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LONG-TERM ENVIRONMENTAL AND ECOLOGICAL IMPACT OF MULTIPURPOSE RIVER VALLEY PROJECTS

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ABSTRACT

Studies on the impact of the Idukki hydro-electric project on tho larger mammals were carried out for a period of about four years from 1981 to 1984. The study area is located in the Idukki district of Kerala. Forest types consist of grasslands, deciduous and evergreen forests. Study methods included collection of details of animals from systematically laid out sample plots, examination of population parameters from sighting data and recording of habitat quality on gridded map, About 75 elphants are Estimated to be present in the area. The herds were of a smaller site indicating disturbance. The proportion of various classes of individuals and their sex ratio was not similar to that in other populations. There were only very few young ones. Number of male elephants in the population was also very low, Animals like sambar. barking deer, jackal and uild dog were present in the study area. But their number was very low. The study area contained wild boar and hare in moderately good numbers. Gaur, bear, tiger and leopard are no more found in the area. The bonnet macaques in tho periphery of the reserve indulged in a great deal of crop raiding. Wild dogs attacked domestic

cattle in a few cases. The study shows that construction of thc Idukki hydro-electric project h3d an advers effect on many animals. In addition to the construction of darns, large scale encroachment and forest colonisation also played an important role in the destruction of animals. As far as animals are considered there werc both negative and positive impacts. The study recommends habitat improvement measures for the Idukki wildlife sanctuary need for keeping the forest continuty of crucial Meenmutty region, and a few other measures to prevent further deterioration of the habitat.

INTRODUCTION

Man's efforts to regulate the flow of rivers and store water far the in dry season has a very early history. Employment of hydel potential for power generation increased the need for constructing more and more dams. Hydel projects are one of the cleanest sources of energy for meeting the ever increasing needs of en industrialised society.

The technological developments of the present century make it feasible to construct larger and larger dams and power houses. Some of the gigantic projects are only scaled up versions of smaller projects, In these cases many new problems arise due to imbalances and factors which were not applicable to the initial system. Side by side with the development of large projects, techniques for assessing their cost-benefit criteria and impact on environment have also keen developed Gregerson and Brooks (1976).

In countries like the U.S.A. and Canada (Tywoniuk, 1983) the details and guidelines of a project which is likely to have considerable impact on the environment is released well in advance of the commencement of the project. Public in general and residents near the project area are given an oppertunity to express their views (Rosen. 1976).

An environmental impact statement is prepared by the proponents of the projects with the help or experts in the field. In the case of the Slave river project in Canada which is expected to have considerable impact on delta harbouring bison and whooping crane the required information for the preparation of the environmental impact statement is currently being collected (Tywoniuk, 1963).

OBJECTIVES

The Kerala Forest research Institute studied the impact of the Idukki project on the larger mammals as part of a multidisciplinary study. The objective of the study was to collect data about the larger mammals One herbivore (elephant), one carnivore (wilddog) and one primate (bonnet macaque) was studied. The impact of construction workers staying in the project area drawing of power lines, laying of roads, development of township, resettlement of displaced people on wild animals were examined. The structure of forest was also documented.

In addition to these there are a few more factors not directly related to the project, but which certainly has an impact on the wild animals. Examples of these

synergistic factors are, increase in pace of forest clearance, encrochement, peculiar political situation of Idukki favouring these etc. These two types of factors had a combined effect on the animals. But since the study area selected is in the immediate neighbourhood of the project, the project hod comparatively more impact on the wild animals. Thus for a critical assessment of thc environmental impact of the Idukki hydroelectric project, reliable data on various aspects on ecology and forests should be available both before and during the construction of the dam. Since such data were found to be wanting it is only appropriate to study analogous areas which can be considered similar to what Idukki forests could have been before the construction of the darn. With this assumption studies were initiated in areas, like, Silent Valley reserve Muthikkulam Reserve and Nelliampathy Reserve pertaining to various aspects of the vegitation like floristics, physiognomy of the forest, plant species diversity, indicator species etc. The results thus derived enable us to analyse the possible environmental impacts in the project area pertaining to plant ecology. Data collected on the wild animals of Silent Valley and Periyar, two relatively undisturbed areas were used as a bench mark for comparing with the situation in Idukki.

ENVIRONMENTAL IMPACT STUDIES

Any activity is bound to have both beneficial as well as harmful results. In the case of hydro-electric projects earlier attention was paid only to cross efforts arising out of implementation of the project. Now, methods developed in connection with technology assessment, impact analysis and cost-benefit Evaluation are available for examining the cumilative effetcs of component activities of a project. Now a days, cost– benefit analysis is customary before implementation of a rivcr valley project. This was carried out in the case of the Idukki project also by the Kerala State Electricity Board and the project executed cause of the over-whelming benefits.

In many cases the impact of tne project on environment is assessed before the commencement of the project. In the case of the Rocky Reach hydro-electric proect in U.S.A the submersion area included a very important nesting site for endangered mourning doves. Measures for planting up the area adjoining submersion area with trees that are suitable as nesting trees to the birds were recommended (Patterson, 1961). Oliver and Barnett (1966) recommended steps like not removing

brush at high pool levels, acquisition of surrounding land to) provide alternate habitat for animals and intensive management of remaining areas to increese carring capacity in the Wells Hydro-electric project in U.S.A. In India, the Silent Valley project was given up after evaluating cost-benefit and environmental impacts (Variava, 1982) The Bedthi project in Karnataka was also absndoned due to protest from people in the submersion and surrounding areas which led to a re-examination of cost benefit-analysis. The cost turned out to be too high and hence the project was abandoned.

General guidelines to be adopted in preparation Environmental Impact Assessment (E I A) is giveri by Munn(1979) The main points according to this are (i) The EIA should include all relevant physical, biological, ecological and social factors(ii) EIA should include study of alternatives including that of no action. (iii) The EIA spatial frame work should include an area larger then encompassed by the action. (iv) The time frame may be divided into phases of during construction, immediately after construction and three decades after construction. Checklists, flow diagrams and matrix approach are the commonly used approaches in EIA (Sorenson and Moss, 1973, Warren and Preston 1973)

The Battelle System (Whitman, 1971) assigns values between 0.0 to 1.0 to the parameters assessed. The Iterative method of Aegerter and Messerli (1981 examines the impacts in an iteractive way till either significant impact is apparent or the impact becomes trivial, In the Leopold matrix, project actions and their impacts are given values between -10 to +10. In the present study for EIA a method similar to the ones mentioned above was employed.

STUDY AREA

The study area is in the Idukki District of Kerala and lies between latitudes 09°45' to 09°55' N, and longitudes 76°50' and 77°05' E. It is about 150 Km^2 in extent and is situated around the Idukki reservoir Fig 1). Physiographically the area is a hilly terrain with elevation ranging from 800 to 1000 m. About 70 km^2 of forest between the two arms of the reservoir were declared as a wildlife sanctury in 1976, A few undisturbed patches of forests are seen adjacent to the road sides and hence the precise limits of the study area are those included along the road road from Kulamavu to Kattappana which include inter alia the sanctuary also.

TOPOGRAPHY AND BOUNDARIES

Idukki:

Idukki project area is situated in the Western Ghats. Kerala and are about 40 kms wide in this region. The Idukki reservoir is on the western edge of the hills. The drop in altitude on the weston side is used for generating power. All the other three sides are high elevation areas, the eastern edge along

Plate 1. Main forest types in the Idukki region.

Plate 2. Grasslands adjoining the lake.

Plate 3. Cardamom cultivation inside the forest.

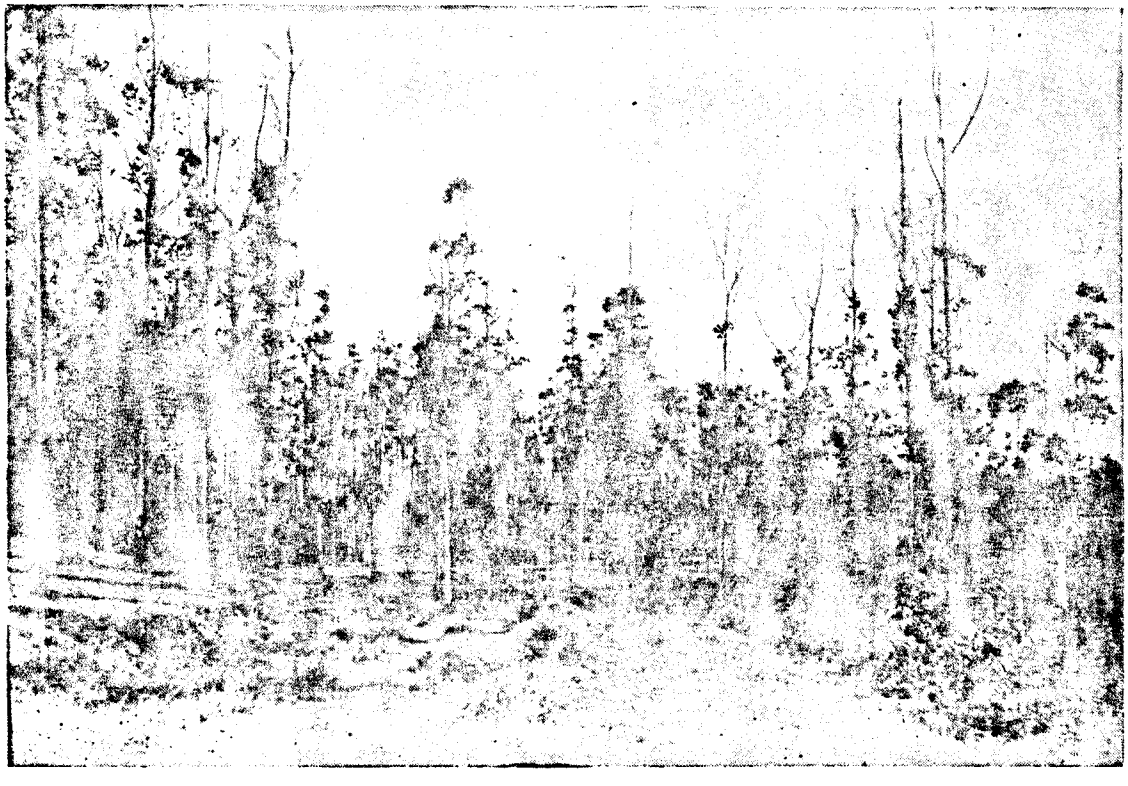


Plate 4. Eucalyptus plantation in the Meenmutty region.

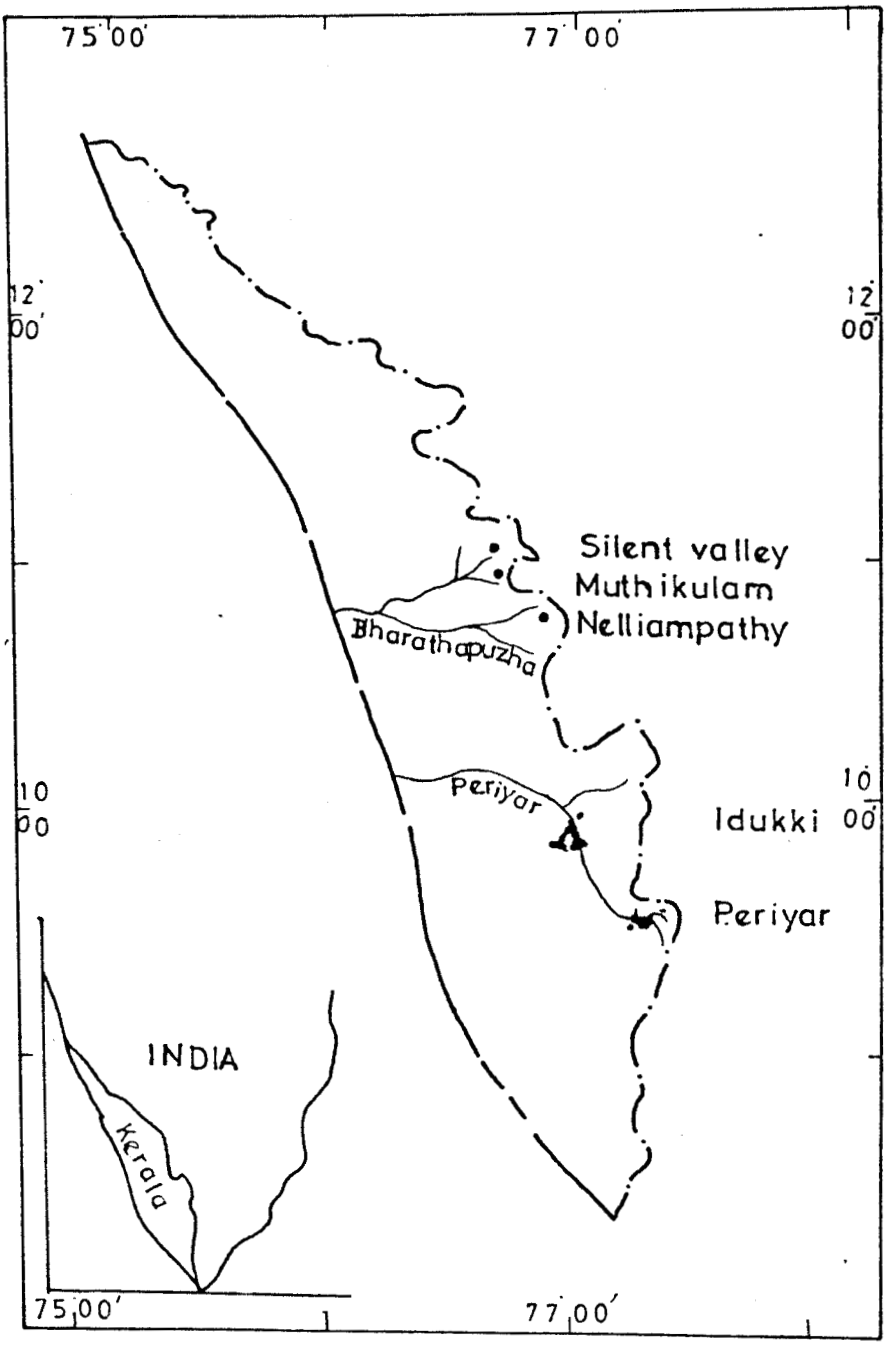


Fig.1 Location of the study sites.

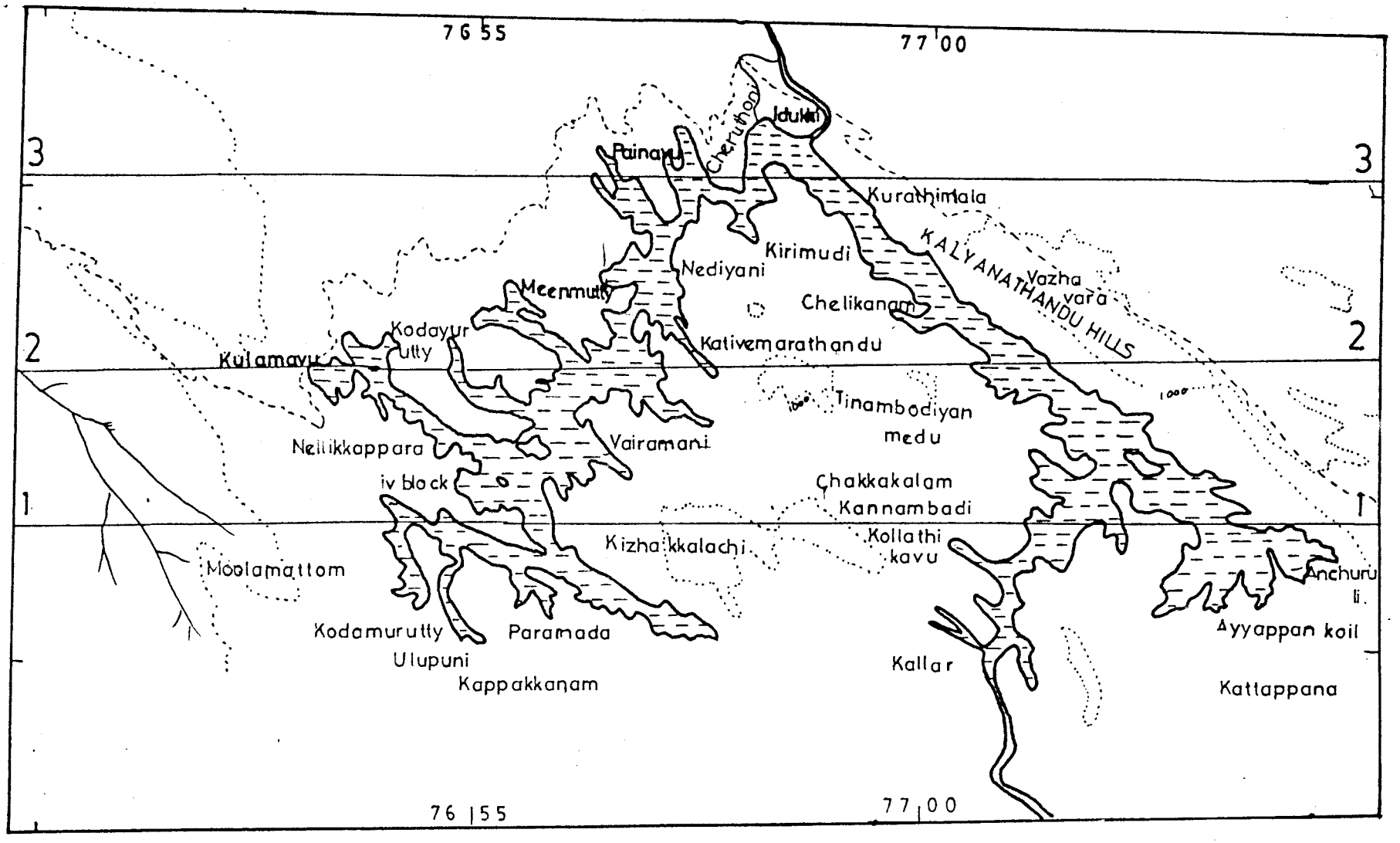


Fig.2 Location of reservoir and important places. 1 2 3 _ Altitude profiles.

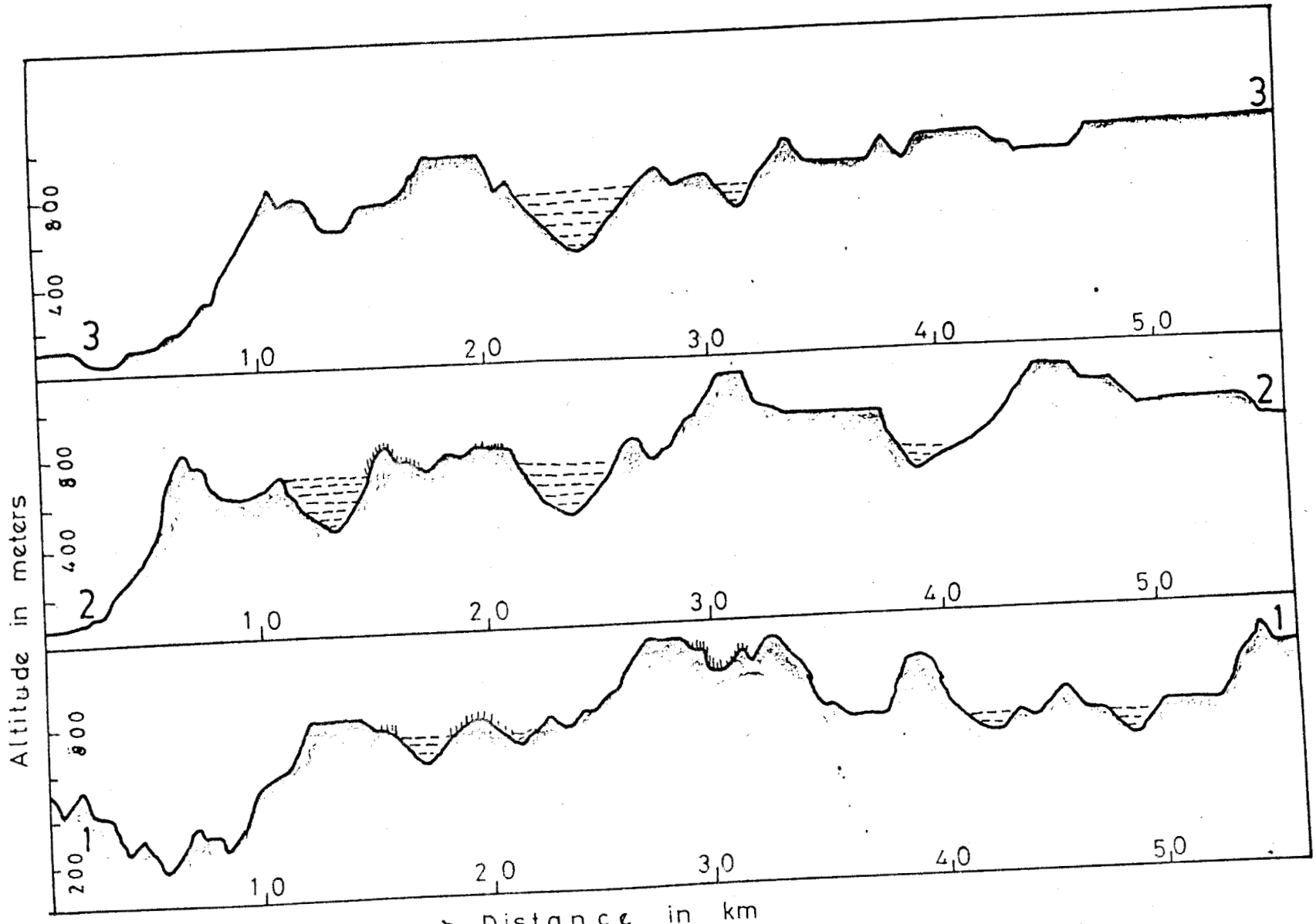


Fig.3'. Altitude profiles along three parts of the study area.

