

ANT SPECIES RICHNESS AND DIVERSITY IN SOME SELECTED LOCALITIES IN WESTERN GHATS, INDIA

**Raghavendra Gadagkar, Padmini Nair, K. Chandrashekara
and D.M. Bhat**

Centre for Ecological Sciences, Indian Institute of Science,
Bangalore - 560 012, INDIA.

ABSTRACT

We have sampled ants from twelve different localities in the Uttara Kannada district of Karnataka, India using both a package of standardized trapping methods as well as by intensive all-out-search. The relative efficacies of trapping versus all-out-search are compared. Different methods of trapping are also compared among themselves. A check list of all ants seen by all methods put together, identified up to the genus level is provided. Different localities are compared by the similarity and diversity of their ant fauna. A weak but statistically significant positive correlation between ant species diversity and plant species diversity is demonstrated. This report provides the first estimates of the diversity and abundance of ants for any forest habitat of India.

INTRODUCTION

Social insects in general, and ants in particular, have achieved unprecedented ecological success and dominance in tropical ecosystems. In a Brazilian tropical forest, ants have been estimated to have a biomass four times that of all vertebrates put together (Wilson, 1990). Being such dominant and successful components of ecosystems, it is likely that ants would turn out to be good indicators of the well-being of ecosystems (Daniels, 1991). And yet methods reliable for sampling of ants are entirely inadequate (Romero and Jaffe, 1989). More surprising is the fact that very little information exists regarding the ant fauna, and even less regarding its success and dominance in the tropical forests of Asia. We report here the results of a study of ant species diversity in some selected localities of Western Ghats in Southern India and provide the first estimates of ant species richness and diversity for any Indian forest habitat.

MATERIALS AND METHODS

Study sites - All our study sites were located in the Uttara Kannada district of the state of Karnataka, India. The forested study sites fall broadly into two categories reflecting different levels of disturbance, namely, the Reserve Forests (R.F.) (relatively less disturbed) and the Minor Forests (M.F.) (relatively more

disturbed) Sites representing both these categories were chosen in the coastal plains as well as at higher elevations (approximate altitude 600 m).

Selection of study sites in this manner ensured that these sites represented habitats under different environmental conditions and levels of disturbance. In addition to these forested habitats, three monoculture plantations (Pl.) and a leaf manure forest (Betta land) were also chosen for study. At each of these sites, sampling was carried out in three one hectare plots. Thus a total of 36 one hectare plots from 12 habitat types were sampled. A brief description of each study site is given in Table 1. The study was carried out during December, January, February and March which is part of the dry season in these localities.

Sampling Methods

Trapping Methods - Four trapping methods were employed. All insects caught in the traps were collected and identified up to the family level. A preliminary analysis of data from all insects in general is given in Gadagkar *et al.* (1990). A more detailed analysis of ants, identified up to the genus level is given in this paper.

1. **Light trap** - a portable light trap which can be easily assembled and dismantled was fabricated using locally available inexpensive material. The light trap uses a 10 inch fluorescent light source (Eveready Fluorolite; 6 watts) powered by 1.5 volt battery cells. The main framework of the trap consists of four iron legs, an aluminium roof and two aluminium baffles, between which the light source is placed. Insects attracted to the light were collected through a funnel in a cyanide jar, below the light. One light trap was placed in the centre of the plot. The light was switched on at dusk and allowed to burn itself out as the batteries drained after about seven hours. The insects trapped in the jar were collected the next morning and preserved in 70% alcohol.
2. **Net Sweeps** - Net sweeps were carried out to collect insects off the vegetation. The nets used in systematic sweeping of the ground level vegetation were made of thick cotton cloth with a diameter of 30 cm at the mouth and a bag length of 60 cm. For carrying out net sweeps the plot was divided into 100 quadrats, measuring 10m x 10m each. Six such quadrats were chosen at random and the entire ground level vegetation in the chosen quadrat was covered during the sweeping. Net sweeps were always done between 10.00 h - 12.00 h. The insects collected from each quadrat were transferred into polythene bags containing a cotton wad dipped in chloroform. Insects were later separated from the litter and preserved in vials containing 70% alcohol.
3. **Pit-fall traps** - The pit-fall traps consisted of a 2.5 litre plastic jar with an opening of 9 cm in diameter, buried at ground level and protected from rain by a tripod stand carrying a plastic plate of about 30 cm diameter at a distance of about 15 cm above the ground. One pit-fall trap was placed in each of the five randomly chosen 10m x 10m quadrats. Each jar carried 25 ml of 0.05%

