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Biological Species Diversity in s[ome] Localities in Western Ghats

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INTRODUCTION

The Centre for Ecological Sciences at the Indian Institute of Science has inititiated several long term ecological studies in the district of Uttara Kannada in Karnataka. These studies are broadly aimed at providing a careful scientific description of the biological and other resources of the area, their present day patterns of use by the local people as well as suggestions for more ecologically sound patterns of use. A very important component of the resources available to the people of Uttara Kannada district is the biological diversity present in the forests of the district. The aim of one specific study, of which this constitutes an interim report, has been to take stock of the biological diversity of the area. To begin with insects, birds and plants have been chosen as representative groups. These groups constitute a very substantial proportion of the biological diversity of these localities and are also relatively easily studied. The objectives of this investigation are three-fold: (a) to develop and test suitable methodology that is appropriate for the quantitative and reasonably unbiased estimation of the levels of diversity under the prevailing conditions, (b) to examine the prospects for and if possible initiate long term monitoring of the above mentioned groups using methodologies developed here and (c) to generate at least some base line data on insect, bird and plant communities that would permit the asking of interesting questions from the point of view of community ecology. A prime question in this regard concerns the factors that regulate the numbers of species and their richness in different habitats.

METHODOLOGY

1. Study sites

All study sites are located in Uttara Kannada district of Karnataka. The study sites fall broadly into two categories, reflecting diferent levels of disturbance. The two categories are the reserve forest and the minor forest. Sites representing these categories were choosen in coastal plains (Down- ghats) and at higher elevations (Up-ghat, approximate altitude 600 m). Selection of study sites in this manner ensured that these sites represent habitats under different environmental conditions and levels of disturbances prevailing in them. In additon to these forested habitats three plantations and a leaf mannure forest were chosen for the study. At each of these sites sampling was carried out in three one hectare plots; the plots serving as replicates. Thus a total of 36 one hectare plots from 12 habitats were sampled. Each of these plots was serially numbered as detailed below:

	Reserve forest	Minor forest	Plantations
Down-ghat	Santgal (Nos. 1-3)	Chandavar (Nos. 10-12)	Areca (Nos. 34-36)
	Nagur (Nos. 4-6)	Mirjan (Nos. 7-9)	
Up-ghat	Bidralli (Nos. 16-18)	Bengle (Nos. 13-15)	Teak (31-33)
	Sonda (Nos.19-21)	Bhairumbe (Nos. 22-24)	Eucalyptus (Nos. 28-30)
			Betta (Nos. 28-30)

2. Sampling methods

(a) Insects

To assess insect species diversity, collections were made using five different sampling methods which were standardized after extensive field trials. A brief description of the methods employed is as follows (for a detailed description of sampling methods see CES Tech. Report No. 5, 1984).

(i) Net sweeps : Insect nets designed to collect sweep samples from vegetation were used in systematically sweeping the ground level vegetation. Six quadrats each measuring 10m x 10m were randomly chosen in each plot and the ground level vegetation was covered during sweeping. Insects from each of the sub-plots were preserved in alcohol till sorting.

(ii)Light trap: A portable light trap operating on batteries was placed in the middle of the plot and operated for six hours from dusk. Insects were removed from the trap the following morning and preserved in alcohol after being appropriately labelled.

(iii)Pit-fall trap: Five pit-fall traps were placed in randomly chosen quadrats. The trap consisted of a plastic jar which was buried at ground level and a tripod with a plastic plate to prevent rain water from getting into the trap.

(iv) Scented trap: This trap consisted of a plastic jar suspended on a wooden peg and protected from rain by a plastic plate with just enough gap between the mouth of the jar and the plate for the insects to move in. The trap was baited with fermenting jaggery solution which was artificially scented.

All the traps were set up in the plots between 3.00 and 5.00 pm. Insects were removed from the traps the following morning and the traps were cleaned for use again. The insects from each of the traps were preserved separately in alcohol.

(b)Birds:

Sampling for birds was done by walking along fixed transects. During every sampling event, each one hectare plot was uniformly covered in five transects. The time spent in doing this was 100 minutes. While walking along a transect, a range of 10 metres on either side of the observer was the zone of actual counting. Thus the entire hectare was covered without any overlap. Birds were identified based on sightings and calls. Birds flying far above, requiring the help of field glasses for identification were not included in the analysis. The sampling was done over the three hectares of each locality for five hours in the mornings over three consecutive days.

(c)Plants:

In each of the twelve localities, one hectare plots were chosen for the purpose of sampling of plant species. The plant species diversity estimates are divided into three components. In the first component, all woody plants having a circumference of 10 cm and above at the height of 132 cm from the ground level were enumerated. The second component consisted of sampling of individuals of shrub species as well as saplings of tree species with a circumference of less that 10 cm at height of 132 cm. This was done in ten randomly chosen quadrats of size 10mx10m within the one hectare plot. Thus all woody individuals that are

below 10 cm circumference were included in this estimate. The third component of herb layer estimation was carried out in a total of 20 quadrats of size 0.5x0.5 m. All the herbaceous vegetation was clipped to the ground level and oven dry weight of each of the species was estimated. In the diversity calculations for the herb layer, biomass was used instead of numbers. Forthnightly visits were arranged to collect all species that came into flower.

Canopy Cover Index

A subjective classification of habitats into disturbed and less disturbed categories is alone not sufficient to estalish any relationship between patterns of diversity and levels of disturbance as we realised from our preliminary results. An attempt is made in the present study to develop a possible index to quantify levels of disrturbance for the forests of Uttara Kannada. One of the major causes of disturbance in tropical forest is a tree fall, both man made and natural, which leads to large scale changes in the understory vegetation. The extent of canopy cover could thus be one good measure of disturbance.

A relative estimate of the extent of canopy cover was obtained by the presence or absence of canopy at randomly chosen points in the study plots. Fifty such points at the intersection of line transects running across the plot at right angles were chosen to make observations on the canopy cover. The observer was required to reach each of these points systematically walking along the transects. At each of these points the observer took a count of number of trees whose canopy intersected his line of sight immediately above his head. Shrubs, tree branches and

leaves obstructing the line of sight at less than 10 feet above ground were not counted. The number of trees which formed a canopy over these fifty points was added up and a mean value was obtained for the plot, which has been termed as Canopy Cover Index. The coefficient of variation(CV) of Canopy Cover Index was also computed to compare variation in the extent of canopy cover within plots. A high coefficient of variation means a greater variation in the extent of canopy cover. Depending on the extent of canopy cover a mosaic of habitat patches in the form of understory vegetation in different stages of succession are created which lend heterogeneity to the habitat.

5.Preservation of specimens and data recording

(a) Insects:

All Insects collected were stored in alcohol for sorting. The insects were identified upto the family level and within the family, species were seperated based on morphological differences (recognisable taxonomic unit) each such specimen was given a serial number within that family. The same number was given to the species collected from any locality in the study area. For each locality, plot and sub-plot, information on the Order, Family, serial number, number of nymphs or larvae and the number of adults was recorded.

