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Diversity of ants (Hymenoptera: Formicidae) in the University of Kerala Campus, Thiruvananthapuram, India

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ABSTRACT: Survey conducted on the ant diversity in the Kerala University Campus revealed a total 64 species under six subfamilies. Species belonging to the Myrmicinae dominated (51.5%) followed by Formicinae (20.6%), Ponerinae (13.2%), Dolichoderinae (4.4%), Pseudomyrmicinae (4.4%) and Dorylinae (1.5%). Endemic species *Camponotus invidus* Forel, 1892 *, Cardiocondyla parvinoda* Forel, 1902*, Carebara spinata* Bharti & Kumar, 2013 and *Tetramorium rossi* (Bolton, 1976) were recorded in the campus. *Anoplolepis gracilipes* (Smith, 1857)*, Paratrechina longicornis* (Latreille, 1802)*, Monomorium carbonarium* Smith 1858*, Solenopsis geminate* (Fabricius, 1804)*, Strumigenys membranifera* Emery, 1869*, Tetramorium bicarinatum* (Nylander, 1846) and *Hypoponera ragusai* (Emery, 1894) (introduced species) were found in the campus. The results showed that the campus is rich in ant diversity. The sites with human interference showed less diversity. A potential new species in the genus *Lepisiota* was recorded. *Trichomyrmex abberans, Carebara spinata, Crematogaster anthracina, Crematogaster biroi* and *Nylanderia indica* are new records.

KEYWORDS: Formicidae, subfamilies, Shannon-Wiener diversity index, Shannon Evenness Index, Margalef's index

Ants are one of the most important among insects in terms of their contribution to the ecosystem. They can function as ecosystem engineers by changing the chemical and microbial properties of the soil they occupy (Holec and Frouz, 2006). Ant mounds have been shown to increase the nitrates and phosphorus in the soil (Nkem *et al.*, 2000) and act as indicators of soil microbial biomass restoration (Andersen and Sparling, 1997). In addition to changing soil properties, ants also help in seed dispersal (Gammans *et al.*, 2005). They are important predators both in forests (Philpott and Armbrecht, 2006) and in agro-ecosystems (Mollot *et al.*, 2012). Ants have been reported as biocontrol agents in banana (Abera-Kalibata *et al*., 2008; Mollot *et al*., 2012; Wang *et al*., 2016), in mango and citrus (Offenberg *et al*., 2013; Thurman *et al.,* 2019). This is one of the main reasons they have been shown to increase crop yield (Offenberg and Wiwatwitaya, 2010; Evans *et al*., 2011) Ant species diversity can be used as indicators to environmental changes (Tiede *et al*. 2017). Microclimatic changes can cause ant diversity to change and this can be used in bio-monitoring (Perfecto and Vandermeer, 1996). Ants are well understood, easy to sample and have a high biomass and diversity, which

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strengthen the logic in using them as bio-monitoring tools. Ant diversity indices can be used much better as indicators compared to many other taxa (Osborn *et al.*, 1999).

The present study aims to understand the ant diversity in the University of Kerala Campus, Kariavattom, Thiruvananthapuram. There have been studies on ant diversity in campuses across India previously by many authors (Ramesh *et al.*, 2009; Yashavantakumar *et al*., 2016; Begum and Sandeep, 2018; Khan, 2018). This is the first comprehensive study of ants in the campus at Kerala University.

The survey was conducted for a period of three years from 2017 to 2019. Habitats were selected from the University of Kerala Campus (08^0 33'52.2"N and 076^0 53'14.8"E, elevation 53m above MSL). The entire campus, around 350 acres of land, divided into north and south regions were selected for the survey. From the north side, site 1 (Botanical garden), site 2 (mixed vegetation with bushy plants) and site 3 (woody plantation) were selected. From south region, site 4 (fruit trees predominantly sapota), site 5 (monoculture *Acacia* plantation), site 6 (mixed vegetation), and site 7 (bank area of a freshwater pond) were selected (Plate 1).

