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Nest density of *Aneuretus simoni* Emery (Sri Lankan Relict Ant) and *Stereomyrmex horni* Emery in three forest regions in western and southern Sri Lanka

R. K. S. Dias and H. P. G. R. C. Ruchirani

Department of Zoology, University of Kelaniya, Sri Lanka

Corresponding author's e-mail: rksdias@kln.ac.lk

ABSTRACT. *Aneuretus simoni* Emery and *Stereomyrmex horni* Emery are two endemic and rare ant species in Sri Lanka. The presence or absence and nest density of these species was surveyed to find out if they inhabit locations outside the previously recorded habitats, and to verify their conservation status. Colonies were surveyed by thorough inspection, breaking decaying pieces of wood and the removal of leaf litter in a forest in Western Province (Kalugala Proposed Forest Reserve – KPFR) and two forests in Southern Province (Kuluna Kanda Proposed Forest Reserve – KKPFR and Wilpita "Aranya Kele" in Oliyagan Forest Reserve – WFR). *Aneuretus simoni* nests were recorded in 7.5% of quadrats, with a nest density of 0.30 nests m^{-2} at the site of KPFR, whereas this species was more common at KKPFR , occurring in 23.3% of samples with a nest density of 0.93 nests m^{-2}. At WFR site, *A. simoni* nests were found in 6.7% of samples at a nest density of 0.27 nests m^{-2}. *Stereomyrmex horni* Emery was found in 15% of quadrats at 0.6 nests m^{-2} at KPFR and 3% of quadrats at 0.13 nests m^{-2} at WFR. At KKPFR, *S. horni* was not encountered. The discovery of the presence of *A. simoni* in the three forests, *S. horni* in two of the forests, and the co-occurrence of the two endemic species in two habitats, are new findings of this survey. Nest density of *A. simoni* at the current sites was higher than those recorded from Gilimale Forest Reserve and Kirikanda forest, whereas this is the first record of nest density of *S. horni* in Sri Lanka. Our findings suggest that *A. simoni* is much more common than previously reported and that its present conservation status as a Critically Endangered species should be re-assessed.

Keywords: nest density, frequency of nest occurrence, Kalugala Proposed Forest Reserve, Kulunakanda Proposed Forest Reserve, Wilpita "Aranya Kele"

INTRODUCTION

Aneuretus simoni Emery (subfamily: Aneuretinae) and *Stereomyrmex horni* Emery (subfamily: Myrmicinae) are rare endemic ants in Sri Lanka (Bolton 1995). Distribution of *A. simoni* was earlier reported from only a few forests (Wilson *et al.* 1956, Jayasuriya and Traniello 1985, Dias and Perera 2011) but it was discovered in Sinharaja Forest Reserve (Perera *et al.* 2006, Gunawardane *et al*. 2008) and Kirikanda Forest (Dias *et al*. 2011, 2013) more recently. Sinharaja Forest Reserve is bounded by Kalutara District in Western Province to the west and Galle and Matara Districts in Southern Province to the south, and surveys of *A. simoni* in the forests that lie close to Sinharaja Forest and situated in the above Districts (Fig. 1) are essential to determine its conservation status

and distribution in Sri Lanka. *Stereomyrmex horni* was originally reported from a location in the wet zone, Bandarawela, in 1901 (Emery 1901). It was rediscovered in Anuradhapura Sanctuary, a dry mixed evergreen forest (08° 20' N, 80° 23' E, elevation 108 m), in the dry zone in February 2008, more than 106 years after its first record in Sri Lanka (Dias *et al*. 2011, Fig. 2). This species has not been recorded in recent ant surveys in the wet zone. To clarify their conservation status and distribution in Sri Lanka, *A. simoni* and *S. horni* were surveyed in three wet evergreen lowland forests; Kalugala Proposed Forest Reserve in the Western Province, Kulunakanda Proposed Forest Reserve, and Wilpita "Aranya Kele" (a part of Oliyagan Forest Reserve) in the Southern Province of Sri Lanka, in 2011 and 2012 (Fig. 1). Here, we report on the presence or absence of nests, nest density, and frequency of occurrence of nests of each species in each forest.

METHODS

Description of sites

Each site consisted of 50 – 60 m high *Dipterocarpus*, *Shorea* and *Doona*, and *Semecarpus*, *Garcinia* and *Callophyllum* trees ranging to around 30 m in height. Species of *Humboldtia*, *Strobilanthes* and many ferns formed the understory at the sites. A dense leaf litter layer covered the ground of each site.