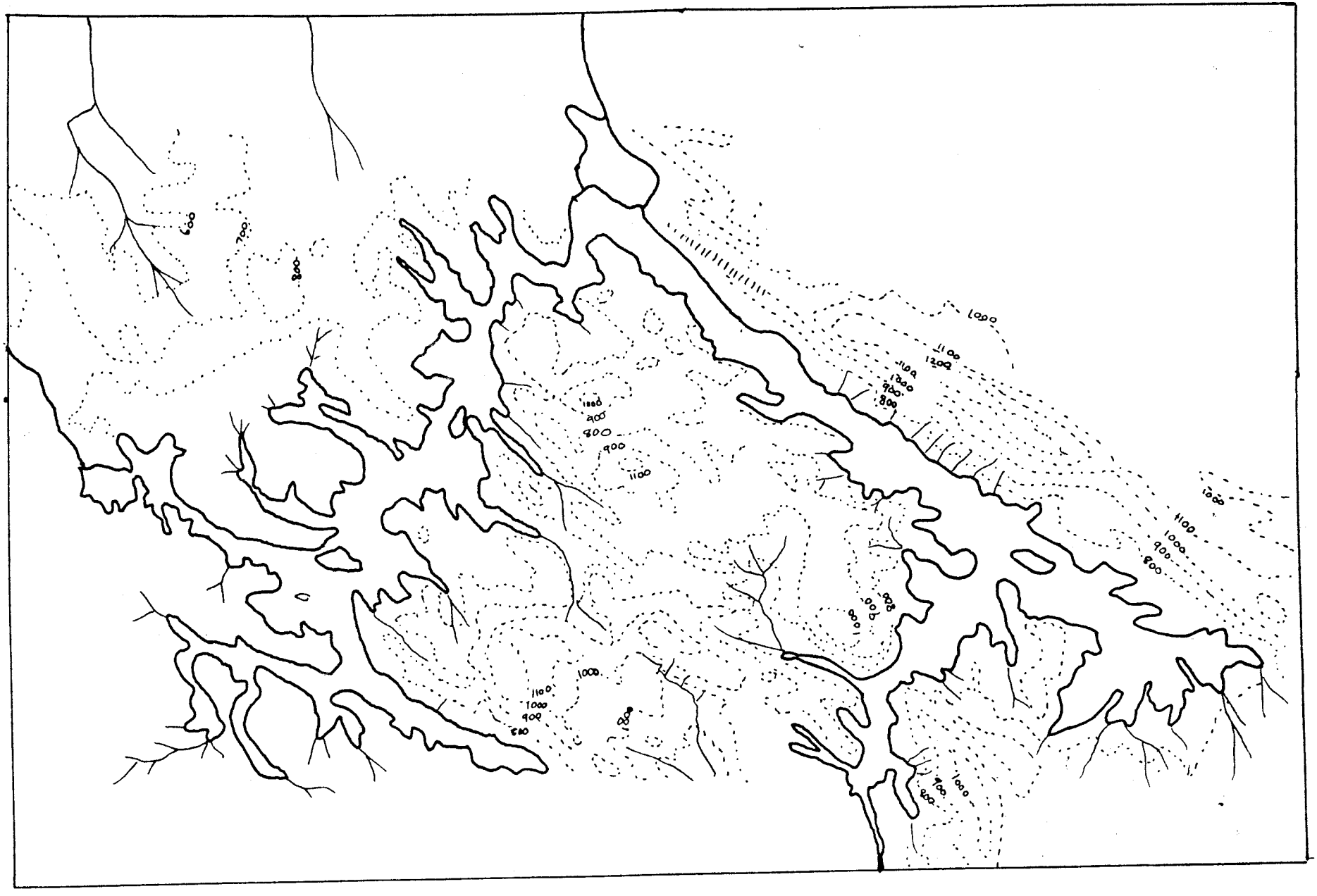


Fig. 4 Topography and drainage pattern.

the state boundary formingthe crest line. The Idukki and Cheruthonidams from the northern boundary. The north-ea stern end north-western portions are inhabited. The southern end of the study area is also bounds by a chainof settlement On the south-western corner is Poolamattam (inhabited) where the power house is situated. On the south-eastern corner is the inha-itcd areas of Ayyappankoil (Fig. 2), The Kulcmavu-Iduki road form the western boundary. To thewest of the rord are forested slopes and the reservoir is on the eastern side. The Idukki-Kattappane road form the eastern boundary of the study area. There is a hill chain between this road and the reservoir. The reservoir is shaped with Idukki at the apex, western arm ending near Kulamavuand the eastern arm near Kanchiyar and Ayyappankoil. There is a ridge between the two arms with a few peeks about 1220 m high. Altitudinal profiles along three points in the study areas show these details (Fig. 3 and 4).

Silent Valley R. F.

The Silent Valley forest in Palghat District of Keralra. is situated between $76^{\circ}20'$ and $76^{\circ}35'$ E and $11^{\circ}00'$ and $11^{\circ}15'$ N. The entire reserve of about 93 km^{2} is situated on a plateau of about 1000 m.

Because of steep elevation on all sides, accessibility is very much limited and this has contributed to this area remainng relatively undisturbed.

The Silent Valley reserve is bordered by the vested forests of Nilambur Division on the west. vestc forests of Palghat Division on the south, Attappadi reserve forests on the east and the Nilagirison the north. The elevation ranges from 700 to 2400 m,

Periyar

The Periyar Tiger Reserve covers an area of 777 km^2 and is situated in the Iduklti District of Kerala. It lies between $09^{o}15'$ and $09^{o}40'N$ a n $77^{o}00'$ and $77^{o}30'$ E. It is bounded by the steer slopes of the crestline on the northern and easter side. The western edge gradually slope down to the plains, The Pamba-Periyar ridge form the southern boundry. The area is highly undulating.

A masonary dam was constructed near the confluence of Mullayar and Periyar the main tributaries of River Periyar creating a lake of about 26 km^2 in 1895 to irrigate the dry eastern plains of Tamil Nadu.

The work was at a very slow pace involving only a few hundred workers. Because of this reason the disturbences during/construction period could have been camparctively) less. Due to the long time span after completion the ecosystem seems to have stabilised and this project is often cited as an example of a project which has been environmentally benecficial.

Muthikkulam R.F.

Situated in the Siruvani plateau of Palghat District, and lying at longitude $76^{o}35'$ to $76^{o}36'$ E and latitude $10^{o}55'$ to $10^{o}56'$ N and covering roughly 90 Km^2 this area is completely outoff from the east north and west, This is a high rainfall zone with ecological conditions rathcr similar to thosc *of* Silent valley. There has been significant disturbances around the dam site but the edges of the plateau have fairly undisturbed and pristine vegetation

Nelliampathy R.F.

It is situeted immediately south of the Palghat gap and rises steeply from tho Palghat plains to an averageelevation of about 900m. Its eastern edge

is formed by the Anamalai and is some what drier while the southern and western parts recieve copious rainfall resulting in luxuriant evergreen forests. While the vast extent of the natural aevergreen forests have been eliminated by cash craps like coffee,tea, cardmom etc., two significant patches are still loftun-disturbed one in the catchment of a tributary of Kuriarkutty river and the other along the southern and adjoining Sholayar hydel project. The location of all these areas are depicted in Fig. 1 .

CLIMATE

Temperature

At a macrolevel temperature does not contribute anything significant in the distribution of the ever-green forests in Kerala. The figures available to any one area arc equally applicable to others. Hence the data available for Idukki is summarised below.

The mean annual temperature is around 26°C with March, April and May constituting the hottest months of the year. The average temperature valuess fluctuate between 25 to 31°C, thus displaying an amplitude of 6°C. The absolute minimum of 17.2°C is registered during January and the absolute maximum of 35°C during May.

On the other hand, the cumulative effect of rainfall and the extent of dry season are the crucial factors. In all the areas mentioned above the dry season lasts uniformly for four months.

Rainfall

Thekkady receives about 2300 mm rainfall an year. The other four areas receive very heavy rainfall both from the southwest (June to September! as well as north east monsoons (October to mid December). However, the Sulk of the precipitation is brought about by the southwest monsoon. The rainfall data gathered for the four stations are presented in the following table and graphically represented in Fig, 5.

As can be seen from Table 1, the annual rainfall is exceptionally high, often over 3000 mm. Individual years of rainfall exceeding 5000 mm are not uncommon, The relative humidity is also high almost throughout the year. These combinations of high rainfall coupled with hot and humid conditions favour the growth of a rich, tropical wet evergreen vegetation in all the areas.

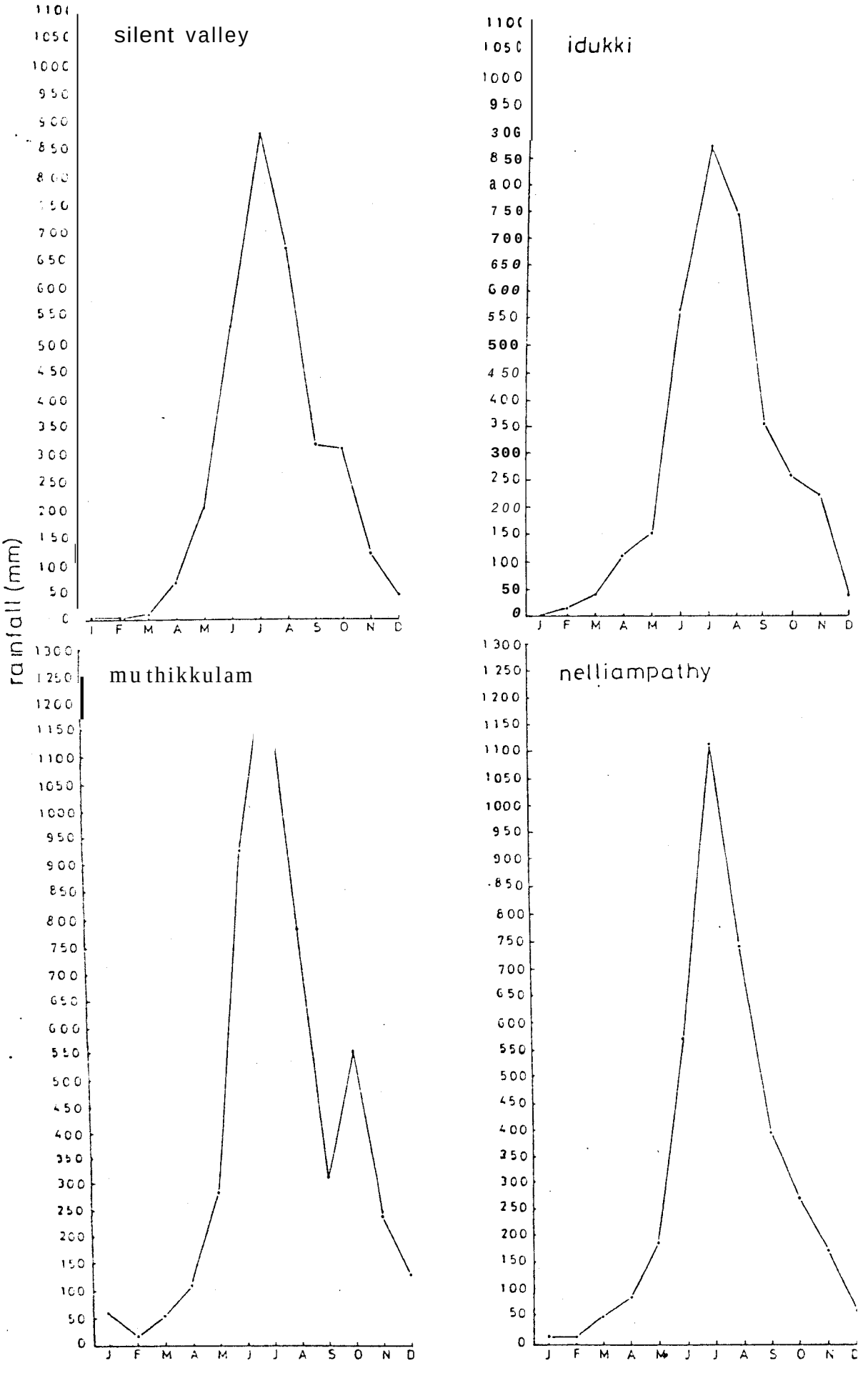
Table 1

	Idukki (8 years)	Silent Valley (9 years)	Nelliampathy (12 years)	Muthikkulam (12 years)
January	.**	6	in	57
February	15	2	12	17
March	40	13	49	53
April	109	67	83	109
May	151	202	180	265
June	569	531	570	925
July	876	886	1107	1268
August	752	679	734	7fC
September	360	319	394	314
October	260	309	272	5s 1
November	225	121	181	21
December	36	45	61	13
TOTAL	3393	3180	3661	4731

Figures are in mm

Fig.5

RAINFALL PATTERN



FOREST TYPES

Even within the limited geographical area the forests at Idukki exhibit considerable variation in florestic composition structure and physiognomy Persistant and heavy anthropic pressures of over nearly three decades have vastly altered the natural vegetation of the area and presently the tropical wet evergreen forests are confined to a very restricted portion with the semi evergreens bordering the road sides and the moist deciduous ones predominating the area.

Following the classificetion of Champion and Setin (1968) atleast three major forest types could be recognised in the study area.

1. West coast tropica1 evergreen forest
2. West coast semi evergreen forest
3. South Indian moist deciduous forest

West coast tropical evergreen forest

It occupies a very restricted portion in the Nagarampara Range and Ayyappan Koil Range Cine solid chunk of this type of forest, with very little human interfererence is seen adjacent to the civil station

near Pynavu (Plate 1 and 2). Most of these forests are presently under cardamom cultivation. Plate **3).** As only the ground is cleared for raising cardamom and the crown left intact for providing shade the Iandsat imageries often provide wrong information identifying it as wet evergreen forest.

Main climatic conditions charecterising this type of Forest are:

(a) higher rainfall than the plains due to orography

(b) reduction in the length of the dry season,

(c) night condensation almost through out the year.

This forest is the prime source of timber for railway sleepers and plywood industries.

Physiognomically it is feetured hy its luxurience of vegetation, diversity of life forms and formation of typical stratification. Trees of the top canopy often attain a height of nearly 45 m and possess a clean, smooth, cylindrical bole upto about 30 m. A good fraction of the constituents are buttressed at base. -Epiphytes are numerous and are

represented by orchids, ferns, mossess and aroids. Grasses are absent or sparse. Leaves are thick and glossy and very often pinkish when young.

Common species constituting the top canopy and second storey are:

Artocarpus heterophyllus, Cullenia exarillata, Persea macrantha, Calophyllum apetalum, Canarium strictum, Elaeocarpus tuberculatus, Holigarna arnottiana, Myristica dactyloides, Aporosa lindleyana, Cinnamomum spp. and Polyalthia fragrans.

Shrubs are represented by Strobilanthus spp., Calamus spp., Pandanus spp., Clerodendrum infortunatum, Glycosmis pentaphylla etc.

Lianas like Entada pursaetha and various species of Dioscorea are common.

West coast semi evergreen forests

It occurs very often along the roadsides and barks of the reservoir and its extent is not spread to 2 large area. Its ecological factors are more or less the same as those of the evergreen forests exepting that it is a derwed one from the evergreen and intermediate to that of moist deciduous forest.

This type of forest; is featured by lofty trees and the top canopy is an admixture of evergreen and deciduous species, the latter shedding its folioge during the dry season. Due to shedding of leaves and penetration of light to the ground a few heliophilous species are commonly met with.

The common taxa constituting the top cenopy end second storey are:

Artocarpus heterophyllus, Persea macrantha, Calophyllum apetalum, Canarium strictum, Polyalthia fragrans, Aporosa lindleyana, Cinnamomum spp. (all evergreens), Lagerstroemia microcarpa, Terminalia paniculata, T. tomentosa, T. bellerica, Bombax [illegible], Tetrameles nudiflora and Vitex altissima (all deciduous). The undergrowth is comprised of a dense, impenetrable mat of Strobilanthus Lianas are represented by Entada pursetha, Butea parviflora,, Dioscorea spp. and a few others.

South Indian Moist Deciduous Forest

Over sixty percent of the forested area is dominated by this type. Extensive areas within the arms of the reservoir and along its margins are

covered by this type of forest. Although. the whole area has a potential to support a wet evergreen type of forest persistant axing has resulted in vast areas being covered by moist deciduous forest. Besides, grazing and repeated annual fires have prevented this forest towards further progress in physiognomy. Most of these forests are also in retrogressive stage from a higher type such as evergreens and semi evergreens and as this type of forest is more or less stable, under the present conditions within the sanctuary area it can be termed as a "sub-climax".

The top canopy is made of various species of Terminalias Tectona grandis Dalbergia latifolia Pterocarpus marsupium, Bombax ceiba, Grewia tilliaefolia, Lagerstroemia microcarpa, Vitex altissima Xylia xylocarpa and Albizia spp. The second storey, if recognised; comprises of Careya arborea, Dillenia pentagyna, Emblica officinalis, Haldinia cordifolia Mitragyana parviflora, Schleichera oleosa and Randia brandisii. Lianas are featured by various species of Acacias, Butea parviflora, Spatholobus roxburghii, Calycopteris floribunda and Bauhenia spp.

There are substantial areas of forest blanks which are termed as South Indian subtropical hill savanna by Champion and Seth (1968). This is an outcome of repeated annual fires and only pyroresistant grasses like Themeda, Cymbopogon etc. with some fire hardy species like Careya arborea, Butea monosperma, Wendlandia notoniana etc. are seen.

under the grassland afforestation scheme, the Kerala Forest Development Corporation has been raising plantations of Eucalyptus grandis in some locolitins of the catchment area (Plate 4). All these forest types have been subjected to anthropic pressures of various degrees and their status have been broadly described by Karunakaran (1975).

HISTORY

By the end of the 18th century most of the low lands of Kerala had been colonised. Idukki being at rather a higher elevation was left almost untouched. This region as a whole was rather unsuitable for occupation, Factors like high rainfall, elevation, cold and high incidence of- maleria prevented the settlers.

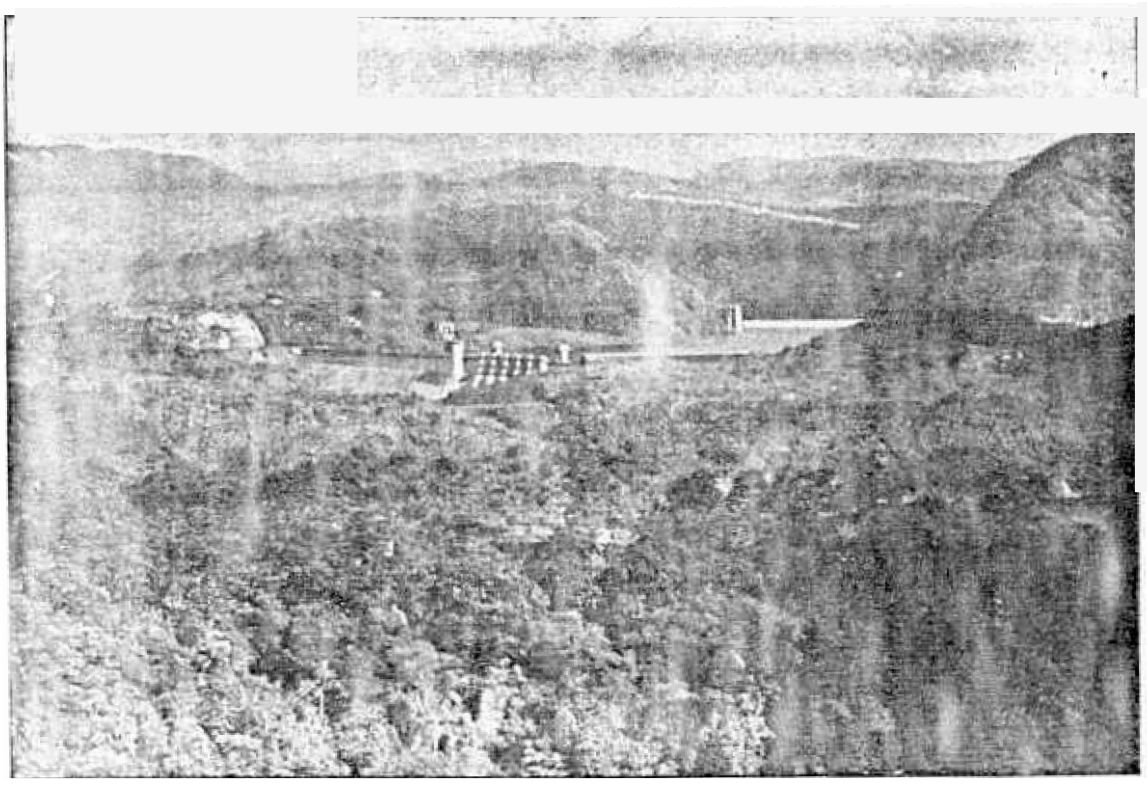


Plate 6. View of Idukki and Cheruthoni dams.

