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Frequency of nest occurrence and nest density of *Aneuretus simoni* Emery (Sri Lankan Relict Ant) and other ant fauna in an abandoned rubber plantation (Kirikanda Forest) in southwest Sri Lanka

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ABSTRACT. *Aneuretus simoni* Emery, a Critically Endangered ant species endemic to Sri Lanka, was studied in Kirikanda Forest in Kalutara District. The nest occurrence and nest density of ant species was investigated using 240 quadrats (0.5 m x 0.5 m), in six 100 m^2 plots, on 15 January, 5 May and 24 July 2010, and recording the number of ground nests belonging to any ant species within each quadrat. Fallen twigs and decaying wood pieces within each quadrat were also examined. Twenty-two ant species, belonging to 16 genera, were identified. The nest density of *A. simoni* observed on the three occasions was 0.15, 0.10 and 0.15 nests m^{-2} respectively, and the nest frequency was 3/80, 2/80 and 3/80 respectively. The current findings confirm that *A. simoni* is a resident species in Kirikanda Forest. Conservation practices should be implemented and encouraged in this forest to protect this species.

Keywords: *Aneuretus simoni* Emery, nest density, Aneuretinae, Formicidae, Sri Lankan Relict Ant

INTRODUCTION

Aneuretus simoni Emery, the single living representative of the subfamily Aneuretinae, has been recorded only from Sri Lanka (Wilson *et al.* 1956; Jayasuriya & Traniello 1985; Bolton 1994). The Social Insect Specialist Group (1996) of IUCN listed this species as Critically Endangered globally. It has now been recorded in the Peradeniya area of Kandy District (Wilson *et al.* 1956), and several forests in Ratnapura District: Pompekelle Forest Reserve (Wilson *et al.* 1956; Dias & Chaminda 2001; Dias 2004, 2006b; Dias & Perera 2004), Sri Pada Mountain (Adam's Peak: Wilson *et al.* 1956), Gilimale (Jayasuriya & Traniello 1985; Dias 2006a, 2008) and Sinharaja Forest Reserve (Perera *et al.* 2006; Gunawardene *et al.* 2008). The forest "Kirikanda" in Kalutara District of southwest Sri Lanka, a rubber plantation abandoned for about 40 years (Abeysinghe, a villager, personal communication, 2010) and declared a "forest" in May 2002 (Forest Department of Sri Lanka, personal communication), lies very close to the Sinharaja Forest Reserve boundary, and the presence of *A. simoni* in this forest was reported by Ruchirani (2010) and Dias *et al*. (2011).

Few studies have quantified the nest densities of *A. simoni*. Jayasuriya & Traniello (1985) reported nest densities of *A. simoni* in three study plots in Gilimale Forest of 0.017, 0.023 and 0.033 colonies m^{-2} in 1979, and noted the species was distributed in areas with an annual rainfall of 2000-5000 mm and an elevation of at least 450 m above mean sea level. Kirikanda Forest has a lower elevation than this, and so the nest density and frequency is of interest. Therefore the nest density and nest frequency of *A. simoni* and other