The insects were preserved either as dry specimens if large, of in alcohol if small. The specimens from each localities are being preserved seperately.

(b) Birds:

A Check-list of birds recorded in Uttara Kannada

district was prepared by the available records of birds of Uttara Kannada in literature. The same check-list was used in the field to quickly record the birds that were sighted during the observation.

(c) Plants:

Apart from collecting data on the numbers of species of plants and the individuals that comprise them a systematic collection of all the species of plants was also made. These plants have been suitably processed and lodged in the herbarium.

5. Statistical analysis:

Shannon-weiner diversity index was calculated for all localities, as given by the formula:

$$H = -\sum_{i=1}^{s} pi \ln pi$$

Where pi is the proportion of the i^{th} species in the community (Pielou,1975). In addition to the above index Morishita-Horn similirity indices were also computed to measure similarity or the lack of it between plots. The index is given by the formula (Horn, 1966):

$$C_\lambda = \frac{2\sum (n_{ii} \cdot n_{ji})}{(\lambda_1 + \lambda_2) \cdot N_1 N_2}$$

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

N_j is the number of individuals in sample j and n_{ji} is the number of individuals of species i in the sample j.

Kendall's Coefficient of Rank Correlation, a non-parametric test, was employed to search for correlations, if any between Insect, Bird and Plant species divertiy. The same test was also

used to establish correlation between the extent of canopy cover, the coefficient of variation of canopy cover and the diversity of insects, birds and plants.

RESULTS AND DISCUSSION

1. Insects:

The data available on insect species diversity is presented in table 1. The table shows the number of orders, families species and numbers of individuals collected and the diversity index for each plot.

No consistent patterns of diversity seem to emerge from the available data. One important point very subtle although, that emerges from the data is that the reserve forests which are relatively less disturbed are not necessarily more diverse than minor forests or plantaions. In fact the minor forests seem to have relatively larger number of species and a higher diversity index. This is more clear when pairwise comparisons are made between a reserve forest and its corresponding minor forest. The comparison between Bidralli reserve forest and the Bengle minor forest shows that three plots in the reserve plot yielded 135, 132 and 81 species whereas the minor forest yielded 158, 101 and 164 species. The diversity indices for these plots follows a similar trend. Such a pattern, although not very strong is true of other plots also and the same may become more consistent when data on the remaining replicate plots from these localities becomes available.

One reason for the lower diversity of reserve forests could be that the reserve forests are only relatively less disturbed

Table 1

INSECT SPECIES DIVERSITY IN SOME SELECTED LOCALITIES OF WESTERN GHATS IN UTTARA KANNADA, KARNATAKA

Locality	Plot No.	No. Orders	No. Families	No. Species	No. individuals	Shannon-Weiner Index of Diversit
Santgal	1	7	34	76	141	4.04
	2	8	30	60	166	3.30
	3	9	35	85	196	3.91
Chandavar	10	9	49	98	386	3.03
	11	8	35	75	754	1.92
Hegur	4	11	34	66	310	2.78
	5	5	25	65	265	2.61
	6	8	28	61	190	3.60
Nirjan	7	8	37	81	928	1.80
Sonda	19	8	34	76	201	3.69
	20	5	28	70	173	3.71
	21	4	33	63	253	3.14
Bhairumbe	22	10	29	65	168	4.20
Bidralli	16	10	68	135	280	4.34
	17	11	55	132	391	3.23
	18	12	42	81	504	2.04
Bengle	13	12	74	158	496	4.29
	14	5	44	101	437	3.68
	15	10	66	164	565	4.41
Areca	34	7	41	88	841	2.74
Teak	31	7	29	53	143	3.13
Eucalyptus	28	12	65	200	651	4.45
Betta	25	8	40	104	433	3.68

and the nature and the frequency of disturbance these forests have undergone in the past may very well be influencing the present diversity. More importantly however, an increase in the level of diversity can be expected in habitats which undergo moderate levels of disturbance (Connell,1978). This perhaps may explain the increased diversity in the minor forests.

It is also of interest to note that 200 species,and Shannon-Weiner index of 4.45 the highest for any locality in the present study was recorded from Eucalyptus plantation. Mirjan a highly degraded minor forest had the lowest species richness and species diversity among all the study plots. The number of individuals was however highest in Mirjan(see Table 1).

Morishita-horn similiraity index was used to explore the degree of uniformity of different localties(Fig. 1). The indices show very little overlap between localities indicating very low levels of similarity between localities.

2.Birds:

The results on bird species diversity in 12 localities of Uttara Kannada, Karnataka are given in table 2. The diversity of birds, as was the case with insects, seems to increase in the minor forests. The patterns appears to be more consistent in the case of birds because the data is available for all the 36 plots where sampling was carried out. Except for Nagur and Mirjan, a comparison of reserve forest with minor forests brings out the differences very clearly.

