HABIT AND HABITAT ANALYSIS OF SELECT MEDICINAL PLANTS IN NATIVE AND DOMESTIC ENVIRONMENTS

By

N. MINI RAJ

THESIS

Submitted in partial fulfilment of the
requirements for the degree

Doctor of Philosophy in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Plantation Crops and Spices
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 654
KERALA, INDIA

1997

'the more we know, the more unknown remains'

DECLARATION

I hereby declare that the thesis entitled "**Habit and habitat analysis of select medicinal plants in native and domestic environments**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship, associateship or other similar title, of any other university or society.

Vellanikkara
10.8.97

N. MINI RAJ

CERTIFICATE

Certified that the thesis entitled "**Habit and habitat analysis of select medicinal plants in native and domestic environments**" is a record of research work done independently by **Ms.N. Mini Raj**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Dr.E.V. Nybe
Major Advisor, Advisory Committee
Associate Professor and Head
Department of Plantation Crops & Spices
College of Horticulture
Vellanikkara, Thrissur

Vellanikkara
10.7.97

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms.N. Mini Raj**, a candidate for the degree of **Doctor of Philosophy in Horticulture**, agree that the thesis entitled **"Habit and habitat analysis of select medicinal plants in native and domestic environments"** may be submitted by Ms.N.Mini Raj, in partial fulfilment of the requirement for the degree.

Dr.E.V.Nybe
Major Advisor, Advisory Committee
Associate Professor & Head
Department of Plantation Crops & Spices
College of Horticulture, Vellanikkara

Dr.Alice Kurien
Associate Professor
Department of Plantation Crops
and Spices
College of Horticulture, Vellanikkara
(Member)

Dr.R.Keshavachandran
Associate Professor
Department of Plantation Crops
and Spices
College of Horticulture, Vellanikkara
(Member)

Dr.Luckins C. Babu
Associate Professor and Head
Department of Tree Physiology & Breeding
College of Forestry, Vellanikkara
(Member)

Dr.A.Augustin
Assistant Professor (Sel. Grade)
(Biochemistry)
AICRP on M & AP
College of Horticulture, Vellanikkara
(Member)

EXTERNAL EXAMINER

(DR. P.C. SIVARAMAN NAIR)

ACKNOWLEDGEMENT

In connection with this endeavour, I would like to record my gratitude to numerous people surrounding me for their encouragement, affirmation, honest feed back and for the abundant supply of fresh hope to stay at tough tracts.

First, and foremost to Dr. E.V. Nybe, with whom I had the privilage of working with as the major advisor of the Ph.D. committee for all his magnanimity and sensitive spirit throughout the study. I owe him much for the timely suggestions and unstinting support for the successful completion of this programme in time.

Dr. Luckins C. Babu, with whom I have discussed all the taxonomic problems encountered in the study, has been fertile in suggestions and prodigal in assistance. My special gratitude to him.

Dr. R. Keshavachandran was good enough to help in the photographic works. I wish to acknowledge his kindness.

I am especially endebted to Dr. Alice Kurien for offering valuable suggestions during the course of the study. Her critical comments indeed helped me a lot in improving the text.

The days in the Biochemistry lab were indeed tiring. Dr. A. Augustin always came forward with his expertise in Phytochemistry to choose the right path in the not-so-familiar methodologies. His critical comments in interpreting the results were also valuable. To him, I express my unreserved gratefulness.

I would like to record my special gratitude to Dr. N.N. Potty who has been instrumental in the very formulation of this project. His penetrating questions have contributed a lot in sharpening my own thinking and also to view this study in all the dimensions.

My profound thanks are also due to Prof. P.V. Prabhakaran and Sri. S. Krishnan in resolving the statistical intricacies of my data.

I warmly thank Ms. Sreejaya, who accompanied me to forests and helped me a lot in the preparation of herbaria. My sincere thanks are also due to Dr. Sureshkumar of Radio Tracer Lab for being kind enough to do the soil analysis for me.

At one point or other, all my colleagues were involved in this endeavour. To every one with whom I have had discussions and to all my teachers who were so generous to me during the tight course programme, I express my sincere thanks.

The warmth and generosity of the teaching and non-teaching staff of the department of Plantation Crops and Spices is pleasantly acknowledged.

I am also grateful to Dr.A.I.Jose, The Associate Dean and Dr.C.C.Abraham, former Associate Dean, for providing all facilities needed for the smooth conduct of the study.

I also acknowledge the services of the staff of the University and College Libraries, especially Mr.Abdul Razak for providing me with the latest information on the subject.

My gratitude is also due to the Kerala Agricultural University for granting me study leave for undergoing the Ph.D. programme.

The assistance rendered by the eminent persons outside the University need to be acknowledged.

Most cordial was the welcome by Dr.S.Shankar, Head, Agroforestry Division, KFRI. He was so generous in providing me the best of the facilities in conducting the forest studies. My pleasent gratitude to him. His project staff - Anil, Amrith, Vinayak and Saji were always with me in the forest life. I would like to thank them for all the assistance given to me, for the warmth, and friendship, which made every moment inside the forest memorable.

Dr.N.Sasidharan, Head of Minor Forest Division, KFRI was kind enough to identify the herbarious, inspite of his busy schedule. I express my gratitude to him.

Mr.Subash Kuriakose, the artist of KFRI provided me with many excellent photographs. My special thanks to him.

The scientists and library staff of TBGRI, Palode, CCAR, Thiruvananthapuram, KRTADS, Kozhikode, NBPGR substation, Vellanikkara, CUSAT, Kochi, Aryavaidyasala, Kottackal, Aryavaidya Pharmacy, Coimbatore and LSPSS, Coimbatore were helpful in many ways at some stage or the other of the study. I thank all.

My obligation to the tribes of the 'Thamaravellachal' settlement cannot be expressed in words. They whole heartedly accepted me into their culture and let me experience the forest in all it's totality. Their intutive yet scientific approach and thinking infact has enlightened me a lot. My heartfelt thanks to them, especially to Ayyappettan, my friend, philosopher and guide in the forest.

The award of the Jwaharlal Nehru Scholarship by the J.N.M. Fund was indeed a boost to my chtusiasum. I thank them profusely.

More personally, I would like to thank all my intimate friends for their love, concern and encouragement. The Ayurveda background to which I belong has been an added advantage to me. I owe much to my family for this.

It was Mr. Joy who typed the manuscript neatly and promptly. I thank him.

and

finally to me myself and that power which
drives me all along

MIRAJ. N.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

IUCN	- International Union for Conservation of Nature and Natural resources
CSIR	- Council for Scientific and Industrial Research
CIMAP	- Central Institute for Medicinal and Aromatic Plants
RRL	- Regional Research Laboratory
ICAR	- Indian Council of Agricultural Research
KFRI	- Kerala Forest Research Institute
MDF	- Moist deciduous forests
SEG	- Semi ever green
MSL	- Mean sea level
gbh	- girth at breast hight
LGR	- Linear growth rate
CGR	- Compound growth rate
TLC	- Thin layer chromatography
TFA	- Total free amino acids
Rf	- retention factor
PNV	- the habitat Pongunilkuuna Vazhi
KP-1	- the habitat Karadippara-1
KP-2	- the habitat Karadippara-2
KC-1	- the habitat Kalluchal-1
KC-2	- the habitat Kalluchal-2
VK-1	- the habitat Vellamkananapara-1
VK-2	- the habitat Vellamkaranapara-2
M-1	- the habitat Methanampara-1
M-2	- the habitat Methanampara-2
AK	- the habitat Aanakuzhi

Introduction

INTRODUCTION

India has one of the oldest, richest and most diverse cultural traditions associated with the use of medicinal plants. The remarkable fact is that it still remains as a living tradition. Over 7500 species of plants are estimated to be used by 4635 ethnic communities,for human and veterinary health care,across the various eco-systems,from the transhimalayas to the southern tip of India and from the West coast to the far corners of the north east (Shankar *et al.*, 1997). In the codified medical texts of Ayurveda, a recent study enumerates around 1,700 species of plants that are fully documented in terms of their biological properties and actions and over 10,000 herbal drug formulations that are recorded for a range of health conditions. However, an exhaustive inventorisation of the medicinal plants of India is yet to be completed. While there exist several ethnobotanical studies confined to scattered geographical pockets in the country, there is at the moment, no exhaustive and reliable inventory available of all the medicinal plants of India.

The more important concern however, is that the availability of medicinal plants is presently under serious threat. Over 95 per cent of the medicinal plants used by the Indian industry today are collected from the wild. Estimates suggest that over half a million tonnes of dry raw material is indiscriminately and most destructively collected from the wild each year (Shankar *et al.*, 1997). A threat assessment exercise as per the latest IUCN guidelines, for southern India has already listed 74 species of medicinal plants that are rare, endangered and threatened.

It is only in nature, that plant diversity at the genetic, species and ecosystem levels can be conserved on a long term basis. Unless plant populations are conserved in the wild, that is in their natural habitats, in viable breeding populations, they run the risk of extinction. Medicinal plant populations have large and often disjunct areas of distribution, while there are also endemic species confined to a few pockets. Detailed botanic and ecological studies need to be carried out in these areas to document them and to study their populations and the natural conditions in which they grow.

Figures projecting demand and trade in medicinal plants globally indicate a steep upward trend in the near future. We can not rely on the natural resources any more. Domestication/cultivation efforts are to be initiated urgently. Today, out of 400 odd species (excluding spices) that are used in medicine, only less than 20 species are under commercial cultivation.

Unlike crop plants, the quality and quantity are equally important in medicinal plants. The active principles in these plants are certain secondary metabolites like alkaloids, glycosides, coumarins or steroids which are related with the ecology rather than the normal physiology of the plant. The environmental conditions to which the plant is exposed influence the production of these secondary metabolites and ultimately the efficacy of the drug. Though scarce, there are experimental evidences to strengthen the fact that the secondary metabolite production and the properties of the medicinal plants differ with change of habitat. More simply, it is the habit-habitat interactions that decide the quality. So, any improvement method or management practice should be designed in such a way that it is not at the expense of its quality. Under domestication outside the normal

habitat or ecological range, many of the medicinal plants tend to behave differently. An understanding of the biological and ecological background of the species in their normal habitat is hence essential to understand their conservation biology as well as to predict their behaviour under artificial cultivation.

With these background information, the present investigation "Habit and habitat analysis of select medicinal plants in native and domestic environments" was taken up. The study aimed at surveying the Peechi hills to prepare an inventory of native medicinal plants. It also envisaged elucidation of the characteristics of select medicinal plants and the influence of native and domestic environments in regulating the expression of their potential. Morphological and physiological patterns of growth and development, plant associations, interactions, regeneration etc. were also to be studied in identified extraction sites. It also aimed at developing indices for extraction and also to evolve *in situ* conservation and production strategies in medicinal plants.

REVIEW OF LITERATURE

2.1 Medicinal plant resources in India

The humid moist tropical forests of the country still present a remarkable diversity of medicinal plants that defy comprehension. The total angiosperm flowering plants of India comprises approximately 18,000 species, of which 2,500 species possess medicinal or aromatic properties.

The main reason for this remarkable diversity in a single country is the great diversity of ecosystems which it has supported down the ages. Almost every major type of habitat is to be found here - from areas of the heaviest rainfall to the driest desert, from the coldest to the hottest climatic conditions, from the highest elevation down to the sea level. Ecosystem-wise, India has 42 vegetation types, 16 major forest types, 10 biogeographical zones and 25 hot spots of endemic centres (Nayar, 1996). Presence of African, European, Chineese and Indo-Malayan elements is another peculiar feature of the flora and fauna of India. It is the sum total of such remarkable diversity which has made India a gene bank for a number of medicinal and aromatic plants.

If we take region-wise diversity, the great mountain chains of Himalayas, the Western Ghats, Vindya and Satpura ranges, Eastern Ghats and the Khazi and Mezo hills harbour about 90 per cent of the medicinal plants. Most of these plants are rare and endemic and are found only in the wild.

2.1.1 Vegetation types of Western Ghats

In Peninsular India, the only remaining islands of relatively undisturbed natural ecosystems are in the Western Ghats. Tropical moist forests dominate in this area. The complex topography, high rainfall, relative inaccessibility of the tract and biogeographic isolation have helped the Western Ghats retain their biodiversity to some extent - atleast until very recently (Nair, 1991).

The status of vegetation of the Western Ghats has been discussed by Subramanyan and Nayar (1974). These mountain ranges in Kerala supports tropical rainforests, tropical moist deciduous forests, tropical dry deciduous forests, shola forests and riparian forests. There are a number of ecological niches depending upon altitude, light/shade regimes, rainfall variations and edaphic factors (Nayar, 1997).

Nair and Daniel (1986) discussed the flora of these different vegetation types in their study. The Evergreen forests consist of distinct stories of trees and a ground layer of shrubs and herbs. All these layers contain several medicinal species.

The dry decidious forests are with a canopy that is light and without any tiers. They occur between 300 m and 900 m above MSL depending upon the rainfall of the area ranging from 100-200 cm. In this forest type also the flora contain several important medicinal plants.

The moist deciduous forests occur between 500 m and 900 m above MSL depending upon the rainfall ranging from 250-350 cm. Some of the evergreen trees

of the higher elevations are found here also. The stratum-wise distribution of plants of MDF also reveals the presence of many medicinal trees and herbs.

A list of the common species encountered in the MDF of Thrissur Forest Division was given by Narayanan (1988) and Swarupanandan and Sasidharan (1992).

Swarupanandan and Sasidharan (1992) have also listed the dominant tree species of the semi evergreen forests of Thrissur.

2.1.2 Medicinal flora of Western Ghats

In all probability, the medicinal plant wealth of the Western Ghats is richer than it is taken to be. A descriptive list of the medicinal plants of Kerala forests has been prepared by Nambiar *et al.* (1985). Nair and Daniel (1986) published a list of about 46 species of important medicinal plants found in Kerala forests.

Among the medicinal plants of Kerala forests, nearly 150 species are used in the manufacture of Ayurvedic medicines on a commercial scale, while others are used by traditional vaidyas and tribals, in most cases as single plant drug (Sasidharan, 1991). A list of 33 medicinal plants required in largest quantities for the manufacture of indigenous medicines has been given which include *Nilgirianthus, Oroxylum, Gmelina, Trichosanthes cucumerina, Pseudarthria viscida, Desmodium, Stereospermum, Symplocos, Holostemma, Coscinium* and many more.

A macro analysis of the distribution of medicinal plants showed that they are distributed across diverse habitats. Around 70 per cent of India's medicinal plants are found in her tropical forests and less than 30 per cent in the temperate forests at higher altitudes. Micro studies showed that a larger percentage of medicinal plants occur in the dry and moist deciduous forests as compared to the evergreen or temperate forests (Shankar *et al.*, 1997). Around 158 families of plants are represented in Indian medicinal plants. The major families are Fabaceae, Euphorbiaceae, Asteraceae, Poaceae, Rubiaceae, Cucurbitaceae, Apiaceae, Convolvulaceae, Malvaceae and Solanaceae.

A study conducted by Raveendran and Pandurangan (1997) in the Kerala Western Ghats revealed that 46 per cent of the flora contained known medicinal plants. Notable among them are *Aristolochia, Capparis, Clausene, Coscinium, Embelia, Piper, Rauvolfia, Curcuma* and *Cinnamomum*. Sixteen rare medicinal plants were reported from this area.

A floristic diversity study of the Agasthyamala area of the Western Ghats by Mohanan *et al.* (1997) located 124 highly medicinal species which demand active conservation measures due to commercial over exploitation.

2.1.3 Endemism

Statistically India is accredited with 17,000 species of higher plants of which 30 per cent are endemic (Amalraj *et al.*, 1991).

Out of the 19 endemic species of the country in the family Commelinaceae, 17 are confined to the southern Western Ghats (Kamathy, 1983).

Swarupanandan (1984) has reported about 50 endemic species from the Western Ghats. Ahmedullah and Nayar (1986) were also of the opinion that about 75 per cent of the endemic taxa are confined to the western ghats region and a majority of them again confined to some small areas, selected hill tops and habitats. Some of the arborescent genera as reported by Nair and Daniel (1986) with more than five endemic species are *Symplocos* (14 spp.), *Cinnamomum* (12 spp.), *Actinodaphnae* (9 spp.), *Garcinia, Holigarna* and *Terminalia* (5 spp. each) and most of them occur in the southern region of Western Ghats. Singh and Subramanyan (1991) pointed out that out of 535 plant species reported from Kerala, about 108 species were found to be endemic to the State.

The most recent report by Nayar (1997) estimated that in the southern Western Ghat region, out of the 3900 species of flowering plants, 1286 are endemics (33%). He highlighted the southern Western Ghats and eastern Himalayas as two hottest of hot spots of floristic diversity and endemism in India .

2.1.4 Rare, endangered and threatened (RET) plants

Many medicinal species have become rare, endangered or threatened due to various factors. Among the over exploited and thereby threatened resources of medicinal plants, noteworthy examples are of *Rauvolfia serpentina, Dioscorea deltoidea, Aconitium deinorrhizeum, Colchicum luteum, Atropa acuminata* and *Gentiana kurroo* (western Himalayas), *Coptis teeta* (Arunachal Pradesh), *Dioscorea prazeri* (eastern Himalayas), *Nardostachys grandiflora* and *Picrorhiza kurroa* (Alpine Himalayas) (Arora, 1983 and Thakur, 1993). Arora (1983) also reported that natural populations in *Rauvolfia* have considerably shrunk in the Western Ghats since the past few decades, because of large scale root collection. Similarly mass

scale exploitation of *Piper peepuloides* sporadically distributed in north eastern hills has resulted in the imbalance in natural populations of the male and female bushes. Clearing of forest under growth has equally hampered the natural regeneration of these plants.

Nair *et al.* (1992) opined that many of our well known medicinal plants are scarce today because of export in vast quantities to different countries. Principal drugs which are exported include *Aconite, Aloe, Dioscorea, Glycyrrhiza, Valerina, Saussurea, Strychnos* and *Rheum* to mention a few.

Babu *et al.* (1993) reported that the plant *Coptis teeta* is on the verge of extinction because of large scale export to Japan and other European countries. He described the present era as an era of species extinctions. Out of the 18 hot spots recognised (species rich threatened areas) 14 were located in the tropics.

Sudhadevi (1992) listed the plants *Alstonia venenata, Coscinium fenestratum, Habenaria latilabris, Rotula aquatica* and *Woodfordia fruticosa* as rare in the forests of Thrissur.

Amalraj *et al.* (1991) enumerated four endangered and eight threatened medicinal species from Western Ghats. The features, uses, distribution and status of *Coscinium, Embelia ribes, Helminthostachys zeylanica, Heracleum candolleanum, Holostemma ada-kodien* and *Rauvolfia* were studied by Dan and Shanavakshan (1991) and these are found becoming potentially rare in southern Western Ghats due to over exploitation.

Among the much needed medicinal plants, *Salacia oblonga, Nervilia aragoana, Aphanamixis polystachya, Symplocos cochinchinensis, Drosera peltata,*

Trichosanthes cucumerina, Rubia cordifolia, Malaxis rheedii and *Iphigenia indica* are found restricted in distribution in Kerala forests (Sasidharan, 1991).

Swarupanandan (1991) recognized five broad categories in species rarity as the evolutionary status of the species, reproductive inefficiency, shrinkage of ecological niches, anthropogenic reasons and paucity of studies.

Twenty five vulenerable medicinal plants of Munnar forest region have been described by Bhat and Padmaja (1991). The reasons for this status and some corrective measures to preserve them were also suggested.

Handa (1992) published a list of 19 threatened/endangered medicinal plants in India. A red data list of South Indian Medicinal Plants published recently, listed 73 medicinal plants under different categories as vulnerable, rare, critically endangered, endangered, extinct, low risk, data deficient, extinct in wild etc. (Shankar *et al.*, 1997).

2.2 Ethnobotanic investigations in Kerala

The mountainous tracts in Kerala are inhabited with large number of aboriginal tribes with distinct cultures, taboos and beliefs. Living close to nature, these tribes have developed their own unique medical systems, have learned to utilise the local herbs for different ailments after centuries of trial and error. Ethno-medico-botanic surveys conducted among these tribes have brought to light several new medicinal plants. After detailed pharmacological and clinical trials, most of these folk medicines have proved effective. *Rauvolfia serpentina* is a classic example.

Viswanathan (1975) studied the genus *Solanum* associated with the tribes of Kerala. Five wild species of *Solanum* viz., *Solanum indicum, Solanum incanum, Solanum xanthocarpum, Solanum torvum* and *Solanum trilobatum* were studied phytochemically and cytogenetically. John (1984) explored the southern parts of Kerala and prepared a select list of 100 drugs commonly used by the experienced elders of 'Kani tribe. He also evaluated the claims by the tribal people in terms of known chemical constituents of the plants. Pushpangadan and Atal (1984) conducted investigations in the Western Ghats among the primitive tribes. Their medicinal herbs were identified and described. Manilal (1984) attempted to identify the medicinal plants mentioned in *Hortus Malabaricus*. Another major study conducted in Kerala in tribal health and medicines was by Nair (1985). Medicinal uses of 93 plants of the tribal area of Champakkad was prepared as a part of the scheme for restoration of degraded environment in Champakkad tribal colony area (KAU, 1986). Pushpangadan (1986) conducted investigations among the 'Kani tribe of Agasthya hills for the plant *Trichopus zeylanicus* that induces evergreen health and vitality. Mathur (1987a) conducted a study among the Wynad tribes and presented data on their etiology, treatment and traditional curing techniques. A detailed account of the ethnomedicine of the Irular tribe of Attappady along with the etiology of illness and treatment was prepared by Mathur (1987b). Sudhadevi (1992) documented the ethnomedicines used by the 'Malayan' tribe of Thrissur district and described the plants. Seventy three plants were reported from Chimminy, 93 from Marottichal, 125 from Sholayar, 108 from Vazhachal and 73 from Vazhani forests.