Table 1. A brief description of study sites

Sites	Vegetation type	Dominant tree species	Remarks
Santagal R.F.	Evergreen	<i>Cinnamomum</i> , <i>Bischofia</i> and <i>Diospyros</i> spp.	Thick tree canopy, understorey of Cane breaks.
Nagur R.F.	Evergreen	<i>Holtgarna</i> and <i>Hopea</i> spp.	Thick tree canopy understorey of saplings.
Mirjan M.F.	Scrub	<i>Ixora</i> , <i>Buchnanla</i> and <i>Terminalla</i>	Highly degraded semi- evergreen.
Chandavar M.F.	Semi-evergreen	<i>Ixora</i> , <i>Aporosa</i> and <i>Hopea</i> spp.	Degraded, understorey of frequently lopped saplings.
Bengle M.F.	Moist deciduous	<i>Terminalla</i> spp.	Degraded, thick undergrowth of grass and annual herbs.
Bidaralli R.F.	Moist deciduous	<i>Terminalla</i> , <i>Xylta</i> and <i>Lagerstromia</i> spp.	Undergrowth of herbs and shrubs mainly <i>Clerodendrum</i> .
Sonda R.F.	Moist deciduous	<i>Terminalla</i> , <i>Xylta</i> and <i>Aporosa</i>	Understorey mainly of <i>Psychotria</i> spp.
Bhairumbe M.F.	Moist deciduous	<i>Caryea</i> , <i>Ziziphus</i> and <i>Randia</i>	Degraded, undergrowth of <i>Chromelina</i> .
Betta land	Moist deciduous	<i>Terminalla</i> and <i>Lagerstromia</i>	Cleared of all undergrowth, maintained for leaf manure.
<i>Eucalyptus</i> Pl.	Monoculture	<i>Eucalyptus</i> spp.	Thick undergrowth of grass and herbs, surrounded by extensive moist deciduous forest.
Teak Pl.	Monoculture	<i>Tectona grandis</i>	Little or no undergrowth except <i>Lantana</i> and <i>Chromelina</i> .
<i>Areca</i> Pl.	Monoculture	<i>Areca catechu</i>	Plantations in valleys, surrounded by evergreen forest on hills.

methyl parathion. The traps were set up between 15.00 h and 17.00 h and were collected the next morning. Insects trapped in the jars were preserved in 70% alcohol. 4. Scented traps - A plastic jar of 2.5 litre capacity was used to fabricate a scented trap. The mouth of the jar was shielded from rain water using a plastic plate allowing a gap of 6 cm between the mouth of the jar and the plastic plate so that insects could freely move into the jar. The trap was baited with 200 ml of saturated jaggery (unrefined cane sugar) solution with two tablets of baker's yeast, 0.05% methyl parathion emulsion and 0.5 ml of pineapple essence. The traps were hung at about 1 m from the ground on a wooden peg. Five such traps were used, one each in the centre of a randomly chosen 10m x 10m quadrat. The scented traps were also set between 15.00 hr and 17.00 hr and collected the following morning. Insects trapped in the jaggery solution were filtered, washed and preserved in 70% alcohol.

Thus one light trap placed in the middle of a one hectare plot working for about 7 hrs (19.00 h to 2.00 h), net sweeps in 6 randomly chosen 10m x 10m quadrats, 5 randomly placed pit-fall traps and 5 randomly placed scented traps, both working for about 18 hrs each constituted one sampling unit.

All-out-search - In addition to trapping insects by the methods described above, an intensive all-out-search to physically collect representatives of as many species of ants as possible was made in each one hectare plot. To the extent possible, the effort involved in this was kept constant. Two persons made the search for one hour between 14.00 h to 15.00 h in every case. No attempt was made to estimate abundance by this method.