Morishita-Horn similarity index again shows little overlap

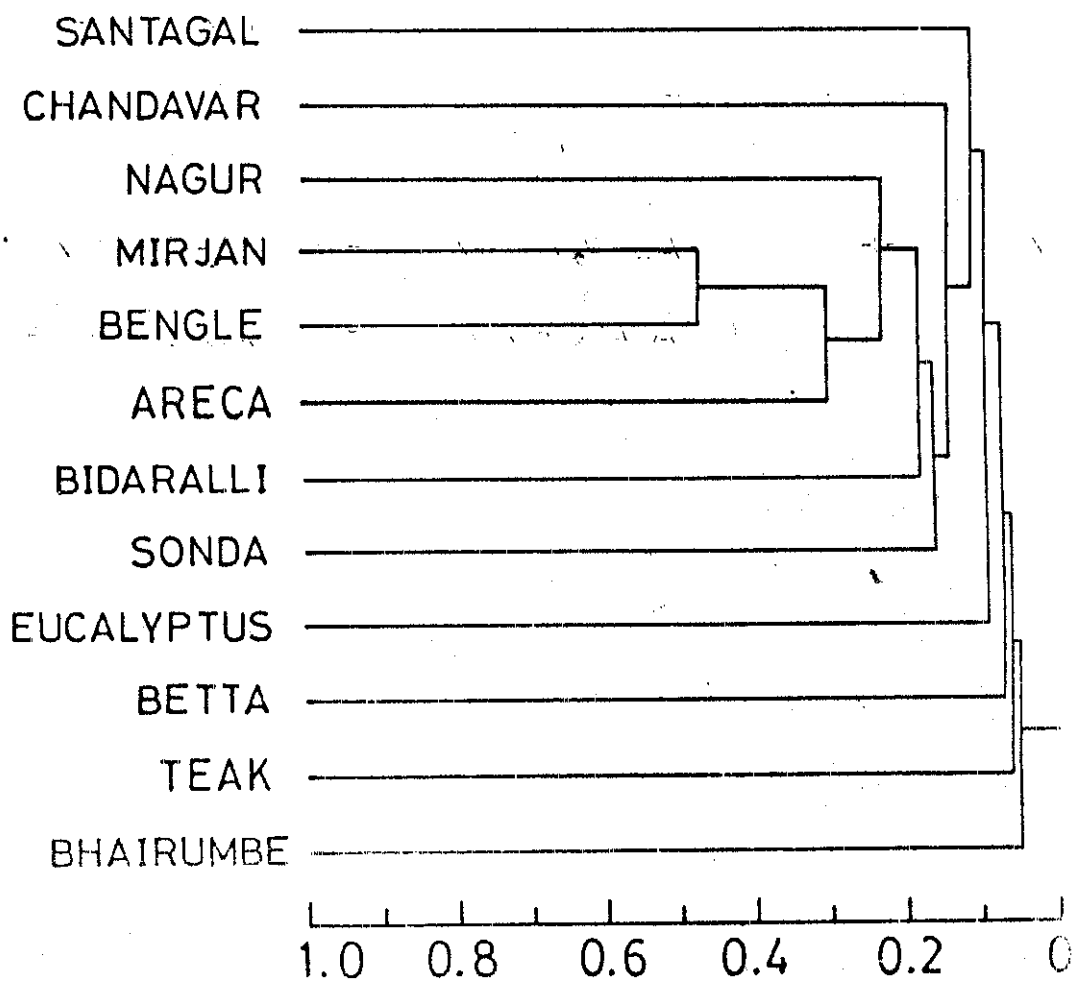


FIG. 1 DENDROGRAM SHOWING SIMILARITIES BETWEEN DIFFERENT LOCALITIES USING DATA ON INSECTS.

Table 2

BIRD SPECIES DIVERSITY IN SOME SELECTED LOCALITIES OF WESTERRN GHATS IN UTTARA KANNADA, KARNATAKA

Locality	Plot No.	No. Species	No. Individuals	Shannon-Weiner Index of Diversity
Santgal	1	8	31	1.86
	2	14	29	2.45
	3	15	31	2.47
Chandavar	10	21	61	2.77
	11	14	42	2.42
	12	12	46	2.18
Nagur	4	8	21	1.80
	5	17	35	2.57
	6	16	40	2.59
Mirjan	7	22	79	2.84
	8	13	30	2.24
	9	16	37	2.61
Sonda	19	17	44	2.61
	20	13	49	2.17
	21	14	40	2.37
Bhairumbe	22	24	107	2.84
	23	29	80	3.03
	24	25	71	2.86
Bidralli	16	10	18	2.14
	17	12	35	2.37
	18	16	46	2.60
Dengie	13	12	29	2.32
	14	16	68	2.39
	15	12	21	2.33
Areca	34	7	12	1.86
	35	4	9	1.33
	36	8	13	1.92
Teak	31	18	37	2.67
	32	14	32	2.46
	33	13	26	2.44
Eucalyptus	28	15	40	2.41
	29	5	18	1.44
	30	11	22	2.17
Delta	25	26	57	3.03
	26	17	33	2.66
	27	30	64	3.22

Morishita-Horn similarity index again shows little overlap between localities(Fig. 2). The wide ranging differences in the species composition of these localities has been discussed elsewehere (CES Tech. Report No. 5, 1984).

3.Plants:

Results of plant species diversity along with taxonomic break up of species of plants is given in table 3. There is again no clear pattern to the plant species diversity in the 12 localities. Unlike in the case of Insects or Birds even a weak association between disturbance and diversity is lacking in the data. The species composition of these localities however follows an interesting pattern. A detailed account of species composition in relation to levels of disturbance is given in CES Tech. report No.9, 1984.

Morishita-Horn similiraity index for plants rules out any overlap between study sites (Fig. 3). The data in case of plants however should be treated with caution since the similarity index has as yet been calculated using only the number of individuals for tree species. The use of only the numberof individuals for both trees and herbs and shrubs is perhaps not very appropriate since the two get equal weightage in the measure of diversity despite enormous differences in their biomass. Efforts are underway to recalculate these using biomass rather than numbers.

Morishita-Horn similirity index calculated for 12 localities using data on insects, birds and plants resembles the pattern obtained for plants alone(Fig. 3 and 4). This is to be expected because the numbers of plants far outweigh the numbers of

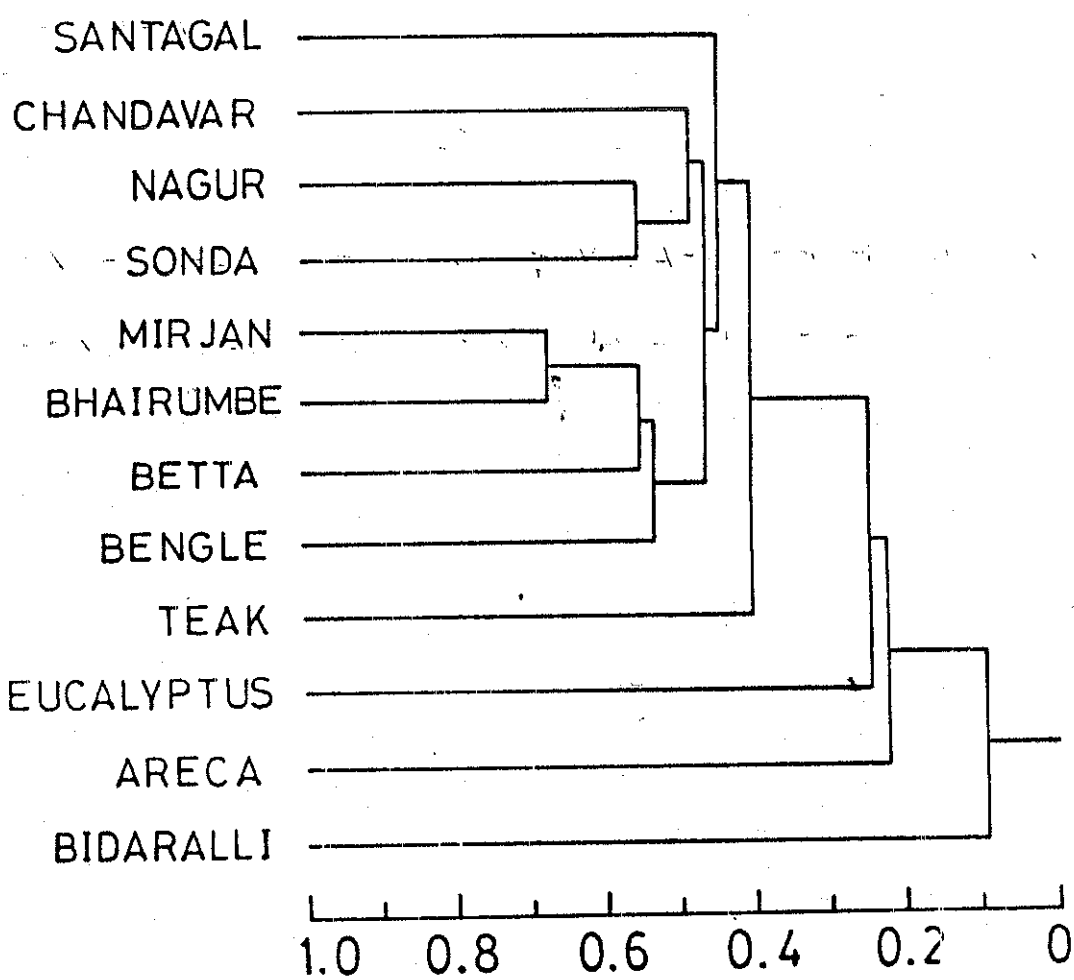


FIG. 2 DENDROGRAM SHOWING SIMILARITIES BETWEEN DIFFERENT LOCALITIES USING DATA ON BIRDS.