2.3 Habit

An analysis of the habit of medicinal plants indicated that they were equally distributed across various habits. One third were trees and an equal proportion shrubs, and the remaining one third herbs, grasses and climbers (Shankar *et al.*, 1997). A very small proportion of medicinal plants were lower plants like lichens, ferns, algae etc. In another study by Raveendran and Pandurangan (1997) in Pathanamthitta, herbs constituted 48 per cent of medicinal flora followed by climbers 22 per cent, shrubs 19 per cent and trees 11 per cent.

A brief review on the habit and uses of the select species and/or their related species is given below.

2.3.1 *Desmodium velutinum* (Willd) DC.(Sanskrit - Prsniparni; Malayalam - Orila)

'Prsniparni' is one of the ten drugs that constitute the 'dasamoola' (ten roots) group. The drug is reported to be a cardiotonic, useful in the treatment of cardiac disorders. It is hot, sweet, diuretic, laxative and nervine tonic (Sivarajan and Balachandran, 1994). Root is the officinal part used in medicine.

Some confusions exist regarding the botanical source of Prsniparni. In Kerala however, *Desmodium gangeticum* DC is used as the drug source (Sivarajan and Balachandran, 1994). Other species of Desmodium like *Desmodium velutinum* and *D. laxiflorum* are also used in several places in Kerala as the drug source.

2.3.1.1 Biochemistry

In *D. gangeticum*, Ghosal *et al.* (1969) reported seven alkaloids viz., N.N-dimethyl tryptamine and its N^6-oxide, hypaporine, hordenine, candicine,

N-Methyl tyramine and ß phenyl ethylamine from the roots. Later, they isolated 12 alkaloids from *D. gangeticum* at different stages of development (Ghostal *et al.*, 1972). The medicinal properties of this plant apparently reside in its alkaloids. Purushothaman *et al.* (1975) isolated two pterocarpanoids - gangetin and desmodin, from *D. gangeticum* and their structures were also illustrated. Purushothaman and Narayanaswamy (1974) also provided a process for the separation of gangetin from the roots of *D. gangeticum*. Thirty one specimens of 14 species of *Desmodium* including *D. velutinum* were tested for flavanoids (Naderuzzaman, 1983). All the 14 species contained a range of flavanoids and individual flavanoids were identified fully from 7 of the 14 species. Behari and Varshney (1986) have reported the presence of 5 sterols from *D. gangeticum* and *D. triflorum*.

2.3.2 *Naravelia zeylanica* (Linn) DC. (Sanskrit - Dhanavalli ; Malayalam - Vaathakkodi)

Naravelia zeylanica seems to be a drug exclusively used by Kerala physicians, which does not find mention in any of the Ayurvedic classics (Sivarajan and Balachandran, 1994). It is a herbaceous climber and the whole plant is used medicinally. It is astringent, bitter, sweet, antihel mintic, depurative, anti-inflammatory and vulnerary and is useful in vitiated conditions of 'Pitha , intestinal worms, skin diseases, leprosy, rheumatic pain, toothache, headache, colic, inflammations, wounds and ulcers. The roots and stems have a strong smell and are used by the tribals against headache. The plant is common on hedges and thickets in almost all districts, especially at higher elevations.

2.3.2.1 Biochemistry

No information is available on the chemical constituents. However, Dhawan *et al.* (1977) while screening this plant for biological activity found that the whole plant had effect on respiration, cardiovascular effects, effect on preganglionically stimulated nictitating membrane and anticancer activity.

2.3.3 *Baliospermum solanifolium* (J. Burm.) Suresh Syn: (*B. montanum*) (Sans: Danti , Mal: Nagadanti)

This is a stout herbaceous plant. Root, which is the medicinal part is purgative, anithelmintic, carminative, rubefacient and anodyne (Sivarajan and Balachandran, 1994). The paste prepared from the root is applied to painful swellings and piles. Leaves cure asthma and seeds are used in snake bite (Kurup *et al.*, 1979). The plant is distributed throughout peninsular India.

2.3.3.1 Biochemistry

Ogura *et al.* (1978) isolated montanin, 12-deoxy phorbol 13-palmitate, baliospermin, 12-deoxy-5ß-hydroxy phorbol 13-myristate and 12-deoxy-16-hydroxy phorbol 13-palmitate from the roots of *B. montanum*. The compounds exhibited anticancerous property.

Pharmacognosy and pharmacology of the plant have been discussed by Raghunathan and Mitra (1982).

2.3.4 *Sida rhombifolia* Linn. ssp. *retusa* (Linn.) Borss. (Sans. Bala ; Mal: Kurunthotti)

The drug is held in great repute by Ayurvedic physicians for the treatment of rheumatism and it forms a chief ingredient of several important

preparations. Root is the officinal part in this erect herbaceous plant. It is reported to be cool, sweet, demulcent, aphrodisiac and tonic. The drug is also useful in neurological disorders, general debility, headache, opthalmia, dysuria, leucorrhoea, tuberculosis, diabetes, fever and uterine disorders (Dey, 1980; Chunekar, 1982).

Many species of Sida are available in India and are used as the drug source in different parts of the country. Nambiar *et al.* (1985) opined that some confusion exists in the botanical identity of the drug which often results in adulteration. While *Sida cordifolia* is the widely used source of the drug in Northern India, Kerala physicians have adopted *Sida rhombifolia* ssp. *retusa* for this drug. But *Sida acuta* is used widely to adulterate this drug. The plant is found throughout the warmer parts of India including Kerala.

2.3.4.1 Biochemistry

Dutta (1963) systematically studied the chemical constituents of various *Sida* species. The roots of *S. rhombifolia, S. vernonicaefolia, S. glutinosa, S. chinensis* and *S. cordifolia* contained steroids, alkaloids and fatty oils. The alkaloid content of the various species ran about 0.053 per cent, a little higher for *S. actua* (0.066%) and *S. glutinosa* (0.064%). Ephedrine was one of the minor alkaloids of various species and the chief alkaloids were highly water soluble.

Gunatilaka *et al.* (1980) studied the pharmacologically important alkaloids of *Sida* spp. including *S. rhombifolia*. Results indicated that all the *Sida* species contained alkaloids and that *S. acuta* and *S. cordifolia* were particularly rich source of alkaloids.

Prakash *et al.* (1981) isolated three types of alkaloidal constituents viz. ß-phenethyl amines, quinazolines and carboxylated tryptamines in addition to choline and betaine from *S. actua, S. humilis, S. rhombifolia* and *S. spinosa*. The qualitative and quantitative variations in the alkaloidal constituents of roots and aerial portions at different stages of growth were also noted.

2.3.5 *Barleria prattensis* Santapau (Sans. Sahachara ; Mal: Madhurakurinji)

'Sahachara' is an important drug in Ayurveda widely used against neurological disorders such as paraplegia, sciatica etc. This drug also helps heal ulcers, glandular swellings, poisonous affections, itching, leprosy and other skin diseases, cough, oedema, toothache and gum diseases and to strengthen the nerves. Root is the officinal part.

Different varieties of 'Sahachara' are found mentioned in the texts and their distinction is mainly based on flower colour. These varieties have been equated with different species of plants, mostly of *Barleria*. The red and white flowered varieties are equated with *Barleria cristata*; yellow flowered with *Barleria prionites* and the blue flowered with *B. strigosa* (Chunekar, 1982). Many authors do not make a distinction of these varieties and equate Sahachara with *Barleria prionitis* (Kapoor and Mitra, 1979). In current practice in Kerala however, another Acanthaceous plant *Nilgirianthus ciliatus* is mainly used as Sahachara (Sivarajan and Balachandran, 1994). There is no documented evidence of *Barleria prattensis* being used as Sahachara. This is a profusely branching gregarious herbaceous plant.

2.3.5.1 Biochemistry

No information is available on the chemical constituents of *Barleria prattensis*. Chemical investigation of *B. prionitis* revealed the active principle as ß-sitosterol (Moitra *et al.*, 1970). Subramanyan and Nair (1972) identified the flavanoids apigenin, naringenin and apigenin glucuronide in the fresh buds and flowers of *B. cristata*. Gupta and Saxena (1984) reported a new acylated lutiolin-7-o-ß-D glucoside from the roots of *B. prionitis*. Chemical examination of the roots of *B. buxifolia* confirmed the presence of barleriaquinone and its structure was established as 1-hydroxy-7-methyl anthraquinone (Gopalakrishnan *et al.*, 1984). Jensen *et al.* (1988) found that *B. lupulina* and *B. prionitis* contained iridoid glucosides while *B. strigosa* was devoid of it. These three species contained the quanternary amino acid betaine. A phytochemical study of the whole plant of *B. prionitis* yielded 3 iridoids (Purushothaman *et al.*, 1988). Biological activity of *B. prattensis* was tested by Bhakuni *et al.* (1988) and they reported no activity.

2.3.6 *Piper longum* Linn. (Sans. Pippali ; Mal. Thippali)

'Thippali' is an important drug that is capable of improving intellect and memory power and also to regain health by dispelling diseases. It is reportedly acrid, hot, light, digestive, appetiser, aphrodisiac and tonic. Dried ripe fruits and roots are the officinal parts (Sivarajan and Balachandran, 1994). While pippali is the dried ripe fruits, 'Pippalimoolam' is the root of this plant.

This dioecious creeper, considered indigenous to the hotter parts of India, is found growing wild in west coast as under growth in the evergreen forests of the Western Ghats. It is also occasionally cultivated.

Root is diuretic and stimulant. Ripe fruits and roots are stomachic, analgesic, antiepileptic, antiinflammatory, sedative, antidysentric, haematic, cholagogue, abortefacient, antihelmintic and used in disorders of the respiratory tract.

2.3.6.1 Biochemistry

Chatterjee and Dutta (1967) isolated piperlongumine and piperlongumi-nine besides piperine and a colorless oil from the roots. Studies on the drug obtained from dried roots and thicker parts of stem, the 'Pippalmool' revealed the presence of piperine (0.15-0.18%), piplartine (0.13-0.2%) and traces of an yellow crystalline alkaloid. Other constituents included triacontane, dihydrostigmasterol, reducing sugars and glycosides (Dastur, 1970).

2.4 Production of secondary metabolites in plants

The active principles are certain secondary metabolites like alkaloids, glycosides, coumarines or steroids in the case of medicinal plants and volatile oil known as essential oils containing different compounds of terpenes or phenols in the case of aromatic plants. These secondary metabolites are however, not directly involved in the normal growth and reproduction of these plants. These are produced by plants perhaps, as a biochemical adaptation to prevent illness or as defense against predators or adaptation to live in association with other plant and animal communities in the particular ecological, edaphic or climatic niche (Pushpangadan, 1992). The biosynthesis of these compounds is controlled genetically and the heritability and expression of which are greatly affected by the abiotic and environmental factors. Great emphasis must be given on time, source of

collection, preservation, drying and storage of plants as these play an important role for maintaining the efficacy of the drug (Tiwari and Pandey, 1992).

2.4.1 Phase effect

In *Physochlaiana orientalis,* proportion of alkaloids differed according to organs and phase (Aslanov, 1983). During fruiting, the maximum total alkaloids and hyoscyanin occurred in the whole plant. The maximum scopalamine occurred in the leaves and roots during fruiting and in the stem during budding. Maximum pyrethrin in chrysanthemum was at the starting of anthesis (Singh *et al.*, 1983). Solasodine content of fruits of *Solanum wrightii* reached a maximum of 2.57 per cent (dry weight) in fruits of 4-4.99 cm diameter and it was recommended that fruits should be harvested at this stage (Indrayanto *et al.*, 1985). In the plant *Adonis amurensis* the total cardenolide content was highest during mass flowering and at the beginning of fruiting (Skurzova and Shnyakina, 1985). Banerjee and Datta (1991) observed that in *Andrographis paniculata,* the accumulation of andrographolide was phase specific. They also found that in *Azadirachta indica,* nimbidin increased with age, while ß-sitosterol decreased.

2.4.2 Seasonal effect

Seasonal effects on secondary matabolites were compound specific. Every individual compound had its specific favourite season (Banerjee and Datta, 1991).

The content of various alkaloids in the leaves of *Adhatoda vasica* showed great variation at different seasons (Pandita *et al.*, 1983). Similarly seasonal variations in the active constituents has been reported by Ghanim *et al.* (1984) in the plant *Balanites roxburghii.*

In *Catharanthus roseus*, the highest quantity of ajmalicine was obtained during summer, lowest in winter, while total alkaloid was highest in winter and lowest in summer (Sen and Datta, 1986). They also found that in *Ervatamia coronaria* leaf, the highest accumulation of coronarids was in rains, while that of total alkaloids was in summer. In *Rauvolfia serpentina* also accumulation of alkaloids (total and reserpine) followed almost a similar trend of rise and fall.

The American podophyllum contained 4-5 per cent podophyllum resin whereas the Indian species contained 7-14 per cent, varying according to season of collection and locality. In certain cases, as much as 20 per cent resin has been recorded. The highest percentage of resin was in May when the plant was in bloom. This resin also had double the amount of podophyllotoxin which is the active constituent used in the manufacture of anticancer drugs (Thakur, 1993).

2.4.3 Habitat effect

Biswas (1955) observed that there was no significant difference in the alkaloid content of roots of *Rauvolfia serpentina* under irrigated agriculture and forestry conditions. Sulochana (1959) noticed that the alkaloid content varied considerably in different geographical regions. In *Datura stramonium*, Chandrasekharan *et al.* (1984) reported that the scopalamine content of cultivated plants was twice as that of wild samples and fluctuated between 0.126 per cent and 0.309 per cent.

Narayanan (1993) observed variation in the root alkaloid content ranging from 1.38 per cent to 2.65 per cent in *Rauvolfia serpentina* from nine geographical locations of Kerala. He opined that the alkaloid content is a highly complex

phenomenon involving environmental factors, species difference and their interaction.

Protein and alkaloid content of *Holostemma annulare* was compared under domesticated and wild conditions by Samuel *et al.* (1993). They found that the protein and alkaloid contents were high in the tubers obtained from domesticated plots when compared to the market samples.

2.4.4 Water stress effect

There are reports of a positive reaction of the plant to limited water supply. It has been stated that water stress increases the alkaloid content of the members of the Solanaceae such as *Atropa belladona*, *Datura* spp. and *Hyocyamus muticus* (Evenari, 1960). Mothes (1978) generalised that the content of alkaloids in wet and cold years was lower than in dry years. Waller and Nowacki (1978) cited experiments performed with *Papaver somniferum, Datura stramonium* and *Hyocyamus niger* and pointed to the fact that the highest alkaloid level in these species was found under climatic conditions of water stress. This effect was illustrated by the finding that *Cinchona* tree produces no quinine during the rainy season.

In a seven year summary analysis of irrigation effects with three standard varieties of tobacco, reported by Mckee and Street (1978), irrigation significantly lowered the percentage of total alkaloids and total nitrogen.

Increase in the content of solasodine from 1.3 per cent under wet conditions to 3 per cent under conditions of water stress has been reported in *Solanum khasianum* fruits by Yaniv and Palevitch (1982).

The beneficial effects of water stress on the yield and composition of essential oils in aromatic plants is not always evident. The effect of irrigation on the content of essential oils in various plants was reviewed by Penka (1978). As a rule, the formation and accumulation of the essential oils tended to increase under dry growing condtions. In additiion, water stress can affect the composition of oil. Gershinzon's (1978) studies on *Satureja doughlasi* clearly indicated the influence of water stress on yield and composition of essential oils. Longenheim *et al.* (1979) studied the effect of moisture stress on composition and yield in leaf resin of *Hymenoea courbaril* and did not find large variations.

2.4.5 Light effect

Light regime of a plant also determine the productivity and quality of its produce (Tilihominov *et al.*, 1976). Shade exerts its positive influence on the quality of the produce in many of the crops like *Cinchona ledgeriana, Rauvolfia gunnanensis* etc. (Fing, 1982). Shade grown ginger recorded high values of oil and oleoresin compared to that grown in open (George, 1992). In contrast to this, a negative correlation of shade and quality of the produce was also reported in clocimum (Balyan *et al.*, 1982; Pillai, 1990). Curcumin content of turmeric rhizome showed a progressive decrease with increase in shade (Varugheese, 1989). In *Coptis japonica,* no significant difference in berberine type alkaloid content was observed (Shibata *et al.*, 1992). Menon (1994) observed that in *Plumbago rosea* there was no marked difference in the content of purified plumbagin in open and shaded conditions eventhough the crude plumbagin was higher under shade. High quality of 'Njavara' - a medicinal rice under shade has also been reported by Menon (1996).

2.4.6 Fertilizer effect

Quality of the produce or the alkaloid content also vary with the fertilizer application. In *Costus speciosus,* Yadav *et al.*,(1983) reported that total diosgenin content increased with N and K application whereas it decreased with P application. The antiemetic activity of tubers of *Pinellia ternata* was highest in the N and K fertilised plots while P reduced it (Kasahara and Hikino, 1983). In opium, the morphine concentration was not affected by N, P and K application (Nigam *et al.*, 1984). In *Catharanthus roseus* NPK fertilization at 40:20:20 kg ha^{-1} produced highest alkaloid yield, six months after sowing. Rao *et al.* (1991) studied the influence of nitrogen on *Artemesia pallans* and found that the levels of N did not affect the davanone content of the essential oil.

2.5 Habitat

Many of the wild medicinal and aromatic plants are highly habitat specific, found only in forests and occupy highly specialised ecological niches with restricted distribution (Pushpangadan, 1992). Assessment of the habitat status of the species requires a detailed investigation on the ecosystem.

Ehrlich and Daily (1993) furnished some reasons to preserve habitats as such. They pointed out that the possible range of genetic variability shrinks in captivity because, together with random chance, it is the adaptation of species to different environmental conditions that give rise to genetic variability. Also continuous extraction of a species with low adaptability elsewhere for the very purpose of ex-situ conservation could trigger off a chain of species endangerment and habitat destruction. As the constituents are separated, the ecosystem services provided collectively by the organisms are lost.

Coptis teeta is a little known herbal species of high medicinal value from eastern Himalayas. Studies by Babu *et al.*, (1993) revealed that there are two sub species having extremely narrow niches. Both differ with respect to the rhizome morphology, reproductive potential and berberine content.

Under domestication outside the normal habitat or ecological range, many of the medicinal plants behave differently. In some cases it becomes difficult to grow them or it may not even survive. In certain other cases they survive and grow but may not be providing the desired result. Attempts to domesticate the plant *Trichopus zeylanicus* sub sp. *travancorensis* through mass multiplication by tissue culture showed that the tissue cultured plants when planted out and analysed, differed in their properties from those found in the wild (Mathrubhoomi, 1994). Hence scientists are now making attempts to grow this plant in the natural habitat itself (Agasthyamalais) with the help of local tribe who have been using the plant for their long and healthy life.

2.5.1 Habitat interactions and associations

The basic ecological concept is that there is an interlocking mechanism among the different plant and animal species of an ecosystem leading to a very significant net work of interaction and interdependance (Ambasht *et al.*, 1994). In this network, the stress or strain placed on any component of biological diversity, habitat condition or the environmental factors immediately affect maximally to the nearest and marginally to the farthest located component of the ecosystem. Therefore, each species howsoever, small or big, has an important position and function for the sustenance and balance of the ecosystem.

The association of plant communities is another important aspect to be noted when studying the habitat of any wild, medicinal or aromatic plant. Because in many instances the production of a chemical substance - alkaloid, glycoside, saponin, coumarin or essential oil constituent may be an adaptive or defensive mechanism evolved by the plant for its survival in a particular forest ecosystem.

In a survey conducted in the arid zone medicinal plants (Yaniv and Palevitch, 1982) it was evident that plants containing alkaloids were relatively few in number in arid zones.

It is known that substances leached from certain plants can have allelopathic or promotive effects on associated plants. In *Costus speciosus*, leaf leachates of *Mangifera indica, Shorea robusta* and *Tectona grandis* increased the percentage sprouting of rhizomes, shortened sprouting time and promoted subsequent growth, while the leaf leachates of *Eucalyptus globulus* inhibited rhizome sprouting and growth. The diosgenin content in rhizome was increased by treatment with mango leachates, unaffected by *Shorea robusta* and *Tectona grandis* leachates and decreased by *Eucalyptus globulus* leachates (Kona and Kushari, 1989).

Oguntimein and Elakovich (1991) investigated the allelopathic potential of extracts and essential oils of three plants commonly used in Nigerian folk medicine. *Chromolaena odorata* appeared to be allelopathically inactive. *Eugenia uniflora* appeared to be growth stimulatory and *Piper guineense* was growth inhibitory at concentration above 400 ppm.

Purushothaman and Viswanath (1993) reported that the pharmaceutical value of plants grown in captivity diminishes in the long run due to the absence of provocation by herbivores, stimulating defensive chemicals.