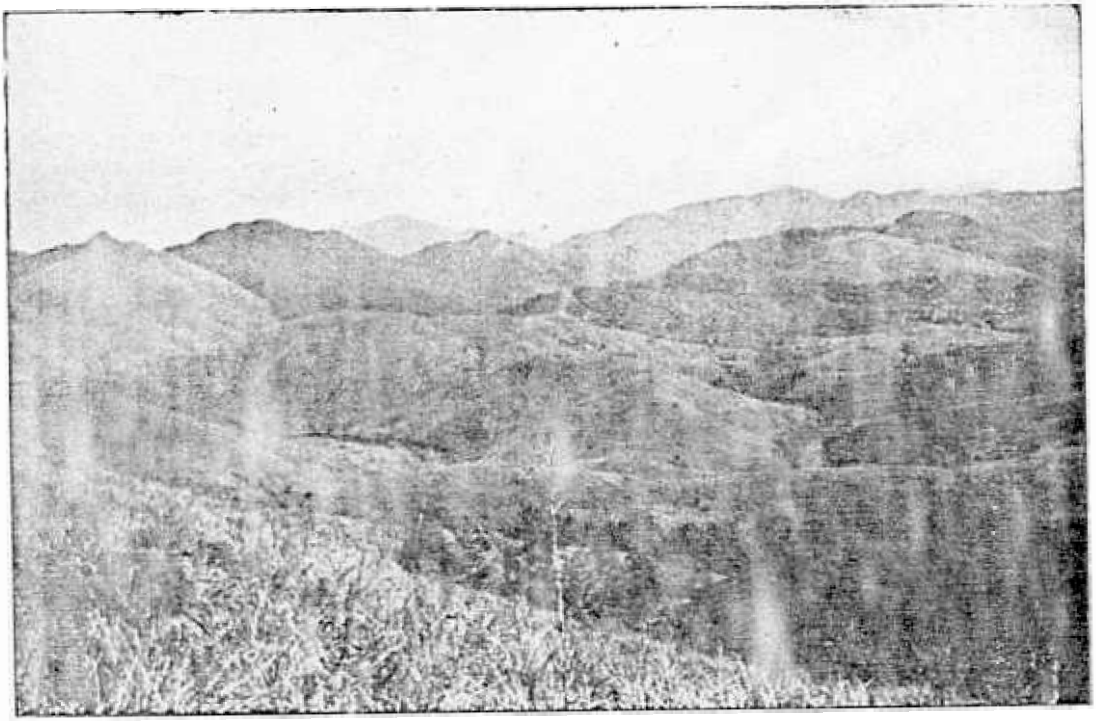


Plate 6. Typical habitat of Periyar region.

References are available from the early part of the 19th century (Ward and Connor1828). Two paths passing through this region served as trade routes between eastern and western coasts. A path from Cumbum to Kothamangalam via Mudirappally and Neriyamangalam was extensively used in those days. Merchants used to take about eight days for traversing the 84 km with cattle. Another route from Cumbum to Kanjirappally vie Peruvanthanam and Kumily was also in use. Pilgrims used to visit the Sabarimala shrine through these routes. Habitations then had not advanced by any siqnificant extent from the plains. Regions like Todupuzha and Moovcttupuzha were just getting colonised at that tine. The Periyar river was described as running through the wildest possible forests by these early authors.

Even during the latter part of the 19th century there does not seem to be any significant change in the situation (Bourdillon, 1693). Hillmen inhcbiting the study area were described by him as practising shifting cultivation. Many indications suggest that these tribals migrated to this part from elsewhere (Nair- 1985 - Personel Communication).

Introduction of cultivation of tea in 1870 altered the face of the hiqh ranges very much. The study area being comparitevely at a lower elevation was not much effected roads were built to connect the high ranges to the nearby towns. While the area under tea cultivation In 1894 was 2372 ha. it rose to 5720.5 ha. by 1908. The estates are at present estimated to occupy an area of 12,150 ha.

Cardomom forests were leased out from 1906 onwards. Cultivations in marshes near forests were also permitted. From 1942 onwards the practice of leasing out forests for cardamon cultivation for 12 to 20 years came into effect. There have been a series of encrochments in the fiftees Ayyappankoil, Pattam colony Vandanmedu, VellathuVel, Kalkanthal and Chakkuvallam colonies came into existence (Varghese, 1977). These settlements had come to occupy large pockects through out the forest. There were few such settlements in the submersion area of the Idukki project as well.

Both Ward and Conor (1827) and Bourdillon (1893) noscribed the river Periyar flowing through a narrow gorge at Idukki. Publicity given to this information

from-member of the Urali tribe is said to have led to the investigations to construct a dam at Idukki. A proposal for a project to produce about 50MW of electricity was made in 1937. In 1947 the scheme was enlarged and modified incorporating dams at Cheruthoni and Kulamavu Consequently, power generation capacity rose to 780 MW. Tho construction of infrastructure facilities like roads and buildings started in 1963. The first stage of the project was commissioned in 1976. The Idukki reservoir has a full reservoir levcl of 734.3 m. The Idukki dam is a double curwature Parabolic arch dam of 163.91 m height. The Cheruthoni dam is a large gravity dam of 133.3 m height and 650 m length (Plate 5). The Kulamavu dam is 99.97 m height, and 384.96 length Plate 6). There are a total of sixgenerators each witha capacity to generate 130 MW of power. Out of these three have been Commissioned. The remaining ones are being installed. Work on stage I1 and 111 of the project involving additional dams in Irattyar and Kallar is in progress.

Implimenatation of the Idukki hydro-electric project brought about rapid improvements in access. sibility and communication to remote areas. Shahi and Ssamuelk 1980) has estimated that the Idukki District has about 50% of the total area under forest.

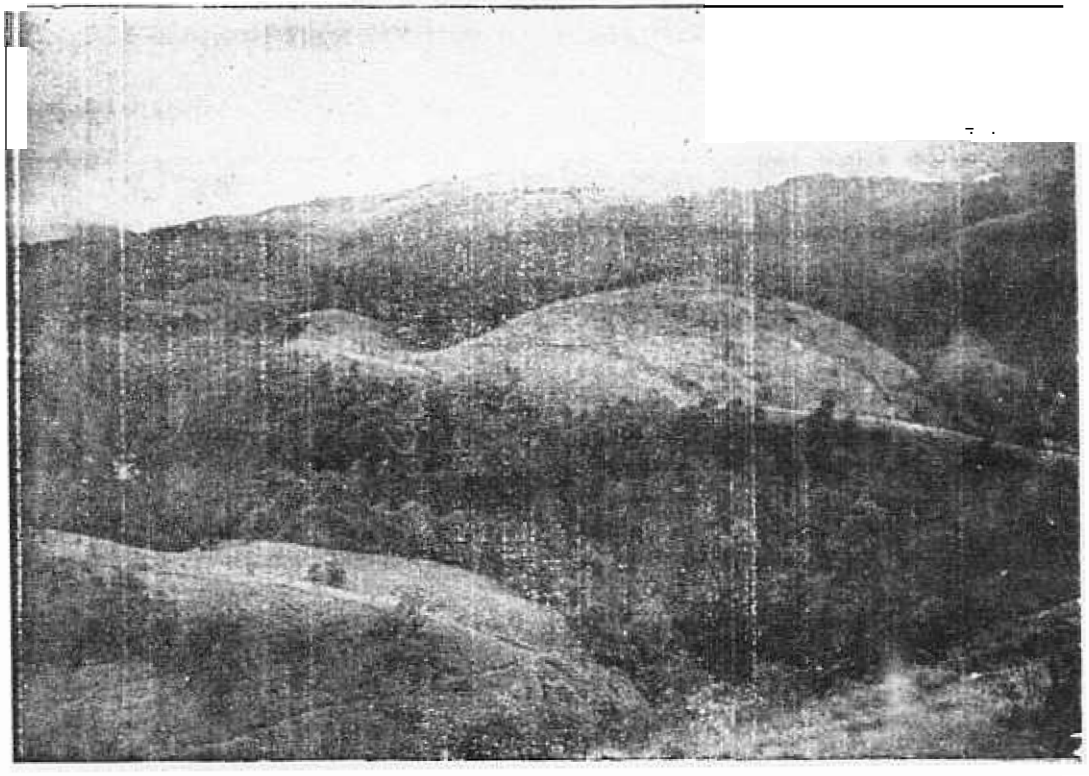


Plate 7. Typical habitat of Silent Valley area.

Plate 8. Elephant tusker in Eucalyptus plantation at Meenmutty.

Animal studies

Sighting records and indirect evidenccs were employcd for documenting animal abundance and distribution. Indirect evidences collected from systematicaly, laid out sample plots were used for collecting data on animal abundance. Habitat quality was recorded on a gridded map by ground check method.

The cultivation pattern was examined with a view to understand raiding of crops by wild animals This was recorded on overlays placed over photographs taken from vantage points. Clustering was employed to find association between different types of disturbances. A combination of qualitative recording and matrix approach was used for EIA.

The entire area was traversed extensively and all sighting and evidence of animals recorded. Details of topography, terrain and vegetation were also recorded. Eighteen sample plots of 20 X 100 m were Laid out systematically (Fig. 6). The plots werelocated on the

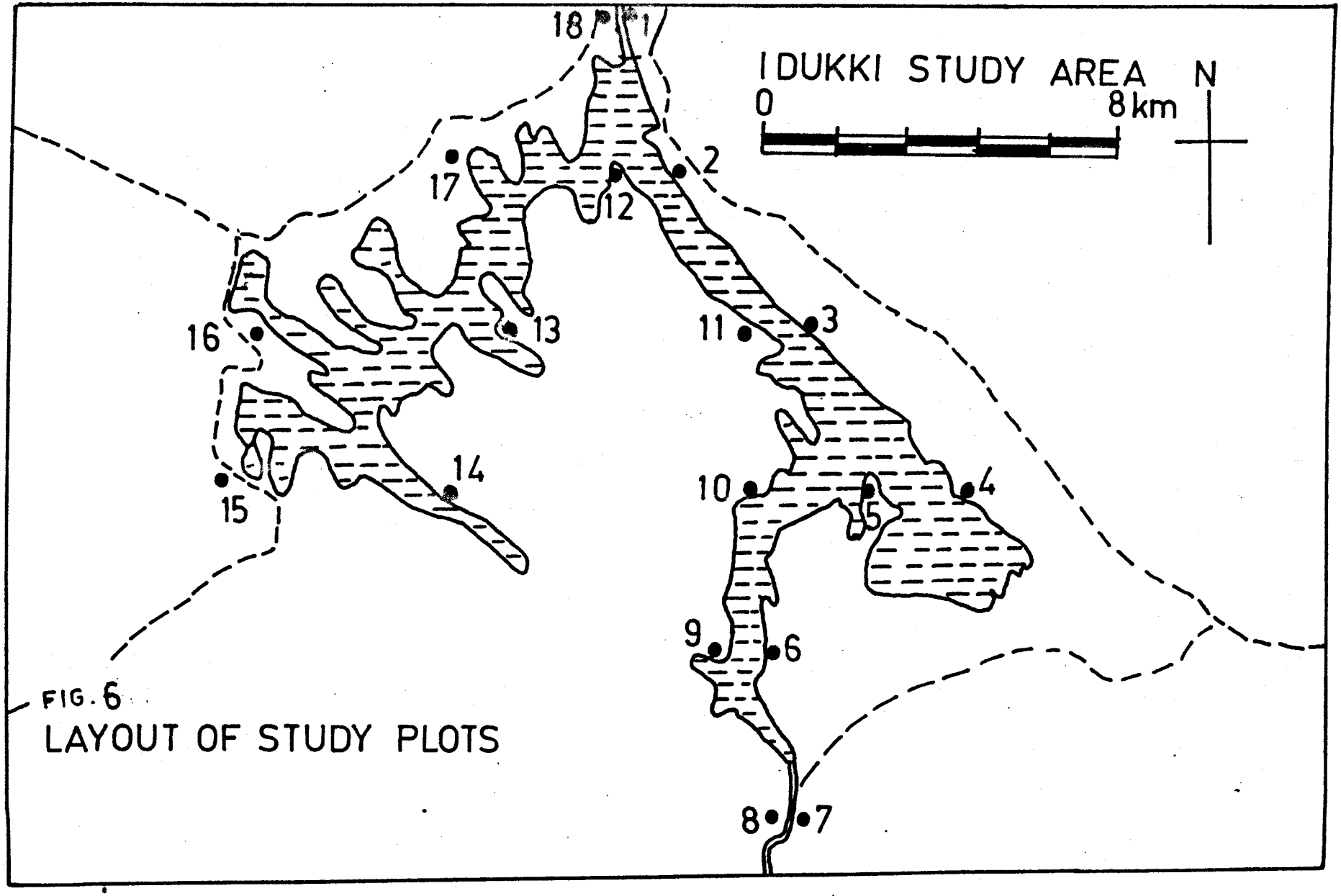


FIG. 6
LAYOUT OF STUDY PLOTS

lake shore. Each plot consisted of five sub plots of 20 x 20 m. The subplots were locottd at suitable distance, from tho water edge to cover different types of vegetaion. The plots were visited once in a month for evidence of animal visits.

Grids of about 0.75km x 0.75krn was made or 1:50,000 maps(Fig. 7). Becausc. of the hilly terrain and grasslands on most hill tops the condition of the forest in several grid elements could be recorded from vantage points. Availability of resources to animals and degree of different types of disturbrnces in east grid element was also recorded. A valley near Kulamavu was selected for recording the forest colonization and cultivation patterns. Photos were taken from vantage points on adjoining hills. Details of forests and cultivation were marked on overlays of those photos. Subsequent changes in items cultivated were monitored and recorded for a period of one year at suitable intervals. An attempt was made to compute the exact area under different crops as the image taken from adjoining hilltop can not be considered to have sufficient photogrammetric accuracy. Similarity of elephpant herds seen in different parts of the study area was examined by cluster analysis of similarity,

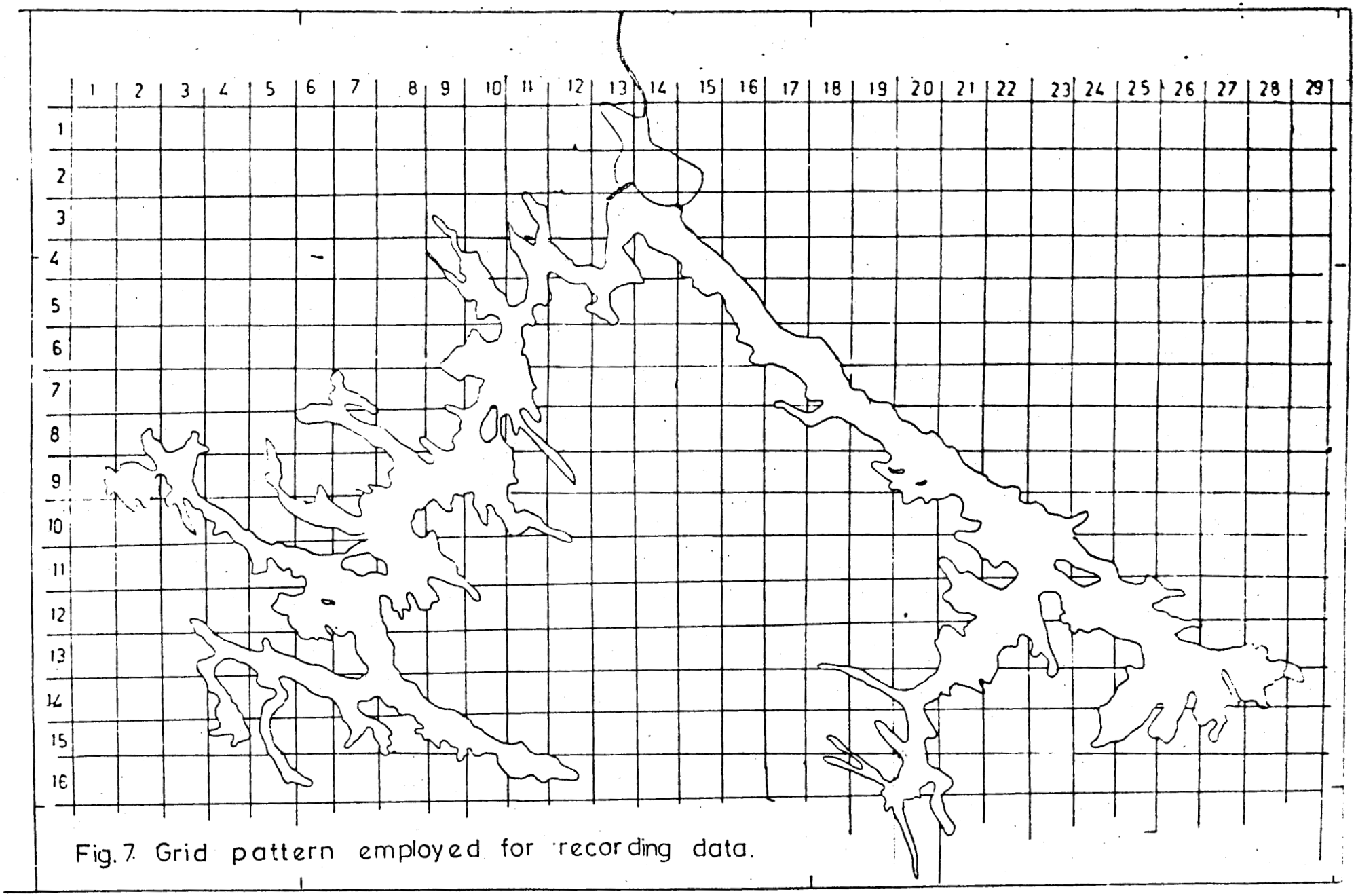


Fig. 7. Grid pattern employed for recording data.

matrix obtained by Jaccard's association coefficient (De Ghett, 1978). In this method similarity

$$S_{ij} = \frac{A}{A+B+C}$$

Where A is the number of times elephant groups i and j were recorded from the same place. B. i alone recorded c, j alone recorded. Association among distarbances were also assessed in this way. In this case the occurance of two disturbances in a gird element was taken as an indication of their association

EIA

In the present study, a combination of different methods like Leopold matrix overlalys, Battelle system;. and the method of Aegerter and Messerli (1961) were adopted EIA. The actions in connection with different stages of the project were identified and its impact on many areas examined. The impacts are assigned for one of the values qualitatively

0.0	no apparent benefit or harm
+0.5	slightly beneficial effect
−0.5	slightly harmful effect
-1 .0	substantial harm
+I .0	substantial benefit

A dash indicates lack of definite information with regard to the particular item.

The scores undereach of these is summed up and interepted.

Details of study of the ecology of two near by river valleys those of Periyar and Silent Valley were used for making comparisons with the conditions present in the Idukki area.

The linear transect method was employed in Silent Valley to assess the status of animals (Vijayan, et al. 1979). The observers walked along forest paths noting down direct sightings and indirect evidence of animals At Periyar 30 sample plots of 100 m x 100 m were laid out around two points selected in such a way as to obtain maximum representation of different forest types (Nair, et al. 1985). The whole plot was searched for elephant and gaur dung. 30 sub plots of 3 m radius marked equidistantly inside the main plot was used for recording feces of other animals collceted once during the wet season and once during the dry season. The pellets accumilated over a period of one month was recorded.

Vegetational studies

One criterion which permits an environmental impact analysisis the species richness and species diversity. Such an investigation in detail was carried for Idukki (which has a potentiality towards wet evergreen type of forest) and the data generated were comapred with other analogous areas,like Silent Valley R.F. Muthikkulam R,F, and Nelliamapthy R.F. All those four areas are situated in an altitudinal rangeof 800-900 m, and with a more or less similar ecological conditions, It needs to be stressed there that while Idukki and Nelliampathy are situated south of the Palghat gap the other two are in the north. In spite of it, the flora in general are more or less same. It is also worth mentioning that all the three areas other than Idukki were all pristine evergreen forests, enabling meaningful comparissions.

The size of the sampling plots were 50 x 50 m in allthe areas and were laid out based on the principle of species are curve (Cain, et al.1956). All species over 10 cm GBH were recorded

Definition of the Terminologies: Used:

(a) Frequency This refers to the degree of dispersion of individual species in an area and is usually expressed in terms of percentage occurrences. It can be calculated as:

$$\%\text{Frequency:} \quad \frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Relative Frequency: (R.F.)} \quad \frac{\text{Number of occurrences of the species}}{\text{Number of occurrences of all species}} \times 100$$

(b) Density: Line frequency, this is also an expression of numerica1 strength of a species and can be calculated as:

$$\text{Density,} \quad \frac{\text{Total number of individuals of 2 species in all quadrats}}{\text{Total number of quadrats studied}}$$

RESULTS

CONDITION BEFORE CONSTRUCTION OF DAM

A knowledge of the status of the animals before construction is essential for describing the impact on animals.