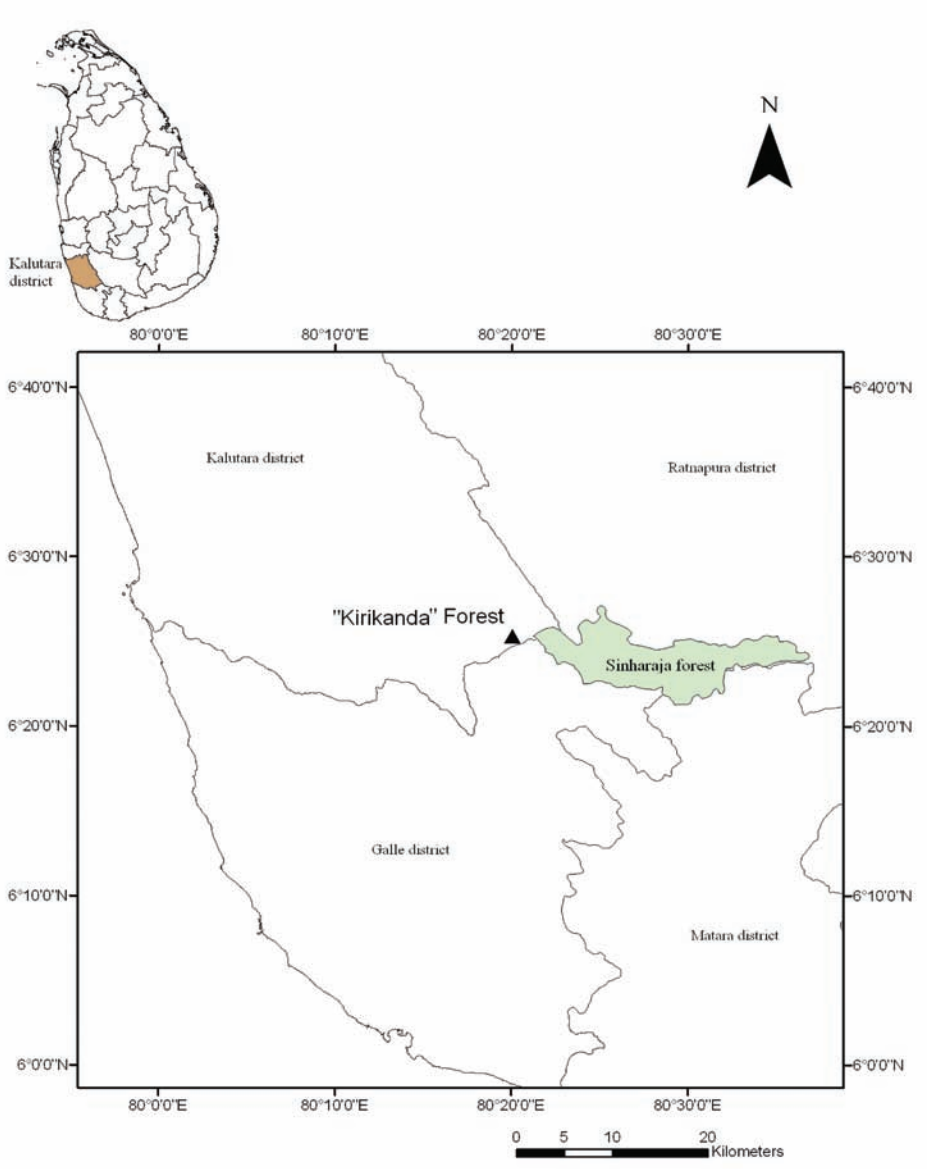

Fig. 1. Location of Kirikanda Forest, our study site, in Kalutara District in the southwest of Sri Lanka (map re-drawn from Gunawardane 2003).

ground-dwelling ant species was recorded at three elevations in Kirikanda in 2010.

METHODS

Description of the study sites

Kirikanda Forest (06°25.306' to 06°25.240' N and 080°20.065' to 080°19.925' E), a 50 ha lowland (100-250 m elevation) evergreen forest in steep hilly terrain, is situated at Danawala in Kalutara District (Fig. 1). The forest receives a mean rainfall of about 2000-3000 mm annually (Jayasinghearachchi 2010) and the forest floor is covered with a dense leaf-litter layer. Local villagers disturb this forest for their various daily needs. Localities at three elevations (respectively Locality A, B and C at ~110 m, ~200m and ~247 m) were sampled; GPS co-ordinates, elevation and dates and times of sampling at each Locality

are shown in Table 1. At each Locality two distinct 100 m^2 plots, respectively A1 and A2, B1 and B2 and C1 and C2, were surveyed for the ground nests of ant species on each occasion. The approximate distance between each pair of plots was 10 m and the three localities were about 50 m from one another.

Field methods

A 0.5 m x 0.5 m quadrat was made by fixing four wooden pegs in the ground and connecting them with a cord. Forty such quadrats were laid at least 2-3 m apart at each of Plot A1 and Plot A2 on 15 January 2010. Another 40 quadrats were laid with similar spacing at each of Plot B1 and Plot B2 on 8 May, and Plot C1 and Plot C2 on 24 July. The nests of ant species were found by carefully removing leaf litter within each quadrat. Fallen twigs and decaying wood pieces within each quadrat were broken and examined for the presence of ant colonies. The number of nests observed within each quadrat was recorded while preserving three to five workers of each ant species from each nest in 70% ethanol, appropriately labeled.