In a study in the Western Ghats in Maharastra region, Sadhale (1991) observed an interesting plant association. *Gloriosa superba* was always found growing inside the thick shrub clumps composed of shrubs like *Vitex negundo, Carrisa congesta* and *Lantana camara*. When *Gloriosa* seeds were formed, they fell within the limits of shrub clump and got natural protection in the seedling stage. But such shrub clumps were always cut from all sides for fuelwood by villagers leading to the disappearance of *Gloriosa*. Tiwari (1993) opined that the complexity of the interactions between species in their natural ecosystems is such that any modification to these ecosystems is likely to lead to the loss of species or atleast of genetic variants.

2.5.2 Regeneration

In the verbal form, regeneration is a cyclic process beginning with flowering and ending with the formation of adult plants, passing through fruits, seeds, seedlings etc. Thus in a wider sense the term applies to all life stages of the plant.

Narayanan (1988) studied the regeneration status of some important MDF trees in the Thrissur Forest Division and observed that the regeneration is under various stresses of which that of human origin was the most hazadrous. Grazing, browsing, fire and illicit cutting were the greatest constraints.

Swarupanandan and Sasidharan (1992) opined that biotic factors were the main causes responsible for the paucity of regeneration in the MDFs. Recurring fire, grazing and browsing by goats and sheep, illicit cutting of saplings and poles, charcoal making etc. were the main reasons for the paucity of regeneration. Besides

the biotic factors, competition offered by weeds, twiners and the less useful species also offered constraints, but to a lesser extent. In some species intrinsic constraints also exist.

Nameer (1993) reported that MDF tend to become SEG if left undisturbed for several years. While the disturbance increases, the diversity of the forest decreases, and disturbance adversely affects the regeneration of the forest.

Regeneration studies on medicinal herbs are almost nil. Both over collection and destructive collection are equally harmful to their regeneration. Benjamin and Anderson (1985) sampled wild ginseng (*Panax quinquefolius*) in protected and unprotected areas and found that in protected sites the productivity was more. Since commercial cultivators selectively removed largest plants, the reproductive capabilities of these populations were greatly reduced. Medicinal plants whose roots, bulbs, rhizomes and tubers are used for extracting drugs are facing a great threat to their existence because of unscientific excavation of these under-ground portions by digging the whole plants (Bisen *et al.*, 1993). The danger is further intensified if excavation/collection is done before fruit or seed setting. The popular drug plant *Chlorophytum tuberosum* is facing a great threat to its existence - villagers and tribals collect the tubers and throw the disc unused. Thus the propagules of this plant are lost for ever. Moreover, the germination percentage of the seed of this plant is also very low. So he suggested that at the time of collection of medicinal plants from one area, complete removal of the whole plant should not be done and only the medicinally useful part be collected without damaging the habitat and the potential propagules.

Destructive collection of medicinal plants by non tribals also poses serious threat to their regeneration. As a result of increasing demand, non tribals are also entering the trade and often their gathering procedures are harmful to the plant as well as the habitat. Martinez (1995) observed that Mexican gatherers who collected medicinal plants in the past followed some traditional practices which protected the species. New collectors, pushed into the trade do not observe the traditional conservation practices. Another report by Shankar *et al.* (1997) pointed out that over 70 per cent of the plant collections in India involve destructive harvesting because of the use of parts like roots, bark, wood, stem and the whole plant (in case of herbs) causing definite threat to the diversity of medicinal plants. Estimates suggest that over half a million tonne of dry raw material is indiscriminately and most destructively collected from the wild each year.

2.5.3 Habitat destruction

It has been pointed out many-a-time that destruction of forests leads to destruction of habitats of plants and animals. Decisions to convert these species rich natural forests to alternative land uses are taken almost exclusively on market value considerations (Nair and Daniel, 1986). Rao (1993) observed that much of the diversity was being lost through extinction caused by the destruction of natural habitats especially in the tropics. Over grazing of ranches, expansion of cash crop agriculture and intensified shifting cultivation also lead directly to the demise of species and habitats. Logging, spread of alien weeds like *Mikania, Eupatorium, Lantana* etc. and the frequent forest fires add to the destruction of natural habitats. Southern Western Ghats which had an original forested area of 35,250 sq km in the past, now have only a strip of forest of 12,000 sq km which have 3900 species of

flowering plants with 1286 endemics. The habitats of endemic species are far more vulnerable than other species (Nayar, 1997). Endemic species once lost, is lost for ever.

Degradation of natural habitats of medicinal plants have led to their diminished supply which in turn has resulted in adulteration of the raw drug. An observation by Nambiar *et al.* (1985) is that *Aegle marmelos* which is of very rare occurrence in Kerala forests was being adulterated by the roots of *Toddalia asiatica* and species of *Limonia*. Martinez (1995) also reported about the adulteration of many of the Mexican medicinal plants.

The habitat is conserved if sufficient and representative samples of relatively undisturbed forests be set aside as natural reserves. The findings of island biogeography generally suggested that if 90 per cent of an original habitat becomes grossly disrupted and the remaining 10 per cent is protected, we can expect to save no more than about half of the species in that particular area (Battisse, 1982).

2.6 Domestication

Medicinal and aromatic plants in general have very short history of cultivation and artificial selection (Pushpangadan and Rajasekharan, 1987). By the relentless collection from the wild without replacement, one out of every 10 plants are either extinct or in imminent danger of extinction (Nair *et al.*, 1991). Only less than 20 species of medicinal plants are under commercial cultivation, while over 400 species are used in production by the industry; a recent report indicates (Shankar *et al.*, 1997). Nair *et al.* (1992) suggested that depending upon the natural habitats of the plant, various zones at different altitudes should be selected for the cultivation of a particular drug. Factors like soil, temperature, irrigation and manuring should be taken into consideration at the time of selecting a drug for cultivation.

History of systematic cultivation of medicinal plants in India is relatively very recent. Experimental cultivation of some of the exotic plants was started in India as early as the beginning of the 18th century. In the Government sector, agro-technology of 40 odd species has been developed by the ICAR - agricultural system and CSIR (CIMAP and RRL Jammu and Jorhat). But most of them are aromatic plants used by the modern pharmaceutical industry. No systematic agro-technology has been developed for the 400 odd species used by the traditional pharmaceutical industry. Much of the propagation and cultivation trials have been concentrated in few crops like *Rauvolfia, Catharanthus, Solanum, Cannabis, Dioscorea, Ocimum, Costus, Opium* and *Senna.*

Cultivation trials have been carried out by Karnick (1977) in *Hemidesmus*; Rajagopalan (1983) in *Kaempferia galanga*; Soldati and Tanaka (1984) in *Panax ginseng*; Nayar (1992) in *Holostemma* and *Indigofera*; Meera (1994) in *Holostemma*; Menon (1994) in *Plumbago* and Menon (1996) in 'Njavara' - a medicinal rice.

Intercropping trials with several medicinal plants have been carried out by Nair *et al.* (1991) and Rajithan (1997).

Socio-economic problems also do exist in the medicinal plant trade. Shankar *et al.* (1997) observed that cultivation is inversely linked to prevalence of easy and cheap collection from the wild, lack of regulation in trade, cornering of the profits from wild collection by a vast net work of traders and middlemen and absence of industry's interest in providing money-back guarantee to growers. In recent years industries like Dabur, Nagarjuna, Zandu, Indian Herbs, Kottackal Arya Vaidyasala, Coimbatore Arya Vaidya Pharmacy and others have made some symbolic efforts initiating cultivation but it forms probably a fraction of their annual production requirements.

MATERIAL AND METHODS

The investigations reported herein were carried out in four different experiments planned one after another based on the results of the previous experiment.

3.1 Experiment I. Survey of the area

3.1.1 Location and study area

Peechi hills, which is an extension of the Nelliampathy hills along the southern tip of Palakkad gap in the Western Ghats was the study area. It forms part of the Peechi-Vazhani wild life sanctuary and falls in the Peechi range in Thrissur forest division. The area lies between the latitudes 10° 25' and 10° 35' N and longitudes 76° 15' and 76° 30'E (Fig.1, Plate 1).

3.1.2 Climate

The area enjoys a warm humid climate characteristic of the region. The main sources of atmospheric precipitation are the South-West and North-East monsoons. The greater portion of the rain is from South-West monsoon which showers between June and September. The North-East monsoon showers during later part of the year between October and November. Generally, May to October are wet months and November to April dry. During the months December to February, the area receive warm winds coming through the Palakkad gap. Relative humidity is always greater than 55 per cent and attains 100 per cent during the rainy months. The details of distribution of precipitation, fluctuations in temperature and relative humidity during the study period are given in Table 1a.

Plate 1. Study area - the Peechi hills

1a A general view of the Peechi hills including the reservoir

1b The moist deciduous forests with the semi evergreens in the upper reaches

a

b

Plate 1. Study area - the Peechi hills

FIG. 1. FOREST MAP OF PEECHI HILLS

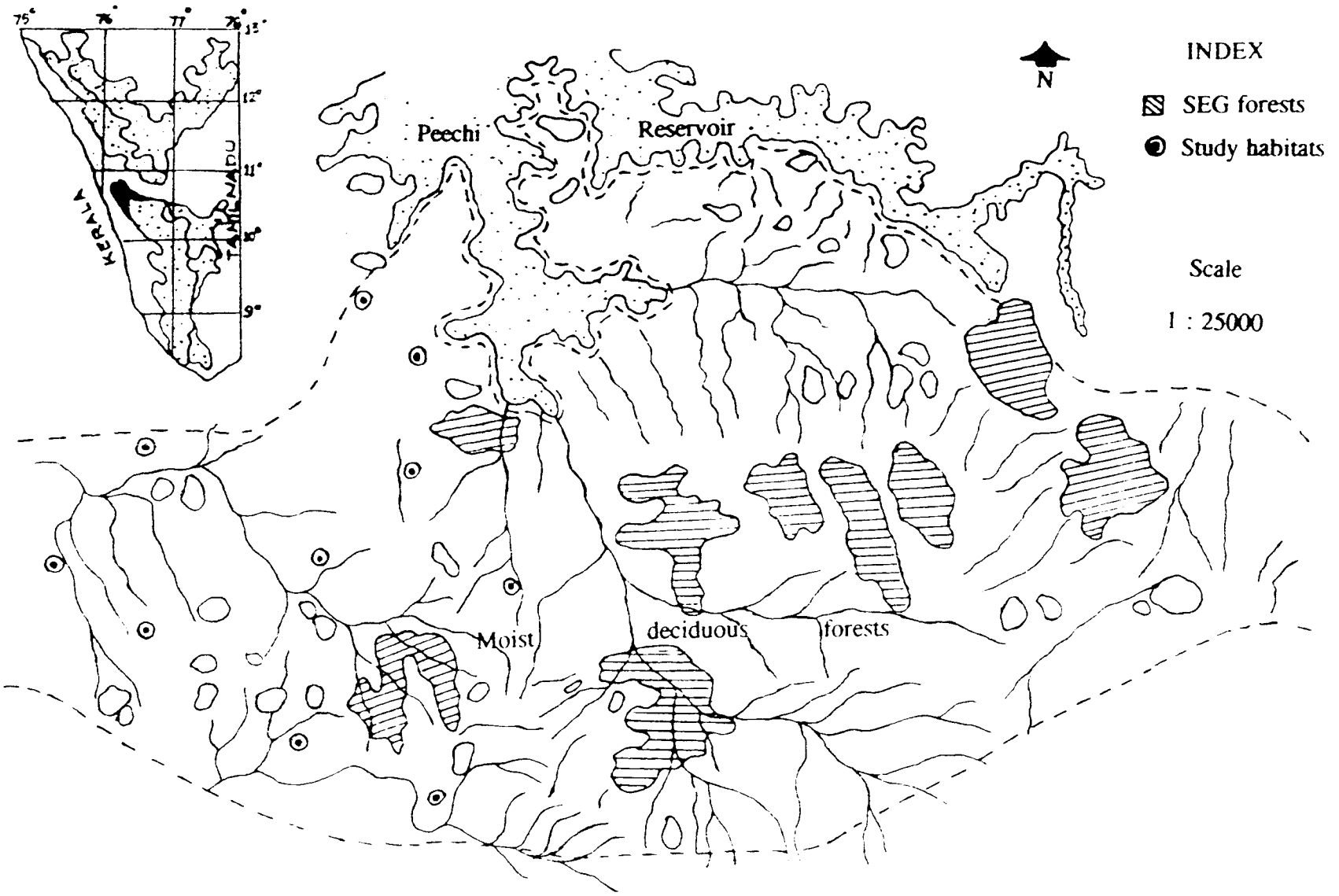


Table 1a. Monthly average of weather data for 1995-96 at Peechi*

Month	Mean temperature (°C)		Mean RH (%)		Rainfall (mm)	Wind velocity (km h^{-1})
	Max.	Min.	Max.	Min.		
1995						
January	34.70	20.50	79.00	47.00	0.00	2.2
February	37.10	22.10	81.00	44.00	0.00	1.6
March	39.20	22.80	82.00	36.00	1.60	1.10
April	38.50	23.70	81.00	46.00	45.40	1.10
May	34.10	22.90	82.00	58.00	333.00	0.80
June	31.90	22.90	83.00	66.00	463.00	0.70
July	29.50	21.70	84.00	70.00	837.60	0.70
August	30.40	22.10	84.00	67.00	401.20	0.60
September	31.30	22.20	85.00	69.00	329.60	1.10
October	33.50	22.00	84.30	63.50	111.00	0.69
November	32.70	21.60	84.00	58.00	56.00	0.40
December	33.60	19.90	78.00	43.00	0.00	1.80
1996						
January	35.00	20.00	78.00	37.00	0.00	0.50
February	34.50	20.00	81.00	54.00	0.00	0.60
March	34.00	22.00	76.00	53.00	0.00	1.10
April	34.00	21.00	75.00	53.00	0.00	0.10
May	34.50	20.00	75.00	51.00	0.00	-

*Recorded at KFRI weather station (Latitude: 10°32' N; Longitude: 76°20' E; Altitude: 100 m)

3.1.3 Physiography

The whole forest division has a highly rugged and undulating physiography, wherein all kinds of aspects are met with. The study area lies in the more or less radiating ridges of the catchment of the Peechi reservoir. There is a check dam at Peechi which irrigate the agricultural lands along the West.

3.1.4 Geology

The hills belong to the crystalline rocks of Archean age comprising chiefly of charnockites, granites and granitic gneisses traversed by basic dykes (GSI, 1976). The active weathering of the ground is very much evident as indicated by the presence of boulders especially in the moist deciduous tracts. The soil is blackish or reddish and loamy.

3.1.5 Vegetation

The natural forest comprise semi-evergreen (SEG) and moist deciduous forests (MDF). Preliminary survey of the medicinal plants was carried out both in the SEG and MDF and the detailed habitat analysis was carried out in the MDF.

3.1.6 Moist deciduous forests (MDF)

The term moist deciduous forest denotes an aggregate forest type. This forest type is classified variously and the sub-divisions received different names in different systems. The MDF s of Thrissur forest division belong to the South Indian MDF s, which again comprise a large number of sub divisions (Champion and Seth, 1968). Present study was conducted in southern moist mixed deciduous forests.

Distributed upto an elevation of 928 m above MSL, these forests are a complex association of different kinds of habitats like reservoirs, man-made forests and natural forests. Along the upper reaches, they form part of the insulation belt around the SEG s. On the lower reaches they are surrounded by settlements and agricultural lands.

Soil and its properties vary considerably depending upon elevation and physiography of the land. Generally it is shallow, except on gentle slopes, where it is moderately deep. The soils belong to the group red soils (oxisols). The surface soil is generally sandy loam in texture and granular in structure while it becomes loamy and massive beneath. The absorbing capacity of the soil is low, except in the humus accumulative layer. Initial stages of laterization are observed where the soils are devoid of a vegetal cover and erosion is active (Sankar *et al.*, 1987).

3.1.7 Physiognomy

During the wet season, because of the thick foliage, the MDF s mimics the evergreens. During this season, their surface morphology is very much like that of the evergreen forests. However, during the dry season, in the MDF s, trees shed their foliage and leave the vertical structure of the stands pellucid.

Totally undisturbed areas are altogether wanting in these mixed deciduous forests. The vegetation is under heavy biotic pressure resulting in excessive opening of canopy and establishment of exotic weeds like *Eupatorium* and *Lantana*.

3.1.8 Tribal settlements

The 'Malayans' are the jungle tribe inhabiting the area. They are divided into two sub tribes, viz. the 'Nattumalayans' (natives) who are probably the original inhabitants of the hills and the 'Kongamalayans' who appear to have immigrated from the forests of the Coimbatore district and settled in the state forests (Iyer, 1987). The Malayans are by tradition somewhat migratory and necessity often leads them to new places, where no inducement can persuade them to remain permanently. They have of late, commenced to live in permanent huts in some localities in the forests.

The primary occupation of the Malayans as of other hill tribes is the collection of minor forest produce. However, now-a-days they have started clearing small portions of the forest near their huts for cultivation and some among them possess a few goats and poultry.

3.1.9 Selection of settlement

There are totally 10 Malayan settlements in the area. All were visited and foraging activity assessed. The 'Thamaravellachal' settlement was selected for the study. It is located 2 km from Vellakkarithadam and 13 km from Vilangannur.

All together there are 20 families in this settlement and all of them earn their livelihood by selling medicinal herbs and other forest produce viz. honey, black dammer, lac etc. Both men and women go for foraging.

3.1.10 Ethno-medicine

Frequent visits were made to the settlement and the herb gatherers were identified. Elder men and women were contacted and details about herbal medicine practiced by them collected. Frequent visits were made to the forests along with them to identify the plants used in these medicines. Voucher specimens were collected and herbaria made. Herbaria were later identified at the Kerala Forest Research Institute Herbarium.

3.1.11 Survey of medicinal plants

The survey of India map of Thrissur Forest division was referred and the forest boundaries and study area were located accurately. A reconnaissance survey was conducted both in the MDF and SEG to have an idea on the native medicinal plants. Exploration tracts were finalised with the help of tribal herb gatherers, to represent the entire area in the MDF and SEG. Periodic forest trips were made to collect the native medicinal plants. Observations like season and extent of occurrence, habit, habitat, parts used and the local name were recorded. Phenological observations like flowering and fruiting were noted in the case of major species. Herbaria were made and they were later identified at the Kerala Forest Research Institute Herbarium.

The survey was conducted for two consecutive calender years starting from September 1994 to September 1996.

A base camp in the forest was fixed at Karadippara, 5 km away from the settlement and the entire study in the the forest was carried out staying there.

The data were later catagorised based on several criteria, by referring to the published reports on the flora (Gamble, 1935) and various publications on endemic, rare, endangered and threatened species (Jain and Sastry, 1980). All efforts were taken to follow the latest botanic nomenclature.

3.1.12 Monitoring of medicinal plants extraction

The herb gathering groups were identified and their collection practices closely monitored. The men and women gatherers were separately monitored during the peak periods of harvest/extraction, ie. from August to April. The major extraction sites were located and the method of extraction of herbs, tubers, roots, fruits, seeds, bark, resin etc. were closely observed. Peak harvest time was noted in major species and an assessment of the approximate quantity extracted was made. Processing methods in various produce/plants were recorded and the marketing channels identified.

3.2 Experiment II. Natural habitat analysis

The MDF was selected for detailed habit and habitat analysis of select medicinal plants.

3.2.1 Choice of species

Based on the abundance and the intensity of extraction, the following species were chosen for detailed habitat analysis and they are described below as done by Warrier *et al.* (1996).

1. *Piper longum* L. Family - Piperaceae

Sub-shrub with slender prostrate or ascending shoots, sometimes climbing. Leaves ovate, acute or acuminate, base cordate, puberulous along nerves below, to 12 x 6 cm; basally 5-7 nerved, petiole to 3 cm long; leaves of flowering shoots smaller with oblique base. Spikes erect, yellow to 5 x 2.5 mm; peduncle to 1.5 cm long, stigmas 3-5. Fruiting spikes to 6 x 1 cm.

2. *Naravelia zeylanica* (L.) Family - Ranunculaceae

A herbaceous climber, young shoots pubescent, leaflets broadly ovate, abruptly acute, base rounded, tomentose beneath, 10-14 x 6-9 cm, basally 5 ribbed; petiole 5-10 cm long, petiolate 2 cm long. Flowers greenish yellow, 1.5 cm across. Outer petals ovate, acute, 4 mm long; innerlinear spathulate, 8 mm long. Achenal style ca 3 cm long.

3. *Sida rhombifolia* L. ssp. retusa (L.) Family - Malvaceae

An erect minutely hairy branched under shrub with a firm woody stem and intricate branches; leaves short-petioled, obovate, truncate or more often retuse and serrate, flowers yellow, solitary and axillary. fruits enclosed within the persistent calyx; separating into one seeded cocci; seeds black, smooth.

4. *Desmodium velutinum* (Willd.) DC. Family - Fabaceae

A sub-shrub, branches fulvous - tomentose. Leaves broadly ovate, acute or obtuse, mucronate, base truncate, velvety tomentose below, puberulous above, to 16 x 12 cm; lateral nerves 6-8 pairs, reticulations prominent; petiole 2-3 cm long; stipules ovate - acuminate; 0.5 cm long, tomentose, flowers 0.4 cm long in long

axillary and terminal racemes. Calyx lobes unequal, tomentose, petals pink or pale blue pods 4-6 jointed, indented along the lower suture, curved, densely tomentose, 2 cm long.