Two approaches were employed for reconstructing the status of animals before construction of the dam. In the first approch the animels found at present in other parts of the Periyar catchment where similar type of forest and physiography occur were analysed and extrapolated to the study area. In the second approch, aged settlers were interviewed and details those prevailed at that time gathered,

The forest and physiography of Thekkady. situated upstream Periyar is very much comparable to that of Idukki. As for as animals are concerned this reserve has enjoyed a protected area status since about a century. Because of this reason good populations of most of the wild animals typical to this region exist ina relatively undisturbed stage (Nair, etal.1985).

Relative Density : (R.D.)

$$\frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

Basal area: It is regarded as one index of dominance of a species, Higher the basal area greater is the dominance. It is measured as girth at breast height.

Relative Basal Area: (R.B.A.)

$$\frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100$$

Importance Value Index (IVI): A total picture of the ecological status of a species with respect to a particular community structure can be obtained only by synthesising the percentage values of R.F., R,D. and R.B.A. These three values added together give the Importance Value Index (IVI) based on which an association is derived. Thus the IVI as such, gives the total picture or sociological structure of a species in a community.

There are sizeable numbcr of elephents, gaur, sambar dear, barking deer, mouse deer, wild pigs, hare, bear, wild dog, panthsr, tiger, bonnet mnceque, Nilgiri Langur and qient squirrel.

In the nineteenth century most of the areas around Idukki might have been a continuous forest. Barring the effect of small scale shifting cultivation practiced by hillmen, there does not seem to have been considerable disturbance at that time. There were only a very few references about the status of animals of the area prior to the construction of the dam. Ward and Connor (1828) and Bourdillon (1893): described animals like elephants, pigs etc. as being present in this tract.

The human settlement in the present submersion area seems to heve occurred during the turn of the century. The settlers report that at that time of colonisation, animals like elephants; gaur, sambar, barking deer, wild pig, bonnet macaque, tiger, panther and bear having been present in the study area.

VEGETATIONAL STUDIES

Based on the species enumeration studies the results obtained have been summarised in table 2, 3, 4 and 5.

Table 2

Tree enumerat ion

(Idukki)

Sl. No.	Name of the species	Relative frequency	Relative density	Relative Basel area	IVI
1	2	3	4	5	6
1.	Cullenia exarillati?	9.84	6.70	39.00	57.54
2.	Mesua nagasarium	8.70	3.40	39.00	52.10
3.	Poliyalthia fragrans	9.42	2.65	38.00	50.07
4.	Litsea bourdillonii	6.02	2.80	27.00	55.82
5.	Macaranga peltata	4.00	2.08	27.92	34.00
6.	Aporosa lindleyana	7.05	0.68	26.02	33.75
7.	Turpinia malabarica	7.95	2.40	22.05	32.40
8	Isonandra lanceolata	4.35	2.80	16.85	24.00
9.	Calophyllum elatum	4.90	2.70	16.20	23.80
10.	Calophyllum tomentosum	3.70	2.40	15.30	21.40
11.	Hydnocarpus alpina	2.90	2.80	14.14	19.84
12.	Atalantia wightii	2.90	3.20	12.59	18.69
13.	Nephelium stipulaceum	5.32	1.40	13.92	18.64
14.	Neolitsea zeylanica	2.90	1.70	11.80	16.40
15.	Glochidion tomentosum	2.90	0.65	13.77	17.32
16.	Artocarpus heterophyllus	4.64	1.70	19.66	16.00
17.	Dysoxylum malabericum	2.90	1.08	12.02	16.00
18.	Palaquium ellipticum	2.72	0.65	10.63	14.00

contd..

1	2	3	4	5	6
19.	Miliusa velutina	1.90	1.40	10.70	14.00
20.	Mimusops elengii	1.90	I .32	10.56	13.78
21.	Actinodaphne malaberica	1.90	0.78	11.02	13.70
22.	Elaeocarpus tuberculatus	1.90	0.65	10.97	13.52
23.	Olea dioica	1.42	0.78	10.80	13.00
24.	Syzygium arnottianum	1.42	0.88	9.74	12.04
25.	Litsea floribunda	1.42	0.34	10.02	11.78
26.	Semecarpus travancorica	0.95	0.47	8.52	9.94
27.	Gomphandra polymorpha	0.95	0.65	7.52	9.12
28.	Knema attenuata	0.47	0.70	3.13	4.30
29.	Persea macrantha	0.47	0.42	3.11	4.00
30.	Bischofia zeylanica	0.47	0.12	2.81	3.40
31.	Aglaia anamallayana	0.47	0.18	1.75	2.40

Table 3

Tree enumeration

(Silent Valley)

Sl. No.	Name of the species	Relative frequency	Relative density	Relative Basel area	IVI
1	2	3	4	5	6
I	Cullenia exarillata	9.90	1.06	32.30	43,26
2.	Palaquium ellipticum	9.95	12.93	4.59	27.47
3.	Elaeocarpus tuberculatus	0.95	0.53	24.80	26.28
4.	Persea macrantha	9.55	11.87	2.27	24.09
5.	Myristica dactyloides	7.11	7.39	2.07	16.57
6.	Cinnamomum sp.	8.06	7.39	0.80	16.25
7.	Holigarna arnottiana	5.69	4.75	4.69	15.13
8.	Mesua nagasarium	6.64	6.60	1.26	14.50
9.	Agrostistachys meeboldii	3.79	7.65	**0.81**	12.25
10.	Garcinia morella	6.64	5.28	0.33	12.25
11.	Gomphandra polymorpha	4.74	4.22	0.26	9.22
12.	Artocarpus heterophyllus	4.74	3.69	0.34	8.77
13.	Antidesma menasu	3.32	3.17	2.08	**8.57**
I4	Drypetes elata	4.27	3.69	0.25	8.21
15.	Villebrunia integrifolia	1.90	2.37	1.60	5.87
16.	Laportea crenulata	1.90	3,69	0.23	5.82
17.	Actinodaphne bourdillonii	1.90	1.85	0.26	4.01

contd. ..

1	2	3	4	5	6
18.	Dysoxylum malabericum	1.90	1.06	0.12	**3.08**
19.	Calophyllum tomentosum	0.95	1.58	0.38	*2.89*
20.	Bochmeria sp.	1.42	1.06	0.36	2.04
21.	Isonandra lanceolata	1.42	1.06	0.28	2.76
22.	Psychotria sp.	1.42	0.79	0.08	2.29
23.	Litsea wightiana	0.95	0.53	0.FO	2.26
24.	Syzygium mundagam	0.95	1.06	0.21	2.22
25.	Cryptocarya lawsonii	0.95	0.90	0.26	2.11
26.	Bischofia javanica	0.47	0.26	1.36	2.09
27.	Jambosa munroii	0.95	0.53	0.12	1.60
28.	Macaranga peltata	0.47	0.26	0.66	1.39
29.	Aglaia anamallayana	0.47	0.26	0.46	1.19
30.	Knema attenuata	0.47	0.26	0.42	1.15
31.	Atalantia wightii	0.47	0.26	0.21	0.94
32.	Pithecellobium bigeminum	0.47	0.26	0.14	0.87
33.	Canarium strictum	0.47	0.26	0.12	0.85
34.	Neolitsea zeylanica	0.47	0.26	0.08	0.81
35.	Euphoria longana	0.47	0.26	0.05	0.78

Table 4

Tree enumeration

(Nelliampathy

Sl. No.	Name of the species	Relative frequency	Relative density	Relative Baselarea	IVI
1	2	3	4	5	6
1.	Cullenia exarillata	**10.80**	*7.36*	*40.80*	58.96
2.	Palaquium ellipticum	9.40	6.30	20.80	36.50
3.	Unona pannosa	7.80	12.53	19.00	29.33
4.	Acrostistachys meeboldii	8.90	8.43	11.25	28.58
5.	Mesua nagasarium	**8.75**	*6.43*	**9.20**	**24.38**
6.	Drypetes alata	**7.40**	**3.80**	**12.20**	**23.40**
7.	Lasianthus ciliatus	**7.40**	**0**.85	**14.75**	23.00
8.	Canarium strictum	**7**.40	**0**.90	**14.70**	**23***.00*
9.	Holigarna arnottiana	7.00	1.80	14.00	22.80
10.	Neolitsea zeylanica	7.00	2.40	12.70	22.10
11.	Psychotria sp.	3.80	0.40	16.80	21.00
12.	Isonandra lanceolata	3.80	1.00	16.00	20.80
13.	Holigarna grahamii	2.40	0.90	16.70	20.00
14.	Atalantia wightii	1.90	0.80	17.20	19.90
15.	Myristica dactyloides	1.90	0.40	17.40	19.70
16.	Polyalthia fragrans	1.90	0.35	16.75	19.00
17.	Lagerenoa peltata	1.90	2.35	14.55	18.80

contd..

1	2	3	4	5	6
18.	Jambosa munronii	1.90	0.45	16.45	18.80
19.	Calophyllum tomentosum	1.42	1.65	15.53	18.60
20.	Artocarpus heterophyllus	1.42	1.00	14.58	17.00
21.	Bischofia javanica	1.42	1.60	13.98	17.00
22.	Memecylon malabaricum	1.42	0.80	14.18	16.40
23.	Euonymous crenulatus	0.95	0.60	10.45	12.00
24.	Aporosa lindleyana	0.95	3.00	7.85	11.80
25.	Antidesma menasu	0.95	2.00	4.85	7.80
26.	Euphoria longana	0.95	1.00	5.05	7.00
27.	Gomphandra polymorpha	0.47	0.38	5.95	6.80
28.	Litsea floribunda	0.47	0.35	5.18	6.00
29.	Mallotus beddomeii	0.47	0.20	4.73	5.40
30.	Phoebe lanceolata	0.47	0.20	4.73	5.40
31.	Glochidion sp.	0.47	0.18	2.35	3.00
32.	Dysoxylum malabaricum	0.47	0.12	1.81	2.40
33.	Goniothalamus thwaitesii	0.47	0.10	1.31	1.88
34.	Actinodaphne bourdillonii	0.47	0.12	0.81	1.40

Table 5

Tree enumeration

Muthikkulam

Sl. No.	Name of the species	Relative frequency	Relative density	Relative Basel area	IVI
1	2	3	4	5	6
1.	Cullenia exarillata	9.60	6.40	39.70	55.90
2.	Palaquium ellipticum	9.95	4.60	36.00	50.75
3.	Dysoxylum malabaricum	9.40	7.80	15.00	32.20
4.	Kolaia anamallayana	8.00	3.40	20.00	31.40
5.	Evodia roxburghiana	7.07	4.40	18.60	**30.07**
6.	Polyalthia fragrans	7.70	3.40	19.74	29.84
7.	Holigarna arnottiana	6.05	4.60	**15.55**	28.41
8.	Syzygium arnottianum	4.45	3.17	19.68	27.30
9.	Euonymous crenulatus	4.80	0.16	21.76	26.72
10.	Dysoxylum ficiforme	7.85	1.58	15.29	24.72
11.	Hydnocarpus alpina	4.74	2.42	15.84	**23.00**
12.	Cryptocaryastocksii	4.74	0.88	17.28	22.90
13.	Phoebe lanceolata	3.32	1.40	17.00	21.80
14.	Myristica dactylodes	3.32	1.64	16.32	21.46
15.	Persea rnacrantha	1.90	4.60	14.52	21.22
16.	Mesua nagasarium	1.90	0.84	18.34	21.08
17.	Drypetes alata	1.90	0.48	18.62	21.00

contd..

1	2	3	4	5	6
18.	Euphoria longana	0.95	1.37	18.43	20.76
19.	Litsea floribunda	0.95	1.42	17.75	20.12
20.	Garcinia morella	I .90	0.30	17.80	**20.00**
21.	Cinnamomum sp.	1.90	0.85	13.25	16.00
22.	Diospyros microphylla	1.42	1.06	13.60	16.08
23.	Harpullia imbricata	1.42	0.66	10.42	12.50
24.	Mallotus philippinensis	1.42	1.88		12.00
25.	Mallotus beddomei	0.95	1.06	9.79	11.80
26.	Artocarpus heterophyllus	0.95	0.80	9.95	11.70
27.	Gomphandra polymorpha	0.45	1.20	8.73	10.38
28.	Memecylon malabaricum	0.95	0.88	7.61	9.44
29.	Knema attenuata	0.95	0.64	7.65	9.24
30.	Macaranga peltata	0.47	**0.16**	5.75	6.38
31.	Isonandra lanceolata	0.47	0.18	3.75	4.40
32.	Calophyllum tomentosum	0.47	0.16	3.69	4.32
33.	Ficus sp.	**0** .47	0.12	3.35	3.94

ANIMAL STUDIES

Evidences of animals were recorded from the sample plots. The density of animals were too low to estimate the population by this method. The results are shown in Table 6. Elephants were present in almost throughout the study area. Animals like sambar, wild pigs, wild dogs, hare, porcupine, barking deer and mouse deer though not readily sighted were present in many plots as indicated by pellets and foot prints. There was no sign of animals like gaur, bear, tiger and panther from the study area.

ELEPHANTS

Elephant is the largest herbivore inhabiting the area. This is also one of theanimals likely to be most affected when habitat is disturbed The .elephants were so much affected because:

(a) the animals move about sevral kilometers in search of fodder and water in a day. Creation of a lake could make this movement difficult.

(b) increased access to forest would naturally lead to an increase in the destruction of elephants for tusk.

Table 6

Occurrence of animals in the sample plots at Idukki

Sl. No.	Location	Elephant	Gaur	Sambar	Barking deer	Mouse deer	Wild boar	Porcupine	Hare	Rodents	Wild dog Jackal	Toddy cat
1.	Kallarkutty	+			+	+	+	+		+		
2.	Dam site	+					+			+		
3.	Narakakkanam	+					+			+		+
4.	Anchuruli	+			+		+					+
5.	Thattathikudi	+								+		
6.	Ayyappankoil	+			+				+	+		
7.	Kodayurutty	+			+	+	+			+		+
8.	Vakavanam	+		+	+	+				+		
9.	Ayyappankoil	+								+		
10.	Kochidukki	+			+		+					
11.	Narakakkanam	+			+		+					+
12.	Dam site	+		+	+	+	+	+	+	+		
13.	Venganam	+			+		+					+
14.	Kizhakkelachi	+					+			+	+	+
15.	Kalamkomathy	+		+	+	+		+	+	+	+	
16.	IV Block	+		+	+	+	+		+	+	+	+
17.	Meenmutty	+			+		+	+		+		

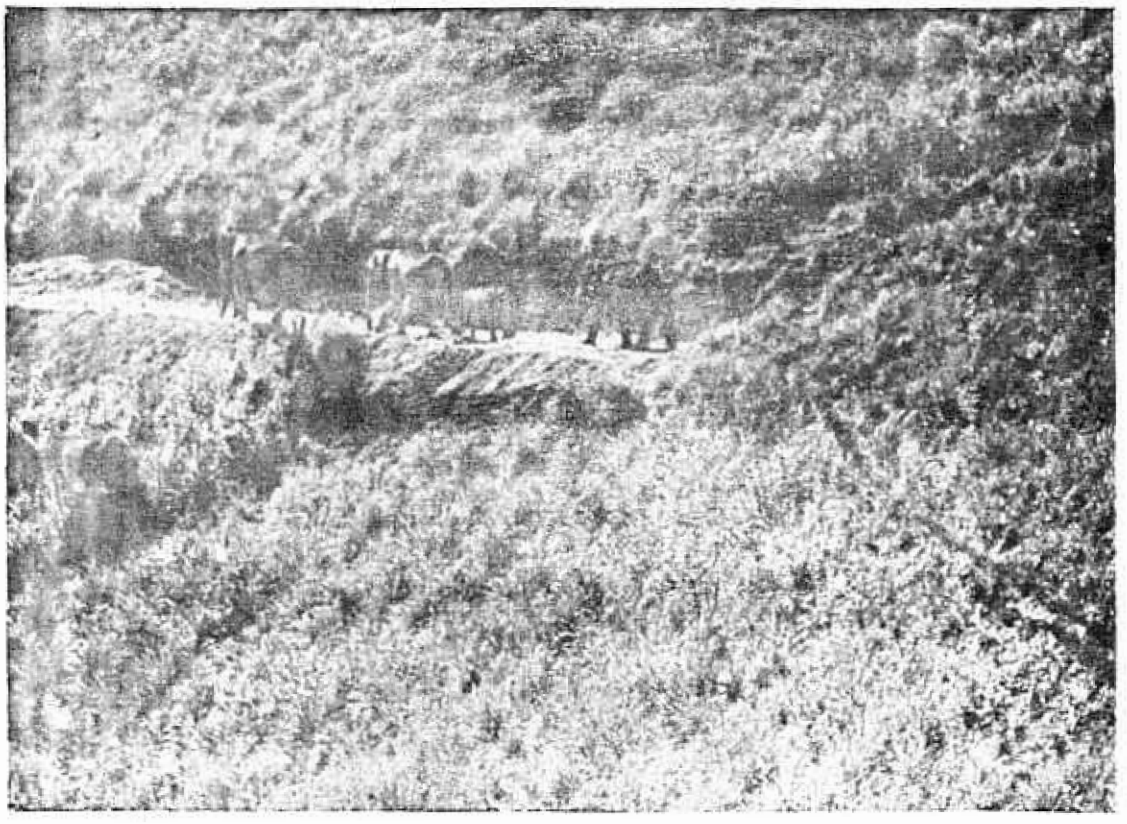


Plate 9. A small group of elephants at Idukki.

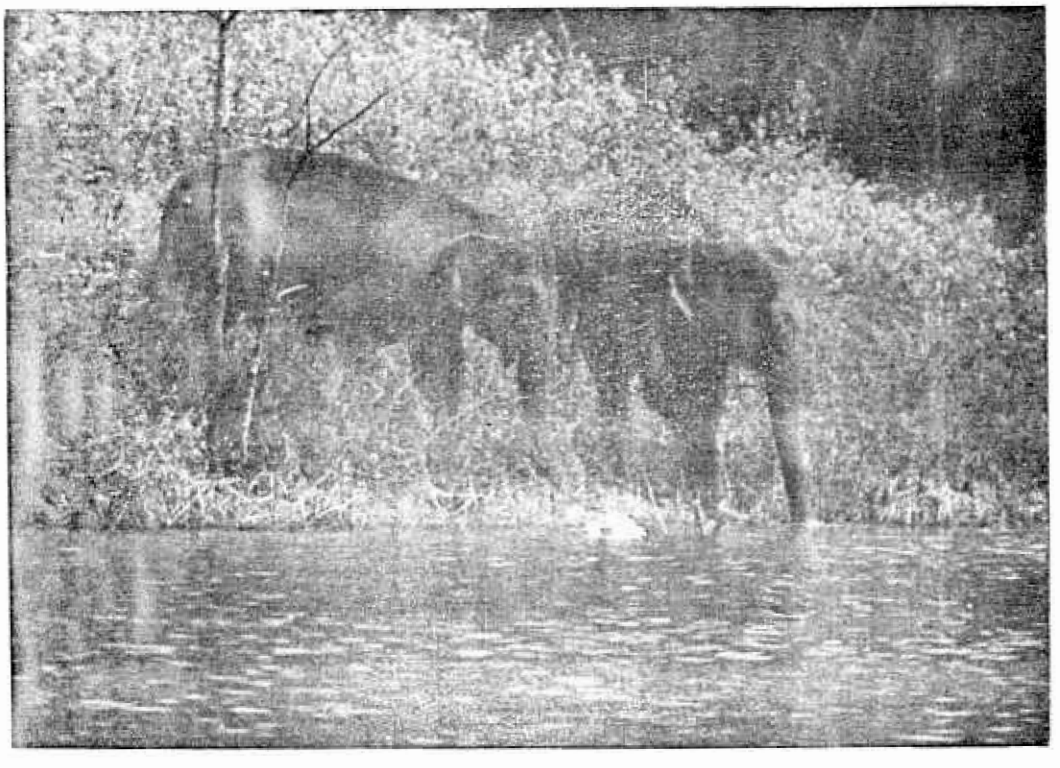


Plate 10 Part of a herd of elephants approaching water.

Plate 11. Same elephants entering deeper water

Plate 12. Bonnet macaque, the only primate of the study area.

The following aspects were investigated:

i. whether there has been fragmentation of habitat as far as elephants were considered.

ii. whether the population parameters like herd composition, sex ratio and group frequency were comparable to that of herds in other population.

iii. to document the movement patters of elephants.

Distribution

The location of the elephant herds sighted is shown in Fig. 8. The elephants seem to move all over though observations are limited to the western portions. The sample plots located in the eastern portion also had sign of elephant's presence.