In each site five quadrants each with an area of 20x20 m^2 were marked and secured from human intervention. Methods used for collecting the ants include, litter sifting, beating low vegetation, and pitfall trap. Litter was collected from 1x1 m^2 quadrats. Hand picking was also done to ensure complete coverage of the sites. Ants collected were preserved (in 70% alcohol) immediately after collection (Agosti *et al.,* 2000). Identification of ants were done as per the keys (Bingham, 1903; Bolton, 1994; Bharti and Kumar 2012; Bharti and Wachkoo 2013a, b; Bharti *et al*., 2013, 2016; Bharti and Akbar 2014a, b). The specimens were processed, labeled and deposited in the museum of the Department of Zoology, University of Kerala. Photographic records of the specimens were taken for future reference. A checklist of all the species collected within the campus was prepared. The diversity indices (Shannon-Wiener diversity index, Shannon Evenness Index and Margalef's index) for the seven different habitats were calculated using the statistical software PAST, 2005.

A total of 710 ants were collected from the seven selected sites, comprising 64 species of ants belonging to six subfamilies viz., Dolichoderinae, Formicinae, Myrmicinae, Ponerinae, Pseudomyrmicinae and Dorylinae (Table 1). Maximum number of species recoerded was in the subfamily Myrmicinae (51.5%), followed by Formicinae (20.6%), Ponerinae (13.2%), Dolichoderinae (4.4%), Pseudomyrmicinae (4.4%) and Dorylinae (1.5%). The number of individuals collected was highest in Formicinae with 187 (52.8%), followed by Myrmicinae (122). Myrmicinae subfamily was more species rich with 34 species.

The presence/absence of ants recorded in the different sites is given in Table 1. Site 2 was more speciose with 43 species, while sites 5 and 7 showed lower species number, 14 and 19 species respectively. Site 1, 2 and 3 in north campus were more diverse (Table 2). The low species indices' rate in the south campus sites 4, 5, 6 and 7 could be due to high human interference. The south campus had more human intervention because most of the area was covered with buildings with little vegetation. Site 5 being a monoculture plantation was one of the reasons for the low diversity index (1.887). Monoculture plantations had low diversity because there were few diverse sources of habitat and food. During the study, there was construction work going on in the area near site 7. Anthropogenic factors like human interference and habitat fragmentation may have been the cause of lowered species diversity (Floren *et al*., 2001;Walter *et al.,* 2018; Martello *et al.,* 2018). This could explain the lowered species index (1.762) in site 7. Site 1 and 6 had more evenly distributed diversity indices (0.5328 and 0.5265 respectively). Site 1 was a botanical garden with a large variety of plants while site 6 had mixed vegetation. The diversity of the habitats in the area reflected in the species distribution. Overall, the site 1 Botanical garden was the most even and diverse site in this study. This shows that an area with natural diverse habitats