5. *Baliospermum solanifolium* (J. Burm.) Suresh Family - Euphorbiaceae

Sub-shrub to 1.5 m tall. Leaves broadly ovate, or 3-lobed, acute or acuminate, base rounded, glabrous or sparsely hispid above and tomentose along the nerves beneath, inciso-crenate, with a pair of glands at base of lamina, to 10 x 15 cm; basally 3-5 nerved with 7-8 other lateral nerves; petiole to 6 cm long. Perianth lobes 4, concave, 1.5 mm long, pubescent. Ovary densely tomentose; style 2-fid. Capsule 3-lobed, 1.2 cm long; seeds ovoid.

6. *Barleria prattensis* (Santapau) Family - Acanthaceae

Glabrous sub-shrub. Leaves ovate or elliptic, acuminate, mucronate, base acute or attenuate, membraneous, to 11 x 5 cm; petiole to 2 cm long. Flowers solitary, axillary terminating into short racemes, bracts linear - subulate, 5 mm long. Outer calyx lobes 2.2 - 2.5 x 2 cm, puberulent along the nerves; inner linear, 1 x 0.1 cm. Corolla funnel shaped, tube 3 cm long, white, lobes subequal, broadly ovate, pink-purple, 1.5 cm long, ovary glabrous, seeds orbicular, glabrous. Endemic.

3.2.2 Community structure analysis

Plants growing together have mutual relationships among themselves and with the environment. Such a group of plants in an area forms a stand. Several similar stands represent a community. Quadrat method was employed to determine the analytical characters of community.

Quadrat method

Natural habitats of the chosen species were located visually and ten different locations were selected at random to represent the whole MDF patch based on altitude, slope, nature of soil, stand composition, density and variability of stands. Permanent plots were laid out in all the ten locations by quadrat method.

A right angled triangle of sides 3, 4 and 5 m was laid out on the ground with the help of a rope. The triangle was marked on the ground with three iron pegs on the corners. Next, by extending the horizontal and vertical sides of the triangle, a 10 m x 10 m quadrat was laid out. The quadrat was marked with iron pegs on the ground and outlined by laying coloured nylon ropes to the pegs.

Quadrat laying was done in March 1995. All the plots were protected from intervention by the tribes for extraction of medicinal plants.

3.2.3 Site characteristics

Preparatory to enumeration, based on general visual observations, a record of the site characteristics of the plots was prepared. Elevation, slope, dominant species, undergrowth, litter cover and other details were noted in the field book. Incidence of fire, cattle grazing, damage by wild animals and such other interventions were recorded then and there. The ten habitats selected for the study and their characteristics are furnished hereunder.

Site characteristics of different habitats in the forest

1. Pongunilkunnavazhi (PNV)

Situated on the far side of Peechi reservoir, 10° 25' N, 76° 24' E, ± 250 m > MSL, flat terrain, rocky; soil dark brown, canopy cover 25 per cent, litter cover 50 per cent, grazing and browsing much less.

2. Karadippara-1 (KP-1)

On the far side of the Peechi reservoir, 10° 25' N, 76° 24' E, ± 230 > MSL, gentle slope, aspect SE, rocks absent, soil black, canopy cover 70 per cent, litter cover 90 per cent, grazing and browsing much less, fire usual.

3. Karadippara-2 (KP-2)

Not far from Peechi reservoir, 10° 30' N, 76° 23' E, ± 220 > MSL, gentle slope, aspect SE, rock absent, soil black, canopy cover 70 per cent, litter cover 90 per cent, grazing less, fire recurring.

4. Kalluchal-1 (KC-1)

Near Peechi reservoir, 10° 30' N, 76° 22' E, ± 200 m > MSL, slope medium, aspect SE, rocks absent, soil blackish, canopy cover 80 per cent, litter cover 90 per cent, adjoinging areas full of lianas, fire recurrent, grazing not common.

5. Kalluchal-2 (KC-2)

Not far from Peechi reservoir, 10° 30' N, 76° 22' E, ± 180 m > MSL, flat terrain, rocks absent, soil brownish, liana diversity and density high, canopy

cover 40 per cent, litter cover 80 per cent, canopy opened up, highly disturbed area, cattle grazing common, fire usual.

6. Vellamkananapara-1 (VK-1)

Far away from Peechi reservoir, near tribal settlement, 10° 25' N, 76° 21' E, ± 140 m > MSL, flat terrain, rocky, soil brownish, canopy cover 20 per cent, litter cover 90 per cent, highly disturbed area, full of *Helicteres* and *Acacia instia*, fire recurrent.

7. Vellamkananapara-2 (VK-2)

Near the tribal settlement, 10° 25' N, 76° 21' E, ± 150m > MSL, flat terrain, rocky, soil brownish, canopy cover 25 per cent, litter cover 90 per cent, highly disturbed area, fire usual.

8. Methanampara-1 (M-1)

Far away from reservoir and the settlement, 10° 15' N, 76° 24' E, ± 240 m > MSL, flat terrain, rocks absent, soil blackish, canopy cover 50 per cent, litter cover 90 per cent, grazing much less, fire not common.

9. Methanampara-2 (M-2)

Far away from the settlement and the reservoir, 10° 15' N, 76° 23' E, ± 220 m > MSL, slope gentle, aspect SE, rocky, soil blackish, plot was burnt in the previous season, canopy cover 45 per cent, litter cover 20 per cent, fire usual.

10. Aanakuzhi (AK)

Far away from reservoir, 10° 30' N, 76° 22' E, ± 190 m > MSL, slope gentle, aspect E, soil brownish, canopy cover 55 per cent, litter cover 20 per cent, burnt in the previous season, canopy opened up, grazing less, fire usual, highly disturbed zone.

3.2.4 Initial enumeration

All the individuals in the plots viz. trees (> 10 cm gbh), tree seedlings (< 10 cm gbh) and shrubs were counted and the percentage herb cover recorded. Height and girth at breast height were noted and entered in data sheets. Number and type of medicinal plants present in each quadrat were noted separately. The data were categorised at various levels and magnitudes.

3.2.5 Experimental plants

With the onset of first summer showers in April 1995, plants started regeneration and in each quadrat, seedlings of the select species were tagged with the help of wooden poles and aluminium tags. Uniform seedlings were tagged in the month of May 1995. Out of 10, only in two quadrats, all the 6 species could be located. However, all the quadrats contained atleast one select species.

3.2.6 Phytosociological analysis

The data were subjected to phytosociological analysis as detailed hereunder.

Frequency

Frequency expresses the distribution or dispersion of various species in a community. From this, percentage frequency was calculated as follows:

$$\text{Percentage frequency} = \frac{\text{No. of sampling units in which the species occurred}}{\text{Total no. of units studied}} \times 100$$

Density

The terms density and abundance represent the numerical strength of species in the community

$$\text{Density} = \frac{\text{Total no. of individuals of a species}}{\text{Total No. of quadrats studied}}$$

Abundance

Abundance is described as the number of individuals per quadrat of occurrence

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species}}{\text{No. of quadrats of occurrence}}$$

3.2.7 Physical and chemical properties of soil

Moisture content of the soil was found out by standard procedure of oven drying.

Chemical properties like pH and EC were determined by standard analytical procedures and was expressed on moisture free basis.

Available nutrients were estimated and the details of methods adopted are given in Table below.

Details of the analytical methods used in the study

Soil characteristic	Method of estimation	Reference
Organic carbon	Walkley-Black (Tritrimetric)	Jackson (1958)
Available P	Ascorbic acid blue colour (Spectrophotometer 660 nm)	Watanabe and Olsen (1965)
Available K	Direct reading after dilution (Flame Photometer)	Jackson (1958)
Available Ca	Direct reading after dilution using $SrCl_2$ as releasing agent (AAS 422.7 nm)	Jackson (1958) and Page (1982)
Available Mg	Direct reading after dilution using $SrCl_2$ as releasing agent (AAS 285.2 nm)	Jackson (1958) and Page (1982)
Available Fe	Orthophenanthroline method (Spectrophotometer 490 nm)	Jackson (1958)
Available Mn	Direct reading (AAS 279.5 nm)	Page (1982)
Available Zn	Direct reading (AAS 213.9 nm)	Page (1982)
Available Cu	Direct reading (AAS 324.8 nm)	Page (1982)

3.2.8 Light measurements

The quantum of photosynthetically active radiation infiltered into the sample quadrat was recorded with the help of line and point quantum sensors.

Measurements were taken in the month of February. Sensors were kept in the plot from sunrise to set and light recorded continuously. Later the data were retrieved and the average of 12 hrs calculated and expressed as percentage.

3.2.9 Growth components

With respect to the tagged plants, growth components were recorded at bimonthly intervals starting from May 1995 to March 1996. One complete life cycle of the plant was covered and there were six observations during the entire period. Plant height, number of primary branches, number of leaves and total leaf area were recorded at all stages. Leaf area was estimated by using leaf area meter. Total dry matter production, root/shoot ratio and the yield of economic part were also recorded. Average valaues for each habitat was worked out at each stage.

3.2.10 Regeneration

With the first summer showers in May, 1996 all the plots were re-enumerated and the extent of regeneration of the select species was recorded. Fire was unanticipated, but it burnt away a few plots in March 1995. Hence burnt and unburnt plots were re-enumerated separately and the percentage regeneration in each species and habitat was worked out.

3.2.11 Plant associations

A healthy patch of each of the select species was located and using a 1 m^2 bamboo frame thirty 1 m^2 quadrats were taken at random and all the individuals inside counted species wise and entered in data sheets. The data were further analysed to find out the probable associations.

3.3 Experiment III. Domestic environment analysis

The experiment was laid out in the experimental field of the College of Horticulture during the South-West monsoon of 1995 ie. on 18-6-95 as a replicated trial with four replications.

Moisture content, chemical properties like pH and EC and available nutrients in the soil were estimated as in the case of natural habitat analysis. Quantum of photosynthetically active radiation reaching the field was also recorded using point quantum sensor as described earlier. Values are presented in Table 2. Weather data for the period is given in Table 1b.

Uniform seedlings of select species were brought from the forest and planted in fully open condition. Planting was on flat beds of 3 m x 1 m x 0.5 m size with a plant to plant spacing of 50 cm. There were 12 plants per replication.

Well dried and powdered Farm Yard Manure was applied at the rate of 5 t ha^{-1} and a fertilizer dose of 50:50:50 NPK kg ha^{-1} was given. Half N, full P and half K were given as basal dose and the remaining N and K in two equal splits, one month and two months after planting. In rainless periods plants were irrigated twice a week.

3.3.1 Growth analysis

Growth components were recorded as in the case of wild plants. The domestic crop was harvested in March ie. after 8 months.

Table 1b. Monthly average of weather data for 1995-96 at Vellanikkara

Month	Mean temperature (°C)		Mean RH (%)		Rainfall (mm)	Wind velocity (km h^{-1})
	Max.	Min.	Max.	Min.		
1995						
January	32.9	22.4	76.0	41.0	0.0	10.4
February	35.4	23.4	79.0	41.0	0.5	12.7
March	37.6	23.8	83.0	37.0	2.8	2.9
April	36.6	24.9	87.0	55.0	118.7	4.7
May	33.5	23.9	91.0	65.0	370.5	3.5
June	31.6	23.1	94.0	77.0	500.4	3.7
July	29.9	23.2	96.0	81.0	884.7	2.1
August	30.6	23.7	94.0	78.0	448.7	2.6
September	30.1	23.5	94.0	70.0	282.5	4.2
October	33.2	23.2	91.0	65.0	110.4	1.3
November	31.3	22.5	91.0	69.0	88.4	0.6
December	32.5	21.3	71.0	43.0	0.0	3.9
1996						
January	33.1	22.4	71.0	35.0	0.0	6.8
February	34.7	23.4	72.0	34.0	0.0	10.1
March	36.4	24.3	82.0	37.0	0.0	9.1
April	34.6	25.0	87.0	59.0	152.0	2.8
May	32.8	25.2	91.0	63.0	95.4	2.3

Table 2. Moisture content, available light, chemical properties and available nutrients in the soil of the domestic environment

Parameters	Content
Available light	95%
Moisture content	5.02%
pH	6.56
EC	0.12 dSm^{-1}
Organic carbon	1.3%
Available P	0.0003%
Available K	0.009%
Available Ca	0.021%
Available Mg	0.005%
Available Fe	39.81 ppm
Available Cu	8.66 ppm
Available Zn	53.67 ppm
Available Mn	100.68 ppm

3.4 Statistical analysis

Growth analysis

Statistical models used for the growth analysis are given by

1. Linear model

$$Y = \alpha + \beta t$$

2. Exponential model

$$Y = \alpha \beta^{t}$$

Linear Growth Rate (LGR) was estimated from the formula

$$LGR = \frac{b}{a} \times 100 \text{ where}$$

b = least square value of the slope ß
a = least square value of the intercept α

Compound Growth Rate (CGR) was estimated from the formula

$$CGR = (b-1) \times 100 \text{ where}$$

b = Antilog ß

Cluster analysis

Habitats were clustered into different groups using the techniques of Principal component analysis (Chatfield and Collins, 1980). First and second principal components were used for grouping the habitats.

Computer analysis

Computations were done using MSTAT-C and SPAR1 statistical packages developed by Michigan State University and the Indian Statistical Research Institute, New Delhi, respectively.

3.5 Experiment IV. Biochemical analysis

Biochemical analyses were carried out both in the wild and domestic plants. Literature on the phytoconstituents, their extraction medium and estimation methods with respect to the select species were nil or limited and all the methods had to be statndardised first. Hence, habitat-wise analysis of each species could not be undertaken. Composite samples were taken instead. Each sample was replicated five times and average worked out.

3.5.1 Preparation of sample

Roots/whole plants were thoroughly washed in water to remove the adhering soil particles. It was then finely chopped and dried under shade. Fully dried material was ground into fine powder in a stainless steel grinder for further analysis.

3.5.2 Selection of suitable solvent for extraction

Different solvents used were

1. Petroleum ether (60-80°C)
2. Hexane
3. Chloroform

4. Ethyl acetate
5. Acetone
6. Methanol

Thirty grams of the finely powdered sample was taken in a filter paper thimble and soxhletted for 10 hrs using 250 ml of the solvent in a water bath. After extraction, the solvent was removed by vacuum drying and the percentage recovery of the crude extractables calculated. Number of siphonings obtained in each solvent was recorded. The experiment was repeated five times with each sample and solvent. From these results the suitable solvent was selected.

3.5.3 Estimation of crude extractables

Based on the results of the previous experiment, Petroleum ether (60-80°C) was selected as the solvent for further analysis.

Soxhlet extraction was carried out as described earlier using Petroleum ether (60-80°C). Percentage of crude extractables was calculated both in the wild as well as domestic crops.

3.5.4 Estimation of soluble sugars

The content of soluble sugars was estimated by Phenol-Sulphuric acid method suggested by Sadasivam and Manikam (1992) with the following modifications.

Weighed 0.1 g of the dry powder and ground with 10 ml of 80 per cent Methanol. Centrifuged. Supernatent was transferred to a test tube. Extraction was

repeated 5 times with 5 ml Methanol each time until the extract was free of sugars (by testing with phenol H_2SO_4). The extracts were pooled and made up to 100 ml with 80 per cent Methanol. Five ml of 5 per cent Lead acetate was added to remove the Phenolic compounds. Excess Lead acetate was precipitated by adding five ml of Potassium oxalate. After centrifugation, the clear supernatent was taken for sugar estimation.

3.5.5 Estimation of starch

The residue after the extraction of sugars was used for starch estimation. The residue was dried in air to remove the traces of methanol. Starch content was estimated by, anthrone method described by Sadasivam and Manikam (1992).

3.5.6 Estimation of total free aminoacids

The total free amino acid content was estimated by the method suggested by Sadasivam and Manikam (1992) using ten per cent iso-propanol as the solvent.

3.5.7 Qualitative tests for alkaloids

All the wild samples were tested for the presence of alkaloids using Mayers, Dragendorffs and Wagners reagents as suggested by Daniel (1991).

3.5.8 Thin Layer Chromatography (TLC)

TLC was carried out to separate the plant constituents and to identify them, as per the procedure suggested by Sadasivam and Manikam (1992). Silica Gel was used as the adsorbant.

3.5.8.1 Sample preparation and application

Petroleum ether extracts of the plant samples were used for TLC. Five micro litre of the sample was applied on the plate using a capillary in a horizontal line about 2 cm from the lower end. Spots were made at 2 cm distance. In the same plate, 3 spots each were made in the wild and domestic samples. Plate was then transferred to a rectangular glass chamber saturated with the solvent system. Solvent system used was Toluene:Ethyl acetate:Diethylamine (7:2:1). Care was taken to see that the level of the solvent was slightly below the level of spots. Plates were kept slanting on the walls of the chamber and chamber was closed tightly with the lid. The solvent was allowed to run up to 2/3rd portion of the plate. Afterwards, it was taken out and allowed to dry in air. Once the development started, the chamber was not disturbed till the run was over.

3.5.8.2 Detection of the compounds

The following detection devices/procedures were used to locate the substances in the chromatogram and later to identify them. Rf values were calculated and colours of the characteristic main zones described. A scale diagram of the thin layer chromatogram showing migration distances and colour of main zones was drawn. Colour photographs were also taken.

After confirmation of results final analysis was done in ready made plates of MERCK (Kiesel Gel 60 wf 254 S).

Detection methods used in Thin Layer Chromatography

Device/spraying agent	Method of preparation	Method of application	Class of compunds identified
1	2	3	4
Ultra-violet rays	Ultra violet rays at 254 nm	Plate was kept inside the UV-cabinet and viewed at 254 nm	Substances that quench fluorescence at short wave length
Ultra violet rays	Ultra violet rays at 365 nm	Plate was kept inside the UV-cabinet and viewed at 365 nm	Substances that fluoresce in long wave UV light
Dragendorffs reagent	By mixing Bismuth sub nitrite (0.6 g) and Potassium iodide (6 g) in conc. HCl and water	Plates after drying were sprayed with DD reagent. Brown or orange zones appear immediately on spraying. colors were intensified by spraying with 5% aqueous solution of sodium nitrite. Evaluated in visible light	Alkaloids
Conc. H_2SO_4	Concentrated H_2SO_4 was used	Plates were sprayed with conc. H_2SO_4 and then heated at 110°C for 10 minutes in oven and evaluated in visible and in UV-365 nm	Alkaloids, terpenoides
*Anisaldehyde-sulphuric acid reagent	0.5 ml of anisaldehyde was mixed with 10 ml glacial acetic acid followed by 85 ml methanol and 5 ml conc. H_2SO_4 in that order	Plate was sprayed with about 10 ml reagent heated at 100°C for 5-10 min. then evaluated in visible or UV-365 nm	Cardiac glycosides

Contd.

Continued

1	2	3	4
*Ninhydrin	1% Ninhydrin in acetone	TLC plate was sprayed with freshy prepared ninhydrin solution and heated at 110 °C and evaluated in visible light	Amino acids
Antimony (iii) chloride reagent	20% solution of Antimony (iii) chloride in chloroform	The plate sprayed with 10 ml of reagent, then heated for 5-6 minutes at 100 °C, evaluated in visible light or UV-365 nm	Detection of cardiac glycosides, saponins

* Reagents used were freshly prepared

3.5.8.3 Detection of iridoids in *Barleria prattensis*

Iridoids were detected by paper chromatography, following the method suggested by Harborne (1972).

3.5.8.4 Development and detection of substances

The paper was viewed under uv light at 254 nm and 356 nm. Later it was sprayed with Anisaldehyde - H_2SO_4 reagent and Antimony (III) chloride reagent as described in TLC and again viewed both in uv and visible light. Rf values of this spots and colour intensities were noted. Scale diagram of the chromatogram was drawn and it was photographed.

3.5.9 Column chromatography

Extracts of *Naravelia* and *Piper* contained chlorophyll pigment which interfered with the colour development in TLC. To remove the pigments, column chromatography was carried out.

Glass column was filled tightly from bottom upto 2 cm with Sodium sulphate unhydrous followed by 20 cm activated Silica gel (200 mesh) and then 2 cm thickness of Sodium sulphate as the top layer. Column was wetted with the solvent ie. Petroleum ether (60-80 $^{\circ}$C). The extract (5 ml) was applied over the top layer of Sodium sulphate using a pipette. Discharge of the solvent was adjusted at the rate of 1 ml/minute. Five fractions were collected in separate bottles and stored.

3.5.9.1 TLC of column fractions

Pigment free fractions obtained from column chromatography were later subjected to TLC and documented in the same manner described earlier.

RESULTS

Results of the four different experiments carried out as part of the project on Habit and habitat analysis of select medicinal plants in native and domestic environments are presented in this chapter.

4.1 Experiment I. Survey of the area

4.1.1 Ethnomedicines

Information on the folk use of medicinal plants collected from 'Malayans', the jungle tribe who inhabit the Peechi hills are presented in the following paragraph.

Among this tribe, people who still depend solely on ethnomedicines for their health care are practically nil. The primary occupation of this tribe being minor forest produce collection, they have very good knowledge on the native medicinal plants. But developmental activities have brought them to the main stream of life and there has been drastic change of life style of this tribe. From a self sustainable system they have fallen victims of the present day consumeristic society and most of them seek the help of modern systems of medicine for ailments. Eventhough all the tribal families were contacted and discussed, only a few people in the older generation could share their knowledge on the details of ethnomedicines passed on to them from their ancestors. Compared to men, it was women who depended on the surrounding herbs for their health problems. Both men and women shared their knowledge without hesitation and accompanied to forests for identifying the plants used in these medicines.