Kalugala Proposed Forest Reserve (KPFR)

This wet evergreen Proposed Forest Reserve of 2907 ha (Boteju & Wattavidanage 2012) lies about 31 km southwest from the boundary of Sinharaja Forest Reserve, in Kalugala, Kalutara District in the Western Province of Sri Lanka (Fig. 1 and Fig. 2, Table 1). The sampling area was characterized by steep terrain and huge boulders are present in the area. Mean annual rainfall received by this forest ranges from 4000 to 5000 mm (Boteju & Wattavidanage 2012).

Kuluna Kanda Proposed Forest Reserve (KKPFR)

This 35 ha wet evergreen mountainous forest, formerly known as "Mahameteriya Mookalana", is situated about 17 km south from the boundary of Sinharaja Forest Reserve, in Thawalama, Galle District in the Southern Province of Sri Lanka. This site suffers regular disturbance from villagers (Forest Department, personal communication).

Wilpita "Aranya Kele" (WFR)

This is part of the Oliyagan Forest Reserve (482.9 ha), which was declared a Forest Reserve on 8 September, 1939 (Gazette notification No. 8497) and lies about 37 km south from the boundary of Sinharaja Forest Reserve, between Akuressa and Kamburupitiya in Matara District in the Southern Province of Sri Lanka (Forest Department, personal communication). This is a secondary wet evergreen forest site that was heavily logged in 1988.

Field methods

Table 1 Date of survey, GPS coordinates, and elevation at each site

Forest site	Date	GPS coordinates	Elevation (m)
KPFR	14/ 08/ 2011	6° 26.77´ N 80° 15.23´ E	95
KKPFR	05/ 04/ 2012	6° 19.59´ N 80° 20.05´ E	250
WFR	22/08/ 2012	6° 05. 59´ N 80° 31.59´ E	104

In each forest, three leaf litter samples were collected randomly along the walking path, at approximately 50 m intervals. These were sifted through a sieve and collected into a white tray, and ants were identified using a low power field microscope. In KPFR, we failed to collect *A. simoni* on the first three attempts, but workers were collected on the fourth attempt. Litter sifting at four such points at either side of the walking path found no *A. simoni* in KKPFR but on the fifth attempt we found workers of this species. In

WFR, *A. simoni* workers were found on the fourth attempt after three failed efforts. Based on these data, a region hosting *A. simoni* was selected for further survey in each forest. Date of the survey in each forest, GPS coordinates and elevation of each site are shown in Table 1.

Forty quadrats were placed randomly 2 – 3 m apart within a 100 m^2 plot in the selected region of KPFR. Each quadrat was 0.5 m × 0.5 m and fixed by four wooden poles connected by a nylon cord on the ground. Similarly, thirty quadrats within a 100 m^2 area were laid at the selected sites in KKPFR and WFR.

Ant nests were found by carefully removing leaf litter and breaking and examining fallen twigs and decaying wood pieces within each quadrat. Two to three workers of each ant species from each nest were preserved in appropriately labelled glass bottles (7 ml) filled with 70% ethanol. Within each quadrat the number of nests occupied by each species was recorded.

Measurement of environmental parameters

Air and soil temperature at the time of sampling was measured using a mercury thermometer. Soil pH was recorded using a soil pH meter (Spectrum Technologies, IQ 150) and depth of leaf litter to the uppermost soil level was measured using a ruler. Three soil samples excluding leaf litter from each plot 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. Soil moisture content was calculated