Table 3

PLANT SPECIES DIVERSITY IN SOME SELECTED LOCALITIES OF WESTERN GHATS IN UTTARA KANNADA DISTRICT, KARNATAKA

Locality	Plot No.	No. Orders	No. Families	No. Species	No. Individuals	Shannon Weiner Index of Diversity
Santgal	2	22	23	62	32700	2.32
Chandavar	10	21	35	70	118400	2.16
Nagur	4	22	39	80	330000	1.38
Mirjan	7	18	28	52	54300	1.94
Sonda	19	22	33	73	307700	1.56
Bhairumbe	22	21	31	61	131900	1.13
Bidralli	16	21	31	55	66200	2.54
Bengle	13	20	34	73	61000	2.87
Areca	34	13	16	23	18500	1.11
Teak	31	14	22	41	14700	2.60
Eucalyptus	28	14	19	39	32700	1.80
Betta	25	23	34	75	71000	1.64

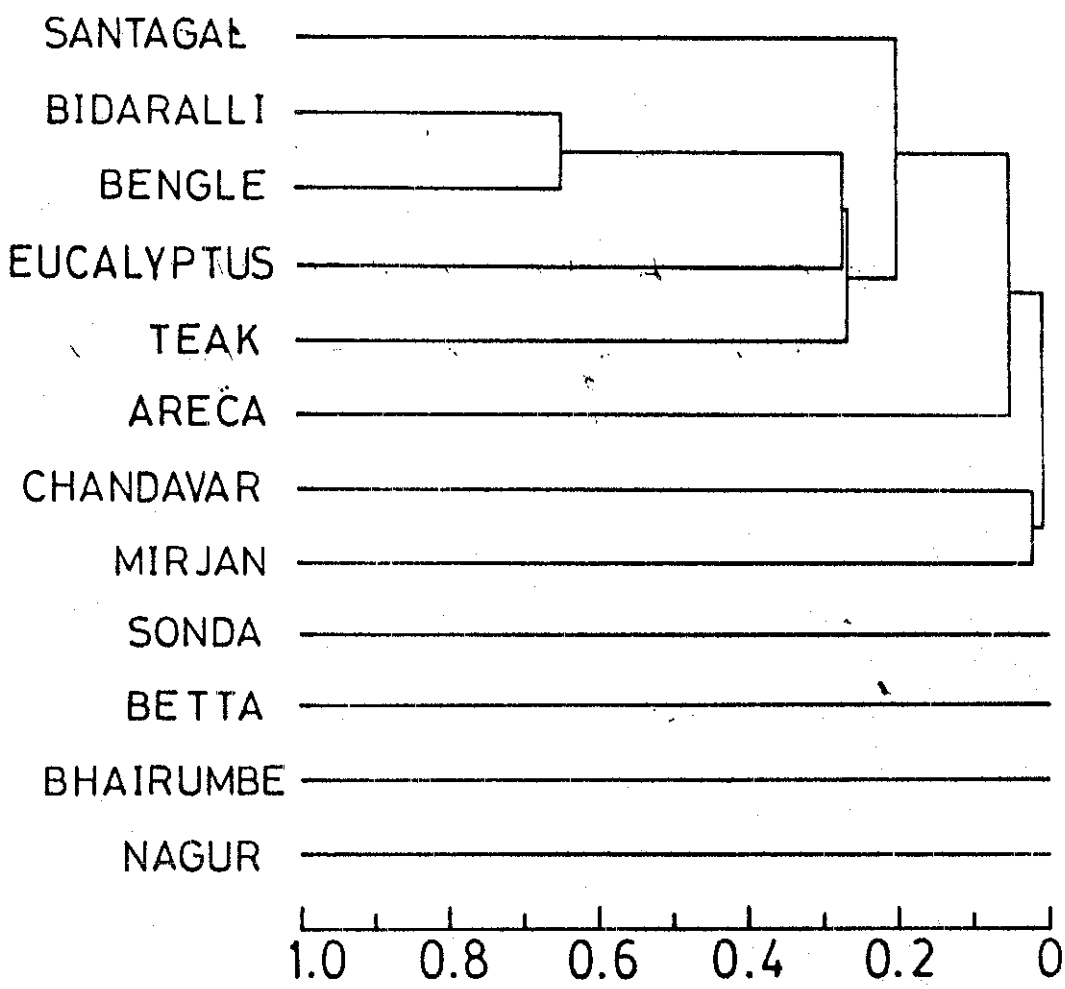


Fig. 3 DENDROGRAM SHOWING SIMILARITIES BETWEEN DIFFERENT LOCALITIES USING DATA ON PLANTS.