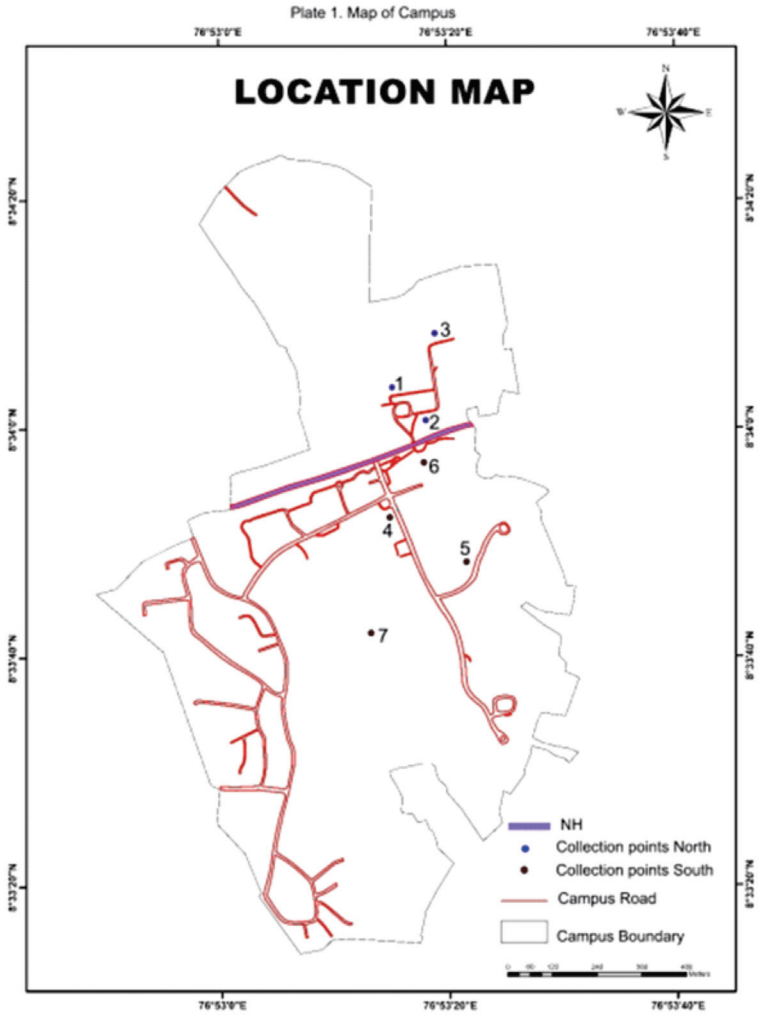

Fig. 1 Map of University of Kerala Campus

can ensure a better diversity for the region. Site 7 was the least diverse site showing that human interference is indeed unhealthy for the ecosystem (Bestelmeyer and Wiens, 1996). The north campus has only three buildings and is covered mostly with dense undisturbed vegetation. It also has a sacred groove which shows that the area is an undisturbed habitat. Consequently, we can find that the species richness is higher as well. The undisturbed habitat has ensured that the species diversity is higher (Walter *et al.,* 2018).When compared with previous studies on ant diversity in campuses, it can be seen that the University of Kerala campus has higher diversity (Yashavantakumar *et al.*, 2016; Ugare *et al.*, 2019).This shows that even though it is an urban area the region is ecologically important.

Anoplolepis gracilipes (Smith, 1857)*, Camponotus compressus* (Fabricius, 1787)*, C. invidus* Forel, 1892*, C. parius* Emery, 1889*, C. rufoglaucus* (Jerdon, 1851)*, Oecophylla smaragdina* (Fabricius, 1775)*, Meranoplus bicolor* (Guerin-Meneville, 1844)*, Monomorium floricola* (Jerdon, 1851)*, Diacamma rugosum* (Le Guillou, 1842) and *Odontomachus simillimus* Smith, 1858 were present in almost all sites. *Anoplolepis gracilipes* is an invasive species which can explain its presence in all sites (Holway *et al.,* 2002). *Odontomachus simillmus* is known to inhabit in

Plate 2. Ants

New Record in Kerala

Fig. 1 *Trichomyrmex aberrans*

Fig. 2 *Nylanderia indica*

Fig. 3 *Crematogaster anthracina*

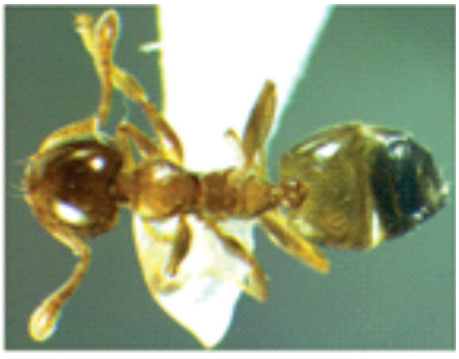

Fig. 4 *Crematogaster biroi*

Fig. 5 *Tetramorium bicarinatum*

;

disturbed areas. *Camponotus* spp. and *D. rugosum* are more generalist feeders and have more resilience to habitat disturbances (Abe and Uezu, 1977). *Plagiolepis jerdonii* Forel, 1894, *Polyrhachis tibialis* Smith, 1858, *Cardiocondyla parvinoda* Forel, 1902, *Carebara spinata* Bharti & Kumar, 2013, *Crematogaster anthracina* Smith, 1857, *C. dohrni* Mayr, 1879, *Monomorium carbonarium* Smith 1858, *Pheidole constanciae* Forel, 1902, *P. peguensis* Emery, 1895, *Strumigenys membranifera* Emery, 1869, *Trichomyrmex abberans* (Forel, 1902), *T. glaber* (Andre, 1883), *Hypoponera confinis* (Roger, 1860), *H. ragusai* (Emery, 1894), *Parvaponera darwinii* (Forel, 1893), *Platythyrea parallela* (Smith, 1859), *Tetraponera aitkenii* (Forel, 1902), *T. allaborans* (Walker, 1859) and *Cerapachys sp.* were found only in one site. Most of these ants