The scientific name, family, local name, habit and habitat of the plant, its therapeutic application, dosage and the manner of use etc. are presented here.

ETHNOMEDICINES PRACTICED BY THE MALAYAN TRIBE IN PEECHI HILLS

1. *Aristolochia indica* L. ('Karalakom') F. Aristolochiaceae
Habit (H). herbaceous climber. Habitat (Ha) MDF

Juice of the leaf consumed against snake and scorpion poisoning.

2. *Butea monosperma* (Lamk) Taub. ('Plaas') F. Fabaceae
H. tree Ha. MDF

Root bark applied as a paste against cracking of skin in the foot. It is also used as an antihelmintic.

3. *Baliospermum solanifolium* (J. Burm) Suresh ('Nagadanti') F. Euphorbiaceae
H. herb. Ha. MDF

Salted rice gruel prepared in the root decoction is used as a purgative.

4. *Caesalpinia mimosoides* Lamk. ('Goomullu') F. Caesalpiniaceae
H. herbaceous climber Ha. MDF

Tender leaves applied as a paste on the forehead of small babies against common cold.

5. *Coscinium fenestratum* Colebr. ('Maramanjakol') F. Menispermaceae
H. woody climber. Ha. SEG

Stem applied as a paste on the forehead in severe headaches.

6. *Caesalpinia bonduc* (L.) Roxb. ('Kazhanji') F. Caesalpiniaceae
H. woody climber. Ha. SEG

Decoction of the endosperm effective against vomiting and bleeding.

7. *Cissampelos pariera* L. ('Malathangi') F. Menispermaceae
H. herbaceaeous climber. Ha. MDF

Coconut oil boiled with the extract of the whole plant, when applied externally cures skin diseases.

8. *Cyathula prostrata* (L.) Bl. ('Cherukadalaadi') F. Amaranthaceae
H. herb. Ha. MDF

Whole plant applied as a paste against swellings.

9. *Curcuma zedoaria* (Christm) Roscoe ('Manjakoova') F. Zingiberaceae
H. herb. Ha. MDF

Extract/essence of the dried rhizome after purification ('Koova nooru') taken by women in genital diseases. Paste of the fresh rhizomes applied over face for lustrous and shining skin.

10. *Centranthera anthelmintica* (Willd) Kuntz ('Kattujeerakom') F. Asteraceae.
H. herb. Ha. MDF

Hot infusion of seeds given to children as anthelmintic.

11. *Canarium strictum* Roxb. ('Thelli') F. Burseraceae
H. tree Ha. SEG

Fumes of the dried resin extracted from this tree repels mosquitoes and purifies air. Fine powder of the dried resin is applied as a paste in coconut oil against cracking of skin in the foot.

12. *Dracaena terniflora* (Roxb.) ('Manjakantham') F. Liliaceae
H. herb Ha. SEG

Used as a panaceae for jaundice.

13. *Desmodium motorium* (Hoult.) Merr. ('Thozhukanni') F. Fabaceae
H. herb Ha. MDF

Women use it as an aphrodisiac.

14. *Entada scandens* (L.) Benth ('Kakkumvally') F. Mimosaceae.
H. Woody climber Ha. SEG

Rice gruel prepared in the decoction of the endosperm of the seed taken with coconut gratings for rheumatic pain.

15. *Embelia tsjeriam-cottam* A.DC ('Ammimuriyan') F. Myrsinaceae
H. shrub Ha. MDF

Rice gruel prepared in the decoction of the root of this plant along with the endosperm of *Entada scandens* and a few cumin seeds; taken consecutively for 7 days wards off severe back pain.

16. *Elaeocarpus munronii* (Wt.) Mast. ('Kodinjii') F. Elaeocarpaceae
H. tree Ha. SEG

Seed paste applied on forehead against headache.

17. *Harpullia arborea* (Blanco) Radlk. ('Puzhukolli') F. Sapindaceae
H. tree Ha. SEG

Outer skin of stem applied as a paste over body to repel leeches.

18. *Holarrhena pubescens* (Buch.-Ham) Wallich x Don. ('Kutakapala')
F. Apocynaceae
H. tree Ha. MDF

Decoction of the seeds in water is useful against amoebiasis.

19. *Ipomoea pesti-gridis* L. ('Puliyadi') F. Convolvulaceae.
H. herbaceous climber Ha. MDF

Leaves ground with cow's milk is consumed against spider poisoning.

20. *Ixora coccinia* L. ('Chethi') F. Rubiaceae
H. shrub Ha. MDF

Coconut oil boiled with the flowers of this plant along with goat droppings on external application wards off skin diseases.

21. *Laportea crenulata* (Roxb.) Gaud ('Aanaveratti') F. Urticaceae
H. shrub Ha. SEG

Used to cause enlargement of glands and high fever to enemies. Usually used to ward off elephant attack in the forest.

22. *Nervilia aragoana* Gaud. ('Orilathamara') F. Orchidaceae
H. herb Ha. MDF

Tuber of the plant used against gonorrhoea.

23. *Naravelia zeylanica* (L) DC ('Vathakodi') Ranunculaceae
H. herbaceous climber Ha. MDF

Fresh roots after crushing if inhaled directly removes common cold; bathing in water boiled with the leaves of this plant removes rheumatic pain.

24. *Thottea siliquosa* (Lamk.) Dirg. Hou ('Alpam') F. Aristolochaceae
H. shrub Ha. MDF

Roots useful against snake poison.

25. *Xylia xylocarpa* (Roxb.) Taub ('Irul') F. Mimosaceae
H. tree Ha. MDF

Decoction of stem bark given to neutralise the problems of overconsumption of honey.

26. *Mangifera indica* L. ('Maavu') F. Anacardiaceae
H. tree Ha. SEG

Green fruits given to nullify the problems of over consumption of honey.

27. *Terminalia bellerica* (Gaertn.) Roxb. ('Thani') F. combretaceae
H. tree Ha. MDF

Believed as an antidote for allergy caused by certain species of *Holigarna* and *Semicarpus*.

28. *Wrightia tinctoria* (Roxb.) R.Br ('Dantappala') F. Apocynaceae.
H. tree Ha. MDF

To get relief from toothache, seven leaves of this tree are chewed like betelvine leaf. Coconut oil exposed to sunlight with few *Wrightia* leaves immersed, on external application is very effective in acute psoriasis. The spines or prickles struck on the body naturally gets ejected out when the milk of the tree is applied on the spot.

From the aforesaid list it is evident that some species have restricted use while others have wide use in medicine. Habitat-wise, 68 per cent of the plants used

in tribal medicines were MDF species and the remaining SEG species. There were 3 endangered species also. Majority of the plants were used in skin disorders and rheumatism. Use of single plant could be observed in certain cases like psoriasis, jaundice etc. However, these remedies require clinical investigations to establish their utility and efficacy in therapeutics.

4.1.2 Medicinal flora of Peechi hills (Plates 2, 3)

A survey was conducted in Peechi hills, the foraging area of the 'Malayans' in the 'Thamaravellachal' settlement to prepare an inventory of native medicinal plants. Total area covered was 67 km^2 and the vegetation included both MDF and SEG forests.

A total of 503 herbariums were made. They were botanically identified and labelled, and are deposited in the herbarium at the Department of Plantation Crops and Spices.

A total of 226 medicinal plants could be identified from the area. Their botanic name, family, vernacular and sanskrit names and the parts used are furnished in Table 3. The plants are distributed in 73 families. The families which are well represented are Fabaceae (19) Euphorbiaceae (15), Rubiaceae (12), Acanthaceae (12), Malvaceae (8), Apocynaceae (7), Sapindaceae, Verbenaceae and Caesalpiniaceae (6 each). *Desmodium* (6), *Dioscorea* (4) and *Ixora* (4) are the three genera which contained maximum number of species.

A categorisation based on the major part used in medicine indicated that roots are used in the case of 60 plants, stem bark in 43, whole plant in 37, seeds in 24, fruits in 17, tubers in 16, leaves in 7, flowers in 4 and other parts / produce like

Plate 2. Medicinal flora of Peechi hills

2a	*Wrightia tinctoria*
2b	*Clerodendrum serratum*
2c	*Sarcostigma kleinii*
2d	*Geophila herbaceae*
2e	*Cassia fistula*
Centre plate	*Dillenia pentagyna*

Plate 2. Medicinal flora of Peechi hills

Plate 3. Medicinal flora of Peechi hills - continued

3a *Holarrhena pubescence*
3b *Nilgirianthus ciliatus*
3c *Dracaena terniflora*
3d *Strobilanthus asperrimus*
3e *Barleria courtallica*

Plate 3. Medicinal flora of Peechi hills

oil, gum, resin, bud, root bark etc. in the remaining 25 plants (Fig.3). In many plants often more than one part is useful in medicine.

Another observation was that in certain drugs more than one plant is used as the source.

Eight plants of the family Acanthaceae are considered as the source of the drug 'Sahachara' or 'kurinji'. They are

Barleria courtallica Nees.

Barleria prattensis Santapau

Barleria acuminata Wt.

Ecbolium viridae (Forsk.) Alston.

Eranthemum capense L.

Nilgirianthus ciliatus (Nees.) Bremek.

Strobilanthus asperrimus Nees.

and

Strobilanthus anceps Nees.

Out of these eight species only two ie. *Barleria prattensis* and *Nilgirianthus ciliatus* are extracted by the tribes on a large scale.

The source of the drug 'Prsniparni' or 'Orila' constituted four plants of the family Fabaceae. They are

Desmodium laxiflorum DC

D. pulchellum Benth.

D. triquetrum (L) DC

and

D. velutinum (willd) DC

Out of these four species, *D. laxiflorum* is considered the best. It has got slightly red, and as the vernacular name indicates some what tuberous roots (which resembles tapioca). Root yield per plant is low and so they rarely extract it, eventhough it gets a higher price in the market. *D. velutinum* is the one extracted in large quantities as the source of the drug 'Orila'.

4.1.2.1 Habit and habitat of medicinal flora of Peechi hills

Habit and habitat allocation of the medicinal plants in Peechi hills is also presented in Table 3.

Between the two forest types the MDF accounted for 64 per cent of the medicinal plants (145) and SEG accounted for 25 per cent (57). The remaining 11 per cent (24) of the plants were present both in the MDF and SEG forests (Fig.4).

Habit-wise, 36 per cent (81) of the native medicinal plants of Peechi hills were trees; 29 per cent (65) herbs; 15 per cent (35) herbaceous climbers; 13 per cent (29) shrubs and seven per cent (16) woody climbers (Fig.5).

In the MDF which accounted for 64 per cent of the total medicinal flora, 31 per cent was constituted by trees and woody climbers and 69 per cent by herbs, shrubs and herbaceous climbers. A reverse trend was observed in SEG where 67 per cent of the medicinal flora were trees and woody climbers and 33 per cent herbs, shrubs and herbaceous climbers.

Another peculiarity observed was the highly restricted distribution of certain species. *Ensete superbum, Malaxis rheedii* and *Bigonia canarana* were found only on rocks. *Embelia tsjeriam - cottam* was common in rocky areas. Population of

Table 3. Medicinal flora of Peechi hills

Sl. No.	Botanic name	Family	Vernacular name	Sanskrit name	Part used	Habit	Habitat
1	2	3	4	5	6	7	8
1	*Andrographis paniculata*(Burm.f.) Wallich ex. Nees.	Acanthaceae	Kiriath കിരിയാത്ത്	Kiratatikkah	Whole plant	Herb	MDF
2	*Barleria acuminata* Wt.	Acanthaceae	Kurinjii കുറിഞ്ഞി	Sahachara	Root	Shrub	MDF
3	*Barleria courtallica* Nees.	Acanthaceae	Kurinjii കുറിഞ്ഞി	Sahachara	Root	Herb	MDF
4	*Barleria prattensis* Santapau..	Acanthaceae	Madhura kurinjii മധുര കുറിഞ്ഞി	Sahachara	Root	Herb	MDF
5	*Ecbolium viridae* (Forsk.) Alston.	Acanthaceae	Kurinjii കുറിഞ്ഞി	Sahachara	Root	Herb	MDF
6	*Eranthemum capense* L.	Acanthaceae	Kurinjii കുറിഞ്ഞി	Sahachara	Root	Herb	MDF
7	*Justicia procumbens* L.	Acanthaceae	Vathachedi വാതച്ചെടി	NA	Root	Herb	MDF
8	*Nilgirianthus ciliatus* (Nees.) Beremek.	Acanthaceae	Karimkurinjii കരിങ്കുറിഞ്ഞി	Sahachara	Root	Shrub	SEG
9	*Rhinacanthes communis* Nees.	Acantheceae	Nagamulla നാഗമുല്ല	Yuthikaparni	Root, leaf, seed	Herb	MDF
10	*Rungia pectinata* (L.) Nees	Acanthaceae	Malankaara മലങ്കാര	NA	Leaf	Tree	MDF
11	*Strobilanthus asperrimus* Nees.	Acanthaceae	Karimkurinjii കരിങ്കുറിഞ്ഞി	Sahachara	Root	Herb	SEG
12	*Strobilanthus anceps* Nees.	Acanthaceae	Karimkurinjii കരിങ്കുറിഞ്ഞി	Sahachara	Root	Herb	Both

Contd.

Table 3.Continued

1	2	3	4	5	6	7	8
13	*Adiantum lunulatum* Burm.	Adiantaceae	Aanavalpannal ആനവാൽപന്നൽ	Hansavati	Whole plant	Herb	MDF
14	*Achyranthes aspera* L.	Amaranthaceae	Vankadalaadi വൻകടലോടി	Apamaargah	Whole plant	Herb	MDF
15	*Aerva sanguinolenata* (L.) Bl	Amaranthaceae	Cherula ചെറുള	Bhadra	Whole plant	Herb	MDF
16	*Cyathula prostrata* (L.) Bl.	Amaranthaceae	Cherukadalaadi ചെറുകടലോടി	Apamaargah	Whole plant	Herb	MDF
17	*Holigarna arnottiana* Hook.f.	Anacardiaceae	Karimcheru കരിംചേര്	Bhallatakah	Stem bark, seed	Tree	SEG
18	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Karasu കരൾ	Jingini	Stem bark, leaf	Tree	MDF
19	*Mangifera indica* L.	Anacardiaceae	Mavu മാവ്	Amva	Stem bark, leaf, seed	Tree	SEG
20	*Semicarpus anacardium* L.F.	Anacardiaceae	Alakkucheru അലക്കുചേര്	Bhallatakah	Seed, stem bark	Tree	SEG
21	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	Ambazham അമ്പഴം	Aamraatakal leaf	Fruit, stem bark,	Tree	SEG
22	*Polyalthia fragrans* (Dalz.) Bedd.	Annonaceae	Nedunaaru നെടുനാര്	NA	Stem bark	Woody climber	Both
23	*Alstonia scholaris* (L.) R.Br	Apocynaceae	Ezhilampaala ഏഴിലംപാല	Saptaparna	Stem bark, resin	Tree	Both
24	*Holarrhena pubescense* (Buch.-Ham.) Wallich ex. Don.	Apocynaceae	Kudakappala കുടകപ്പാല	Kutajah	Root bark, stem bark, seed	Tree	MDF
25	*Ichnocarpus frutescens* (L.) R.Br.	Apocynaceae	Paalvalli പാൽവള്ളി	Sariba	Root	Herbacous climber	MDF
26	*Rauvolfia serpentina* (L.) Benth ex-Kurz.	Apocynaceae	Amalpori അമൽപൊരി	Sarpagandha	Root	Herb	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
27	*Tabernaemontana gamblei* Subram. & Henry	Apocynaceae	Nanthiarvattom നന്ത്യാർവട്ടം	Nandyavartah	Flower, root	Shrub	SEG
28	*Tabernaemontana heyneana* Wall. ex. A.DC.	Apocynaceae	Kambippaala കമ്പിപ്പാല	Kampillakah	Root, flower	Shrub	SEG
29	*Wrightia tinctoria* (Roxb.) R.Br.	Apocynaceae	Dantappala ദന്തപ്പാല	Srikutaja/ krishna kutajah	Leaf, stem bark, latex	Tree	MDF
30	*Amorphophallus paeonifolius* (Dennst.) Nicols.	Araceae	Kattuchena കാട്ടുചേന	Suranah	Corm	Herb	SEG
31	*Aristolochia indica* L.	Aristolochiaceae	Karalakom കരളകം	Iswari	Root, leaf	Herbaceous climber	MDF
32	*Thottea siliquosa* (Lamk.) Dirg. Hau.	Aristolochiaceae	Alpam അൽപം	NA	Root	Shrub	Both
33	*Hemidesmus indicus* (L.) R.	Asclepiadaceae	Naruneendi നറുനീണ്ടി	Sariba	root	Herbaceous climber	MDF
34	*Holostemma ada-kodian* Schult.	Asclepiadaceae	Adapathiyan അടപതിയൻ	Jeevanti	tuber	Herbaceous climber	MDF
35	*Centranthera anthelmintica* (Willd.) Kuntz.	Asteraceae	Kattujeerakam കാട്ടുജീരകം	Somaraji	seed	Herb	MDF
36	*Elephantopus scaber* L.	Asteraceae	Aanachuvadi ആനച്ചുവടി	Gojihva	whole plant	Herb	MDF
37	*Sphaeranthus indicus* L.	Asteraceae	Adakkamaniyan അടക്കാമണിയൻ	Hapusa	whole plant	Herb	MDF
38	*Spilanthus radicans* Jacq.	Asteraceae	Kuppamaniyan കുപ്പമണിയൻ	NA	whole plant	Herb	MDF
39	*Oroxylum indicum* (L.) Vent	Bignoniaceae	Palakappayyani പലകപ്പയ്യാനി	Syonakah	root	Tree	MDF
40	*Radermachera xylocarpa* (Roxb.) K. Schum.	Bignoniaceae	Vedankorana വെടങ്കാരണ	NA	oil from wood	Tree	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
41	*Stereospermum suaveolens* DC	Bignoniaceae	Pooppathiri പൂപ്പാതിരി	Patala	root	Tree	MDF
42	*Bigonia canarana* Miq.	Bigoniaceae	Kalthamara കൽത്താമര	NA	whole plant	Herb	SEG
43	*Heliotropium indicum* L.	Boraginaceae	Thekkada തേക്കട	Urscikali	whole plant	Herb	MDF
44	*Canarium strictum* Roxb.	Burseraceae	Thelli തെള്ളി	Rala	resin	Tree	SEG
45	*Bauhinia malabarica* Roxb.	Caesalpiniaceae	Aarampuli ആരംപുളി	Kancanarah	leaf, flower	Tree	MDF
46	*Caesalpinia bonduc* (L.) Roxb.	Caesalpiniaceae	Kazhanji കഴഞ്ചി	Kuberakshi/ Putikaranja	seed	Woody climber	SEG
47	*Caesalpinia mimosoides* Lamk.	Caesalpiniaceae	Goomullu ഗൂമുള്ള്	NA	leaf	Herbaceous climber	MDF
48	*Cassia fistula* L.	Caesalpiniaceae	Kanikkonna കണിക്കൊന്ന	Aragvadhah	stem bark	Tree	MDF
49	*Cassia tora* L.	Caesalpiniaceae	Takara തകര	Cakramardah	whole plant	Herb	MDF
50	*Saraca asoca* (Roxb.) de Wilde	Caesalpiniaceae	Asokam അശോകം	Asokah	stem bark	Tree	SEG
51	*Celastrus paniculatus* Willd.	Celastraceae	Cherupunna ചെറുപുന്ന	Kangani	bark, seed	Woody climber	MDF
52	*Calophyllum polyanthum* Wall. ex. Choisy.	Clusiaceae	Punna പുന്ന	Punnaga	seed	Tree	SEG
53	*Garcinia gummi-gatta* (L.) Robs.	Clusiaceae	Kudampuli കുടംപുളി	NA	fruit	Tree	SEG
54	*Mesua ferrea* L.	Clusiaceae	Churuli ചുരുളി	Naagakesar	stem bark, seed	Tree	SEG
55	*Calicopteris floribunda* (Roxb.) Poir.	Combretaceae	Pullani പുല്ലാനി	NA	root climber	Woody	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
56	*Terminalia bellerica* (Gaertn.) Roxb.	Combretaceae	Tanni താന്നി	Vibhitaki	seed	Tree	MDF
57	*Terminalia crenulata* Heyne ex Roth	Combretaceae	Neermaruthu നീർമരുത്	Arjuna	stem bark	Tree	MDF
58	*Terminalia paniculata* Roth.	Combretaceae	Pullamaruthu പുല്ലമരുത്	NA	stem bark, flower	Tree	MDF
59	*Argyreia nervosa* (Burm.f.) Boj.	Convolvulaceae	Perumkurumba പെരുംകുരുമ്പ	Murva	root, leaf	Woody climber	MDF
60	*Ipomoea mauritiana* Jacq.	Convolvulaceae	Paalmudukku പാൽമുതുക്ക്	Vidari	tuber	Herbaceous climber	Both
61	*Ipomoea pes-tigridis* L.	Convolvulaceae	Pulichuvadi പുലിചുവടി	Krishnabij	whole plant	Herbaceous climber	MDF
62	*Cucumis callosus* (Rottl.) Cogn.	Cucurbitaceae	Aandanga ആണ്ടങ്ങ	Indravaruni	fruit climber	Herbaceous	MDF
63	*Luffa cylindrica* (L.) M.J. Roem.	Cucurbitaceae	Kattupeechil കാട്ടുപീച്ചിൽ	Dhamargava	fruit	Herbaceous climber	MDF
64	*Momordica dioica* Roxb. ex. Willd.	Cucurbitaceae	Venpaaval വെൺപാവൽ	Vahishi	leaf, fruit, root	Herbaceous climber	MDF
65	*Mukia madaraspatana* (L.) M. Roem.	Cucurbitaceae	Mukkalpiram മുക്കാൽപിരം	Trikosaki	fruit	Herbaceous climber	MDF
66	*Trichosanthes cucumerina* L.	Cucurbitaceae	Kaippanpadavalam കയ്പൻപടവലം	Patolah	fruit	Herbaceous climber	MDF
67	*Cycas circinalis* L.	Cycadaceae	Eentha ഈന്ത	Varaguna	seed, bark, leaf	Tree	MDF
68	*Dillenia pentagyna* Roxb.	Dilleniaceae	Vazhapunna വാഴപുന്ന	Punnaga	flower bud	Tree	MDF
69	*Dioscorea bulbifera* L.	Dioscoreaceae	Chavalkizhangu ചാവാൽകിഴങ്ങ്	Pintalu	tuber	Herbaceous climber	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
70	*Dioscorea hamiltonii* Hook.f.	Dioscoreaceae	Vennikizhangu വെണ്ണിക്കിഴങ്ങ്	NA	tuber	Heeraceous climber	MDF
71	*Dioscorea oppositifolia* L.	Dioscoreaceae	Kaanjalkizhangu കാഞ്ഞാൾക്കിഴങ്ങ്	Sarpakhya	tuber	Heabaceous climber	MDF
72	*Dioscorea pentaphylla* L.	Dioscorcaceae	Nootakizhangu നൂറ്റുക്കിഴങ്ങ്	NA	tuber	Herbaceous climber	MDF
73	*Diospyrus candolleana* Wight.	Ebenaceae	Karimaram കരിമരം	Nila-vriksha	root bark	Tree	SEG
74	*Elaeocarpus munronii* (Wt.) Mast.	Elaeocarpaceae	Kodinji കൊടിഞ്ഞി	NA	seed	Tree	SEG
75	*Antidesma acidum* Retz.	Euphorbiaceae	Perelam പേരേലം	NA	fruit	Shrub	MDF
76	*Antidesma menasu* Miq. ex. Tul.	Euphorbiaceae	Perelam പേരേലം	NA	fruit	Shrub	MDF
77	*Aporosa lindleyana* (Wt.) Baill.	Euphorbiaceae	Vetti വെട്ടി	Valaka	leaf	Tree	Both
78	*Baliospermum solanifolium* (J.Burm) Suresh	Euphorbiaceae	Naagadanti നാഗദന്തി	Danti	root	Herb	MDF
79	*Bridelia scandens* Gehrm.	Euphorbiaceae	Cherukolpanachi ചെറുകൊൽപനച്ചി	NA	root	Shrub	MDF
80	*Bridelia squamosa* (Lamk.) Taub.	Euphorbiaceae	Mullankayani മുള്ളൻകയനി	NA	root bark	Tree	MDF
81	*Cleistanthes collinus* (Roxb.) Benth. ex. Hk. f.	Euphorbiaceae	Oduku ഒടുക്	NA	stem bark	Tree	Both
82	*Croton malabaricus* Bedd.	Euphorbiaceae	Kattuparuthi കാട്ടുപരുത്തി	NA	root	Shrub	MDF
83	*Homonia riparia* Lour.	Euphorbiaceae	Aattuvanchi ആറ്റുവഞ്ചി	Pasanabhedah	root	Shrub	Both