Preservation of specimens and data recording - All insects (except large moths) were stored in alcohol for future sorting. Ants were identified up to the genus level according to the keys by B. Bolton (Holldobler and Wilson, 1990) and within each genus, recognizable taxonomic units (RTU) were separated based on morphological differences. For convenience, the RTUs will be referred to as species throughout this report.

Data analysis

α Diversity: As an index of α (within site) diversity, we computed α of the log series (Fischer *et al.*, 1943) given by the equation,

$$S = \alpha \log_e (1 + N/\alpha)$$

where S is the number of species in the sample, N is the number of individuals in the sample, and α is the index of diversity. α was computed by an iterative procedure.

The standard deviation of α was estimated as $\alpha/\{-\log(1-X)\}$ where $X = N/(N + \alpha)$ (Anscombe, 1970). Using the standard deviation, significant differences in diversity between habitats were judged by a z test. This index is often recommended as a useful measure of α diversity even when the underlying distribution is not necessarily a log series (Krebs, 1985).

β Diversity: β (between sites or between method) diversity was estimated as coefficients of similarity given by the Morishita-Horn index (after Wolda, 1981),

$$C = \frac{2 \sum(n_{1i} \cdot n_{2i})}{(\lambda_1 + \lambda_2) \cdot N_1 N_2}$$

$$\text{when } \lambda_j = \frac{\sum n_{ji}^2}{N_j^2}$$

when n_{ji} is the number of individuals of species i in sample j and n_j is the number of individuals in sample j . The index was computed with data logarithmically transformed as $\ln(n_{ji} + 1)$. Cluster analysis was performed using a simple-linkage algorithm. Where only presence-absence data were available, such as with all-out-search, the Jaccard index was used to compute similarity (Ludwig and Reynolds, 1988).

RESULTS AND DISCUSSION

The Ant Fauna - The ant fauna of the 12 localities in Uttara Kannada district of Karnataka as revealed by all the sampling methods as well as all-out-search consists of 6 subfamilies, 32 genera and 140 species (Table 2).

Trapping versus all-out-search - Since sampling methods for ants are still being worked out it is useful to compare our success by different methods used. The use of trapping methods was somewhat more successful than all-out-search. All the six subfamilies were represented in both methods and, while the traps yielded 31 genera and 120 species, all-out search yielded 27 genera and 101 species (Table 3). More important, the traps and all-out-search yield quite different species; 78 species were common, the traps yielded 42 unique species and all-out-search 20 unique species. The similarity between all traps put together on the one hand and all-out-search on the other was 0.55 (Jaccard index). A combination of both methods is therefore recommended.

Table 2. Ants collected from twelve localities in Western Ghats by a combination of quantitative sampling methods & all-out-search

Subfamilies	Genera	Number of Species
Ponerinae	<i>Cryptopone</i>	2
	<i>Diacamma</i>	1
	<i>Leptogenys</i>	2
	<i>Pachycondyla</i>	3
Dorylinae	<i>Aenicuts</i>	2
	<i>Dorylus</i>	3
Pseudomyrmecinae	<i>Tetraponera</i>	3
Myrmicinae	<i>Aphaenogaster</i>	1
	<i>Cardiocondyla</i>	3
	<i>Cataulacus</i>	2
	<i>Crematogaster</i>	14
	<i>Leptothorax</i>	2
	<i>Lophomyrmex</i>	2
	<i>Meranoplus</i>	2
	<i>Monomorium</i>	17
	<i>Myrmicaria</i>	1
	<i>Pheidole</i>	24
	<i>Pheidologeton</i>	3
	<i>Solenopsis</i>	1
	<i>Tetramorium</i>	5
<i>Trigonogaster</i>	1	
Dolichoderinae	<i>Iridomyrmex</i>	1
	<i>Tapinoma</i>	9
	<i>Technomyrmex</i>	1
Formicinae	<i>Acantholepis</i>	4
	<i>Anoplolepis</i>	1
	<i>Camponotus</i>	12
	<i>Oecophylla</i>	1
	<i>Paratrechina</i>	2
	<i>Plagiolepis</i>	5
	<i>Polyrhachis</i>	6
	<i>Prenolepis</i>	4
Total : 6	32	140