Nest density of *A. simoni* and other ant species was calculated (nest density of each ant species = number of nests of the species in one Locality / sum of the quadrat areas at the Locality (= 20 m^2)). Frequency of occurrence of each species at each Locality was also calculated (frequency of occurrence = number of quadrats that included the nests of that species / total number of quadrats laid at the Locality (= 80)).

Measurement of environmental parameters

Each parameter was measured at three representative places in each Locality and mean values were calculated. Air and soil temperature was measured using a thermometer. Soil pH was recorded using a soil pH meter, and depth of leaf litter using a ruler. Two soil samples from each Locality were collected into polythene bags; a known weight of soil from each sample was dried in an oven at 105°C until a steady dry weight was observed, and the soil moisture content was calculated according to Brower *et al.* (1990). Soil organic matter content in these samples was determined according to Sutherland (2006).

Table 1: A brief description of each locality and GPS co-ordinates, elevation and dates and times of survey at Kirikanda Forest.

Locality/ Plot	Appearance	GPS co-ordinates	Elevation (m)	Date (2010)	Time
A (Plot A1 and Plot A2)	Shrub layer prominent; no upper canopy; slightly steep	06°25.302' to 06°25.306'N 080°20.062' to 080°20.065'E	108-112	15 Jan	8:30 h – 17:00 h
B (Plot B1 and Plot B2)	Upper canopy and shrub layer present; steep	06°25.250' to 06°25.260'N 080° 19.957' to 080°19.988'E	198-202	8 May	8:00 h – 16:00 h
C (Plot C1 and Plot C2)	Upper canopy, no shrub layer; flat land with large boulders	06° 25.240' to 06° 25.253'N 080° 19.925' to 080° 19.932'E	244-250	24 Jul	10:00 h – 15:00 h

Table 2: Presence or absence of ant nests within the 40 quadrats laid out at each plot.

Ant nests	No. of quadrats					
	A1	**A2**	**B1**	**B2**	**C1**	**C2**
Present	30	26	25	27	31	31
Absent	10	14	15	13	9	9