Table 1. Checklist of ants at University of Kerala and their presence in different sites with indication of species endemic (E) and indigenous to India (I)

Sl. No	Subfamily/ Scientific name	Sites	Sl. No	Subfamily/ Scientific name	Sites
	Dolichoderinae		26.	*Crematogaster dohrni* Mayr, 1879	2
1.	*Tapinoma indicum* Forel, 1895	2, 3	27.	*Crematogaster flava* Forel, 1886	1, 2
2.	*Tapinoma melanocephalum* (Fabricius, 1793)	1, 2, 6, 7	28.	*Crematogaster rothneyi* Mayr, 1879	1, 2, 3, 4, 7
3.	*Technomyrmex albipes* (Smith, 1861)	1, 4	29.	*Lophomyrmex quadrispinosus* (Jerdon, 1851)	2, 6
	Formicinae		30.	*Meranoplus bicolor* (Guerin-Meneville, 1844)	1, 2, 4, 5, 6,7
4.	*Anoplolepis gracilipies* (Smith, 1857) —— (I)	1, 2, 3, 4, 5, 6,7	31.	*Messor himalayanus* (Forel, 1902)	3, 5
5.	*Camponotus compressus* (Fabricius, 1787)	1, 2, 3, 4, 5, 7	32.	*Monomorium bicolor* (Bolton, 1987)	1, 4, 5
6.	*Camponotus invidus* Forel, 1892 —— (E)	1, 2, 7	33.	*Monomorium carbonarium* Smith 1858 —— (I)	2
7.	*Camponotus irritans* (Smith, 1857)	2, 3	34.	*Monomorium floricola* (Jerdon, 1851)	1, 2, 4, 5, 6,7
8.	*Camponotus parius* Emery, 1889	1, 2, 4, 5, 6, 7	35.	*Monomorium orientale* Mayr, 1879	1, 2
9.	*Camponotus rufoglaucus* (Jerdon, 1851)	1, 2, 3, 4, 5, 6,7	36.	*Pheidole constanciae* Forel, 1902	4
10.	*Camponotus sericeus* (Fabricius, 1798)	1, 2, 3, 4, 7	37.	*Pheidole peguensis* Emery, 1895	4
11.	*Camponotus sp.* Mayr, 1861	2	38.	*Pheidole* sp. 1 Westwood, 1839	3
12.	*Lepisiota sp.* Santschi, 1926	1	39.	*Pheidole* sp. 2 Westwood, 1839	3
13.	*Nylanderia indica* (Forel, 1894)	6, 7	40.	*Solenopsis geminata* (Fabricius, 1804) —— (I)	2, 7
14.	*Oecophylla smaragdina* (Fabricius, 1775)	1, 2, 3, 4, 5, 6,7	41.	*Strumigenys membranifera* Emery, 1869 —— (I)	2
15.	*Paratrechina longicornis* (Latreille, 1802) —— (I)	1, 3, 6, 7	42.	*Strumigenys aduncomala* De Andrade, 2007 —— (E)	2, 3
16.	*Plagiolepis jerdonii* Forel, 1894	2	43.	*Tetramorium bicarinatum* (Nylander, 1846) ——- (I)	1, 2, 3
17.	*Polyrhachis exercita* (Walker, 1859)	1, 2, 3, 5	44.	*Tetramorium inglebyi* Forel, 1902	1, 2, 3, 4
18.	*Polyrhachis scissa* (Roger, 1862)	1, 6	45.	*Tetramorium lanuginosum* (Mayr, 1870)	1, 3
19.	*Polyrhahis thrinax* Roger, 1863	2, 3, 6, 7	46.	*Tetramorium obesum* Andre, 1887	1, 2
20.	*Polyrhachis tibialis* Smith, 1858	4	47.	*Tetramorium rossi* (Bolton, 1976) —— (E)	1, 2, 4
	Myrmicinae		48.	*Tetramorium walshi* (Forel, 1890)	1, 3, 6
21.	*Cardiocondyla parvinoda* Forel, 1902 —— (E)	1	49.	*Tetramorium smithi* Mayr, 1879	3, 4
22.	*Cardiocondyla wroughtonii* (Forel, 1890)	3, 6, 7	50.	*Trichomyrmex abberans* (Forel, 1902)	3
23.	*Carebara spinata* Bharti & Kumar, 2013 —— (E)	2			
24.	*Crematogaster anthracina* Smith, 1857	5			
25.	*Crematogaster biroi* Mayr, 1897	1, 2, 3			