Table 3. Comparison of ant diversity as measured by quantitative sampling (combination of light trap, net sweeps, scented traps and pit-fall traps, see methods) and all-out-search

	Sampling	All-out-Search
Number of Subfamilies	6	6
Number of Genera	31	27
Number of Species	120	101

Comparison of different methods of trapping - Of the four methods used, Pit-fall traps were most successful followed by Net Sweeps, Scented traps and Light traps, in that order. The fact that Pit-fall traps and Net Sweeps were far more successful is not surprising because crawling insects would most likely be trapped by these methods. What is surprising is that scented traps and light traps yielded a substantial number and diversity of ant fauna (Table 4). It is also interesting that although ant species trapped by net sweeps and pit-fall traps are more similar than those trapped by other methods, there is considerable variation in ant fauna trapped by these two methods (Fig.1A). Comparing ants obtained by each trapping method and by all-out-search using a Jaccard index, we find that ants caught in pitfall traps and those obtained from all-out-search yield the most similar fauna while other methods of trapping, especially scented traps and light traps yield rather different sets of species (Fig.1B). A combination of several different methods for collecting ants is thus of considerable use.

Table 4. Comparison of ant diversity as revealed by different sampling methods

	Light Trap	Net Sweep	Pit-Fall Trap	Scented Trap
Number of Subfamilies	4	5	5	5
Number of Genera	8	21	28	13
Number of Species	15	61	91	32
Number of Individuals	45	709	1896	112

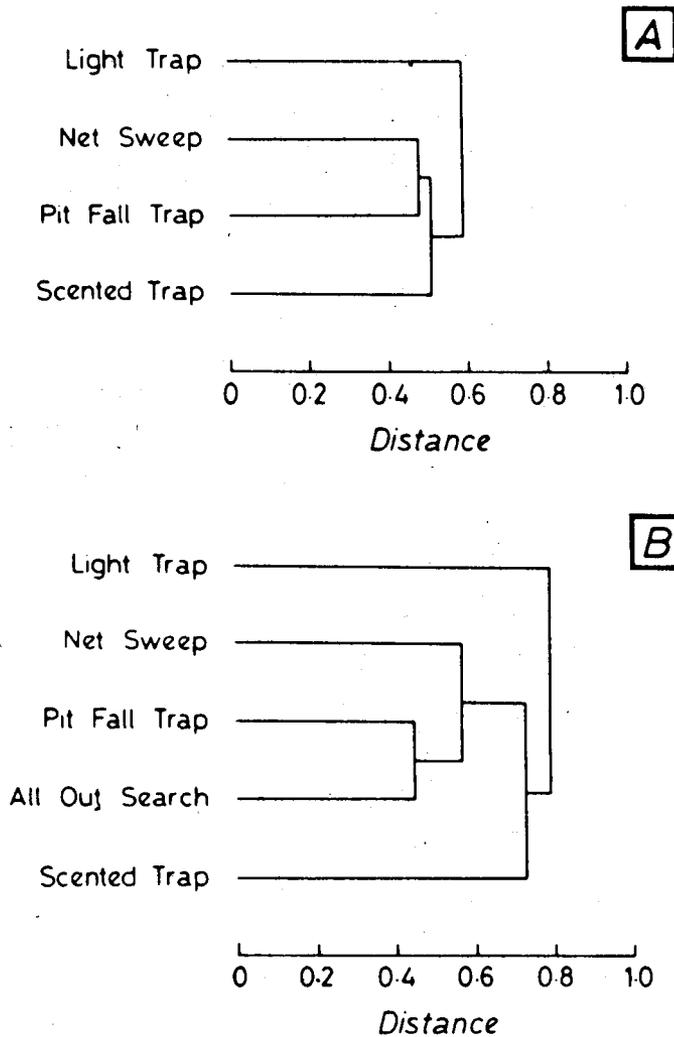


Fig.1 Dendrograms comparing different sampling methods by ant species trapped. Data pooled from 36 plots for each sampling method. A, distance = 1 - Morishita-Horn index of similarity. B, distance = 1 - Jaccard index