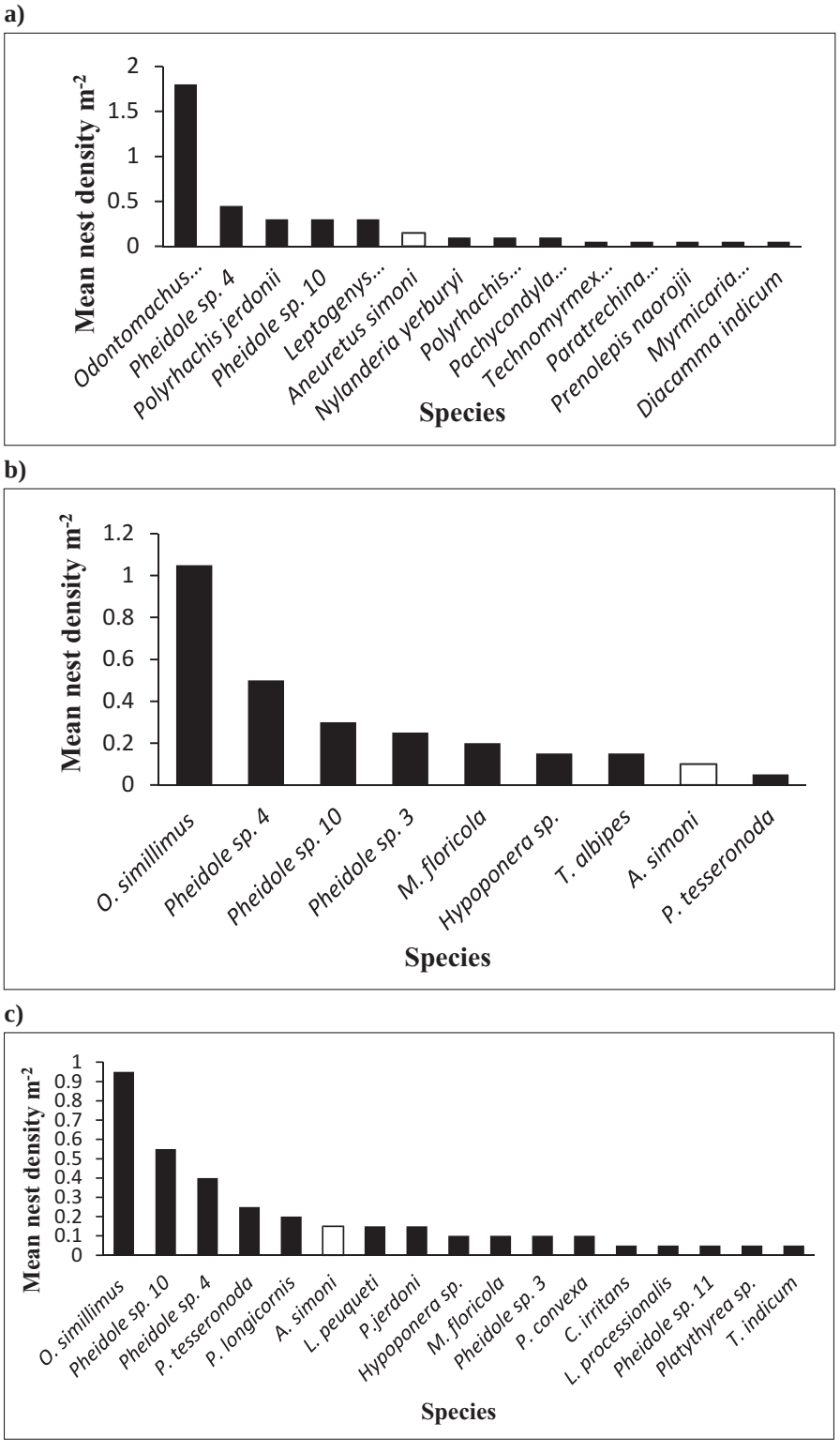

Fig. 2. Rank-abundance diagram for the mean nest density of each ant species observed at Kirikanda Forest in (a) January (at Locality A) (b) May (at B) and (c) July (at C), 2010.

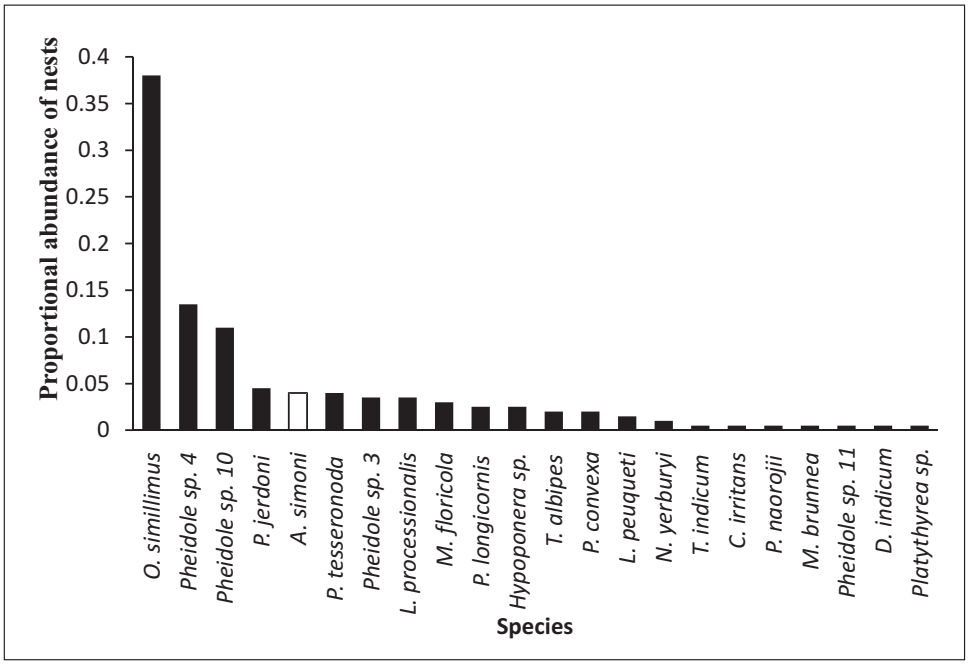

Fig. 3. Rank-abundance diagram (overall) showing the proportional abundance of nests of each ant species observed at Kirikanda Forest.

Rainfall for 15 January and 8 May was obtained from the Meteorology Department, Colombo; rainfall data for the 24 July were not available, but the weather was dry.

Identification of worker ants and flora

Worker ants in each sample were identified to the lowest possible taxonomic level, with the use of a low-power stereo-microscope and with reference to taxonomic keys and morphologicla descriptions (Bingham 1903; Bolton 1994; Bolton *et al*. 2006; Dias 2008). Antennae, mandibles, maxillary and labial palps and legs of workers were dissected out where necessary and observed under a high-power microscope with a drop of glycerol.