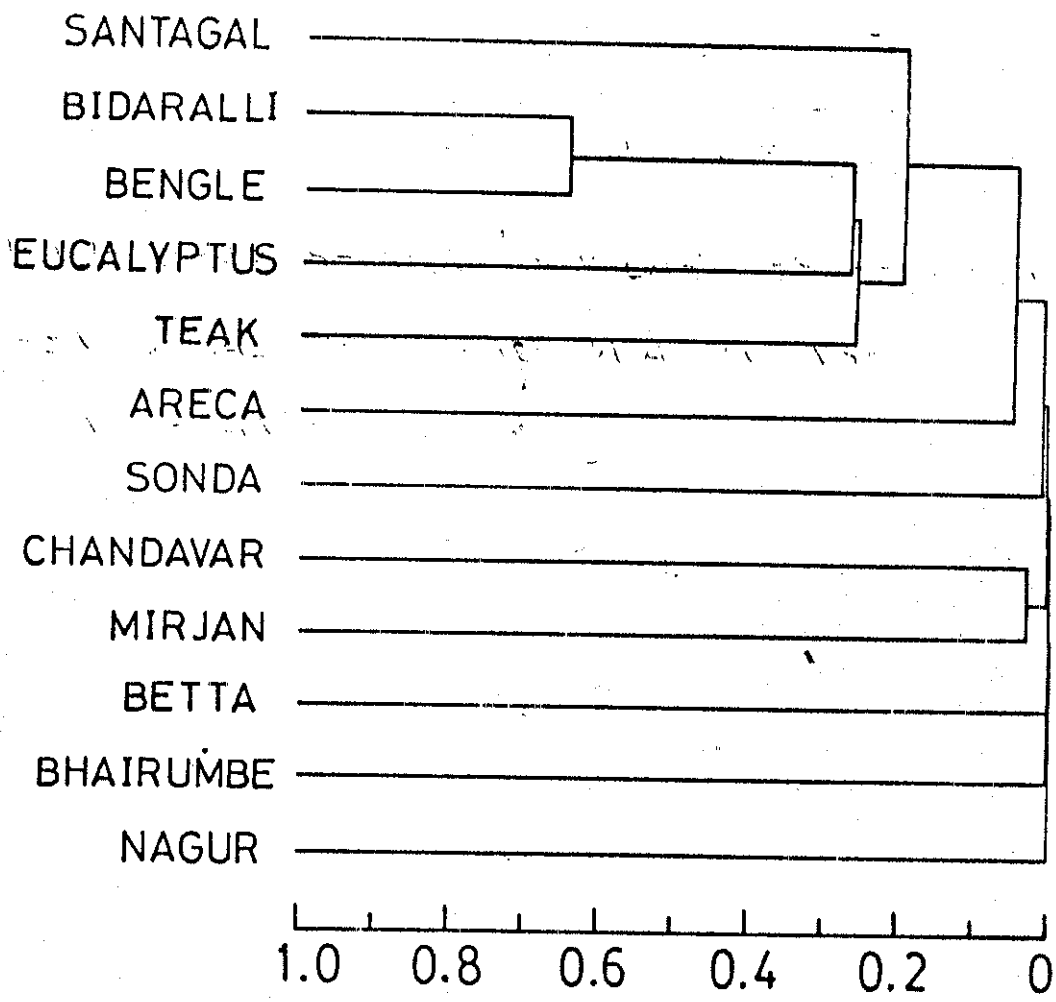


Fig. 4. DENDROGRAM SHOWING SIMILARITIES BETWEEN DIFFERENT LOCALITIES USING DATA ON INSECTS, BIRDS AND PLANTS.

insects or birds obtained through sampling. Only two localities, Bidralli and Bengle with an index of 0.65 show some degree of affinity, the remaining plots being dissimilar.

We have made an extensive search for possible correlations between the numbers of species, numbers of individuals and diversity index of insects, birds and plants but so far we have failed to find any correlations which are statistically significantly different from zero (Tables 4, 5 and 6).

Species Diversity and Habitat Heterogeneityy

Spatial heterogeneity or patchiness of a habitat has been recognised as one of the major factors influencing species richness. The mosaic of habitat patches created by perturbations arising out of biotic or abiotic factors, in fact, lends resilience to communities. Such communities persist by having high dispersal rates between adjacent areas which are undisturbed (Krebs, 1985).

A tree fall in tropical wet evergreen forests is an important abiotic factor which creates patches of habitats different from adjacent areas that are undistirbed. Creation of such patches in the forests due to opening up of the canopy has only been accelerated in recent times due to intensive exploitation of forests by man. Do such large scale disturbances really increase species diversity by increasing habitat heterogeneity as has often been hypothesised? As a first step towards testing this hypothesis an attempt has been made in the present study to obtain a measure of habitat heterogeneity by using the extent of canopy cover and its variance in the study

Table 4

Kendall's Coefficient of Rank Correlation(tau) between Numbers of Species, Numbers of Individuals and Shannon-Weiner Diversity Indices of Insects, Birds, Plants, Understory Vegetation(Herbs and Shrubs) and Insectivorous Birds in some selected localities of Western ghats in Uttara Kannada, Karnataka.

	BIRDS			PLANTS			UNDERSTORY(HERBS AND SHRUBS)			INSECTIVOROUS BIRDS		
INSECTS	No. Species	No. Individuals	Diversity Index	No. Species	No. Individuals	Diversity Index	No. Species	No. Individuals	Diversity Index	No. Species	No. Individuals	Diversity Index
No. Species	-0.06	-0.12	-0.04	-0.02	-0.08	0.15	0.15	-0.06	0.14	-0.17	-0.08	-0.25
No. Individuals	-0.09	-0.03	-0.00	-0.11	-0.17	-0.12	0.06	-0.15	-0.14	-0.26	-0.23	-0.31
Diversity Index	0	0	-0.00	-0.02	-0.02	0.21	0.09	0	0.29	0.01	-0.14	-0.12

In all casses the sample size is 12.
None of the tau values reported here is statistically significant.
To be significant at p(0.05 a tau value of 0.4330 is needed.

Table 5

Kendall's Coefficient of Rank Correlation(tau) between Numbers of Species, Number of Individuals and Shannon-Weiner Diversity Indices of Birds, Plants and Understory Vegetation(Herbs and Shrubs).

	PLANTS			UNDERSTORY (HERBS AND SHRUBS)		
BIRDS	No. Species	No. Individuals	Diversity Index	No. Species	No. Individuals	Diversity Index
No. Species	0.09	0.09	-0.06	0.18	0.09	0.04
No. Individuals	0.03	0.21	-0.12	0.12	0.21	-0.11
Shannon-Weiner Diversity Index	0.08	0.01	-0.04	0.18	0.03	-0.02

In all cases the sample size is 12.
None of the tau values reported here is statistically significant.
To be significant at $p<0.05$ a tau value of 0.4330 is needed.

Table 6

Kendall's Coefficient of Rank Correlation(tau) between Insectivorous Birds and Understory vegetation (Herbs and Shrubs) in some selected localities of Western ghats in Uttara Kannada, Karnataka.

	UNDERSTORY (HERBS AND SHRUBS)		
INSECTIVOROUS BIRDS	No. Species	No. Individuals	Shannon-Weiner Diversity Index
No. Species	0.17	0.05	0.14
No. Individuals	0.14	0.08	0.08
Shannon-Weiner Diversity Index	0.22	-0.03	0.22

In all cases the sample size is 12.
None of the values reported here is statistically significant.
To be significant at $p<0.05$ a tau value of 0.4330 is needed.

plots.

The results of the present study indicate a noticeable increase in in diversity of insects and birds with disturbance in their habitats. It is difficult to substantiate these results based solely on a subjective classification of the study sites as disturbed and less disturbed. A quantitative measure of disturbance, such as the canopy cover index is useful in interpreting the data on diversity in relation to disturbance.

All the 36 plots were ranked based on the canopy cover index. Nagur (plot no. 4) a reserve fsorest had the highest, and Mirjan (plot no. 9) a degraded minor forest the lowest canopy cover index. Coefficient of variation of canopy cover index was calculated to understand the extent of variation in canopy cover within plots. A high coefficient of variation would mean greater variation in the extent of canopy cover within the plot. Figure 5 in fact shows that plots with high canopy cover index have lower coefficient of variation and plots with low canopy cover index have high coefficient of variation.

The results of correlation between canoppy cover incex and CV of canopy cover index and the diversity of insects, birds and plants is summarized in table 7. Numbers of species of insects was significantly negatively correlated (Fig. 6 and 7, table 7) with canopy cover index and positively correlated with CV of canopy cover index(tau=-0.3520 and 0.3600 respecrtively). Numbers of individuals of insects collected was also significantly negatively correlated (tau=-0.3525, Fig. 8) with canopy cover index .