Ant diversity and abundance in Western Ghats - Our results provide the first estimates of ant diversity and abundance for any forest localities of India (Table 5). 8 to 16 genera and 13 to 33 species were caught from 3 hectares of sampling in each of the 12 localities studied. It is not easy to compare these numbers with any other regions of the world. The number of studies are few and use very different methods. Nevertheless the compilation of available literature shows that ant species richness (we can say even less about α diversity because even fewer estimates are available for other regions) in the region studied by us compare reasonably with other tropical habitats of the world (Table 6). Ants accounted for 5.4 to 12.8% of all insect species caught in these localities and 5.1 to 43.2% of all insect numbers caught (see Gadagkar *et al.* 1990, for data on other insect groups sampled in these plots). Although these figures may not match up to some estimates from Brazilian forests where ants constitute 30% of the arboreal arthropod fauna (Wilson, 1990), the numbers given above show that ants constitute a substantial proportion of our insect fauna.

Table 5. Comparison of ant abundance and diversity in different localities

Locality (see Table 1)	No. of Subfamilies	No. of Genera	No. of Species	No. of Individuals	Diversity index (α of log series)	% Ant Species among all insect species trapped	% Ants among all insects trapped
Santagal R.F.	2	10	25	104	10.44	12.7	18.2
Nagur R.F.	5	15	32	159	12.07	21.2	21.9
Mirjan M.F.	5	16	27	149	9.64	12.6	5.1
Chandavar M.F.	5	16	30	118	12.98	12.8	7.0
Bengle M.F.	4	15	29	344	7.55	9.2	22.5
Bidaralli R.F.	3	16	33	423	8.37	10.0	32.4
Sonda R.F.	5	12	21	132	7.04	11.4	20.9
Bhairumbe M.F.	4	14	19	124	6.26	11.0	19.0
Betta Land	4	14	25	267	6.75	10.6	24.2
Eucalyptus PL	4	16	25	368	6.06	6.1	11.6
Teak PL	3	8	16	155	4.48	13.7	43.2
Areca PL	4	9	13	419	2.54	5.4	19.2

Comparison of localities based on ant fauna - The diversity of the ant fauna varied considerably between the 12 localities. Indeed, the several pairs of localities could be distinguished from each other by being significantly different in their levels of diversity of the ant fauna (Table 7). However, no obvious pattern in the similarities between localities were evident when they were compared by a β diversity index (Figure 2). The similarity index varied between about 0.3 to 0.6. This is in contrast to a similar comparison of these localities by all insects trapped, put together, when localities clustered according to their elevation (Gadagkar *et al.*, 1990).

Table 6. Ant species richness in different regions of the world

Locality	Method of Collection	Area	No. of Genera	No. of Species	Reference
Welaka Reserve Florida	-	8 sq.km	30	76	Van Pelt (1956)
North-east Papua New Guinea	-	2.6 sq.km	59	172	Wilson (1959)
Agudos (Sao Paulo, Brazil)	-	2.6 sq.km (approx.)	71	272	Kempf (1964)
Cocoa Plantation Tafo, Ghana	-	2.6 sq.km	63	219	Balton (cited in Room, 1971)
George Reserve Michigan, USA	-	5.6 sq.km	23	87	Talbot (1975)
Amazonian forests, Peru	Fogging	-	40	135	Wilson (1987)
Rio Yuyapichis, Peru	-	-	71	350	Verhaagh (cited by Holldobler and Wilson, 1990)
Cocoa Plantation Ilheus, Bahia Brazil	Berlese funnel extractions from leaf litter	1 ha	-	112	Delabie and Fowler (1990)
Cuzco Amazonico Reserve, Peru	Litter sifting and hand colln.	-	64	256	Cover <i>et al</i> (1990)
Brazilian rainforest	Pit-fall traps and baited traps	-	36	118	Majer and Queiroz (1990)
Australian rainforest	Pit-fall traps and baited traps	-	35	102	Majer and Queiroz (1990)
Tropical forest Chiapas, Mexico	Pit-fall traps baited traps and hand collection	-	28	71	Mackay <i>et al</i> (1991)