The elephants do not have very vast areas for movement. The habitations etart at less than ten kilometers from the study area on the western side. The cultivation on northern side and the Kalyanathandu hill chain restrict the movement of elephants. On the south eastern side cultivations and habitations block the movement of elephants. There are only about a few kilometers of continuous forest available south of

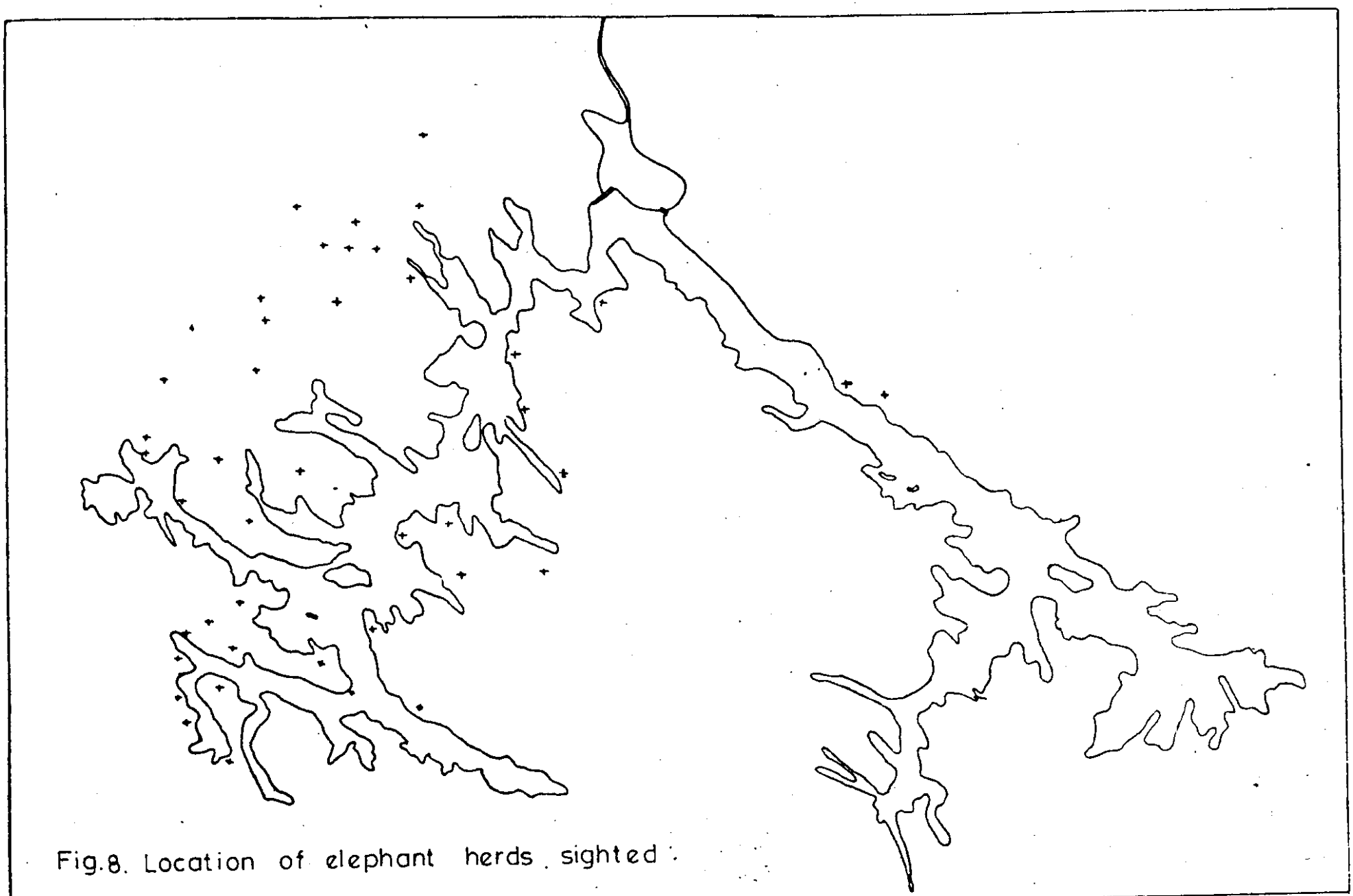


Fig.8. Location of elephant herds sighted

Table 7

Frequency distributions of elephant herds sighted in five selected parts of the reserve

Herd size	Kodayurutty Meenmutty Manjakuzhi-thandu	Uluppuny Kalamkamathy	Nellikkappara Maruthumkanam Vellappara	Viramani Venganam	Idukki
1	10	7	2		
2	4	9	5	2	
3	11	16	10		
4	2	4	3		1
5	1	3	3	3	
6		1	5		
7	3	6	8		
8		2			
9	1	1	1		
10		2		1	1
11	4	2			
12			1		
13		7			
14	4		1		
15	1	4	2		
16					
17					
18					
19					
20	1	1			

Kulamavu region (Fig. 9). Numerous habitations and villages dispersed through out the region also affect the movement of the elephants.

Herd composition

Tht number of elephants in groups sightcd varied from one to fifteen. The frequency distribution of groups sighted is shown in fig. 10. During the period- from January 1985 to January 1904 a total of 321 individuals in 108 herds were sighted. These sightings include repeated sightings of the herds in the area. The elephant population of the reserve is estimated to be around 75. Out of 321 eleven (10.2%) were solitary individuals. Groups exceeding 15 individuals were rare. The majority of the herds had less than I0 individuals in the group (plates 9 to 11). Larger groups like the ones containing 18, 19 or 20 individuals were composed of smaller units grazing in nearby areas.

The frequency distribution of elephants sighted in the five areas were examined for their similarity (Table 7). These five regions were around Meenmutty, Kalamkamathy, Maruthumkanam Pynavu and Idukki. The distribution showed similarity in the three regions Meenmutty,

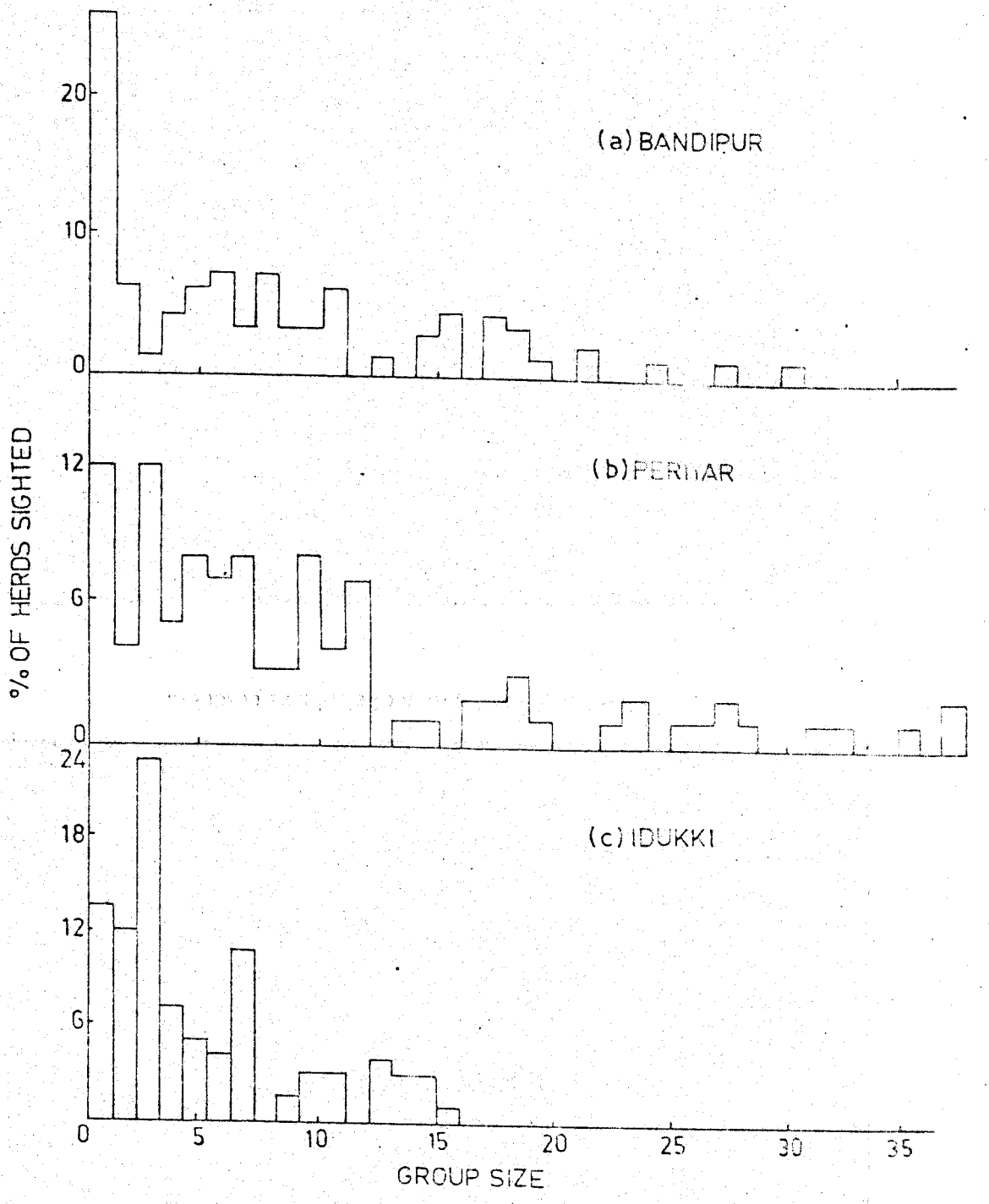


Fig.10 Group size distribution of elephant herds sighted

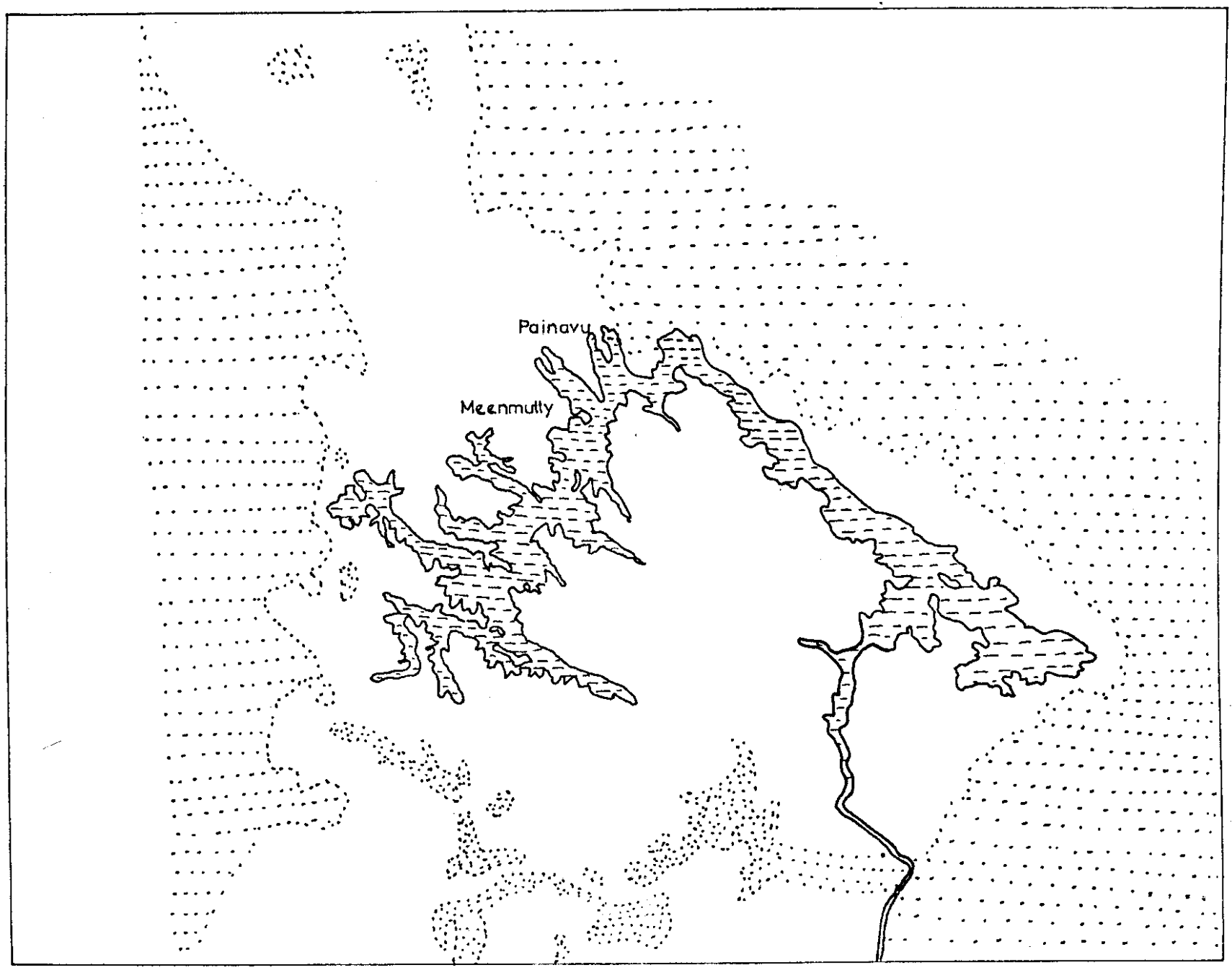


Fig. 9 Habitat continuity for larger mammals. ::: habitations , == reservoir

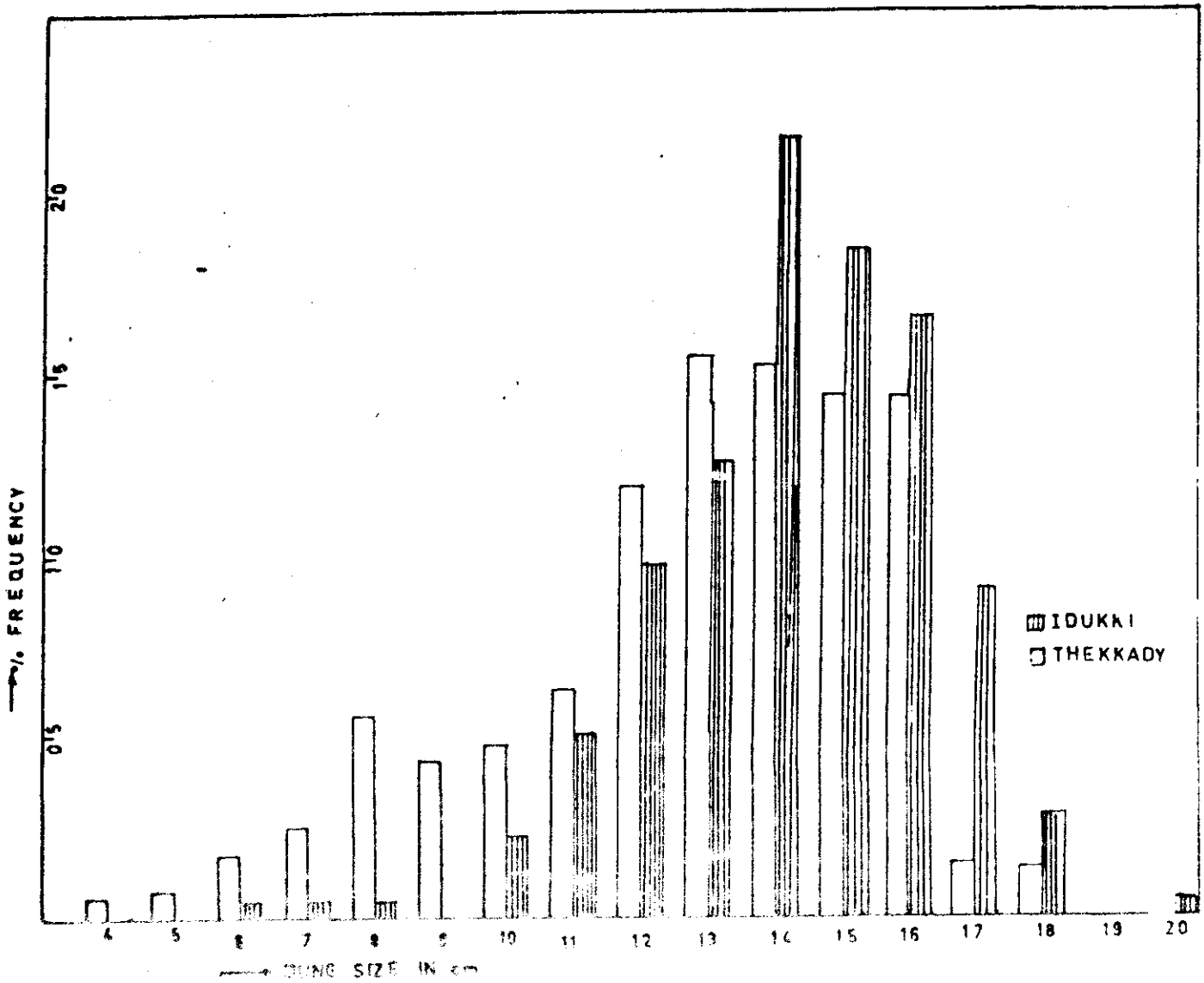


FIG 13 COMPARISON OF DUNG SIZE FREQUENCIES

Kalamkamathy and Maruthumkanam for which sufficient data were available (Fig. 11). This indicates that one and the same herds move over all these areas.

The elephants were classified as calves (less than 14 months age), Juveniles (14 to 40 months) subadults (40 months to 15 years in the case of fema1es and 40 months to 12 years in the case of males as was donc by Eisenberg and Lockhart (1972). A total of 321 individuals in 108 herds were observed in all at the study area. Out of these, themales constituted only three individuals (0.93%). Male elephants in the subadult or juvenile categories were not observed. Among the female elephants there were 305 adults and eight subedults (95.0%) and O.25% respectively). Five young ones (1.55%) could not be sexed accurately (Fig, 12). Details *of* clephant herd composition are shown in Table 8.

A distribution of the elephant dung size also showed 2 similar pattern. There were only few individuals in the smallest size tategory (Fig. 13). Plates 9 to 11 show two of the frequently seen herds.

During the course of the study two different adult tuskers could be identified. One of them had asymmetric tusks with one tusk in rudimentary form (Plate 8). These elephants were sighted at Maruthumkanam and Kodayurutty.

Table 8

Herd composition of elephants sighted

Sl. No.	Gate	Place	Total	Females			Males		
				young	adults	adults	Young	adults	adult
1	2	3	4	5	6	7	8	9	10
1	04.01.83	Kalamkamathy	1			1			
2	31.01.83	DO.	4			4			
3	34.02.83	Do.	1			1			
4	19.02.83	Meenmutty	3			3			
5	22.02.83	DO.	3			3			
6	27.02.83	Ulupuni	2						
7	28.02.83	Do.	1			1			
8	28.02.83	Meenmutty	2			2			
9	01.03.83	Kelamkamathy	2			2			
10	01.03.83	Meenmutty	I						
11	03.03.83	Kalamkamathy	3			3			
12	04.03.83	Nellikkappara	3			3			
13	05.03.83	Maruthumkanam	3			3			
14	09.03.83	Cheri	2						
15	09.03.83	Kodayurutty	2		1	1			
16	21.03.83	Meenmutty	28						
17	21.03.83		15	1		14			
18	02.04.83	Kalamkamathy	3						

contd..

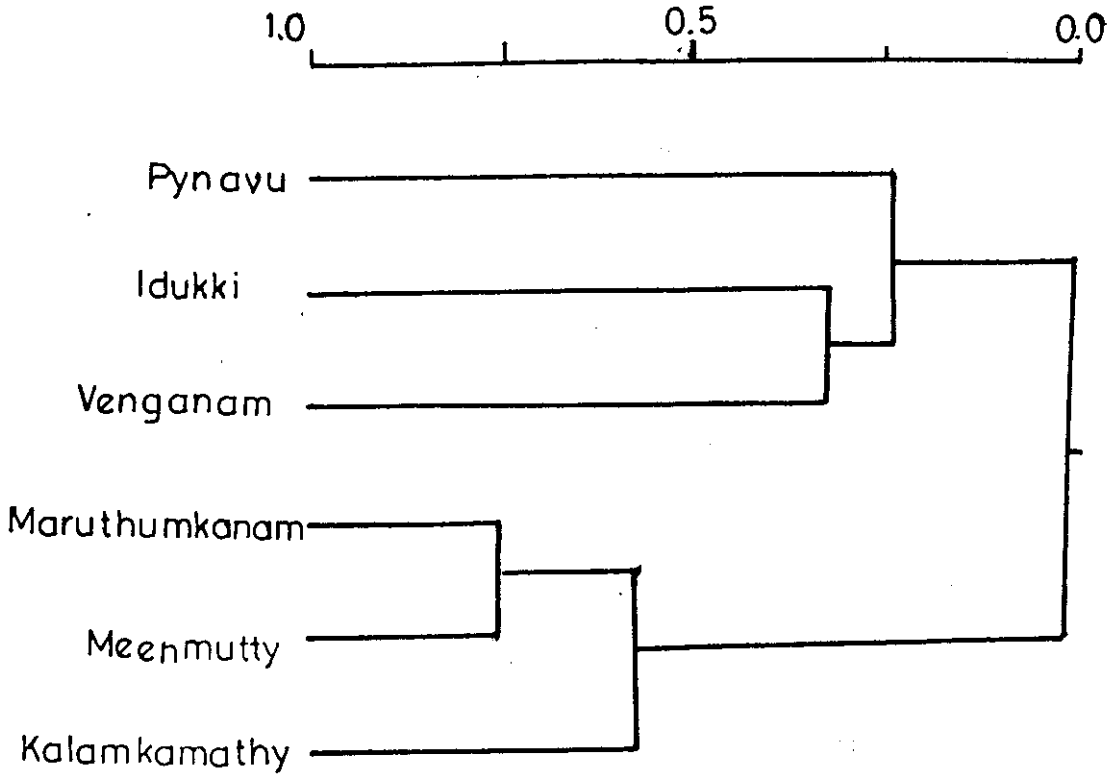


Fig. 11 Similarity of elephant groups sighted in different parts.