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
84	*Macaranga peltata* (Roxb.) Muell. Arg.	Euphorbiaceae	Vatta വട്ട	NA	gum	Tree	MDF
85	*Phyllanthus amarus* Schum. & Thoun.	Euphorbiaceae	Kizharnelli കിഴാർനെല്ലി	Tamalaki	whole plant	Herb	MDF
86	*Phyllanthus emblica* L.	Euphorbiaceae	Nelli നെല്ലി	Aamalaki	fruit	Tree	MDF
87	*Phyllanthus kozhikodianus* Sivar. &Mani	Euphorbiaceae	Kizharnelli കിഴാർനെല്ലി	Tamalaki	whole plant	Herb	MDF
88	*Sauropus quadrangularis* Muell. Arg.	Euphorbiaceae	Madhuracheera മധുരച്ചീര	Aruni	whole plant	Herb	MDF
89	*Tragia involucrata* L.	Euphorbiaceae	Kodithuva കൊടിത്തുവ	Duralabha	whole plant	Herbaceous climber	MDF
90	*Abrus pulchellus* Wall.	Fabaceae	Kunni കുന്നി	Gunja	leaf, seed	Herbaceous climber	MDF
91	Butea monosperma (Lamk.) Taub.	Fabaceae	Plasu പ്ലാശ്	Palash	stem bark, flower, seed	Tree	MDF
92	*Butea parviflora* Roxb.	Fabaceae	Plachuvally പ്ലാച്ചുവള്ളി	Lata-palash	stem bark	Woody climber	Both
93	*Crotolaria pallida* Act.	Fabaceae	Kilukki കിലുക്കി	Sanapushpi	leaf	Herb	MDF
94	*Dalbergia latifolia* Roxb.	Fabaceae	Eetty ഈട്ടി	Shishapa	leaf, seed, bark	Tree	MDF
95	*Desmodium laxiflorum* DC	Fabaceae	Kolliorila കൊള്ളിഓരില	Prsniparni	root	Herb	MDF
96	*Desmodium motorium* (Houtt.) Merr.	Fabaceae	Thozhukanni തൊഴുകണ്ണി	NA	root	Herb	MDF
97	*Desmodium pulchellum* Benth.	Fabaceae	Orila ഓരില	Prsniparni	root	Herb	MDF
98	*Desmodium triquetrum* (L.) DC	Fabaceae	Chuvanna orila ചുവന്നഓരില	Prsniparni	root	Herb	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
99	*Desmodium triflorum* (L.) DC	Fabaceae	Nilamparanda നിലമ്പരണ്ട	Hamsapaadi	whole plant	Herb	MDF
100	*Desmodium velutinum* (Willd) DC	Fabaceae	Orila ഓരില	Prsniparni	root	Herb	MDF
101	*Erythrina variegata* L.	Fabaceae	Murikku മുരിക്ക്	Paribhadrah	stem bark, flower	Tree	Both
102	*Mucuna pruriens* (L.) DC	Fabaceae	Naaikkorana നായ്ക്കൊരണ	Atmagupta	whole plant	Herbaceous climber	MDF
103	*Ormocarpum cochinchinense* (Lour.) Merril	Fabaceae	Kattumuringa കാട്ടുമുരിങ്ങ	NA	leaf, root	Shrub	MDF
104	*Pongamia pinnata* (L.) Pierre.	Fabaceae	Ungu ഉങ്ങ്	Karanjah	stem bark, leaf, root	Tree	Both
105	*Pseudarthria viscida* (L.) W. & A.	Fabaceae	Cherumuvila ചെറുമുവില	Saliparni	root	Herb	MDF
106	*Pterocarpus marsupium* Roxb.	Fabaceae	Venga വെങ്ങ	Asanah	stem bark, heart wood	Tree	MDF
107	*Tephrosia purpurea* (L.) Pers.	Fabaceae	Kozhinjil കൊഴിഞ്ഞിൽ	Sarapankhah	whole plant	Herb	MDF
108	*Tephrosia tinctoria* Pers.	Fabaceae	Kozhinjil കൊഴിഞ്ഞിൽ	Sarapankhah	whole plant	Herb	MDF
109	*Uraria rufescens* (DC.) Schind.	Fabaceae	Valiya muvila വലിയമുവില	Saliparni	root	Herb	MDF
110	*Vigna radiata* (L.) Willezek. var. Sublobata (Roxb.) Verde.	Fabaceae	Kattuzhunnu കാട്ടുഴുന്ന്	Masaparni	whole plant	Herbaceous climber	MDF
111	*Hydnocarpus pentandra* (Buch-Ham.) Oken.	Flacourtiaceae	Marotti മരോട്ടി	NA	seed	Tree	Both
112	*Canscora diffusa* (Wall) R.Br. ex. Roem & Schult.	Gentianaceae	Jeerakappullu ജീരകപ്പുല്ല്	NA	whole plant	Herb	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
113	*Curculigo orchioides* Gaertn.	Hypoxidaceae	Nilappana നിലപ്പന	Musali	tuber	Herb	MDF
114	*Sarcostigma kleinii* Wt. & Arn.	Icacinaceae	Odal ഓടൽ	Imgudi	seed	Woody climber	Both
115	*Orthosiphon aristatus* (Bl.) Miq.	Labiatae	Puchamisa പൂച്ചമീശ	NA	whole plant	Herb	MDF
116	*Pogostemon paniculatus* (Willd.) Benth.	Labiatae	Thricheda തൃച്ചെടി	NA	whole plant	Herb	MDF
117	*Anisochilus carnosus* (L.) Wall ex. Benth	Lamiaceae	Padukoorka പടുകൂർക്ക	Agapada	whole plant	Herb	MDF
118	*Anisomeles indica* (L.) O. Ktze.	Lamiaceae	Karimthumba കരിന്തുമ്പ	Sprkka	whole plant	Herb	MDF
119	*Asparagus racemosus* Willd.	Liliaceae	Satavari ശതാവരി	Satavari	tuber	Herbaceous climber	MDF
120	*Dracaena terniflora* (Roxb.)	Liliaceae	Manjakantham മഞ്ഞക്കാന്തം	NA	root	Herb	SEG
121	*Gloriosa superba* L.	Liliaceae	Menthonni മെന്തോന്നി	Langali	tuber	Herbaceous climber	MDF
122	*Smilax zeylanica* L.	Liliaceae	Kareelanchi കരീലാഞ്ചി	Vanamadhusnahi	root	Woody climber	Both
123	*Cinnamomum malabatrum* (Burm.f.) Berchthold & Presl.	Lauraceae	Edana എടന	Darusila	stem bark, leaf	Tree	SEG
124	*Cinnamomum verum* J.S. Presl.	Lauraceae	Edana എടന	Darusila	stem bark, leaf	Tree	SEG
125	*Persea macrantha* (Nees) Kosterm.	Lauraceae	Kulamaavu കുളമാവ്	NA	stem bark	Tree	SEG
126	*Careya arborea* Roxb.	Lecythidaceae	Pezhu പേഴ്	Kumbhi	bark, flower, fruit	Tree	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
127	*Strychnos nux-vomica* L.	Loganiaceae	Kaanjiram കാഞ്ഞിരം	Kaaraskarah	bark shavings, seed	Tree	MDF
128	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Vallipannal വള്ളിപന്നൽ	NA	whole plant, root	Herb	MDF
129	*Lagerstroemia microcarpa* Wt.	Lythraceae	Venthekku വെന്തേക്ക്	NA	stem bark	Tree	MDF
130	*Lagerstroemia reginae* Roxb.	Lythraceae	Manimaruthu മണിമരുത്	NA	stem bark, seed	Tree	MDF
131	*Abutilon indicum* (L.) Sweet.	Malvaceae	Vankurunthotti വൻകുറുന്തോട്ടി	Atibala	root	Shrub	MDF
132	*Bombax malabaricum* DC	Malvaceae	Poola പൂള	Panchaparni	root, tender fruit, resin	Tree	MDF
133	*Hibiscus furcatus* Roxb. ex. DC	Malvaceae	Pananchakam പനഞ്ചകം	Sathambasthi	leaf, flower	Shrub	MDF
134	*Hibiscus lobatus* (J.A.Murr.) O.Ktze.	Malvaceae	Chemparuthi ചെമ്പരുത്തി	NA	leaf	Herb	MDF
135	*Sida cordata* (Burm. f.) Borss.	Malvaceae	Vallikkurunthotti വള്ളികുറുന്തോട്ടി	Naagabala	root	Herb	MDF
136	*Sida rhombifolia* L. ssp. retusa (L.) Borss.	Malvaceae	Kurunthotti കുറുന്തോട്ടി	Bala	root	Herb	MDF
137	*Thespesia lampas* (Cav.) Dalz. & Gibs.	Malvaceae	Velipparuthi വെളിപ്പരുത്തി	NA	root , leaf	Shrub	MDF
138	*Aglaia lawii* (Wt.) Sald.	Meliaceae	Karakil കാരകിൽ	NA	heart wood	Tree	SEG
139	*Dysoxylum malabaricum* Bedd. ex. Hiern.	Meliaceae	Vellakil വെള്ളകിൽ	NA	heart wood	Tree	Both
140	*Melia dubia* Cav.	Meliaceae	Malaveppu മലവേപ്പ്	Nimbah	leaf, seed, fruit	Tree	MDF
141	*Naregamia alata* Wt. & Arm.	Meliaceae	Nilanaarakam നിലനാരകം	Kandalu	whole plant	Herb	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
142	*Turraea villosa* Benn.	Meliaceae	Pachaparuthi പച്ചപരുത്തി	NA	root	Shrub	SEG
143	*Cissampelos pariera* L.	Menispermaceae	Malathaangi മലതാങ്ങി	Patha	whole plant	Herbaceous climber	MDF
144	*Cyclea peltata* (Lam.) H.f. & Thom.	Menispermaceae	Paadakizhangu പാടക്കിഴങ്ങ്	Patha	tuber	Herbaceous climber	MDF
145	*Coscinium fenestratum* Colebr.	Menispermaceae	Maramanjal മരമഞ്ഞൾ	Daruharidra	stem	Woody climber	SEG
146	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	Pothamruthu പോത്തമൃത്	Amritha	root	Woody climber	MDF
147	*Acacia concinna* DC.	Mimosaceae	Cheevakka ചീവക്ക	Saptala	fruit	Woody climber	Both
148	*Acacia intsia* Wight. & Arn.	Mimosaceae	Incha ഇഞ്ച	Nikunjika	stem bark	Woody climber	Both
149	*Acacia torta* Roxb.	Mimosaceae	Incha ഇഞ്ച	Nikunjika	stem bark	Woody climber	both
150	*Albizia odoratissima* (L.f.) Benth.	Mimosaceae	Kunnivaka കുന്നിവാക	Svetashirisha	leaf	Tree	MDF
151	*Entada scandens* (L.) Benth.	Mimosaceae	Kakkumvalli കക്കുംവള്ളി	Gilla	seed	Woody climber	SEG
152	*Xylia xylocarpa* (Roxb.) Taub.	Mimosaceae	Irumullu ഇരുമുള്ള്	Shimshapa	stem bark	Tree	MDF
153	*Antiaris toxicaria* (Pers.) Lesch.	Moraceae	Arayanjili അരയാഞ്ഞിലി	NA	stem bark, seed	Tree	SEG
154	*Artocarpus heterophyllus* Lamk.	Moraceae	Aanjili ആഞ്ഞിലി	Panasa	stem bark, leaf, fruit	Tree	SEG
155	*Artocarpus hirsutus* Lamk.	Moraceae	Plaavu പ്ലാവ്	NA	stem bark, leaf	Tree	SEG

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
156	*Ficus arnottiana* (Miq.) Miq.	Moraceae	Kallal കല്ലാൽ	Plaksha	stem bark	Tree	MDF
157	*Ficus hispida* L.	Moraceae	Paarakom പാരകം	Kokodumbarika	stem bark, fruit	Tree	MDF
158	*Ficus racemosa* L.	Moraceae	Athi അത്തി	Udumbarah	root, bark	Tree	MDF
159	*Ensete superbum* Roxb.	Musaceae	Kalluvazha കല്ലുവാഴ	Kadali	seed	Herb	SEG
160	*Myristica dactyloides* Gaerta.	Myristicaceae	Pathiri പത്തിരി	Jatiphalam	seed, aril	Tree	SEG
161	*Embelia tsjeriam-cottam* A.DC.	Myrsinaceae	Ammimuriyan അമ്മിമുറിയൻ	Vidangah	root	Shrub	MDF
162	*Syzygium laetum* (Ham.) Gandhi.	Myrtaceae	Njaaval ഞാവൽ	Jambuh	fruit, seed	Shrub	MDF
163	*Jasminum multiflorum* (Burm.f.)	Oleaceae	Kurukuthimulla കുരുക്കുത്തിമുല്ല	Malati	root	Herbaceous climber	MDF
164	*Myxopyrum smilacifolium* Bl.	Oleaceae	Chathuramulla ചതുരമുല്ല	NA	leaf	Herbaceous climber	MDF
165	*Olea dioica* Roxb.	Oleaceae	Vidana വിടന	NA	bark	Tree	Both
166	*Acampe praemorsa* (Roxb.) Blatt. & Mc Cann.	Orchidaceae	Maravazha മരവാഴ	NA	whole plant	Herb	Both
167	*Malaxis rheedii* Sw.	Orchidaceae	Jeevakam ജീവകം	Rishabhaka	Pseudobulbils	Herb	SEG
168	*Nervilia aragoana* Gaud.	Orchidaceae	Orilathamara ഓരിലത്താമര	Padmacarini	tuber	Herb	MDF
169	*Vanda* sp.	Orchidaceae	Maravazha മരവാഴ	NA	whole plant	Herb	Both

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
170	*Biophytum candolleanum* Wt.	Oxalidaceae	Mukkutti മുക്കുറ്റി	Alambusaa	whole plant	Herb	MDF
171	*Pandanus* sp.	Pandanaceae	Pookkaitha പൂക്കൈത	Ketaki	flower, fruit, root	Shrub	SEG
172	*Adenia hondala* (Gaertn.) de Wilde.	Passifloraceae	Muthukku മുതുക്ക്	Vidari	tuber	Herbaceous climber	Both
173	*Passiflora foetida* L.	Passifloraceae	Poochappazham പൂച്ചപ്പഴം	Mukkopeera	leaf, fruit	climber Herbaceous	MDF
174	*Piper attenuatum* Ham.	Piperaceae	Kattukurumulaku കാട്ടുകുരുമുളക്	Maricam	fruit	Herbaceous climber	SEG
175	*Piper longum* L.	Piperaceae	Thippali തിപ്പലി	Pippali	fruit, root	Herbaceous climber	MDF
176	*Piper nigrum* L.	Piperaceae	Kurumulaku കുരുമുളക്	Maricam	fruit	Herbaceous climber	SEG
177	*Bambusa arundinacea* Willd.	Poaceae	Mula മുള	Samsa	tender stem nodes, seeds	Tree	MDF
178	*Naravelia zeylanica* (L.) DC	Ranunculaceae	Vaathakkodi വാതക്കൊടി	Dhanavalli	whole plant	Herbaceous climber	MDF
179	*Zizyphus oenoplia* (L.) Mill..	Rhamnaceae	Kottam കൊട്ടം	NA	leaf	Shrub	MDF
180	*Canthium dicocum* (Gaertn.) Teys. & Binn.	Rubiaceae	Kara കാര	NA	seed	Tree	MDF
181	*Chasalia curviflora* Thw.	Rubiaceae	Vellaamalpori വെള്ളാമൽപൊരി	NA	root	Herb	MDF
182	*Chassalia ophioxyloides* (Wall.) Caraib.	Rubiaceae	Vellakurinji വെള്ളക്കുറിഞ്ഞി	NA	root	Herb	SEG
183	*Geophila herbaceae* (Jacq.) K. Schum	Rubiaceae	Karimuthil കരിമുത്തിൾ	NA	leaf	Herbaceous climber	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
184	*Haldinia cordifolia* (Roxb.) Ridsd.	Rubiaceae	Manjakadambu മഞ്ഞക്കടമ്പ്	NA	seed, bark	Tree	SEG
185	*Ixora brchiata* Roxb.	Rubiaceae	Kattuchethi കാട്ടുചെത്തി	Paranti	root, flower	Shrub	SEG
186	*Ixora coccinia* L.	Rubiaceae	Chethi ചെത്തി	Paranti	flower	Shrub	MDF
187	*Ixora malabarica* Gam.	Rubiaceae	Kattuchethi കാട്ടുചെത്തി	Paranti	root, flower	Shrub	SEG
188	*Ixora nigricans* Br.	Rubiaceae	Kattuchethi കാട്ടുചെത്തി	Paranti	root, flower, bark	Shrub	SEG
189	*Mussaenda glabrata* Hutch.	Rubiaceae	Vellilam വെള്ളിലം	Shrivati	leaf, root	Shrub	MDF
190	*Pavetta* sp.	Rubiaceae	Pavettah പാവട്ട	Paphanah	root, leaf	Shrub	MDF
191	*Randia gardneri* (Bedd.) Thw.	Rubiaceae	Meenkaara മീൻകാര	NA	Seed	Tree	MDF
192	*Atalantia wightii* Tan.	Rubiaceae	Kattunarakam കാട്ടുനാരകം	Atavi-jambira	seed oil, leaf, root	Tree	SEG
193	*Euodia lunu-ankenda* Merr.	Rutaceae	Kanali കനലി	Vana-shempaga	root, root bark	Tree	SEG
194	*Glycosmis pentaphylla* (Retz.) DC.	Rutaceae	Paanal പാണൽ	Asvasakhotah root	whole plant,	Shrub	MDF
195	*Limonia crenulata* Roxb.	Rutaceae	Malanarakam മലനാരകം	NA	seed	Tree	SEG
196	*Xantho xylum rhetsa* (Roxb.) DC.	Rutaceae	Mullilam മുള്ളിലം	Kudashalmali seed oil	fruit, root bark,	Tree	MDF
197	*Allophylus cobbe* (L.) Raeusch.	Sapindaceae	Mukkannanpezhu മുക്കണ്ണൻപേഴ്	NA	root	Tree	SEG

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
198	*Allophylus serratus* (Roxb.) Kurz.	Sapindaceae	Mukkannanpezhu മുക്കണ്ണൻപേഴ്	NA	root	Tree	SEG
199	*Dimocarpus longan* Lour.	Sapindaceae	Chempoovam ചെമ്പൂവം	NA	leaf, seed	Tree	SEG
200	*Horpullia arborea* (Blanco) Radlk.	Sapindaceae	Puzhukolli പുഴുകൊല്ലി	NA	stem	Tree	SEG
201	*Sapindus laurifolia* Vahl.	Sapindaceae	Urulanchi ഉരുളാഞ്ചി	NA	fruit	Tree	MDF
202	*Schleichera oleosa* (Lour.) Oken.	Sapindaceae	Poovam പൂവം	NA	bark, seed	Tree	SEG
203	*Bacopa monnieri* (L.) Pennell.	Scrophulariaceae	Brahmi ബ്രഹ്മി	Brahmi	whole plant	Herb	SEG
204	*Solanum surattense* Burm.f.	Solanaceae	Kantakaari chunda കണ്ടകാരിചുണ്ട	Kantakaari	root, fruit	Shrub	MDF
205	*Helicteres isora* L.	Sterculiaceae	Edampiri valampiri ഇടംപിരി വലംപിരി	Mriga-shringa	seed	Shrub	MDF
206	*Sterculia guttata* Roxb. ex DC.	Sterculiaceae	Kavalam കാവളം	NA	seed, bark, leaf	Tree	MDF
207	*Sterculia urens* Roxb.	Sterculiaceae	Thondi തൊണ്ടി	NA	seed, bark, leaf	Tree	MDF
208	*Strychnos colubrina* L.	Strychnaceae	Vallikanjiram വള്ളികാഞ്ഞിരം	NA	seed	Woody climber	SEG
209	*Symplocos cochinchinensis* (Lour) S. Moore.	Symplocaceae	Pachotti പാച്ചോറ്റി	Lodhvah	stem bark	Tree	SEG
210	*Grewia tiliifolia* Vahl.	Tiliaceae	Chadachi ചടച്ചി	Dharmana	stem bark	Tree	MDF
211	*Celtis cinnamomea* Lindl. ex. Planch.	Ulmaceae	Poothiyunarthi പൂതിയുണർത്തി	NA	heart wood	Tree	SEG
212	*Pimpinella heyneana* Wall.	Umbelliferae	Jeerakappullu ജീരകപ്പുല്ല്	NA	whole plant	Herb	MDF

Contd.