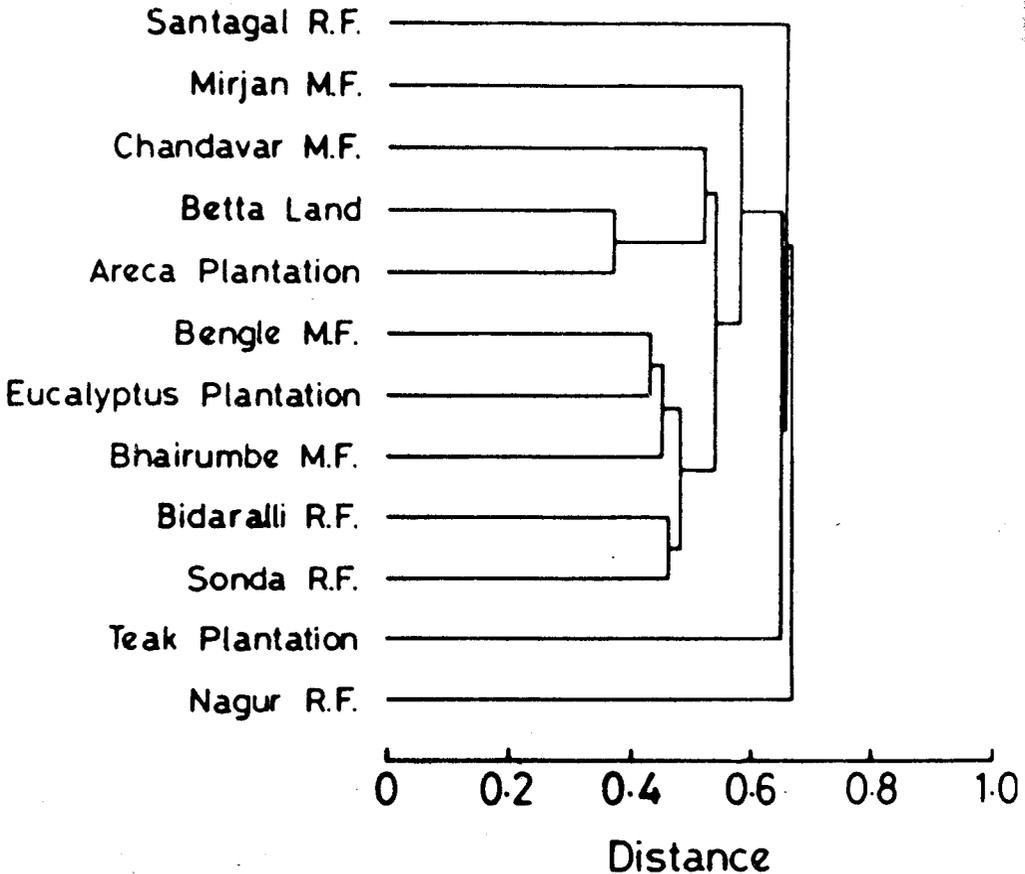


Fig.2 Dendrogram comparing different localities by their ant species diversity (distance = 1 - Morishita-Horn index of similarity). Data pooled from three one hectare plots for each locality