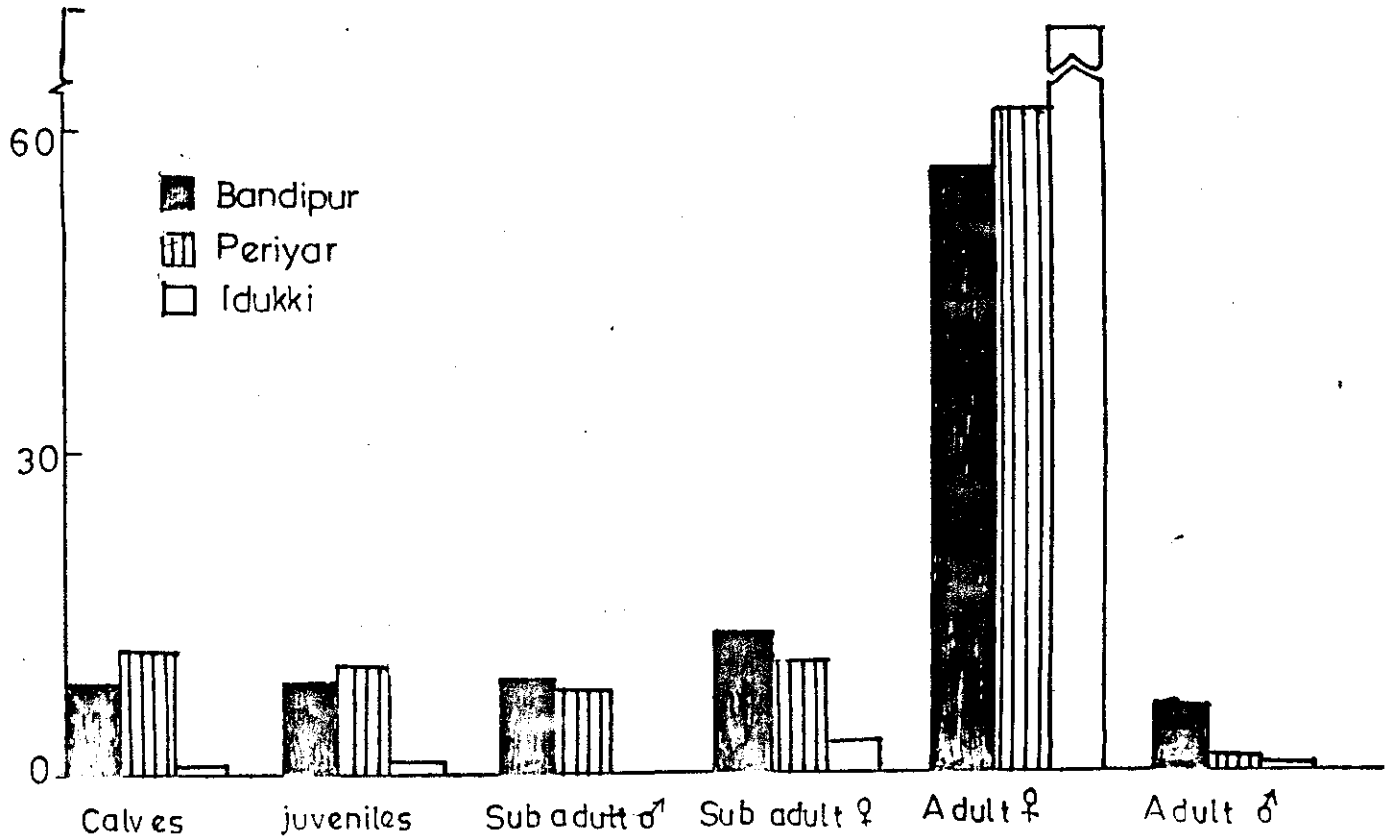


Fig 12 Age class distribution of elephants in populations of Bandipar, Periyar and Idukki.

1	2	3	4	5	6	7	8	9	10
19	05.04.83	Maruthumkanam	7			7			
20	06.04.83	Do.	3			3			
21	06.04.83	Kalamk amathy	7			7			
22	06. 04.83	Maruthumkanam	3						
23	07.04 .83	Kalamkamathy	7			7			
24	08.04.83	Maruthumkanam	7			7			
25	09.04.83	Kalanlkamathy	5			5			
26	11.04.83	Do.	6						
27	11.04.83	Maruthumkanam	3			3			
28	16.04.8 3	Manjakuzhithandu	4			4			
29	21.04.83	Venganarn	2			2			
30	23.04.83	Vellappara	2			2			
31	30 .04.83	Uluppuni	2			2			
32	02.05.83	Kalamkemathy	4			4			
33	02.05.83	Kalamkamathy	12			12			
34	03.05.83	Maruthumkanam	4			4			
35	03.05.83	Do.	9			9			
36	04.05.83	Do.	4						
37	04.05.83	Do.	9						
38	04.05.83	Maruthurnkanam	7			7			
39	04.05.83	Manjakuz hit handu	7						
40	04.05.83	Do.	7						
41	04.05.83	Do.	1			1			

Contd...

1	2	3	4	5	6	7	8	9	10
42	05.05.83	Manjakuzhithandu	3			3			
43	05.05.83	Vellappara	5			5			
44	06.05 .83	Maruthurnkanam	3						
45	06.05.83	Vellppara:		5			5		
46	09.05.83	Kalamkamathy	20			20			
47	11.05.83	Maruthumkanam	3			3			
48	11.05.83	Manjakuzhithandu	3						
49	20.05.83	Kalamkamathy	7			7			
50	20.05.83	Maruthumkanam	3			3			
51	21.05.83	Kalamkamathy	7			7			
52	23.05.83	Vellppaara	2			2			
53	06.06.83	Kalamkamathy	2			2			
54	10.06.83	Maruthumkama	10						
55	10.06.83	Maruthumkanam	7			7			
56	10.06.83	Maruthumkanam	1						
57	13.06.83	Manjekuzhithandu	7			7			
58	14.06.83	Do.	4			4			
59	21 .06.83	Meenmutty		3			3		
60	21.06.83	Kodayurutty	1			1			
61	22.06.83	Meenmutty	1						
62	22.06.83	Do.	3			3			
63	22.06.83	Kodayurutty	3			3			
64	23.06.83	Do.	1						
65	27.06.83	Do.	14		1	13			

contd..

1	2	3	4	5	6	7	8	9	10
66	27 06.83	Meenmutty							
67	28.06.83	Kodayurutty	13						
68	26 .08 .83	Do.	13						
69	06.07.83	Kalsmkamathy	3		3				
70	07.07.83	Do.	13	1	4	6			
71	08.07.83	D o .	10						
72	09.07.83	Do.	15						
73	09.07.83	Manakuzhithandu	13	1	1	11			
74	11.07.83	Kalamkamathy	6						
75	13.07.83	Manajkuzhithundu	11						
76	01.08.83	Maruthurnkanam	2						
77	05.08.83	Kalamkamathy	3						
78	06.08.83	Do.	3						
79	17.08.83	Manjakuzhithundu	5			5			
80	19.08.83	Uluppuni	1			1			
81	02.09.83	Kalankarnathy	2						
82	05.09.83	Maruthumkanam	15						
83	08.09.83	Vairamani	5						
84	09.09.83	Manjakuzhithandu	6						
85	13.09.83	Kalamkamathy	5						
86	I4.09.83	Do.	15						
87	22 .09.83	DO	10						
88	22.09.83	Vairamani	5						

1	2	3	4	5	6	7	8	9
89	26.09.83	Maruthumkanam	3			3		
90	26.09.83	DO.	2			2		
91	26.09.83	Do.	6					
92	26.09.83	Do.	15					
93	01.10.83	Kalamkamathy	2			2		
94	06.10.83	Do.	8					
95	21.10.83	Maruthumkanam	6					
96	14.10.83	Manjakuzhithandu	3			3		
97	27.10.63	DO.	18					
98	09.11.83	Meenmutty	6					
99	10.11.83	Do.	7			7		
100	10.11.83	Do	7			7		
101	12.11.83	Do.	12					
102	14.11.83	Go.	8	1				
103	14.11.83	Do.	7			7		
104	15.11.83	Do.	9			7		
105	15.11.83	Do.	9					
106	09.12.83	Kalamkamathy	8					
107	16.12.83	Manjakuzhithandu	3					
108	22.12.83	Kalarnkamathy	3					
		Total		5	8	306	0	0 3

Movement

The movements of few herds of elephants were recorded. Most of the herds could be tracked only for a few days They remained in an area for one or two days and movedaway to adjacent areas The route taken by one of the herds is shown in Fig. 14.

OTHER ANIMALS

There were only two sightings of sambar. Evidence of this barkingdeer, hare and wild boar were obtained from the sample plots. On a few occassions wild pigs were sighted in many areas there were abundant signs of more.

Carnivores

The main carnivores noted were jackal and the wild dog. Jackals were observed on a few occassions. There were onlv indirect evidence of wild dogs. There were several cases of wild dogs attacking domestic goats and cattle. Tiger and leopard were not sighted.

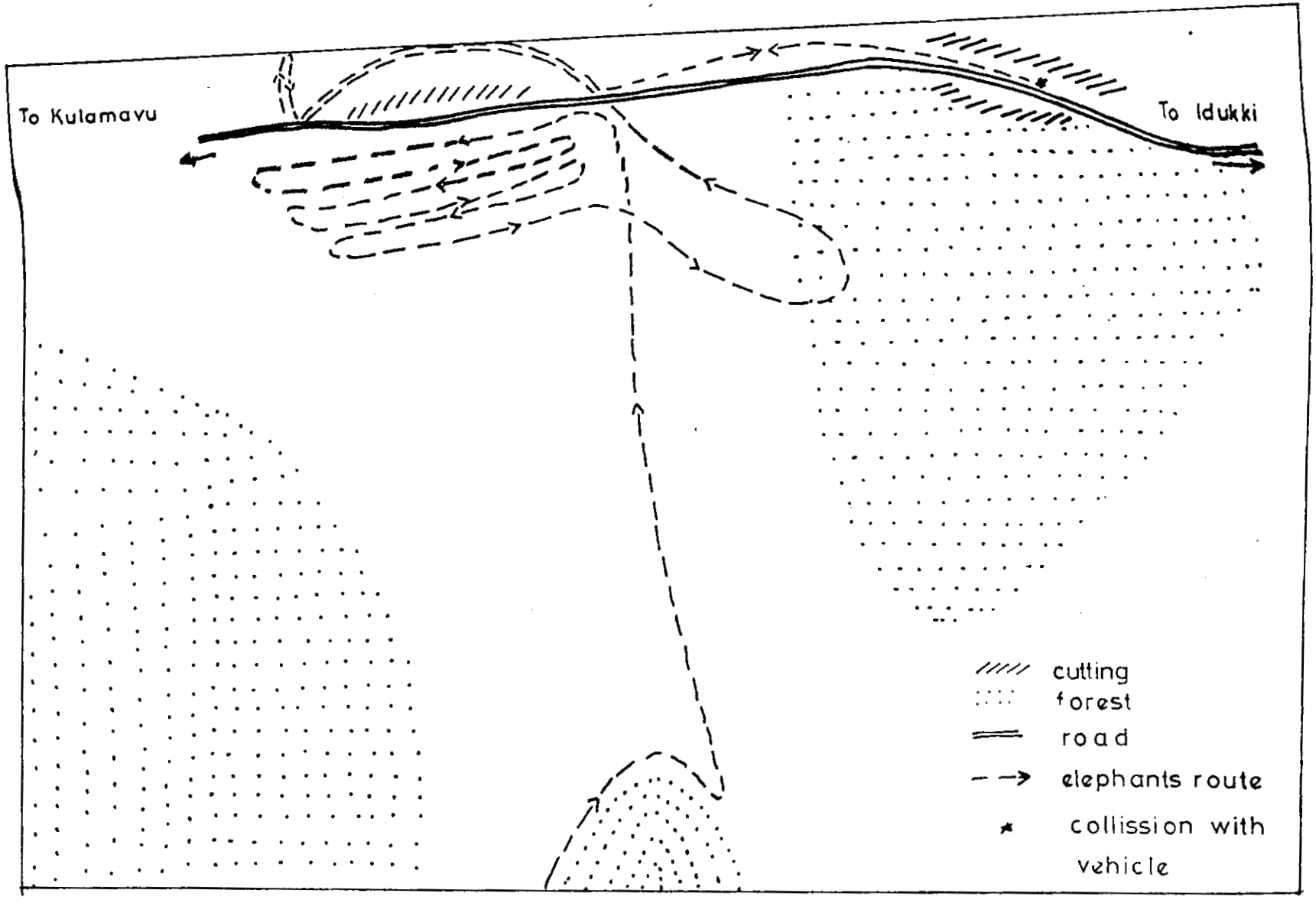


Fig. 14 Route taken by elephants.

Primates

Bonnet macaque was the only primate seen. Troupe of this animals were sighted at Meennutty, Kalamkamathy and near the Butterfly value Chamber (BVC). The troupe size and other details of the monkeys of the BVC region was examined in more detail. The troup size varied from few individuals up to about 40 individuals. The distribution of the troupe size of the monkeys sighted is shown in Fig. 15. The range of the monkeys was limited to few sq. kms. around the region. The animals also indulged in a great deal of crop raiding. Troupe of bonnet macaques seen inside the forest were comparatively more shy. Their troupe size was also smaller.

HABITAT QUALITY

Tho availability of fodder and water in the grids is shown in Fig. 16. The occurrence of elephants were also plotted on the same map and relation between the two examined. Water is available throughout the year in areas near the lake. The tops of ridges do not have water in the dry season. However, both these regions support lush grass growth. Elephants were seen to use both these habitats.

SECONDARY IMPACTS

The region has undergone many changes after the completion of the project. These cannot be directly attributed to the blocking of the river or impounding water. Some of these are human settlements, fire, cattlegrazing, establishment of plantations end emergence of a township in the area. These were due to the increased accessibility of the area.

fire

Fire is not a new entrent to this region Shifting cultivators and cattlegrazers set fire to. the forest and the grasslands. Increased habitation and accessibility had made fire an annual phenomenon, Regeneration of trees were found to be severaly affected due to fire. Burning of grass lands with Eucalyptus plantations are also of common occurrence.

fuel collection

As in the case of other places near forest, people in the study area gather the fuelwood for cooking from the forest. The construction of large number of quarters tea shops etc. have put a high demand on fuel. Many

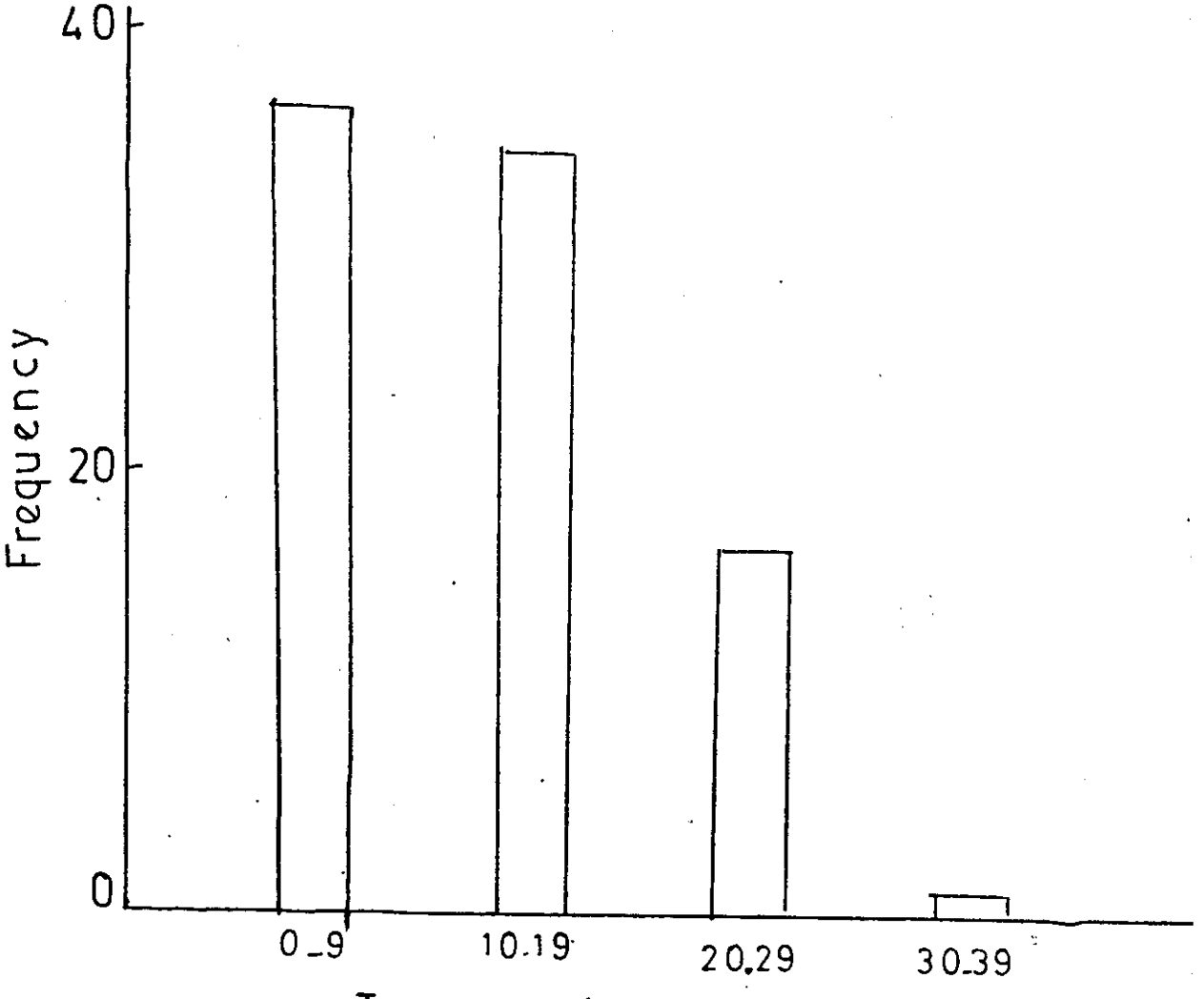


Fig. 15 Distribution of troupe size of Bonnet macaques.

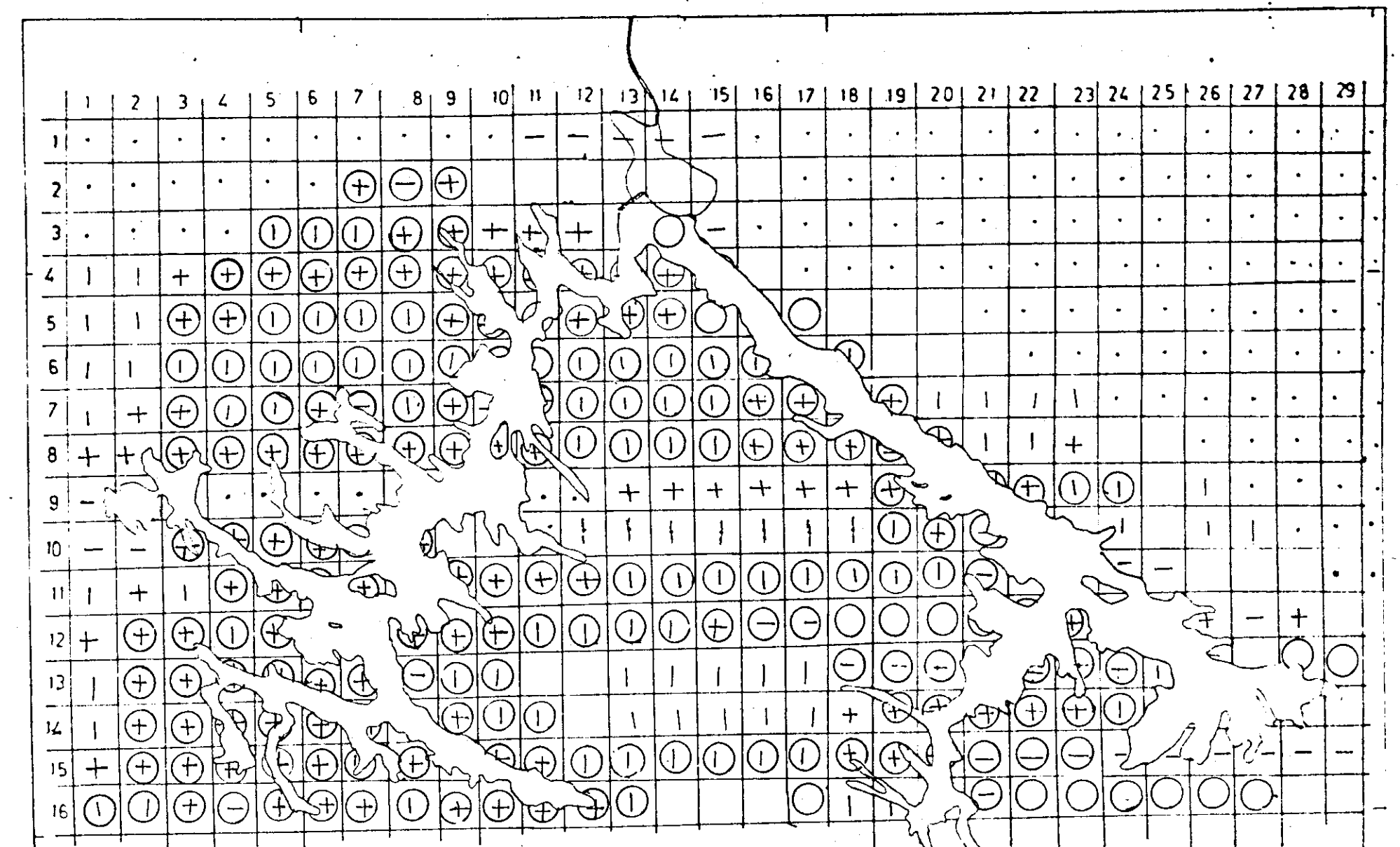


Fig.16 Distribution of elephants, availability of water, grass and fodder.