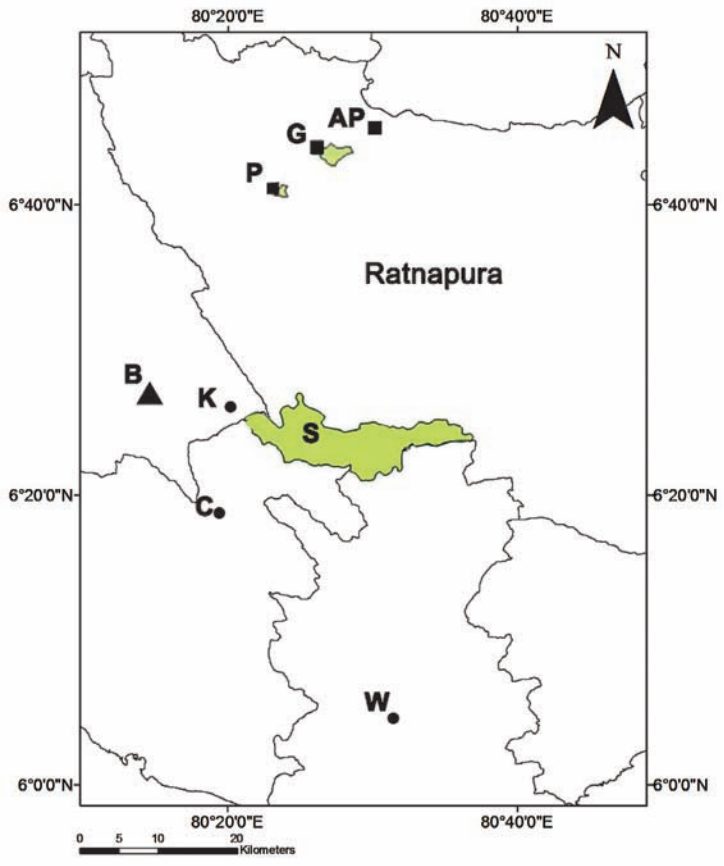

Fig. 1. Map of south-western Sri Lanka showing the habitats of *A. simoni* recorded earlier in Ratnapura District (AP – Adam's Peak; G – Gilimale Forest; P – "Pompekelle"; S – Sinharaja Forest; K – Kirikanda Forest) and the currently recorded habitats; KPFR (B) in Kalutara District; KKPFR (C) in Galle District; WFR (W) in Matara District (re-drawn and enlarged from Gunawardane, 2003).

according to Brower *et al*. (1998). Each parameter was measured at three representative locations in each site and mean values were calculated.

Identification of worker ants

Worker ants collected from each site were identified to the lowest possible taxonomic level with the use of a low-power stereo-microscope and reference to taxonomic keys and morphological descriptions (Bingham 1903; Bolton 1994; Dias 2008). Antennae, mandibles, maxillary and labial palps, and legs of workers were dissected where necessary and observed under a high-power microscope (Olympus CX 21, X1000) with a drop of glycerol.

Data analysis

Nest density of *A. simoni* and other ant species was calculated as total number of nests of each species / sum of the area of the quadrats sampled at that site (e.g., at KPFR, 40 quadrats of 0.25 m^2 = 10 m^2 and thus 3 nests = 0.3 m^{-2}). Frequency of occurrence was estimated as the percentage of quadrats in which each ant species occurred at each site (e.g. 3 quadrats at KPFR (total n = 40) = 7.5%).

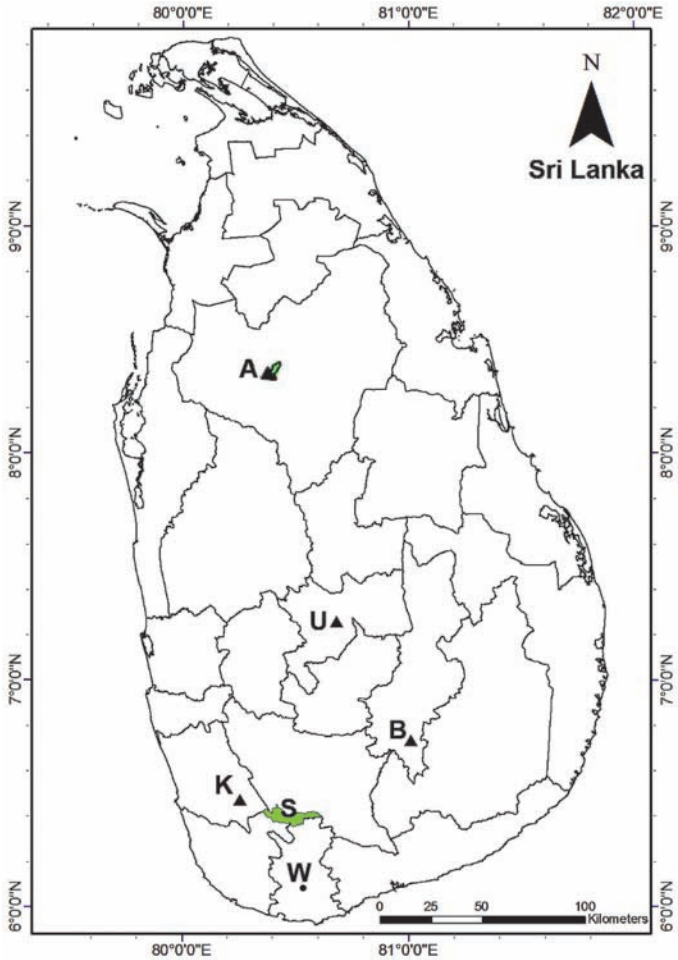

Fig. 2. A map of Sri Lanka showing records of *S. horni* from previous studies (B: Bandarawela; A: Anuradhapura Sanctuary) and in the current report (K: KPFR, Kalutara District ; W: WFR, Matara District). U marks a previously known location (Kandy, Kandy District) of *A. simoni* which is not shown in Fig. 1.