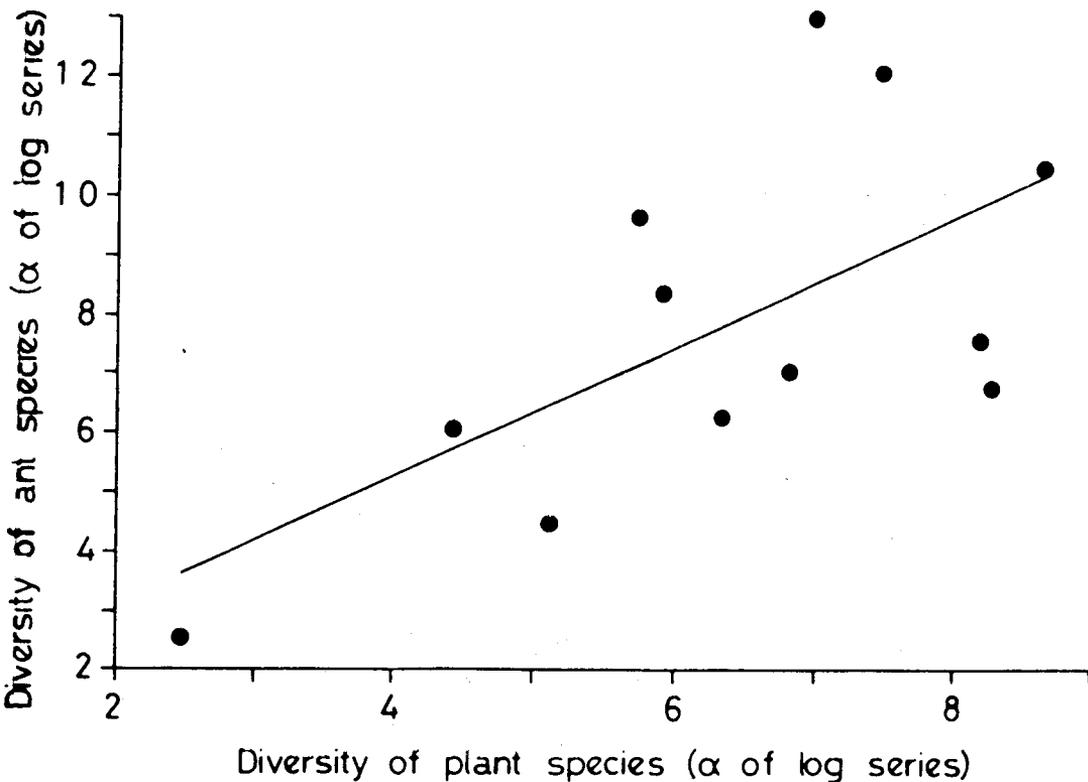


Fig.3 Scatter plot showing the relationship between plant species diversity and ant species diversity. For both ants and plants, diversity is measured by α of the log series. The fitted line is given by the equation $Y = 0.99 + 1.08X$. The slope is significantly greater than zero, $p < 0.02$. The relationship between ant species diversity and plant species diversity is also evident from a correlation analysis: Pearson product moment correlation = 0.63, $p < 0.05$; Kendall's rank correlation coefficient = 0.42, $p = 0.05$.

The possible causes of variation in ant diversity - Although small sample sizes (we studied only 12 localities) preclude us from drawing any firm conclusion regarding the possible causes for variation in ant diversity from locality to locality, two trends are evident. The first is that disturbed localities show lower richness and diversity in their ant fauna. This is particularly clear with the monoculture plantations and the Betta land (Table 5). There is evidence in the literature for reduction in ant diversity due to disturbance. A significant reduction in ant species richness was found after slashing and burning of a tropical forest in Mexico (Mackay *et al.*, 1991). We find a weak but statistically significant positive correlation between ant species diversity and plant species diversity; the latter was measured in a parallel study of plant diversity in the same plots where the ants were trapped (Bhat *et al.*, 1987) (slope of linear regression significantly different from zero, $p < 0.01$; Pearson product moment correlation = 0.63, $P < 0.05$; Kendall's rank correlation coefficient = 0.42, $p = 0.05$) (Figure 3). This is in contrast to an inverse correlation between bird species richness and woody plant species diversity noted in the same general locality (Daniels *et al.*, 1992).

We believe that the results of this preliminary study justify the launching of more detailed investigations on the role of ants in tropical forests of Western Ghats, on the possible use of ants as indicators of ecological disturbance and of on the causes of variations in ant species diversity richness.

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REFERENCES

- Andersen, A.N. 1992. Regulation of "momentary" diversity by dominant species in exceptionally rich ant communities of the Australian seasonal tropics. *Am. Nat.*, 140: 401-420.
- Anscombe, F.J. 1970. Sampling theory of the negative binomial and logarithmic series distributions. *Biometrika*, 37: 358-382.
- Bhat, D.M., S.N. Prasad, M. Hegde, and C.J. Saldanha. 1987. Plant diversity studies in Uttara Kannada district. *Technical Report No.9*, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.