-=water, 1=grass, 0=elephant

persons are engaged in collection and sale of fuel wood. As a result of this, tree density has been gradual:: reduced around the habitations.

Tribals

The study area has flew hillmen settlements. Traditionally they practiced shifting cultivation. Displacement has affected those people much more than the settlers. Manyof thc displaced tribals settled down in nearby forest areas rather than going to other regions.

Resettlement

Persons evicted from the submersion area were paid compensation. Most of these people moved and settled within 20 to 30 km distance from the project arcs. Many persons were reported to have migrated to forest areas above the maximum water level and settled there. Many of the workers who came in for the construction work also encroached forest and stayed over.

During the later phases, the issue of resetting affected persons became a much more serious problem. This was because of their organizational strength and political backing. They were able to extract substantial compensation from the government. In addition,

arrangements had to be made to resettle them in the place of their choice. The place chosen was adjacent to the developing township and civil station. About 200 ha. of forest had been cleared for this purpose between Pynavu and Cheruthoni.

Township

A decision to put up the headquarters of the Idukki district at Pynavu had been taken (Plate 13). The possibility of making use of the buildings constructed in connection with the Idukki project is reported to have been one of the reasons for choosing Pynavu. This decision had a far reaching effect on the environment of this region compared to all other activities done in recent timcs. The people from the submersion area of Idukki stage 11 and 111 are also planned to be resettled near the civil stetion (Plate 14). Work in connection with putting up of more offices and living quarters around the civil station is in progress. As a result of all these activities, a break in the forest continuity between Pynavu and Cheruthoni would occur.

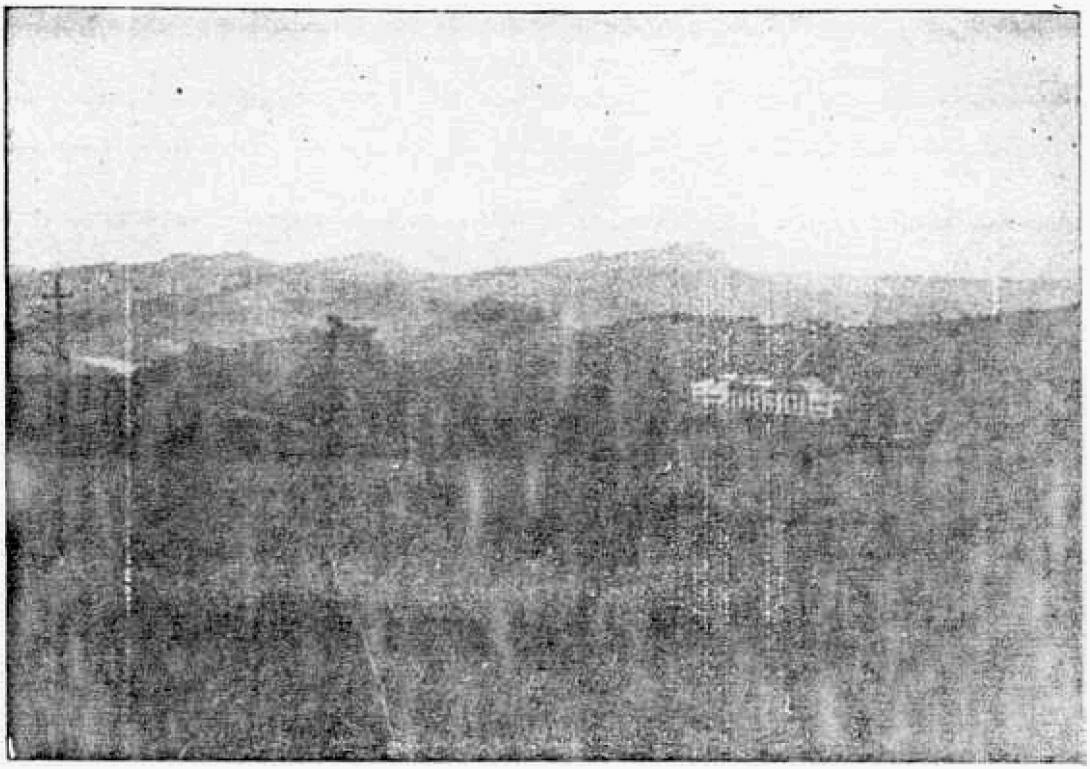


Plate 13. Idukki civil station constructed amidst evergreen forest.

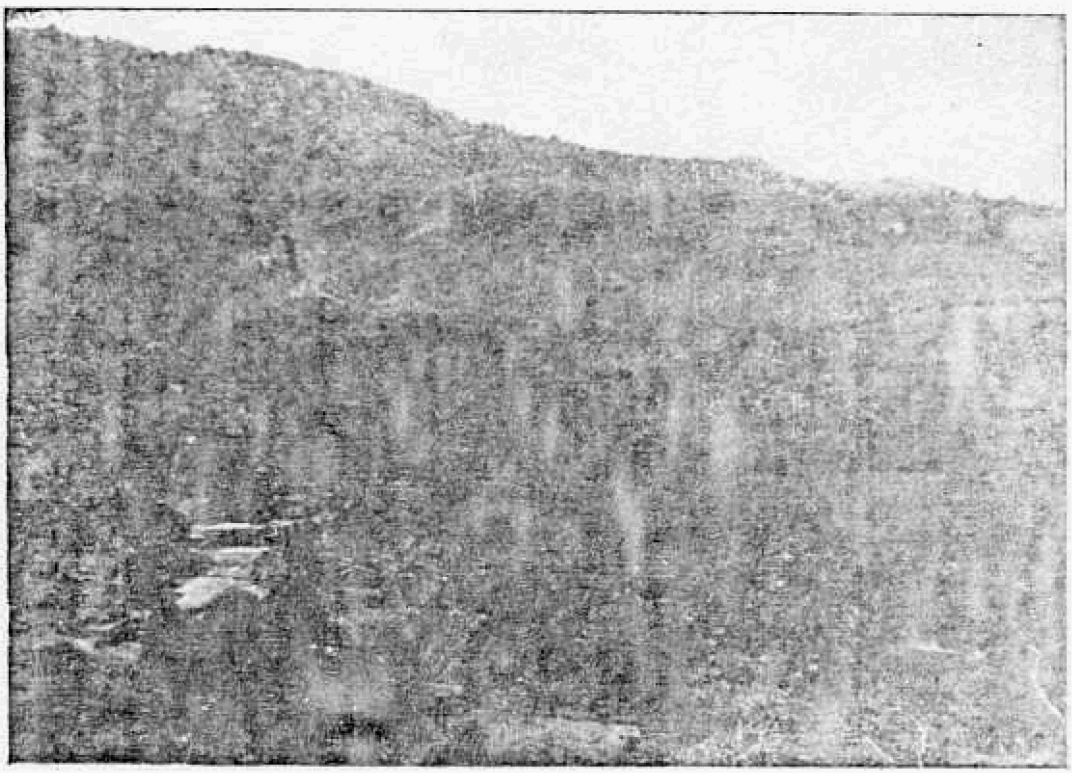


Plate 14. Typical example of an encroached area. The forest in the background has been cleared for resettling of people.

Encroachment

Encrochement of forest in the vicinity of the project area continues unabated. The encrochment cultivate paddy, tapioca, ginger, turmeric, coffee, colocasia, sugarcane, plantain, arecanut, coconut, pepper and lemon grass. Plates 14 and 15 show such areas. They gradually annex parts of adjoining forest to their cultivation by shifting the temporary bounderies and trenches.

Idukki - Wildlife sanctury

The catchment arms of most of the river valley projects in Kerala are declared as wildlife sanctuaries. In the case of Idukki also the area between the two arms of the reservoir were declared as a wildlife sanctuary, wide notification no.7898/FM3/76 AD dated 9.2.76. Agriculture (Forest Misc.) of Government of Kerala. But activities in connection with protection of the animals are yet to start.

ENVIRONMENTAL IMPACT STATEMENT

The environmentel impact on 12 types of activities pertaining to the vegetation and wild animals were examined. Values of -1.0, -0.5, 0.0, + 0.5 or-1.0 were assigned to these according to the nature of their impact.

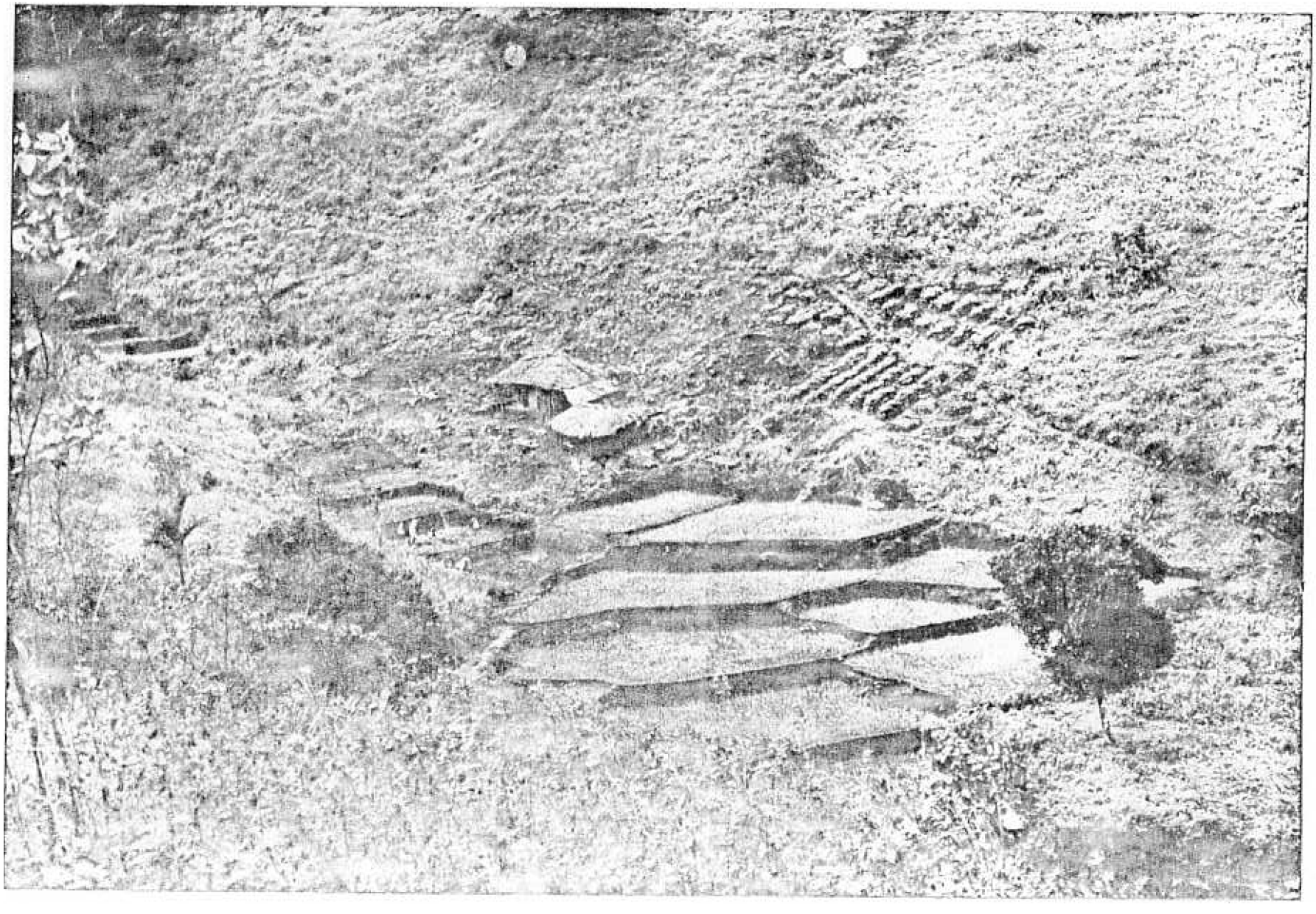


Plate 15. One of the localities selected for recording crop raiding, cultivation pattern and its change.

The activities chosen and values assigned are tabulated in table 9. A total of 4 activities were found to have harm full effects 4 beneficial acts were identified. One partially harmful and two partially beneficial aspects were also identified.

Table 9

Environmentel impact values assigned to the parameters considered

Sl. No.	Irnpnct area	Impact				
		-1.0	-0.5	0.0	+0.5	+1.0
1.	Vegetation denudation	+				
2.	Colonization by weeds	+				
3.	Chance of fire	+				
4.	Effect on invertebrates			-		
5.	Impact on birds			-		
6.	Impact of an aquatic birds					+
7.	Fishes		+			+
8.	Endangered animals			+		
9.	Elephant	+			+	
10.	Sambar				+	
11.	Wild pig					+
12.	Hare					+
	Total	4	1	1	2	4

DISCUSSION

The Idukki region remained as a relatively undisturbed state till the beginning of the century. Large scale forest occupation, for cultivation end settlement occurred during the late forties, There were many villages in the submersion area of the Idukki project. The disturbance to wild animals of the region existed even before construction of the project. But at that time all the animals characterestic of this forest type that existed in the study area were reported to have been present. Many species of larger mammals like the gaur, bear, tiger; panther were exterminated during the construction period of the dams. This-was not because of activities in connection with the project alone, The role played by the spreading encroachments around the project area also played an equally important role in the destruction of forest and decimation of wildlife,

VEGETATION

From the tables 2, 3, 4 and 5 it is clear that the forests in Idakki have undergone maximum distrubances leading to poverty in species richness. While only 31 genera and 174 species could be recorded in Idukki the corresponding figures are 35/325 in Silent Valley; 33/297 in Muthikkulam and 34/379 in Nelliampathy,

FIG-17 Species area curve for four evergreen forests

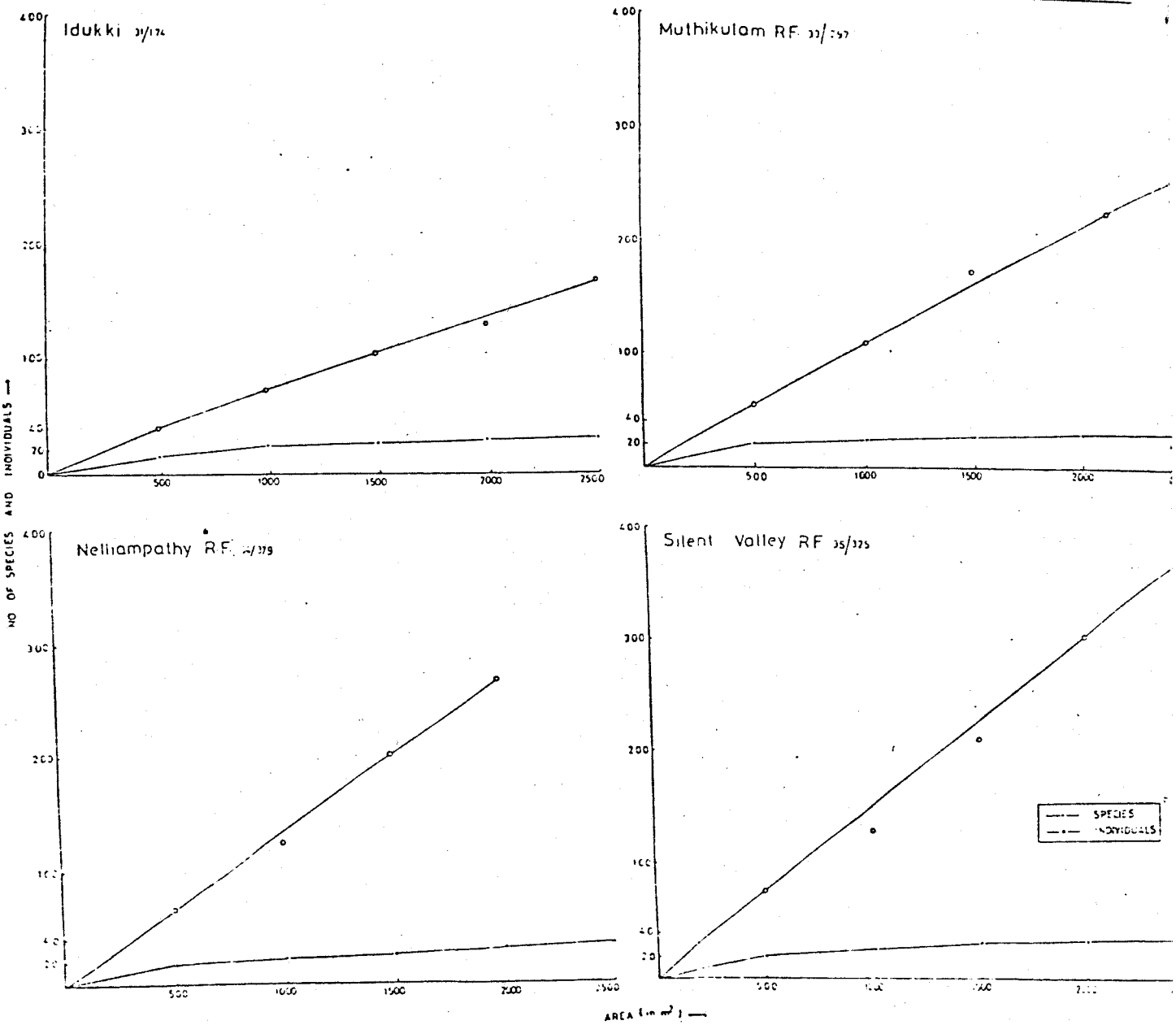
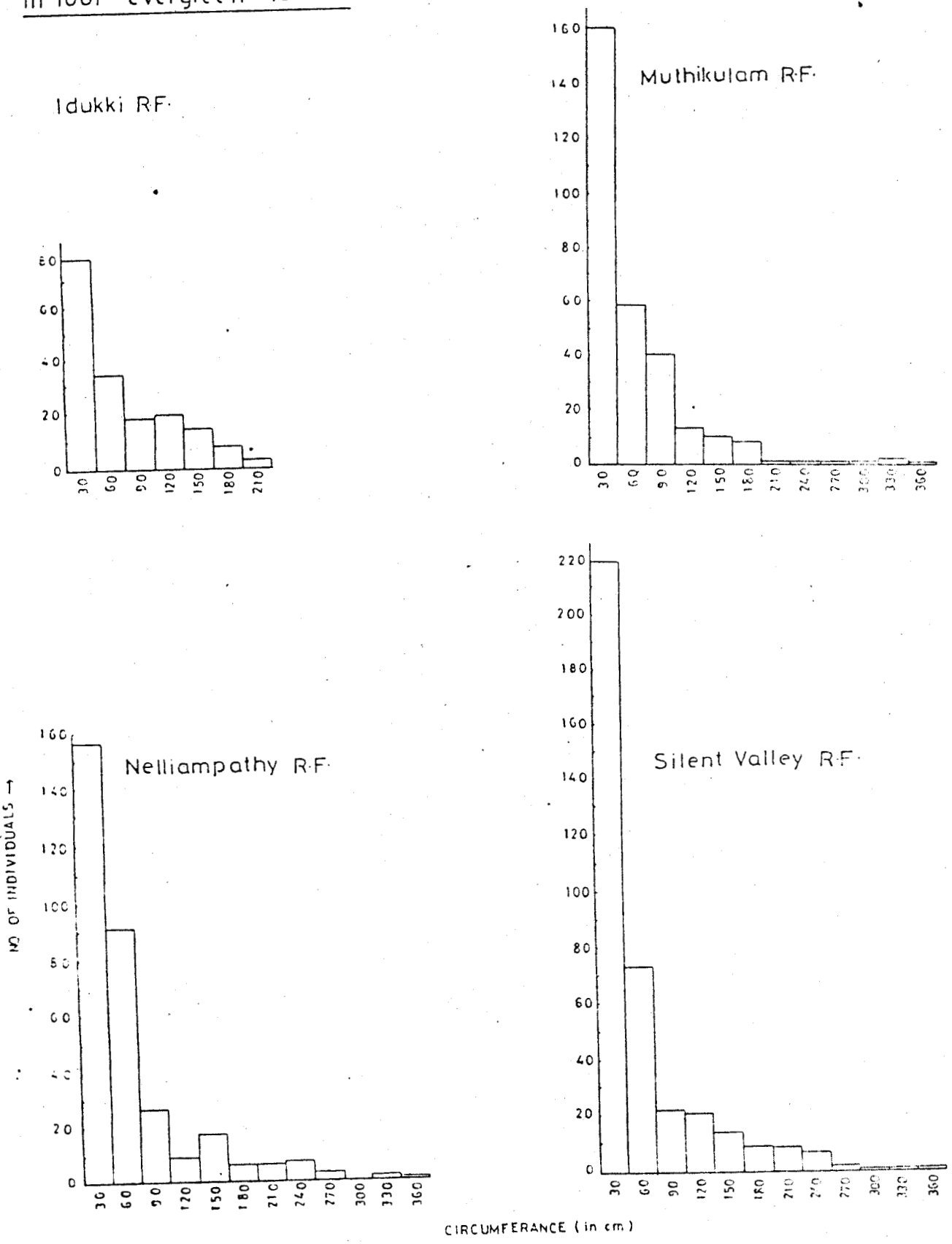


FIG. 18. Histogram showing circumferance classes in four evergreen forests.