RESULTS

Nest density and frequency of nest occurrence of ant species

Systematics, nest density, and frequency of nest occurrence of each ant species observed at the sites are summarized in Table 3. At KPFR site, 29 of 40 quadrats had ant nests. The nest density and frequency of nest occurrence of *S. horni* (0.6 m^{-2} and 15%) were higher than those observed for *A. simoni* at this site.

Ant nests were observed in 12 of 30 quadrats at KKPFR site. The highest nest density and frequency of nest occurrence was for *A. simoni* at this site, while *S. horni* was not observed. Ant nests were found in 18 of the 30 quadrats laid at the WFR site. Lower nest density (0.27 m^{-2}) and frequency of nest occurrence (6.7%) were observed for *A. simoni* at the site (see Table 3).

During our study we observed mild air and soil temperatures at the three sites (Table 2). Soil moisture content was higher at KKPFR and WFR, soils were relatively acidic at KPFR and the leaf litter layer was thicker at WFR (Table 2).

DISCUSSION

The discovery of *A. simoni* nests in the currently examined forests extends the range of this species to the forests in Galle and Matara Districts and in turn, to the Southern Province of Sri Lanka for the first time (Fig. 1). This species was also recorded in a forest in Western Province from Kirikanda Forest, in 2010. These data also reveal the survival of this species at a low elevation, 95 m above mean sea level, much lower than in previous studies in which it was recorded above 450 m (Jayasuriya and Traniello 1985) and at 108 – 250 m (Dias *et al.* 2013). Nest density of *A. simoni* recorded at sites of 10 × 10 m in the three forests was much higher than 0.017, 0.023 and 0.033 m^{-2} recorded using a similar approach in three demarcated areas at Gilimale Forest Reserve in 1979 (Jayasuriya and Traniello 1985) and 0.15 and 0.10 m^{-2} of forest soil by laying quadrats in Kirikanda Forest in 2010 (Dias *et al.* 2013). Current findings indicate the present conservation status of *A. simoni* in Sri Lanka, which is reported as a Critically Endangered species (Social Insects Specialist Group (1996) cited in IUCN (2013)) should be re-assessed.

Environmental conditions at the time of detection of *A. simoni* in Gilimale Forest Reserve (Dias and Perera 2011), Sinharaja Forest Reserve (Perera *et al.* 2006), Kirikanda Forest (Dias *et al*. 2013) were comparable to those observed at each forest during the current survey. This suggest that future surveys for *A. simoni* should be conducted in areas with air temperature ranging between 21°C and 29°C, soil temperature between 21°C and 27°C, soil moisture % between 23.3 and 37 and a litter depth of between 2 and 6 cm. However, soil temperature tolerance range of *A. simoni* workers, as determined from a laboratory experiment (conducted with 40% soil humidity and pH = 6, in soil from Kirikanda Forest), was 23°C – 32°C, perhaps due to their ability of acclimation under laboratory conditions (Ruchirani, 2010). This species was not encountered in dry mixed evergreen forests, uncultivated lands, and

Table 2 Environmental conditions recorded at each site (mean ± S. D.) during the survey period.

Factor	KPFR	KKPFR	WFR
Air temperature °C	27.3 ± 0.6	29.0 ± 0.0	28.0 ± 1.0
Soil temperature °C	25.3 ± 0.6	26.3 ± 0.6	28.3 ± 1.2
% Soil moisture	26.6 ± 2.7	46.7 ± 17.8	36.1 ± 7.2
Soil pH	4.8 ± 0.3	7.4 ± 0.2	6.9 ± 0.21
Depth of leaf litter	3.9 ± 0.4	4.0 ± 1.0	5.0 ± 1.0
Weather during our observation	Slight rain followed by dry weather (heavy rain on the previous day)	Dry weather (heavy rain on the previous day)	Slight rain followed by dry weather (heavy rain on the previous day)

Table 3 Systematics, nest density and frequency of occurrence of ant species at each site of KPFR, KKPFR and WFR FNO = Frequency of Nest Occurrence. The data of our focal species are given in bold.