The pattern of bird species diversity which seemed to

Table 7

Kendall's Coefficient of Rank Correlation(tau) between (1) Numbers of Species, Numbers of Individuals and Shannon-Weiner Diversity Index of Insects , Birds and Plants and (2) the Canopy Cover Index and its Coefficient of Variation, in some selected localities of Western ghats in Uttara Kannada, Karnataka

	Canopy Cover Index	CV of Canopy Cover Index
	tau	tau
	INSECTS (sample size=23)	
Species	-0.3520**	0.3600**
Individuals	-0.3525**	0.2218
Diversity Index	-0.0358	0.2187
	BIRDS (Sample size=36)	
Species	-0.1727	0.2275
Individuals	-0.2022	0.2594*
Diversity Index	-0.1949	0.2135
	PLANTS (Sample size=12)	
Species	0.2595	-0.1374
Individuals	-0.1212	0.0606
Diversity Index	-0.2121	0.0303

*p<0.05, ** p<0.02. None of the other tau values reported here is statistically significant.

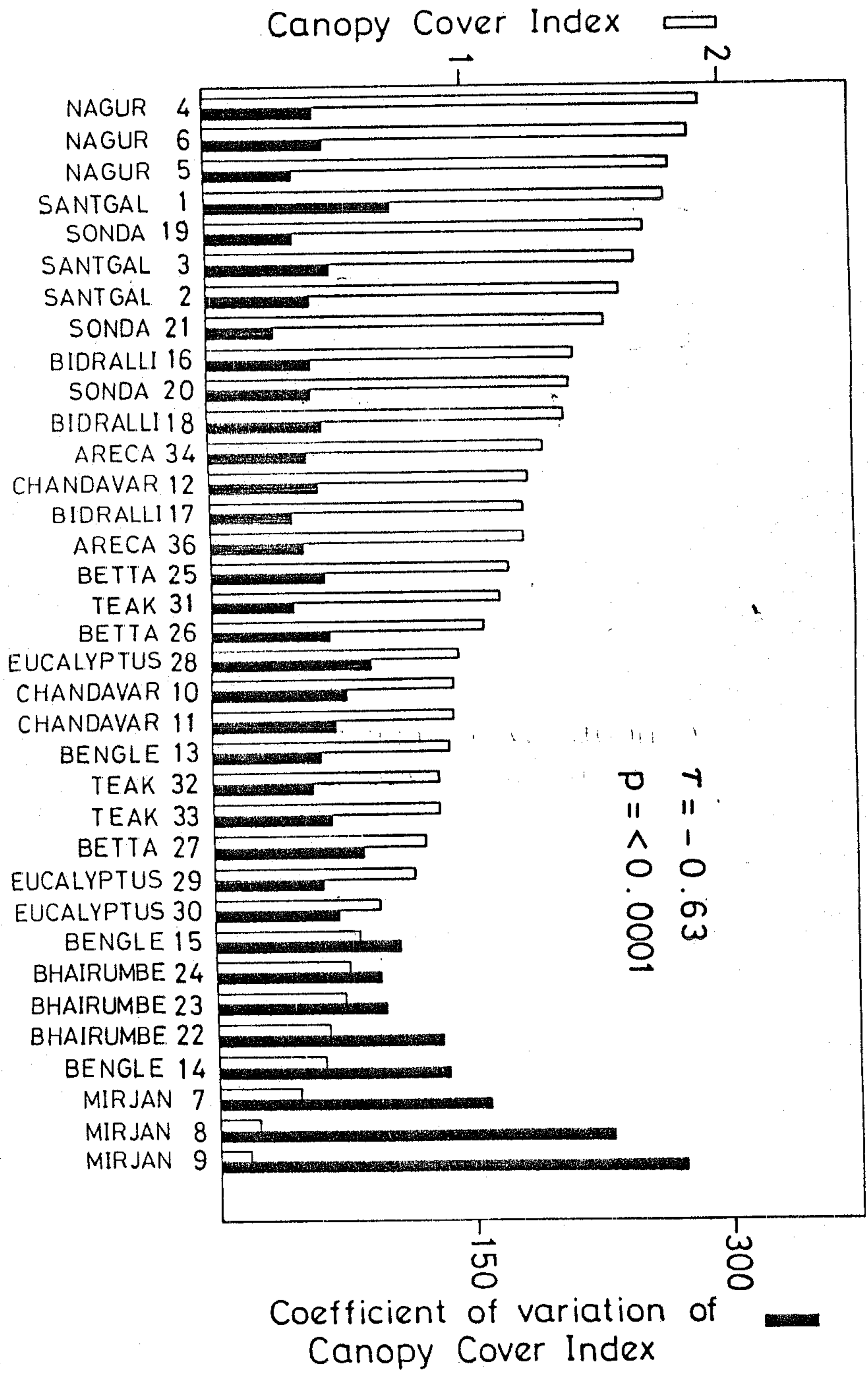


Fig. 5 ... and C.V. of Canopy Cover Index

Fig. 6 Correlation between Canopy Cover Index and Number of Insect Species

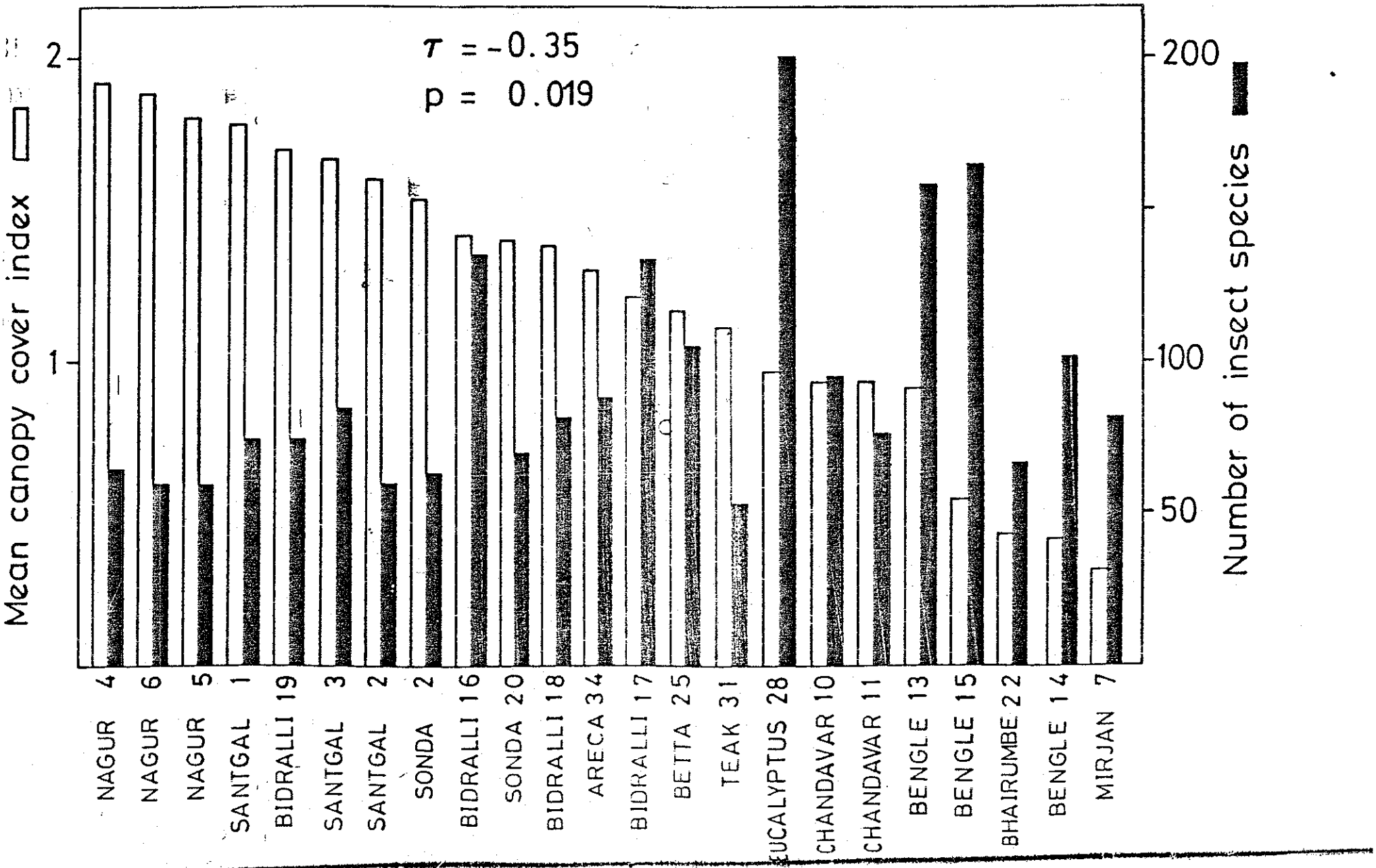


Fig. 7 Correlation between C.V. of Canopy Cover Index and Number of Insect species