Secondly, Cullenia-Palaquim association has been found to be the dominant and codominant in all the three areas, in Idukki it is featured by the association of Cullenia-Mesua. Palaquim ellipticum has been relegated to the back ground indicating that this species would have been heavily exploited during the past.

Thirdly, no species in Idukki has attained a girth of over 210 cm while in all other places trees of upto 300 cm girth are encountered, This suggests the point that all the big trees were removed from Idukki either prior to or during the construction of the reservoir.

The histogram showing the frequency of the girth classes and the species area curve from the four evergreen sites are given in Fig. 18.

Studies along similar lines were also carried out in different parts of the world (Richards, 1952) and Cousens (1951 & 58) for Malaya, Ashton (1964) and Bruning 1968 for Brunei and Sarawak respectively. Knight (1975) for Panama, Rollet (1969 & 74) for Venezuelan Guyana and Cameroon respectively and Fitikan and K1inge (1975) for Amazonia). (1983, Personal communication) .Pascal who conducted detailed investigations in Attappady R.F. adjacent to

Silent Valley had also obtained a similar figure viz., 32 species and 303 individuals in an area of 2000 m^2. The figures for tropical Amazonia in an area of 2500 m^2 shows 42 species including climbers.

Thus it is conclusively proved that Idukki is one of the highly disturbed ecosystems in contrast to the rest;.

ELEPHANTS

An analysis of the distribution of group sizes sighted reveal a clear peculiarity of the elephant population of Idukki. In undisturbed populations herd sizes go up to30 or more individuals. The Idukki pattern of smaller herds characteristic of a population that is highly disturbed. fig 10 compares the distribution in two relatively undisturbed populations with that of Idukki. Eisenberg and Lockhart (1972) reported a pattern similar to that of Idukki in elephant populations of Sri Lanka,

The herd composition and sex ratio of elephants of Idukki also show several pecularities. The sex ratio is very much different from 1:1 round in healthy populations. The number of adult male elephants in the population is very low at Idukki. The proportion of young ones in the

population is also very low (Fig. 12). These facts indicate that the elephant population at Idukki is in 8 state of decline.

A total of about 50-75 elephants Pound to be in habitating the area. As many as 25 elephants were counted in a day grazing in adjacent areas. Even though the reservoir at many places is a barrier, the elephants seen to cross at narrow points and go to almost all parts of the reserve. The elephant herds observed were found to spend most of the time feeding.

Increased accessibility and human presence depriving the animals of their habitat bring in certain other kind of disturbances also. The following exemple of a herd observed near the road from 16:15 hours to 18.00 on **9.11.1983** show the extent of such disturbance.

16: 15 Elephants feeding.

16: 38 A jeep passing along the road stopped to watch the elephants.

: 39 Bus passed Did not stop.

: 44 A jeep passed.

: 52 A bus passed,

: 53 A jeep came and halted on the road to watch the elephants. People in the jeep started shouting to attract the elephant's attention.

: 55 Elephants stopped feeding due to disturbance.

57 Elephants resumed feeding.

17: 00 A car passed, Blow horns to attract elephants attention.

: 01 The jeep left.

: 09 A car came and stopped.

: 12 A jeep came and stopped.

: 19 A bus passed. A car passed.

: 22 A jeep passed blowing the horn.

: 28 Elephants made sound.

: 34 A bus passed continuously blowing horns and playing loud music.

: 56 A bus passed.

18: 00 A truck passed.

These kinds of disturbances though do not harm the animals physically may force the animals to retreat to other less disturbed areas.

The elephants seems to be confined to a limited area. All the sorrounding areas are under cultivation. The only connection with any large chunk of forest is on the Meenmutty side (Fig. 9). There are also numurous habitations inside the area.

OTHER ANIMALS

Among the other animals the wild big and hare are particularly noticeable. The wild pigs raid crops in cultivated areas and hence there are frequent reports of them. The abundance of hare is again an indication of a disturbed habitat. The wild dogs in the area indulge in lifting the cattles. This is an unusual bchaviour and probably is due to the lack of wild prey.

The troup size of the bonnet macaques seen in the BVC area were smaller than those found in other habitats . These monkeys have been displaced from the area when the work in connection with Idukki stage II and III commenced at the beginning of 1984.

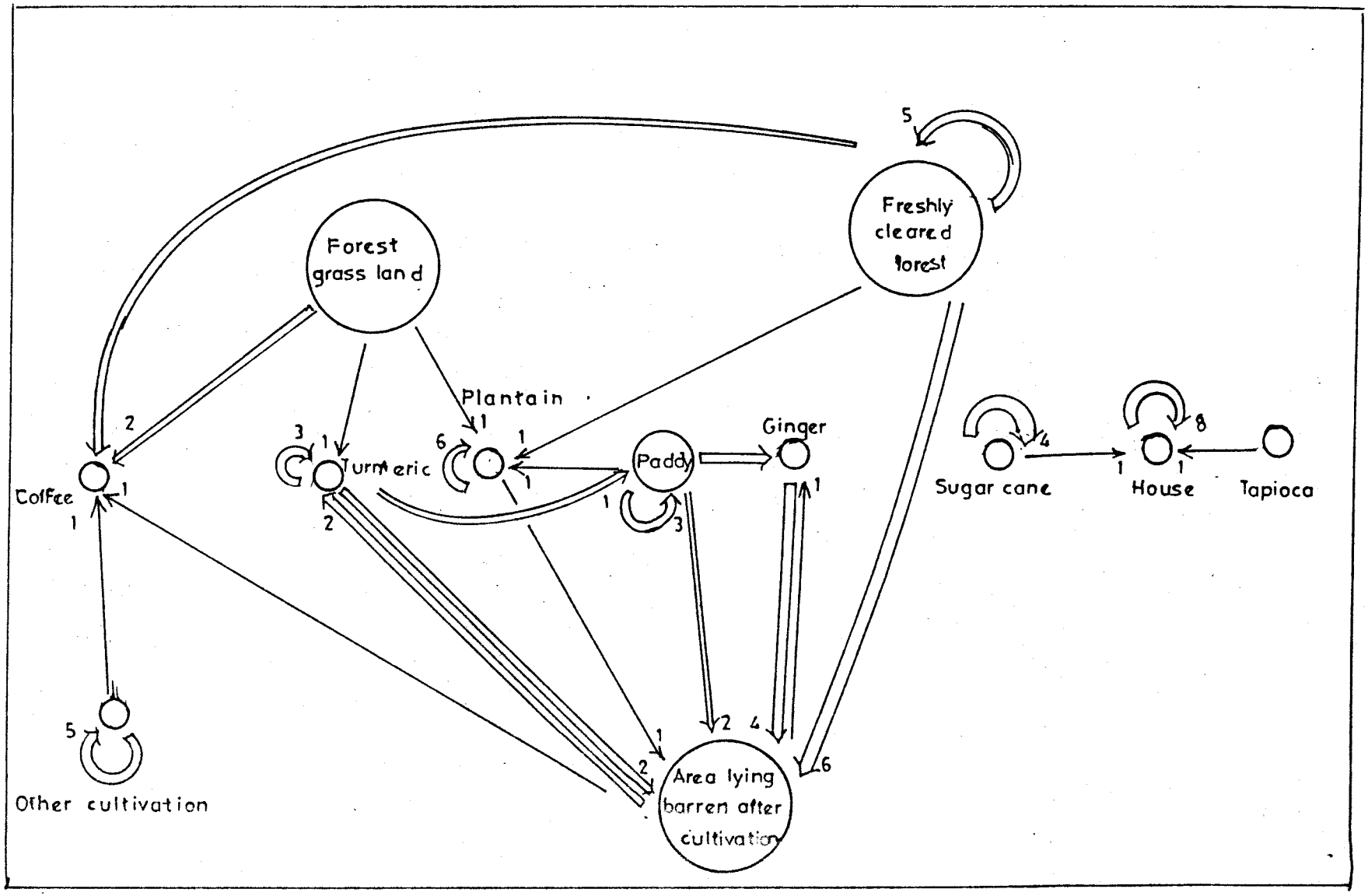


Fig. 19 Transitions in cultivation pattern.

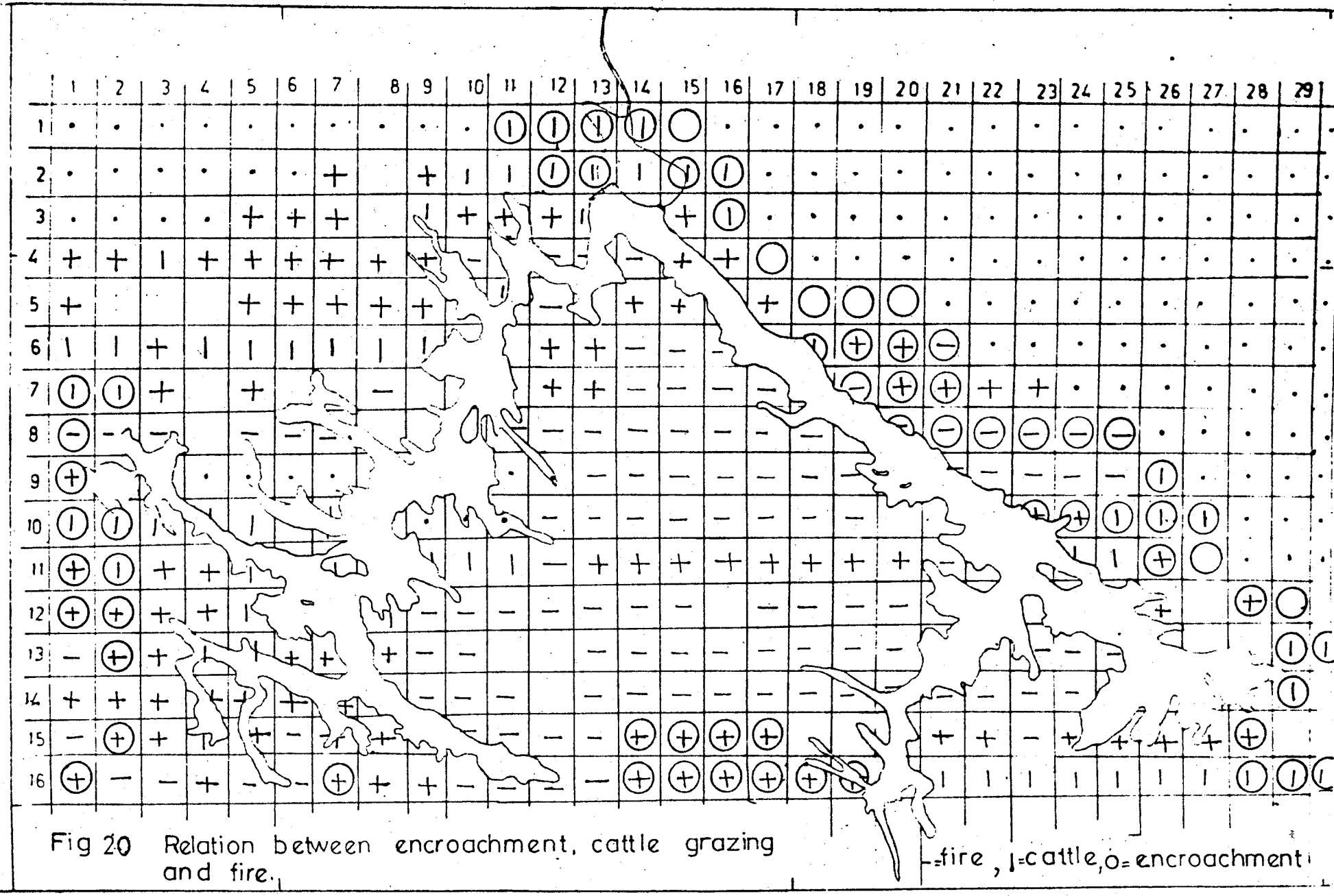


Fig 20 Relation between encroachment, cattle grazing and fire.

SECONDARY IMPACTS

The biotic disturbances like fire, fuel wood collection, cattle grazing,encroachment, illegal wood cutting etc., reduce the habitat quality. Encroachments into forest continue unabated even near the Kulamavu dam.

There is a time delay between clearance of forest and cultivation. There is also considerable delay between subsequent crops. This is probably because of the caution exercised for being evicted from the encroached areas, The forest area is slowly but steadily converted into land for cultivation. Forest grassland are convertedto coffee, turmeric or plantain cultivation. This nay be followed by cultivation of paddy, ginger or othsr crops. After cultivation of these crops the fields are often left barren for severel months (Fig. 19). Wild pigs raid crops of paddy, sugar cane and tubers. Plate 15 show one of the frames analyzed for these details.

Fig, 20 shows the relation between encroachment, cattle grazing and fire. The incidence of cattle grazing and fire are more near the habitations But the parts of reserve at a distance are also not free from this.

Fig. 21 shows that encroachments and plantations are assaciated. There is association between roads and plantations as well as between roads and encroachment,

ENVIRONMENTAL IMPACT ASSESSMENT

The EIA shows both beneficial and harmful impacts. It can be seen that most of the harmful aspects arose not so much due to the construction of dam or impounding water but from the unchecked human incursions into the forest habitat making use of the increased accessibility of the area.

CONCLUSION

The forests and larger mammals in Idukki region have been disturbed by the construction of the project. Many factors not directly related to the project also played an important part in the destruction of the habitat.

RECOMMENDATIONS

In order to improve the general condition of the forest a few suggestions are made. These concern the evergreen vegetation near the civil station leasing forest for cardamom cultivation,afforestation, wildlife

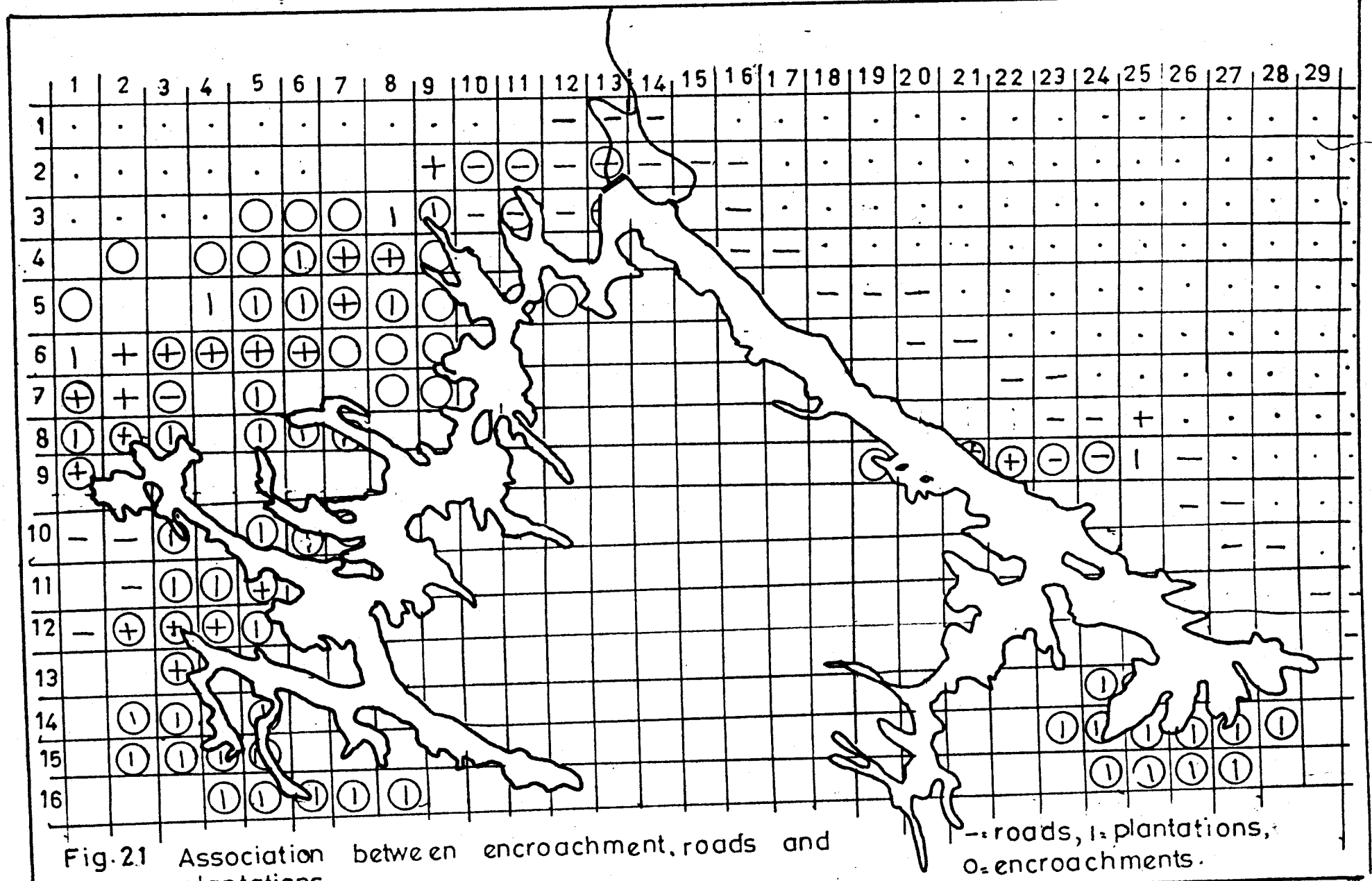


Fig. 2.1 Association between encroachment, roads and plantations.

-: roads, I: plantations, O: encroachments.

sanctuary, encroachments and developing township. Before going into the details we should bear in mind thet the regition has been to a great extent irrevocably damaged, a township and resettlement colonies laid out. The area does not have much scope for being brought back into a continuous habitat for wild animals without coming into. conflict with what is already established.

1. The investigations reveal that in the study area the tropical wet evergreen forests are confined to only a small patch near Painavu. This area alone in Idukki has the maximum species richness and diversity and an all out effort should be made to conserve this area. The civil station pose a direct threat to this vegetation.

2. This area also possess a good generation of important timber species like Cullenia exarillata, Mesua nagasarium, Polyalthia fragrance, etc, and hence their total preservation is doubly important.

3, From a survey along the Kulamavu Idukki road a few patches of evergreens are seen here and there while the majority of them are under cardamom plantations.

While in the areas not planted with cardamom shows good regencration those under cardamom are abso1utely nil. Hence no more evergreen forests should be leased out for cardamom cultivation.

4. The study also points out a lot of barren areas requiring immediate afforestation. The area has been declared as a wildlife sanctuary and hence habitat restoration is very important. It needs to be stressed here that extreme caution should be exercised in the choice of suitable species if any massive afforestation scheme is taken up.

5. Though declared, as a wildlife sanctuary a decode back hardly any managament towards this end has been done so far. Nor the area declared as wildlife sanctuary have enough divesity or food availability to sustain populations of animals. A large portion of the region in between the Kulamavu-Idukki road and Idukki-Kattappana road should be included in the sanctuary

The objective of a wildlife sanctuary is providing a habitat for endangered and endemic species of plants and animals. Idukki has very little scope to be developed to cater to the aesthetic and recreational

requirement of the developing township and tourists. On many of the isolated areas near the lake, animals can be introduced and kept in a semi natural environment with supplemented food as a kind of safari park. If facilities for boating is developed the tourists who come for viewing the dams and associated structures can also view the animals from the boat.

The elephants present in the region are already under pressure. To sustain the population stops likc introduction of male elephants, preferably makhnas will have to be thought of. A place like Meenmutty has the greatest elephant concentration. This is also the region being developed as the Idukki township. Therefore, steps will have to be taken not to spread the town towards Meenmutty and to prevent the elephants wandering into habited areas.

6. In connection with the township two irrevocable steps – that of putting up the civil station in the middle of the forest arid clearing an area near it for resettlement of people had been taken, The plans are to develop the areas around into a township. It may be more advantageous to have the living quarters of staff etc., near

Idukki or Kulamavu rather than around Paynavu It can be seen that the civil station and resettlemnt area has made a break in the forest continuity already,

7. Many of the cultivable valleys in this region are being encroached, It is very essential to maintain forest continuity. If people are to be settled, setling them in a planned way at a suitable place at the periphery of the hebitat is what is advisable. Most of the encroachments have come up in the post few years. The people in the small pockets inside the forest may be relocated in a planned way as part of a management objective to create habitat continuity, The encroachment that came up during the study period beside the road leading to the bottom of Kulamavu dam is an eye sore. It blocks the way for the development of the immediate environs of the dam, and spoil the beauty of the scenary. This may be removed.

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