Sl. No	Subfamily/ Scientific name	Sites	Sl. No	Subfamily/ Scientific name	Sites
51.	*Trichomyrmex glaber* (Andre, 1883)	1		Smith, 1858	1, 2, 4, 5, 6
	Ponerinae		59.	*Parvaponera darwinii* (Forel, 1893)	2
52.	*Anochetus graeffei* Mayr, 1870	1, 2, 3, 6	60.	*Platythyrea parallela* (Smith, 1859)	*4*
53.	*Brachyponera jerdonii* (Forel, 1900)	1, 2, 3, 6		Pseudomyrmecinae	
54.	*Diacamma rugosum* (Le Guillou, 1842)	1, 2, 3, 4, 5, 6, 7	61.	*Tetraponera aitkenii* (Forel, 1902)	2
55.	*Hypoponera confinis* (Roger, 1860)	6	62.	*Tetraponera allaborans* (Walker, 1859)	2
56.	*Hypoponera ragusai* (Emery, 1894) —— (I)	1	63.	*Tetraponera nigra* (Jerdon, 1851)	1, 3
57.	*Leptogenys peuqueti* (Andre, 1887)	1, 2, 3, 7		Dorylinae	
58.	*Odontomachus simillimus*		64.	*Cerapachys sp.* Smith, F., 1857	2

(E) - Species endemic to India; (I) - Species indigenous to India

Table 2. Diversity indices in the different sites of campus

Site	No. of species	Shannon-Wiener	Shannon Evenness	Margalef's Index
1	37	2.981	0.5328	6.146
2	43	2.63	0.3302	4.407
3	29	2.574	0.4858	6.796
4	20	2.232	0.4657	4.288
5	14	1.887	0.4712	3.215
6	20	2.254	0.5265	4.212
7	19	1.762	0.3066	3.722
North Campus	61	3.207	0.4752	8.593
South Campus	32	2.66	0.4085	5.782

were found in only site 2 which perhaps due to the site being mixed vegetation as it provides more microhabitats for different ants.

In addition to the high species diversity five species, *Trichomyrmex abberans, Carebara spinata, Crematogaster anthracina, C. biroi,* and *Nylanderia indica* were found as new records from Kerala (Figs. 1-5) and the specimens were deposited at Department of Zoology, University of Kerala, Kariavattom. The first records were published as two papers (Antony *et al.*, 2018; Antony and Prasad, 2019) (Figs. 6-8). *A potential new species belonging to the genus, Lepisiota* was also found and the species is yet to be identified. These range extensions were identified using Bharti *et al.* (2016). *Camponotus invidus, Cardiocondyla parvinoda, Carebara spinata,* and *Tetramorium rossi* are species endemic to India found in the campus. *Anoplolepis gracilepis, Paratrechina longicornis, Monomorium carbonarium, Solenopsis geminata, Strumigenys membranifera, Tetramorium bicarinatum,* and *Hypoponera ragusai* are introduced species found in the campus.

The present study shows that the University of Kerala Campus, Kariavattom, is highly species rich with numerous endemic species of ants. The diversity patterns found in the study are similar to that found in previous studies where human interference showed a lowered diversity. The campus diversity must be preserved to ensure the better conservation of ant species. The results also show that ant diversity can be used to understand the anthropogenic impact on forested areas.

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