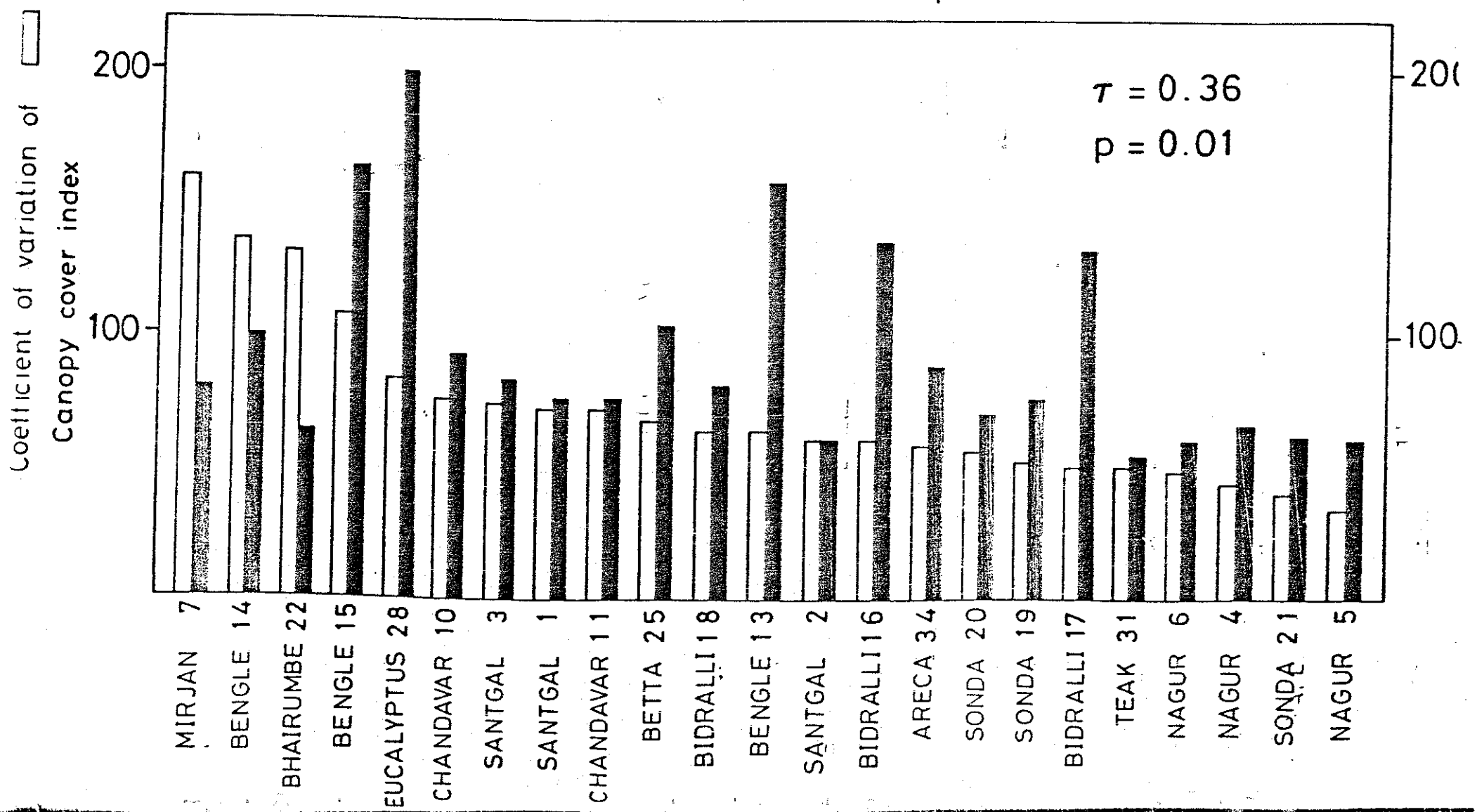


Fig. 8 Correlation between Canopy Cover Index and Total Number of Insects

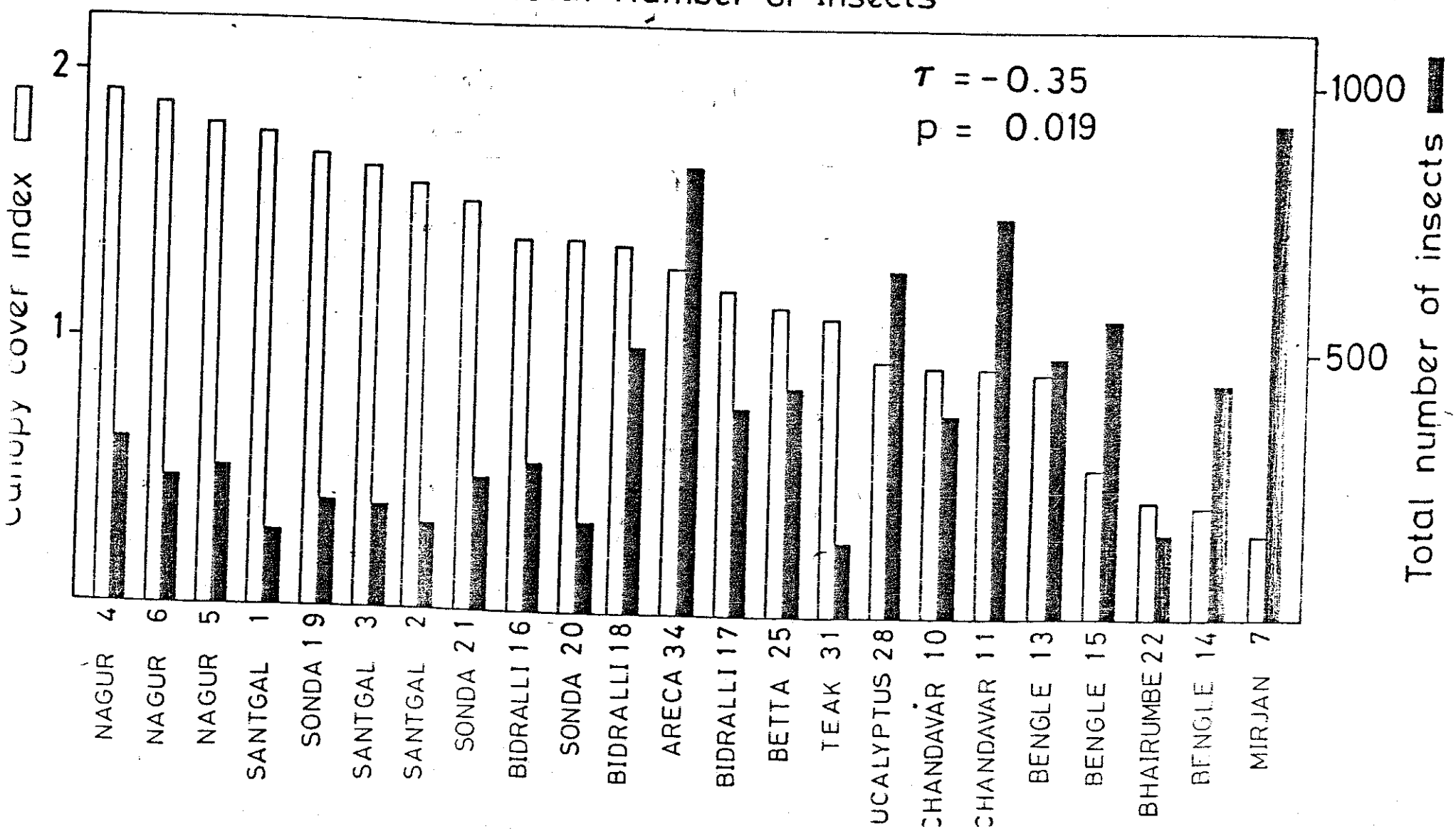
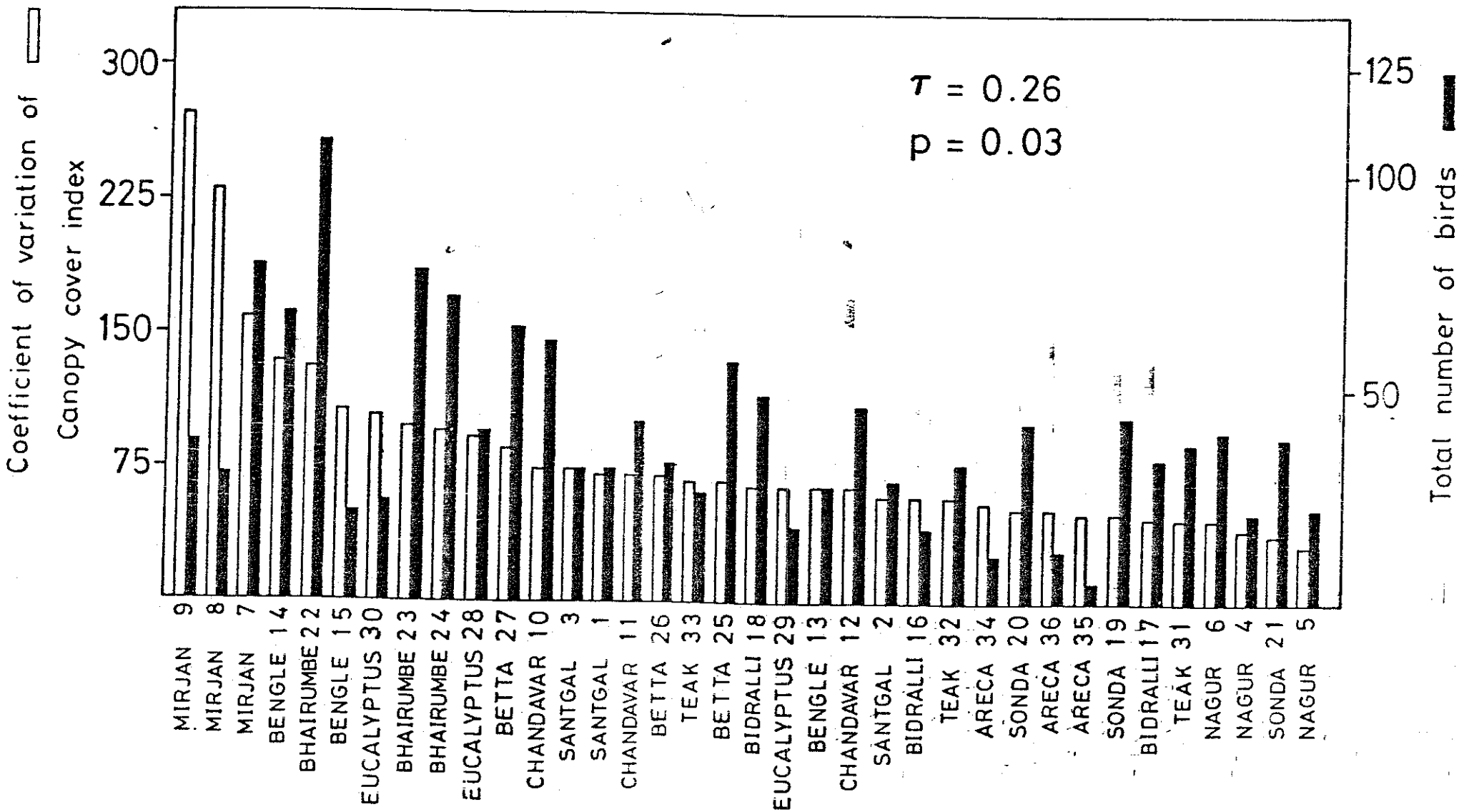


Fig. 9 Correlation between C. V. of Canopy Cover Index and Total Number of Birds



suggest a relationship between diversity and levels of disturbance even more strongly than insect diversity is not borne out by Kendall's coefficient of rank correlation. Only the number of individuals of birds is significantly positively correlated(tau=0.2594, Fig. 9) with CV of canopy cover index. As for plants there is no correlation between diversity and canopy cover index, which is not unexpected given the small sample size, note that data on plants is not based on replicate plots.

These results can be further strengthened by more data and some rigourous statistical analysis. There is every reason to expect a stronger correlation between canopy cover index and diversity once the data becomes available for all the 36 plots. Analysis of data taking into consideration the taxonomic composition of species, the guild structure and long term monitoring of some study sites with respect to diversity and disturbance would contribute to a better understanding of of the role of disturbance in determining diversity and community structure.

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