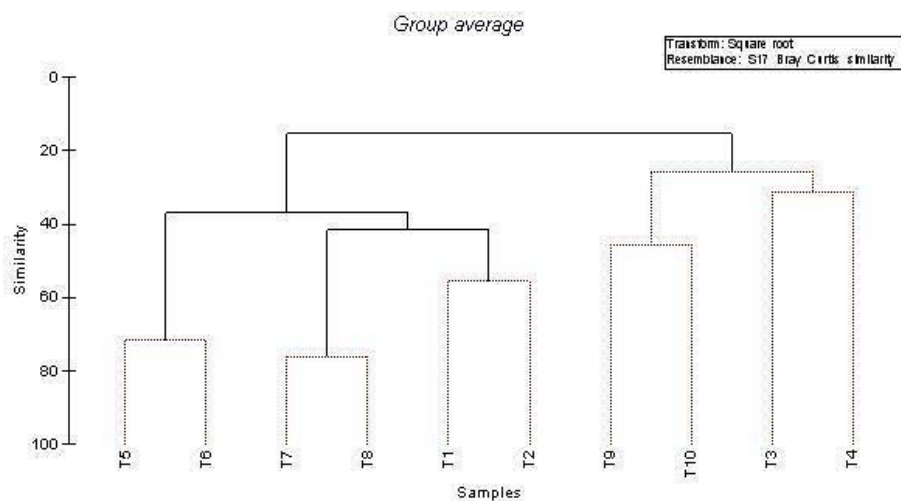
**Figure 1:** Species accumulation curves for the ants collected from the hand picking method and Winkler extraction method along the 10 transects installed along an elevation gradient in the Hanthana Forest Reserve.

Table 2: Species richness, abundance and diversity indices of ants sampled along the 10 transects in the Hanthana Forest Reserve.

Transect No.	Forest Type	Species richness (Total no. of spp.)	Abundance	Margalef diversity (richness index)	Fisher's α (richness index)	Simpson dominance index Lambda	Simpson evenness index 1-Lambda
T1	MWd	18	1092	2.43004	3.06138	0.52028	0.47972
T2	MWd	23	635	3.40894	4.67626	0.54363	0.45637
T3	PPu	12	169	2.14429	2.95230	0.25017	0.74983
T4	PPu	13	100	2.60577	3.98591	0.12540	0.87460
T5	MWc	13	406	1.99788	2.56345	0.50835	0.49165
T6	MWc	9	365	1.35596	1.66908	0.77278	0.22722
T7	MW	28	3218	3.34303	4.21782	0.69907	0.30093
T8	MW	19	2601	2.28901	2.77632	0.57357	0.42643
T9	PP	9	83	1.81043	2.56647	0.16272	0.83728
T10	PP	5	21	1.31383	2.07618	0.26077	0.73923

**Figure 2:** Dendrogram of ten 100 m transects (T1 & T2 – MWd; T3 & T4 – Ppu; T5 & T6 – MWc; T7 & T8 – MW; T9 & T10 – sampled for ants along an altitudinal gradient in the Hanthana Forest Reserve using group average clustering from Bray-Curtis similarities (samples connected by solid lines are significantly different while that of dotted lines are not).

of broad-leaf weeds (PPu) that harboured a comparatively higher number of species. The highest species number and abundance of litter ants in mixed woodland may be largely due to its diverse habitat heterogeneity compared to pure pinus plantations that consist of adult pine trees with a thick mat of decaying pine needles and debris with almost no understory vegetation (Murray *et al.*, 2009).

The overall comparison shows that Pine plantations were not rich in ant species compared to the mixed woodlands in the Hanthana Forest. Similarly, the abundance of ants was found in the order of MW > MWd > MWc > PPu and PP. The highest values for both Margalef diversity and Fisher's α were recorded by MW and MWd. Simpson dominance index was lowest in Pine plantations (in Both PP and PPu) while Simpson evenness index was highest in both Pine plantations.

Cluster analysis revealed distinct differences among

the ant assemblages found in the five study sites (Figure 2). Accordingly, the two major vegetation types (pine and mixed woodlands) separated at 20% similarity threshold indicating a significant difference in ant assemblages between the study sites with two different vegetation types. The two different pine plantations, one with a sparse undergrowth of broadleaf weeds (where the transect T3 and T4 were laid) and the pure pine plantations (where the transect T9 and T10 were laid) were different in relation to ant assemblages. However, the ant assemblages recorded from the two pine plantations (T9 and T10) was not different. Similarly, there is a significant difference in ant assemblages between the groups T1, T2, T7, T8 and the group T5, T6. All these transects were from different mixed woodlands, but T5 and T6 indicated a completely different ant assemblage in woodland which was an abandoned coffee plantation more than 100 years before.

According to the analysis, the ρ value 0.3 ($P=3\%$) which falls within the simulated values indicated a weak relationship between the ant assemblages and site characteristics given as weather parameters and ground cover characteristics.