Plants in association with *A. simoni* nests were identified by bringing relevant parts to the laboratory and comparing them with authenticated specimens in the herbarium of the Department of Botany, University of Kelaniya. Scientific names of the plants are given according to www.theplantlist.org.

Results

One-hundred-and-seventy quadrats (71%) contained nests of ants, whereas 70 (29%) had no nests. Twenty-two species of 16 genera and five subfamilies of ants occupied nests at the three elevations in 2010 (Table 3). Nests of 14 species, 11 genera and five subfamilies of ants were recorded from Locality A (Table 3), where nests of *A. simoni* and three other species were observed at both Plots. Nests of nine species, seven genera and four subfamilies were recorded from Locality B, at which nests of *A. simoni* and five other species were observed at both Plots. Nests of 17 species, 12 genera and five subfamilies were recorded from Locality C, where nests of *A. simoni* and seven other species were observed in both Plots. The nests of *Odontomachus simillimus* F. Smith had by far the highest frequency of occurrence at all three localities, whereas nests of other species had lower frequencies that ranged from 1/80 to 9/80.

The frequency of occurrence and the nest density of *A. simoni* ranged from 1/80 to 3/80 and 0.10 to 0.15 nests m^{-2} respectively at

Table 3: Number of nests found, in 40 quadrats, at each plot, with nest density and frequency of occurrence (proportion of 80 quadrats) for each ant species. Scientific names given according to Bolton et al. (2012) and www.antweb.org. Reference numbers given for the unnamed species refer to the first author's collection at the Department of Zoology, University of Kelaniya, Sri Lanka.

Subfamily	Genus / species	Locality A				Locality B				Locality C			
		Plot A1	Plot A2	Nest density m^{-2}	Frequency of occurrence	Plot B1	Plot B2	Nest density m^{-2}	Frequency of occurrence	Plot C1	Plot C2	Nest density m^{-2}	Frequency of occurrence
Aneuretinae	*Aneuretus simoni* Emery	2	1	0.15	3/80	1	1	0.10	2/80	2	1	0.15	3/80
Dolichoderinae	*Tapinoma indicum* Forel	-	-	-	-	-	-	-	-	-	1	0.05	1/80
	Technomyrmex albipes (F. Smith)	-	1	0.05	1/80	2	1	0.15	3/80	-	-	-	-
Formicinae	*Camponotus irritans* (F. Smith)	-	-	-	-	-	-	-	-	1	-	0.05	1/80
	Paratrechina longicornis (Latreille)	-	1	0.05	1/80	-	-	-	-	3	1	0.20	4/80
	Nylanderia yerburyi (Forel)	-	2	0.10	2/80	-	-	-	-	-	-	-	-
	Polyrhachis convexa Roger	1	1	0.10	2/80	-	-	-	-	-	2	0.10	2/80
	Polyrhachis jerdoni Forel	4	2	0.30	6/80	-	-	-	-	-	3	0.15	3/80
	Prenolepis naoroji Forel	-	1	0.05	1/80	-	-	-	-	-	-	-	-
Myrmicinae	*Monomorium floricola* (Jerdon)	-	-	-	-		4	0.20	4/80	-	2	0.10	2/80
	Myrmicaria brunnea Saunders	-	1	0.05	1/80	-	-	-	-	-	-	-	-
	Pheidole sp. 3		-	-	-	1	4	0.25	5/80	1	1	0.10	2/80
	Pheidole sp. 4	3	6	0.45	9/80	4	5	0.5	9/80	2	4	0.4	6/80
	Pheidole sp. 10	2	4	0.30	6/80	4	1	0.3	5/80	5	4	0.55	9/80
	Pheidole sp. 11	-	-	-	-	-	-	-	-	1	-	0.05	1/80
Ponerinae	*Diacamma indicum* Santschi	1	-	0.05	1/80	-	-	-	-	-	-	-	-
	Hypoponera sp.	-	-	-	-	3	-	0.15	3/80	1	1	0.10	2/80
	Leptogenys processionalis (Jerdon)	4	2	0.30	6/80	-	-	-	-	-	1	0.05	1/80
	Leptogenys peuqueti André	-	-	-	-	-	-	-	-	2	1	0.15	3/80
	Odontomachus simillimus F. Smith	17	17	1.80	34/80	10	10	1.05	20/80	9	8	0.95	17/80
	Pachycondyla tesseronoda (Emery)	2	-	0.10	2/80	1	-	0.05	1/80	5	-	0.25	5/80
	Platythyrea sp.	-	-	-	-		-	-	-	-	1	0.05	1/80

Table 4: Environmental conditions observed during sampling at Kirikanda Forest.