Subfamily	Species	KPFR		KKPFR		WFR	
		Nest density m^{-2}	FNO%	Nest density m^{-2}	FNO%	Nest density m^{-2}	FNO%
Aneuretinae	***Aneuretus simoni* Emery, 1893**	**0.3**	**7.5**	**0.93**	**23.3**	**0.27**	**6.7**
Dolichoderinae	*Tapinoma indicum* Forel,1895	–	–	0.13	3.3	–	–
	Tapinoma melanocephalum (Fabricius, 1793)	–	–	0.13	3.3	–	–
	Technomyrmex albipes (Smith F., 1861)	–	–	0.13	3.3	0.80	20
Formicinae	*Anoplolepis gracilipes* (Smith F., 1857)	-	-	0.13	3.3	0.27	6.7
	Nylanderia yerburyi (Forel, 1894)	0.1	2.5	–	–	0.27	6.7
	Polyrhachis illaudata Walker, 1859	0.1	2.5	–	–	–	–
Myrmicinae	*Cardiocondyla nuda* (Mayr, 1866)	–	–	0.27	6.7	–	–
	Myrmicaria brunnea Saunders, 1915	0.3	7.5	–	–	–	–
	Pheidole sp. 1	–	–	–	–	–	–
	Pheidole sp. 7	–	–	–	–	–	–
	Pheidole sp. 8	–	–	–	–	–	–
	Pheidole sp. 10	0.7	17.5	–	–	–	–
	Pheidole sp. 12	0.2	5.0	–	–	–	–
	Pheidole sp. 13	0.1	–	–	–	–	–
	Pheidologeton diversus (Smith F., 1858)	–	–	–	–	–	–
	Pristomyrmex sp.	–	–	–	–	0.13	3.3
	***Stereomyrmex horni* Emery, 1901**	**0.6**	**15**	–	–	**0.13**	**3.3**
	Solenopsis sp.	–	–	0.27	6.7	–	–
	Tetramorium bicarinatum (Nylander, 1846)	0.1	2.5	–	–	–	–
	Tetramorium sp.	–	–	–	–	–	–
Ponerinae	*Anochetus longifossatus* Mayr, 1897	–	–	–	–	0.13	3.3
	Hypoponera confinis (Roger, 1960)	1.3	32.5	0.13	3.3	0.27	6.7
	Leptogenys processionalis (Jerdon, 1851)	0.1	2.5	–	–	–	–
	Odontomachus simillimus Smith F., 1858	0.2	5.0	0.40	10.0	0.80	20.0
	Pachycondyla luteipes (Mayr, 1862)	–	–	0.13	3.3	–	–
	Pachycondyla rufipes (Jerdon, 1851)	–	–	0.13	–	–	–
	Ponera sp.	–	–	–	–	0.13	3.3

cultivated lands in the dry zone (air T °C: 25.2 – 34.8, soil T °C: 25.5 – 35.2, soil moisture %: 1.9 – 20.4) surveyed from November 2007 to October 2008 (Kosgamage 2011).

Stereomyrmex horni, another rare and endemic species to Sri Lanka, has previously been recorded from the dry zone in North Central Province (Fig. 2), and discovery at KPFR and WFR extends the range of this species to Western (KPFR) and Southern Provinces (WFR). The occurrence of *A. simoni* and *S. horni* together in two forests was further novel finding of this study, and points to a similar ecological niche for both species. Nest density of *S. horni* was recorded for the first time (Table 3).

In a previous ant survey in the dry zone of Sri Lanka, *S. horni* was detected in Anuradhapura Sanctuary (Dias *et al.* 2011) and air and soil temperature recorded during that survey (air T °C: 29.6 ± 0.9, soil T °C: 28.6 ± 1.3) were slightly higher than currently recorded values (air T °C 27.3, 28; soil T °C 25.3, 28.3), but soil moisture % (6.4 ± 1.6) was very low, while leaf litter was absent (Peiris, 2012). It seems, therefore, that *S. horni* can survive in habitats with a wide range of soil moisture conditions and in the absence of leaf litter.

Current findings confirm that surveys on these two rare and endemic ant species should be extended to other forests with environmental conditions similar to those reported here, and to Forest Reserves that lie close to the boundaries of Sinharaja Forest Reserve, in western and southern Provinces and Ratnapura District of Sri Lanka, to further re-assess their conservation status in Sri Lanka.

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