Table 3. Continued

1	2	3	4	5	6	7	8
213	*Laportea crenulata* (Roxb.) Gaud.	Urticaceae	Aanaveratti ആനവെരട്ടി	NA	leaf	Shrub	SEG
214	*Pauzolzia zeylanica* Benn.	Urticaceae	Kallurukki കല്ലുരുക്കി	NA	whole plant	Herb	MDF
215	*Callicarpa tomentosa* (Gaertn.) Merr.	Verbenaceae	Naaikumbil നായ്ക്കുമ്പിൾ	NA	root	Tree	MDF
216	*Clerodendrum serratum* (L.) Moon.	Verbenaceae	Cheruthekku ചെറുതെക്ക്	Bharngi	root	Herb	MDF
217	*Gmelina arborea* Roxb.	Verbenaceae	Kumizhu കുമിഴ്	Kaasmari	root	Tree	MDF
218	*Lantana camara* L.	Verbenaceae	Poochedi പൂച്ചെടി	NA	whole plant	Shrub	MDF
219	*Tectona grandis* L.F.	Verbenaceae	Thekku തെക്ക്	Saka	stem bark	Tree	MDF
220	*Vitex altissima* L.F.	Verbenaceae	Mayilellu മയിലെള്ള്	NA	bark, leaf	Tree	MDF
221	*Cayratia pedata* (Lamk.) Juss ex. Gagnep.	Vitaceae	Amarchakkodi അമർച്ചക്കോടി	Godhapadi	root	Woody climber	SEG
222	*Leea asiatica* (L.) Ridsd.	Vitaceae	Manipperandi മണിപ്പരണ്ടി	NA	root	Shrub	SEG
223	*Costus speciosus* (Koenig) Smith	Zingiberaceae	Channakkoova ചണ്ണക്കൂവ	Canda	tuber	Herb	MDF
224	*Curcuma longa* L.	Zingiberaceae	Manjal മഞ്ഞൾ	Haridra	rhizome	Herb	Both
225	*Curcuma zedoaria* (Christm.) Roscoe	Zingiberaceae	Manjakkova മഞ്ഞക്കൂവ	Vanaharidra	rhizome	Herb	Both
226	*Zingiber* sp.	Zingiberaceae	Kaatinji കാട്ടിഞ്ചി	Ardrakah	rhizome	Herb	Both

MDF - Moist Deciduous Forest; SEG - Semi Ever Green; NA - Not available

Homonia riparia was restricted near streams. *Costus speciosus* and *Curcuma zedoaria* also preferred to grow near water sources. *Piper longum* was abundant and luxurious in growth on slopes.

4.1.3 Endemic medicinal plants in Peechi hills

Various publications and reports on endemic plants of Western Ghats were referred and the list of endemic taxa of medicinal plants prepared (Table 4).

Twenty two plants growing in Peechi hills are endemic to Western Ghats. They are distributed over 18 families. Major families include *Acanthaceae* (4), *Euphorbiaceae* (2) and *Rubiaceae* (2). The genus *Barleria* has three endemic species.

4.1.4 Rare, Endangered and Threatened species in Peechi hills

A regional assessment of Rare, Endangered and Threatened (RET) species was made and the information is presented in Table 5,(Plates 7, 8).

There are altogether 25 RET species distributed in 21 families out of which 10 are endangered, six rare and nine threatened with respect to Peechi hills.

4.1.5 Medicinal plants extracted from Peechi hills

Out of the 226 native medicinal plants identified from Peechi hills, not all are extracted by its natives. Major species which are extracted with their peak flowering and extraction periods are furnished in Table 6. Only 77 species (34% of the native medicinal plants) are collected by the tribes from this area.

Table 4. Endemic medicinal plants in Peechi hills

Sl. No.	Botanic name	Family
1	*Barleria acuminata* Wt.	Acanthaceae
2	*Barleria courtallica* Nees.	Acanthaceae
3	*Barleria prattensis* Sant.	Acanthaceae
4	*Nilgirianthus ciliatus* (Nees) Bremek.	Acanthaceae
5	*Holigarna arnottiana* Hook.F.	Anacardiaceae
6	*Polyalthia fragrans* (Dalz.) Bedd.	Annonaceae
7	*Tabernaemontana heyneana* Wall.	Apocynaceae
8	*Bigonia canarana* Miq.	Bigoniaceae
9	*Elaeocarpus munronii* (Wt.) Mast.	Elaeocarpaceae
10	*Croton malabaricus* Bedd.	Euphorbiaceae
11	*Phyllanthus kozhikodianus* Sivar. & Mani.	Euphorbiaceae
12	*Mucuna pruriens* (L.) DC.	Fabaceae
13	*Cinnamomum malabatrum* (Burm.f.). Berehthold & Presl.	Lauraceae
14	*Lagerstroemia microcarpa* Wight.	Lythraceae
15	*Dysoxylum malabaricum* Bedd. ex. Hiern.	Meliaceae
16	*Artocarpus hirsutus* Lamk.	Moraceae
17	*Syzygium laetum* (Ham.) Gandhi.	Myrtaceae
18	*Bambusa arundinacea* Wild.	Poaceae
19	*Ixora malabarica* Gam.	Rubiaceae
20	*Mussaenda glabrata* Hutch.	Rubiaceae
21	*Atalantia wightii* Tan.	Rutaceae
22	*Cayratia pedata* (Lam.) Juss ex. Gagnep.	Vitaceae

Table 5. Rare, endangered and threatened medicinal plants in Peechi hills

Sl. No.	Botanic name	Family	Status
1	*Rauvolfia serpentina* (L.) Benth. ex Kurz.	Apocynaceae	E
2	*Holostemma ada-kodian* Schult.	Asclepiadaceae	R
3	*Bigonia canarana* Miq.	Bigoniaceae	R
4	*Canarium strictum* Roxb.	Burseraceae	T
5	*Saraca asoca* (Roxb.) de Wilde.	Caesalpiniaceae	E
6	*Ipomoea mauritiana* Jacq.	Convolvulaceae	E
7	*Momordica dioica* Roxb. ex. Willd.	Cucurbitaceae	E
8	*Trichosanthes cucumerina* L.	Cucurbitaceae	E
9	*Cycas circinalis* L.	Cycadaceae	R
10	*Phyllanthus emblica* L.	Euphorbiaceae	R
11	*Pseudarthria viscida* (L.) W & A.	Fabaceae	T
12	*Asparagus recemosus* Willd.	Liliaceae	T
13	*Gloriosa superba* L.	Liliaceae	E
14	*Cinnamomum malabatrum* (Burm.F.) Berchthold & Presl.	Lauraceae	T
15	*Persea macrantha* (Nees) Kosterm.	Lauraceae	T
16	*Coscinium fenestratum* Colebr.	Menispermaceae	E
17	*Acacia concinna* DC.	Mimosaceae	T
18	*Ensete superbum* Roxb.	Musaceae	T
19	*Embelia tsjeriam* cottam A.DC.	Myrsinaceae	R
20	*Myristica dactyloides* Gaertn.	Myristicaceae	T
21	*Malaxis rheedii* Sw.	Orchidaceae	R
22	*Nervilia aragoana* Goud.	Orchidaceae	E
23	*Adenia hondala* (Gaertn) de Wilde.	Passifloraceae	T
24	*Solanum surattense* Burm.f.	Solanaceae	E
25	*Symplocos cochinchinensis* (Lour) S. Moore.	Symplocaceae	E

E - Endangered
T - Threatened
R - Rare

Plate 7. Rare, endangered and threatened plants in Peechi hills

7a	*Bigonia canarana* - found only on rocks (Rare)
7b	Young vine of *Adenia hondala* (Threatened)
7c	*Ensete superbum* - abundant on rocks (Threatened)
7d	*Malaxis rheedii* - another orchid on rocks (Rare)
7e	Seedling of *Coscinium fenestratum* (Endangered)
7f	*Pseudarthria viscida* (Rare)
Centre plate	*Ipomoea mauritiana* - valued for its underground tuber (Endangered)

Plate 7. Rare, endangered and threatened medicinal plants in Peechi hills

Plate 8. Rare, endangered and threatened plants in Peechi hills - continued

8a	*Phyllanthus emblica* in fruits (Threatened)
8b	*Acacia concinna* in pods (Threatened)
8c	*Myristica dactyloides* in flower (Threatened)
8d	*Holostemma ada-kodien* in flower (Rare)
8e	*Canarium strictum* with the resin (Threatened)
8f	*Saraca asoca* in flower (Endangered)
Centre plate	*Nervilia aragoana* - a ground orchid (Endangered)

Plate 8. Rare, endangered and threatened medicinal plants in Peechi hills

A perusal of the table reveals that in general, the peak flowering period in the annuals coincided with October-January with exceptions of *Adenia, Malaxis, Ipomoea mauritiana* and *Nervilia*. In *Ipomoea mauritiana* and *Adenia* it was Feb.-April and the two orchids *Nervilia* and *Malaxis* flowered during June-Aug. In the case of tree species no definite pattern in flowering was observed.

Extraction period also varied in different species. In general, it could be inferred that roots and whole plants are extracted from July-Dec. and stem bark from Dec.-May. Tubers/rhizomes are extracted mostly in the period July-Jan., with the exceptions of *Adenia* and *Ipomoea mauritiana* which are harvested almost throughout the year. Fruits and seeds are collected as and when they mature. Pseudobulbils of the orchid *Malaxis* is collected throughout the year. *Canarium strictum* which yields a resin is also tapped year round.

A comparison of the flowering and extraction time revealed that in general, in annuals, extraction started even before the plants entered into the reproductive phase. No definite trend could be observed in the case of tree species.

4.1.6 Medicinal plants extracted on a regular basis from Peechi hills

Out of the 77 plants listed in Table 6, only some are collected regularly in large quantities. Others are extracted demand based. Plants collected regularly in vast quantities are *Adenia, Canarium, Myristica, Malaxis, Acacia instia, A. concinna, Sapindus, Coscinium, Hydnocarpus, Terminalia bellerica, Dilleniya, Curcuma, Persea, Rauvolfia, Piper longum, Antidesma, Asparagus, Baliospermum, Holostemma, Nervilia, Nilgirianthus, Barleria prattensis, Mucuna, Sida, Hemidesmus, Cinnamomum, Gmelina, Stereospermum, Oroxylum, Lagerstroemia,*

Table 6. Major medicinal plants extracted from Peechi hills with their peak flowering and extraction periods

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
1	*Barleria prattensis* Santapau.	Acanthaceae	*										*	*	root
			x						x	x	x	x	x	x	
2	*Nilgirianthus ciliatus* (Nees) Bremek.	Acanthaceae										*	*	*	whole plant
			x						x	x	x	x	x	x	
3	*Achyranthes aspera* L.	Amaranthaceae	*									*	*	*	whole plant
			x						x	x	x	x	x	x	
4	*Cyathula prostrata* (L.) Bl.	Amaranthaceae	*									*	*	*	
			x						x	x	x	x	x	x	
5	*Lannea coromandelica* (Hoult.) Merr.	Anacardiaceae	*	*	*	*									stem bark
			x	x	x	x	x					x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
6	*Holarrhena pubescense* (Buch.-Ham.) ex. Don.	Apocynaceae				*	*	*	*		*	*	*		stem bark
			x	x	x	x	x				x	x	x		
7	*Rauvolfia serpentina* (L.) Benth ex. ADC	Apocynaceae	*								*	*	*	*	root
			x						x	x	x	x	x	x	
8	*Wrightia tinctoria* (Roxb.) R.Br.	Apocynaceae		*	*	*	*	*							stem bark
			x	x	x	x	x				x	x	x		
9	*Hemidesmus indicus* (L.) R.	Asclepiadaceae	*								*	*	*	*	root
			x							x	x	x	x	x	
10	*Holostemma ada-kodien* Schult.	Asclepiadaceae									*	*	*	*	root
			x						x	x	x	x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
11	*Oroxylum indicum* (L.) Vent.	Bignoniaceae	*	*	*										root
			x					x	x	x	x	x	x	x	
12	*Stereospermum suaveolens* L.	Bignoniaceae				*	*	*					*	*	root
			x							x	x	x	x	x	
13	*Bigonia canarana* Miq.	Bigoniaceae									*	*	*	*	whole plant
			x					x	x	x	x	x	x	x	
14	*Canarium strictum* Roxb.	Burseraceae		*	*	*									resin
			x	x	x	x	x	x	x	x	x	x	x	x	
15	*Caesalpinia bonduc* (L.) Roxb.	Caesalpiniaceae	*	*	*	*									seed
									x	x	x	x	x	x	
16	*Saraca asoca* (Roxb.) de Wilde.	Caesalpiniaceae		*	*	*									stem bark
			x	x	x	x	x								

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
17	*Garcinia gummigatta* (L.) Robs.	Clusiaceae				*	*	*							fruit
									x	x	x	x			
18	*Mesua ferrea* L.	Clusiaceae		*	*	*	*	*							stem bark
			x	x	x	x	x								
19	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	*	*	*	*									seed
						x	x	x	x						
20	*Terminalia paniculata* Roth.	Combretaceae							*	*	*	*	*	*	stem bark
			x	x	x	x	x								
21	*Ipomoea mauritiana* Jacq.	Convolvulaceae		*	*	*									tuber
			x	x	x	x	x	x	x	x	x	x	x	x	
22	*Cucumis callosus* (Rottl.) Cogn.	Cucurbitaceae										*	*	*	fruit
													x	x	

Contd.

Table 6.Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
23	*Trichosanthes cucumeriana* L.	Cucurbitaceae								*	*	*	*	*	fruit
												x	x	x	
24	*Cycas circinalis* L.	Cycadaceae	*	*	*	*									seed
							x	x	x	x					
25	*Dillenia pentagyna* Roxb.	Dilleniaceae	*	*	*	*									flower bud
			x	x	x										
26	*Dioscorea bulbifera* L.	Dioscoreaceae									*	*	*	*	tuber
			x	x	x					x	x	x	x	x	
27	*Dioscorea hamiltoni* Hook. F.	Dioscoreaceae									*	*	*	*	tuber
			x	x	x					x	x	x	x	x	
28	*Dioscorea oppositifolia* L.	Dioscoreaceae								*	*	*	*	*	tuber
			x	x	x					x	x	x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month											Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
29	*Antidesma acidum* Rtz.	Euphorbiaceae	*	*	*										fruit
						x	x	x							
30	*Antidesma menasu* Meq. ex. Tul.	Euphorbiaceae	*	*	*										fruit
						x	x	x							
31	*Baliospermum solanifolium* (J. Burm.) Suresh	Euphorbiaceae									*	*	*	*	root
			x							x	x	x	x	x	
32	*Phyllanthus emblica* L.	Euphorbiaceae								*	*	*	*		fruit
			x	x									x	x	
33	*Desmodium laxiflorum* DC	Fabaceae	*								*	*	*	*	root
			x						x	x	x	x	x	x	
34	*Desmodium pulchellum* Benth.	Fabaceae	*								*	*	*	*	root
			x						x	x	x	x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
35	*Desmodium triquetrum* (L.) DC	Fabaceae	*								*	*	*	*	root
			x						x	x	x	x	x	x	
36	*Desmodium velutinum* (Willd.) DC	Fabaceae	*								*	*	*	*	root
			x						x	x	x	x	x	x	
37	*Mucuna pruriens* (L.) DC	Fabaceae									*	*	*	*	whole plant
			x						x	x	x	x	x	x	
38	*Pseudarthria viscida* (L.) W & A	Fabaceae										*	*	*	root
			x						x	x	x	x	x	x	
39	*Pongamia pinnata* (L.) Pierre.	Fabaceae		*	*	*	*								stem bark
			x	x	x	x	x								
40	*Pterocarpus marsupium* Roxb.	Fabaceae		*	*	*	*								stem bark
			x	x	x	x	x								

Contd

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
41	*Uraria rufescens* (DC) Schind.	Fabaceae									*	*	*	*	root
			x						x	x	x	x	x	x	
42	*Vigna radiata* (L.) Willezek. var. Sublobata (Roxb.) Verde	Fabaceae									*	*	*	*	whole plant
			x						x	x	x	x	x	x	
43	*Hydnocarpus pentandra* (Buch.-Ham.) Oken	Flacourtiaceae	*									*	*	*	seed
				x	x	x	x								
44	*Cinnamomum malabatrum* (Burm.f.) Berchthold & Presl.	Lauraceae	*	*	*								*	*	stem bark
			x	x	x	x	x								
45	*Cinnamomum verum* J.S. Presl.	Lauraceae		*	*	*	*								stem bark
			x	x	x	x	x								
46	*Persea macrantha* (Nees) Kosterm.	Lauraceae	*										*	*	stem bark
			x	x	x	x	x								

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
47	*Asparagus racemosus* Willd.	Liliaceae										*	*	*	tuber
			x							x	x	x	x	x	
48	*Strychnos nux-vomica* L.	Loganiaceae	*	*	*	*									bark shavings
			x	x	x	x	x								
49	Lagerstroemia microcarpa Wt.	Lythraceae				*	*	*							stem bark
			x	x	x	x	x						x	x	
50	*Lagerstroemia reginae* Roxb.	Lythraceae		*	*	*	*								stem bark
			x	x	x	x	x								
51	*Sida rhombifolia* L. ssp. retusa (L.) Borss.	Malvaceae										*	*	*	root
			x						x	x	x	x	x	x	
52	*Aglaia lawii* (Wt.) Sald	Meliaceae	*	*	*										heart wood
			x	x	x	x	x					x	x	x	

Contd.