Parameter	Locality			Range
	A	B	C	
Air temperature °C	27.6 ± 1.07	27.4 ± 1.07	28.5 ± 0.44	26 – 29
Soil temperature °C	25.9 ± 0.58	26.3 ± 0.24	27.1 ± 0.15	25 – 27
Soil pH	6.6 ± 0.03	6.5 ± 0.02	6.1 ± 0.03	6 – 6.5
Mean depth of litter layer cm	2.95 ± 0.02	2.9 ± 0.05	2.9 ± 0.01	2.8 – 3.0
Soil moisture content %	36 ± 0.71	32 ± 0.05	37 ± 0.88	32 – 37
Soil organic matter content %	12 ± 0.23	11 ± 0.07	12 ± 0.11	11 – 12
Rainfall mm	11	38	No record	11 - 38

the three levels of elevation (Table 3). Mean nest density of *A. simoni* was ranked 6th, 8th and 6th at the three localities (Fig. 2), and 5th when all data were pooled (Fig. 3).The highest mean nest density was observed for *O. simillimus* at all three localities (Fig. 2). Higher mean nest densities than those of *A. simoni* were also recorded for two *Pheidole* spp. at the three localities and for the pooled data.

Mild temperatures, slightly acidic soil pH, high soil moisture and low levels of soil organic matter content were evident at each locality. Only slight differences in each parameter were noticeable at the three localities at the time of sampling, and highest temperatures were recorded in July at Locality C (Table 4).

Nests of *A. simoni*

A single nest was observed in a piece of decaying wood 3 cm in diameter, and two nests were observed in a superficial layer of the soil but covered with leaf litter. The other five nests were found beneath the leaf litter, on the flat surfaces of rocks. Nests were observed in shady places, and various plants, *Blechnum orientale* L., *Caryota urens* L., *Freycinetia* sp., *Garcinia* sp., *Neprolepis* sp., *Piper chuvya* Miq. and *Strobilanthes* sp., were observed close to the nests.

DISCUSSION

Kirikanda Forest receives a mean annual rainfall of about 2000-3000 mm and therefore lies within the rainfall range recorded by Jayasuriya & Traniello (1985), but the elevations (108-250 m) were much lower in the present study, suggesting the lower limit may reflect habitat availability rather than an influence of altitude *per se*. Nest densities of *A. simoni* recorded from Kirikanda Forest were some five times higher than those recorded by Jayasuriya & Traniello (1985) from Gilimale Forest in 1979. The presence of *A. simoni* in both plots surveyed on each visit, and at the three localities of Kirikanda Forest, confirmed that the environmental conditions (Table 3) are favourable for the species. The ability of the species to survive in abandoned rubber plantations has implications for its conservation status. Conservation practices should be developed to protect this rare species.

The most frequent ant species at Kirikanda was *Odontomachus simillimus*, although very few individuals were observed in each colony. The nests of *O. simillimus* were not observed in close proximity to colonies of *A. simoni*. However, *Pheidole* sp. 10 colonies were observed in close proximity to *A. simoni* nests six times, and spatial associations should further be investigated in future studies.

Nesting microhabitats recognised in previous studies of of *A. simoni* were all materials of plant origin, such as hollow cores of decaying fallen twigs, leaf-litter and the bark of rotting logs (Wilson *et al*. 1956; Jayasuriya & Traniello 1985; Dias & Chaminda 2001; Dias 2004; Perera & Dias 2004). An additional nesting microhabitat recorded in the present study was flat rock surfaces covered by leaf litter.

Sinharaja Forest Reserve (Fig. 1) (where *A. simoni* is abundant) is bounded by Kalutara District to the west and Galle and Matara Districts to the south (Gunawardane 2003). Ant surveys in the forests close to Sinharaja Forest boundary in the latter two Districts are highly recommended to determine the wider range of *A. simoni* in Sri Lanka.

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