The overall findings of this study indicated that the vegetation type may be the major factor that governs the difference in ant assemblages irrespective of the altitude of each study site. The small altitudinal range from 400 m to 1200 m within which the Hanthana Forest falls in may be the reason for not having a relationship of ant assemblages. This result is similar to the study conducted by Ribas and Schoereder (2007) who found that tree density and structural heterogeneity affected species richness of litter ants in the Brazilian Pantanal. Therefore, the present study highlights the importance of natural forests in supporting litter ant fauna that play a major role as ecosystem engineers.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

Financial support given by the Peradeniya University Research Grant: RG/2011/38/S and field help given by graduate students are greatly acknowledged.

REFERENCES

- Bestelmeyer, B.T., Agosti, D., Alonso, L.E., Brandao, C.R.F., Brown Jr., W.L., Delabie, J.H.C. and Silvester, R. (2000). Field techniques for the study of ground-dwelling ants. In: Agosti D., Majer, J.D., Alonso, L.E., and Schultz, T.R. (Eds.): *Ants: Standard methods for measuring and monitoring biodiversity – Smithsonian Institution Press, Washington, DC*, 122-144.
- Bharti, H. (2008) Altitudinal Diversity of Ants in Himalayan Regions (Hymenoptera: Formicidae). *Sociobiology* **52**(2): 305-322.
- Bingham, L.C.T. (1903) The fauna of British India including Ceylon and Burma. Hymenoptera vol. II. Ants and Cuckoo-wasps. Taylor and Francis. London. 506 pp.
- Bolton, B. 1994. *Identification guide to the ant genera of the world*: Harvard University Press, Cambridge, Mass. 222 pp.
- Bruhl, C.A., Mohamed, M. and Linsenmair, K.E. (1999) Altitudinal Distribution of Leaf Litter Ants along a Transect in Primary Forests on Mount Kinabalu, Sabah, Malaysia. *Journal of Tropical Ecology*, **15**(3): 265-277. <https://doi.org/10.1017/S0266467499000802>
- Dias, R.K.S., Kosgamage, K.R.K.A. and Peiris, H.A.W.S. (2012). The taxonomy and conservation status of ants (Order: Hymenoptera, Family: Formicidae) in Sri Lanka. *The National Red List 2012 of Sri Lanka*, 11.
- Gunawardene, N., Majer, J. and Edirisinghe, J. (2012). Correlates of ant (Hymenoptera: Formicidae) and tree species diversity in Sri Lanka. *Myrmecological News* **17**: 81-90.
- Gunawardene, N.R., Majer J.D. and Edirisinghe J.P. (2008). Diversity and richness of ant species in a lowland wet forest reserve in Sri Lanka. *Asian Myrmecology* **2**: 71-83.
- Holldobler, B. and Wilson, E.O. (1990). *The ants*. Belknap Press of Harvard University Press, Cambridge. 732.
- Karunarathna, D.A.G.N.B. and Karunaratne, W.A.I.P. (2013). Two new localities of Sri Lankan Relict Ant *Aneuretus simoni* Emery, 1893 (Formicidae: Aneuretinae) with the very first record in the intermediate zone. *Journal of Threatened Taxa* **5**(11): 4604-4607. <http://dx.doi.org/10.11609/JoTT.o3334>.
- Longino, J.T. and Colwell, R.K. (1997). Biodiversity assessment using structured inventory: capturing the ant fauna of a tropical rain forest. *Ecological applications*, **7**(4): 1263-1277.
- Murray, B.R., Baker, A.C. and Robson, T.C., (2009). Impacts of the replacement of native woodland with exotic pine plantations on leaf-litter invertebrate assemblages: a test of a novel framework. *International Journal of Ecology*. Article ID 490395, 6 pages. <https://doi.org/10.1155/2009/490395>.
- Ribas, C.R. and Schoereder, J.H. (2007). Ant communities, environmental characteristics and their implications for conservation in the Brazilian Pantanal. *Biodiversity and Conservation* **16**: 1511-1520. <https://doi.org/10.1007/s10531-006-9041-x>.
- Samson, D.A., Rickart E.A. and Gonzales, P.C. (1997) Ant Diversity and Abundance along an elevational gradient in the Philippines, *Biotropica* **29**(3): 349-363.
- Silva, T.H.S.E., Karunarathna, N.B. and Karunaratne, W.A.I.P. (2017) Competence of Litter Ants for Rapid Biodiversity Assessments. *International Journal of Biodiversity*. Volume 2017, Article ID 6582191, 10 pages. <https://doi.org/10.1155/2017/6582191>.
- Theunis, L., Gilbert, M., Roisin, Y. and Leponce, M. (2005). Spatial structure of litter-dwelling ant distribution in a subtropical dry forest. *Insectes sociaux* **52**(4), 366-377. <https://doi.org/10.1007/s00040-005-0822-0>
- Uys, C.J. (2012). The impact of pine plantations and alien invertebrates on native forest and fynbos invertebrate communities in Table Mountain National Park (Doctoral dissertation, University of Cape Town).
- Van der Woude, C., Anderson, A.N. and Houswe, A.P.N. (1997) Ant communities as bioindicators in relation to fire management of spotted gum (*Eucalyptus maculate* Hook.) forest in south-east Queensland – Memories of the Museum of Victoria **56**: 671-675.
- Wilson, E.O., Eisner, T., Wheeler, G.C. and Wheeler, J. (1956). *Aneuretus simoni* Emery, a major link in ant evolution. *Bulletin of the Museum of Comparative Zoology* **115**(03): 81-105.