- Cover, S.P., J.E. Tobin and E.O. Wilson. 1990. The ant community of a tropical lowland rain-forest site in peruvian amazonia. In: *Social Insects and the Environment*. G.K. Veeresh, C.A. Viraktamath, and B. Mallik, (Eds.) *Proc. of 11th International Congress of IUSSI. Bangalore, India*, P.699-700.
- Daniels, R.J.R. 1991. Ants as biological indicators of environmental changes. *Blackbuck*, 7: 51-56.
- Daniels, R.J.R., N.V. Joshi and M. Gadgil. 1992. On the relationship between bird and woody plant species diversity in the Uttara Kannada district of South India. *Proc. Natl. Acad. Sci. (U.S.A)* 89: 5311-5315.
- Delabie, J.H.C. and H.G. Fowler. 1990. Cryptic species assemblages in tropical and temperate latitudes. In: *Social Insects and the Environment*. G.K. Veeresh, C.A. Viraktamath, and B. Mallik, (Eds.), *Proc. of 11th International Congress of IUSSI*, Bangalore, India, p.695-696.
- Fisher, R.A., A.S. Corbet and C.B. Williams. 1943. The relation between the number of species and the number of individuals in a random sample of an animal population. *J. Antm. Ecol.*, 12: 42-58.
- Fittkau, E.J. and H. Klinge. 1973. On biomass and trophic structure of Central Amazonian rain forest. *Biotropica*, 5: 2-14.
- Gadagkar, R., K. chandrasekara and P. Nair, 1990. Insect species diversity in tropics: Sampling methods and a case study. *J. Bombay nat. Hist. Soc.*, 87: 337-353.
- Holldobler, B. and E.O. Wilson. 1990. *The Ants*, Springer - Verlag.
- Kempf, W.W. 1964. On the number of ant species in the neotropical region. *Studia Entomologica*, n.s. 7: 481-482.
- Krebs, C.J. 1985. *Ecology - The Experimental Analysis of Distribution and Abundance*. Harper & Row, New York.
- Ludwig, J.A. and J.F. Reynolds. 1988. *Statistical Ecology - A primer on methods and computing*. John Wiley and Sons, New York.
- Mackay, W.P., A. Rebeles, H.C. Arredondo, A.D. Rodriguez, D.A. Gonzalez and S.B. Vinson. 1991. Impact of the slashing and burning of a tropical rain forest on the native ant fauna (Hymenoptera: Formicidae). *Sociobiology*, 18: 257-268.

- Majer, J.D. and M.V.B. Querioz. 1990. The composition of ant communities in Brazilian atlantic rainforests. In: *Social Insects and the Environment*. G.K. Veeresh, C.A. Viraktamath, and B. Mallik, (Eds.), *Proc. of 11th International Congress of IUSSI, Bangalore, India*, p.704-706.
- Romero, H. and K. Jaffe. 1989. A Comparison of Methods for Sampling Ants (Hymenoptera, Formicidae) in Savannas. *Biotropica*, 21: 348-352.
- Room, P.M. 1971. The relative contribution of ant species in the Ghanian cocoa farms. *J. Anim. Ecol.*, 40: 735-751.
- Stork, N.E. 1987. Guild structure of arthropods from Bornean rain forest trees. *Ecol. Entomol.*, 12: 69-80.
- Talbôt, M. 1975. A list of the ants (Hymenoptera: Formicidae) and the E.S. George reserve, Livingstone country, Michigan. *Great Lakes Entomologist*, 8: 245-246.
- Van Pelt, A.F. 1956. The ecology of the ants of Welaka Reserve, Florida (Hymenoptera: Formicidae). *American Midland Naturalist*, 56: 358-387.
- Wilson, E.O. 1959. Some ecological characteristics of ants in New Guinea rain forests. *Ecology*, 40: 437-447.
- Wilson, E.O. 1987. The arboreal ant fauna of Peruvian Amazon forest: A first assessment. *Biotropica*, 19: 245-251.
- Wilson, E.O. 1990. *Success and Dominance in Ecosystems: The Case of the Social Insects*. O. Kinne (Ed.), Ecology Institute, D-2124 Oldendorf/Luhe, Federal Republic of Germany.
- Wolda, H. 1981. Similarity indices, sample size and diversity. *Oecologia (Berltn)*, 50: 296-302.