112555

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
53	*Dysoxylum malabaricum* Bedd. ex. Hiern.	Meliaceae	*	*											heart wood
			x	x	x	x	x						x	x	
54	*Coscinium fenestratum* Colebr.	Menispermaceae										*	*	*	stem
			x	x	x	x	x	x	x	x	x	x	x	x	
55	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae								*	*	*	*	*	root
			x						x	x	x	x	x	x	
56	*Acacia concinna* DC	Mimosaceae										*	*	*	fruit
			x	x	x	x								x	
57	*Acacia intsia* Wight & Arn.	Mimosaceae										*	*	*	stem bark
			x									x	x	x	
58	*Entada scandens* (L.) Benth.	Mimosaceae	*	*								*	*	*	seed
						x	x	x	x	x	x				

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
59	*Xylia xylocarpa* (Roxb.) Taub.	Mimosaceae			*	*									stem bark
			x	x	x	x	x								
60	*Ensete superbum* Roxb. Cheerm.	Musaceae										*	*	*	seed
			x	x	x	x									
61	*Myristica dactyloides* Gaertn.	Myristicaceae	*	*										*	seed, aril
					x	x	x								
62	*Embelia tsjeriam-cottam* A.DC	Myrsinaceae									*	*	*	*	root
			x						x	x	x	x	x	x	
63	*Malaxis rheedii* Sw.	Orchidaceae						*	*	*					pseudobulbil
			x	x	x	x	x	x	x	x	x	x	x	x	
64	*Nervilia aragoana* Gaud.	Orchidaceae						*	*	*					tuber
											x	x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month											Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
65	*Adenia hondala* (Gaertn) deWilde	Passifloraceae		*	*										tuber
			x	x	x	x	x	x	x	x	x	x	x	x	
66	*Piper longum* L.	Piperaceae								*	*	*			stem, root
			x						x	x	x	x	x	x	
67	*Piper nigrum* L.	Piperaceae								*	*	*			fruit
			x	x	x										
68	*Naravelia zeylanica* (L.) DC	Ranunculaceae	*	*									*	*	root
			x	x	x	x	x	x	x	x	x	x	x	x	
69	*Chasalia curviflora* Thw.	Rubiaceae								*	*	*	*		root
			x						x	x	x	x	x	x	
70	*Atalantia wightii* Tanaka	Rutaceae	*										*	*	root
			x	x	x							x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month												Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
71	*Xanthoxylum rhetsa* (Roxb.) DC	Rutaceae	*	*	*										fruit
					x	x	x								
72	*Sapindus laurifolia* Vahl.	Sapindaceae	*	*									*	*	fruit
				x	x	x									
73	*Heclicteres isora* L.	Sterculiaceae									*	*	*		fruit
			x	x								x	x		
74	*Symplocos cochinchinensis* (Lour.) S. Moore	Symplocaceae	*	*	*	*									stem bark
			x	x					x	x	x	x	x	x	
75	*Gmelina arborea* Roxb.	Verbenaceae	*	*	*	*									root
			x							x	x	x	x	x	
76	*Curcuma longa* L.	Zingiberaceae						*	*	*					rhizome
			x	x								x	x	x	

Contd.

Table 6. Continued

Sl. No.	Botanic name	Family	Month											Part harvested
			Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sept 9	Oct 10	Nov 11	Dec 12	
77	*Curcuma zedoaria* (Christim.) Roscoe	Zingiberaceae						*	*	*					rhizome
			x	x								x	x	x	

* flowering period
x extraction period

Ensete, Entada, Caesalpinia crista, Xylia, Garcinia, Phyllanthus emblica, Vigna sp. *Pseudarthria, Uraria* and different species of *Desmodium* (43 species). Three fourth are MDF species and one fourth SEG species. Half of them are trees and half shrubs or herbs.

4.1.7 Method of extraction

Men, women and children go for foraging. Women and children go in groups whereas men usually go alone with their dogs. Most of the SEG species are extracted by men since they are located far away and involve high risk. In the MDF, herb and shrub roots are dug out by women only, whereas roots of trees like *Oroxylon, Stereospermum, Gmelina* etc. are dug out by men. Other MFPs like honey, lac, bitumen etc. are collected exclusively by men.

During rainy season (July-Nov.), the gatherers come back to the settlement after the days collection and in the dry period ie. after December the whole family move inside the forest, stay there in temporary sheds near a water source and do the foraging from there. After a week or so the collection is pooled together and taken to market.

Extraction methods vary with the part used (Plates 4, 5). Roots are dug out using a special sharpened wooden device. Undamaged roots fetch premium price and hence as far as possible they dig out the roots without breakage. Shallow rooted plants like *Sida, Barleria, Piper* etc. are uprooted by pulling the plant out whereas deep rooters like *Baliospermum, Rauvolfia, Desmodium* etc. are dug out with the wooden pole. In the case of tubers like *Asparagus*, the bunch of tubers is excavated without damage. Huge tubers like *Adenia* grow both upwards and downwards and

Plate 4. Extraction of drugs

4a Extraction of honey - 'Kurunthen'
4b Extraction of black dammer - the resin from *Canarium strictum*
4c Extraction of stem bark of Cinnamon
4d Extraction of stem bark of *Acacia instia*

a

b

c

d

Plate 4. Extraction of drugs

Plate 5. Extraction of drugs - continued

5a Extraction of *Adenia hondala* tuber
5b Stem bark of *Acacia instia* - processing
5c *Coscinium* vines - processing
5d *Acacia concinna* - gathering of fallen pods

Plate 5. Extraction of drugs

are mostly visible outside. Tubers of upto 50 kg are extracted without much difficulty. All the *Dioscorea* spp. tuber very deep (upto 1 m) and are hence lifted out with the wooden device. While harvesting plants like *Asparagus, Adenia, Curcuma, Malaxis* etc. a portion of the tuber with a live sprout is usually left behind for regeneration in the next season.

Stem bark of *Acacia instia* is extracted by skilled men and women. Mature woody vines are cut into one metre length pieces and the outer bark is stripped off by beating with an iron mallet.

Honey is one of the major MFPs collected by this hill men. There are different types of honey. 'Vanthen' made by the large bees is the chief source. It is extracted by skilled men using specialised techniques in the new moon period.

4.1.7.1 Destructive harvesting

Ever increasing demand, scarcity of the resource and entry of non-tribal population from the neighbouring villages etc. have lead to destructive harvesting of many valuable plants (Plate 6).

The resin from *Canarium strictum* is extracted by making incisions on one side of the tree. Now-a-days the tree is incised from all the sides at the breast height which results in premature death of the tree. Some times the trees are even heated from bottom to get a quick flow of the resin.

In *Cinnamomum* the stem bark is collected by cutting down the entire tree and then removing the bark.

Tribal people use to harvest *Phyllanthus* fruits by shaking the branches and then gathering the mature fallen fruits. Now-a-days people are cutting down the entire branches and forcefully separating the immature and mature fruits.

Stem bark of *Persea macrantha* is also extracted now by lopping down huge trees.

The highly valued pods of *Acacia concinna* used to be collected by the tribes by shaking the woody climber and gathering the fallen pods. However, the present way of collection is by cutting down the entire vine at the bottom. After 2-3 days they come and collect the pods which by that time might have withered and fallen down. Natural regeneration of this species is very low and it has become a threatened species now.

In the traditional practice, only fully ripe and split fruits of *Myristica* used to be gathered by the tribes. But now, even before they get ripe branches are cut down and fruits are forcefully separated from them to take out the seed and the aril. Fruits of *Hydnocarpus* and *Sapindus* are also collected in a similar manner.

In *Coscinium*, the population of which is meagre is Peechi hills, harvesting is done by cutting down the entire vine.

In all these cases, destructive harvesting leads to low quality drug at the same time making the regeneration of the plants especially those with long prebearing periods very difficult. All the above said plants have either become rare, endangered or threatened due to the unscientific extraction practices.

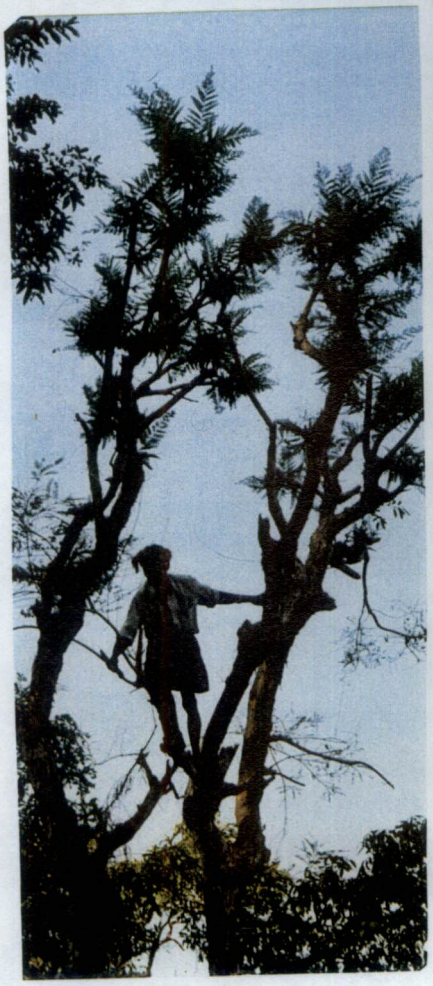
Plate 6. Destructive harvesting

6a *Persea macrantha* tree cut down for extracting the stem bark

6b *Phyllanthus emblica* tree with branches cut down for the collection of fruits

6c *Canarium strictum* over tapping for the resin has resulted in the death of the tree. It's struggle for survival by putting forth a new shoot from below

a



b

c

Plate 6. Destructive harvesting

4.1.8 Processing

Some drugs are sold fresh while others are sold after drying, still others after processing. *Vigna vines, Mucuna vines, Nilgirianthus, Barleria, Piper longum* roots, *Asparagus* tubers, *Adenia, Hemidesmus* etc. are sold fresh. Tuberous roots like *Holostemma, Rauvolfia* etc. are cut into small pieces, dried and sold. *Desmodium, Pseudarthria, Baliospermum, Sida* etc. are sold after drying. *Curcuma* rhizomes are cut into small pieces dried and sold. In *Malaxis* only the green pseudobulbils are marketed. In *Nervilia*, another orchid, the white tubers are separated, cleaned and sold. The stem barks after extraction are spread over the nearby rocks and after complete drying are taken to market. *Terminalia, Hydnocarpus* and *Myristica* seeds are sold after drying. *Coscinium* vines are cut into small pieces giving a slanting cut on both the sides, fully dried and sold. Bark of *Acacia instia* after extraction is dried under shade in winds. If dried in open it turns black and gets only very low price in market.

4.1.9 Marketing

There existed a Tribal Co-operative Society at Vellakkarithadam which pooled all the MFPs from Peechi hills and marketed. The society is functionless since 1993 and now these people bring everything to Thrissur market for sale. Though there are no middlemen in the trade, since these tribes lack the bargaining capacity, they get only very meagre prices for their produce. Only a few produces viz., honey, black dammer and drugs like *Holostemma, Coscinium, Acacia* pods etc. get a reasonable price. On an average a kilogram of any root fetches only Rs.5-8.

4.1.10 Common substitutes/adulterants in the drugs from Peechi hills

A close monitoring of the drugs extracted by the tribes revealed the practice of substitution/adulteration in certain drugs. List of genuine drug and the substitutes/adulterants along with the part used and family are furnished in Table 7.

Aegle marmelos and *Santalum album* are the two trees which do not grow naturally in Peechi hills. Roots in the former and heart wood and stem bark of the latter were found adulterated by some other native trees in Peechi hills, as shown in the Table 7.

Roots of *D. triquetrum* and *D. pulchellum* were often mixed with that of *D. velutinum* of the same family.

Plants like *Ipomoea, Rauvolfia, Saraca, Santalum* etc. were substituted/ adulterated with plants of different families whereas *Pseudarthria, Lagerstromoea, Trichosanthes* etc. were mixed up with plants of the same family.

In most of these cases it was not sure whether they do it deliberately or not. Only by pharmacological studies, we may be able to say for certain whether these are adulterants or substitutes.

4.2 Experiment II. Natural Habitat Analysis

Ten different habitats having the natural population of the select species were selected and quadrats of 10 m x 10 m laid out for detailed analysis. All the habitats were characterised using different parameters and the results are furnished in Tables 8, 9, 10, 11 and 12.

Table 7. Common adulterants/substitutes in the drugs from Peechi hills

Sl. No.	Genuine drug			Adulterant/Substitute		
	Botanic name	Family	Part used	Botanic name	Family	Part used
1	2	3	4	5	6	7
1	*Aegle marmelos* (L.) Corr.	Rutaceae	Root	*Atalantia wightii* Tan	Rutaceae	Root
2	*Desmodium velutinum* (Willd) DC	Fabaceae	Root	*Desmodium triquetrum* (L.) DC	Fabaceae	Root
				Desmodium pulchellum Benth.	Fabaceae	Root
3	*Ipomoea mauritiana* Jacq.	Convolvulaceae	Tuber	*Adenia hondala* (Gaertn.) de Wilde	Passifloraceae	Tuber
4	*Lagerstroemia reginae* Roxb.	Lythraceae	Stem bark	*Lagerstroemia microcarpa* Wt.	Lythraceae	Stem bark
				Xylia xylocarpa (Roxb.) Taub.	Mimosaceae	Stem bark
5	*Pseudarthria viscida* (L.) W & A.	Fabaceae	Root	*Uraria rufescens* (DC) Shind.	Fabaceae	Root
6	*Rauvolfia serpentina* (L.) Benth. ex. Kurz.	Apocynaceae	Root	*Chasalia curviflora* Thw.	Rubiaceae	Root

Contd.

Table 7. Continued

1	2	3	4	5	6	7
7	*Santalum album* L.	Santalaceae	Stem bark	*Persea macrantha* (Nees) Kosterm.	Lauraceae	Stem bark
8	*Santalum album* L.	Santalaceae	Heart wood	*Dysoxylum malabaricum* Bedd. Hiern.	Meliaceae	Heart wood
				Aglaia lawii (Wt.) Sald.	Meliaceae	Heart wood
9	*Saraca asoca* (Roxb.) de Wilde	Caesalpiniaceae	Stem bark	*Mesua ferrea* L.	Clusiaceae	Stem bark
10	*Trichosanthes cucumerina* L.	Cucurbitaceae	Fruit	*Cucumis callosus* (Rottl.) Cogn.	Cucurbitaceae	Fruit

4.2.1 Stand composition

Table 8 gives information on the stand composition of the study plots (100 m^2) in each habitat. Habitats KC-2, KP-2, KP-1 and KC-1 contained more number of trees, tree seedlings and shrubs, whereas the herb cover was maximum in AK, M-1, M-2 and KC-1. With respect to diversity KC-1 and M-1 stood first.

Population density of experimental plants in the study plots is furnished in Table 9. Habitats KC-1 and VK-2 contained all the chosen species. Among the species, *Piper* and *Naravelia* were present in all the ten habitats. *Barleria* was present only in two, and the remaining species were present at least in five habitats.

4.2.2 Phytosociological analysis

Data given in Table 10 indicate that density value was maximum for *Piper* and abundance for *Barleria*. With respect to percenting frequency, *Piper* and *Naravelia* recorded maximum values.

4.2.3 Physico-chemical properties of soil

Data pertaining to the physico-chemical properties of soil in different habitats are presented in Table 11. Soil pH ranged from 5.36 to 6.09 and organic carbon per cent from 1.31 to 2.30. Available P ranged from 0.13 to 0.22. There was not much variation in the content of available K. Content of secondary and micronutrients also varied with the habitat.

4.2.4 Available light and moisture content

Table 12 presents the available light and moisture percentage of the study

Table 8. Stand composition in different habitats in the forest

Habitats (area 100m^2)	No.of large trees	No.of tree seed-lings	No. of shrubs	Herb cover (%)	No.of tree spp.	No.of shrub spp.	No.of herb spp.	No.of med. plant spp.
PNV	3	54	33	25	17	6	8	21
KP-1	3	116	39	30	18	4	6	19
KP-2	2	127	54	50	16	6	8	21
KC-1	6	101	41	80	15	7	20	30
KC-2	3	185	12	30	15	5	8	20
VK-1	3	101	9	30	18	3	13	22
VK-2	2	120	18	35	18	5	10	22
M-1	5	58	30	80	11	7	20	24
M-2	2	106	4	80	13	3	12	26
AK	3	94	4	85	11	3	7	1

Table 9. Population density of experimental plants in different habitats in the forest

Habitats (area 100m^2)	Species (No.)					
	Desmodium	*Piper*	*Naravelia*	*Sida*	*Baliospermum*	*Barleria*
PNV	NP	6	6	NP	NP	NP
KP-1	NP	6	1	NP	8	NP
KP-2	NP	6	3	NP	8	NP
KC-1	6	6	5	5	8	15
KC-2	NP	5	5	NP	5	NP
VK-1	5	5	5	NP	NP	NP
VK-2	5	5	5	5	1	10
M-1	5	5	5	10	NP	NP
M-2	5	5	5	10	NP	NP
AK	5	5	4	5	NP	NP
Total	31	54	44	35	30	25

NP - Not present

Table 10. Phytosociological parameters of select species in the forest

Parameters	Species					
	Piper	*Naravelia*	*Sida*	*Desmodium*	*Baliospermum*	*Barleria*
Density	9	5	4.5	5	4	6
Abundance	9	5	9	8.3	8	30
Percentage frequency	100	100	50	60	50	20

Table 11. Chemical properties of soil in different habitats in the forest

Habitat	pH	EC (dSm^{-1})	Org. C %	Av. P %	Av. K %	Av. Ca %	Av. Mg %	Av. Fe ppm	Av. Cu ppm	Av. Zn ppm	Av. Mn ppm
PNV	5.72	0.047	1.79	0.17	0.024	0.280	0.298	25.5	0.8	4.1	7.3
KP-1	5.73	0.039	2.26	0.13	0.023	0.320	0.371	21.6	0.9	2.1	26.4
KP-2	5.36	0.032	1.42	0.14	0.024	0.314	0.364	20.9	1.3	1.9	13.7
KC-1	5.74	0.024	2.30	0.19	0.036	0.331	0.198	16.5	0.6	1.3	7.5
KC-2	5.62	0.042	1.58	0.22	0.027	0.350	0.176	22.4	0.6	0.8	8.1
VK-1	5.81	0.039	1.36	0.17	0.032	0.281	0.261	17.5	0.5	0.6	57.1
VK-2	5.70	0.042	1.47	0.19	0.038	0.282	0.271	14.8	0.6	0.6	38.6
M-1	6.09	0.076	2.19	0.22	0.022	0.341	0.291	27.4	0.6	2.0	17.0
M-2	5.88	0.064	1.82	0.21	0.030	0.365	0.292	16.7	0.9	0.5	6.9
AK	5.69	0.133	1.31	0.16	0.034	0.289	0.171	12.9	0.6	1.6	18.7

Av. - Available

Table 12. Available light and moisture in different habitats in the forest

Habitat	Available light (%)	Moisture (%)
PNV	50.03	8.03
KP-1	23.35	21.54
KP-2	23.36	17.74
KC-1	30.52	14.52
KC-2	49.85	11.00
VK-1	57.51	5.03
VK-2	57.87	9.98
M-1	41.00	15.85
M-2	49.95	11.70
AK	49.63	7.19

habitats. Available light ranged from 23.35 to 57.87 per cent and moisture from 5.03 to 21.54 per cent.

4.2.5 Habitat clustering

The cluster analysis carried out by principal component analysis with nine variables viz., altitude, available light percentage, moisture percentage, herb cover, litter cover, canopy cover, number of trees, number of shrubs and number of tree seedlings resulted in nine clusters. KP-1 and KP-2 fell in the same cluster.

Another clustering attempted using the soil parameters viz., pH, organic C, available P, K, Ca, Mg, Fe, Cu and Mn resulted in two clusters. Habitats AK, KC-1, KC-2, KP-2 and VK-2 fell in one cluster where as M-1, KP-1, VK-1, PNV and M-2 fell in another cluster.

4.2.6 Habitat analysis

Mean values of the biometric observations viz. plant height, number of branches, number of leaves and total leaf area, taken at bimonthly intervals in each of the habitats are presented. The last observation which coincided with the month of March is not given, since 90 per cent of the plants withered off by that time.

4.2.6.1 *Piper longum*

Piper longum was present in all the 10 habitats and there were 54 experimental plants altogether. Results of the biometrical parameters are given habaitat-wise in Table 13.

Table 13. Biometric observations of *Piper longum* in different habitats in the forest

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
PNV	May	20.8	1.2	3.1	212.5
	July	27.8	1.2	4.3	294.3
	Sept	39.6	1.2	4.3	299.8
	Nov	61.6	1.2	4.8	396.2
	Jan	13.5	1.0	0.8	66.0
KP-1	May	43.3	1.0	5.5	332.7
	July	48.3	1.0	6.6	407.8
	Sept	58.0	1.3	7.1	459.4
	Nov	100.8	1.3	8.3	541.8
	Jan	80.0	1.0	4.5	292.6
KP-2	May	106.0	1.4	8.2	469.2
	July	118.4	1.4	9.8	780.6
	Sept	201.8	1.4	12.4	1159.0
	Nov	230.8	1.4	14.6	1178.9
	Jan	58.0	1.4	2.2	177.6
KC-1	May	68.6	1.0	8.8	709.0
	July	76.6	2.0	11.0	890.2
	Sept	158.6	2.0	17.0	1380.6
	Nov	158.4	2.0	17.6	1380.7
	Jan	138.4	1.4	11.0	862.9
KC-2	May	60.0	2.5	14.0	1138.5
	July	67.0	3.0	16.0	1305.8
	Sept	137.0	3.0	22.5	1828.1
	Nov	132.0	2.0	23.0	2075.0
	Jan	27.5	2.0	4.5	366.1
VK-1	May	41.4	1.2	7.4	475.6
	July	49.0	1.4	9.6	643.4
	Sept	52.4	1.6	9.6	649.1
	Nov	52.0	1.6	9.6	649.1
	Jan	27.6	1.0	4.6	311.0

Contd.

Table 13. Continued

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
VK-2	May	30.4	1.2	5.0	348.9
	July	37.6	1.2	6.6	457.9
	Sept	38.0	2.0	8.0	460.4
	Nov	38.0	1.9	8.4	461.2
	Jan	17.8	1.2	5.0	274.5
M-1	May	40.6	1.2	4.6	316.4
	July	54.0	1.2	6.4	440.7
	Sept	5 6.4	1.6	6.6	457.8
	Nov	56.4	1.7	6.0	455.4
	Jan	21.4	1.2	1.4	106.2
M-2	May	26.6	1.6	8.0	543.2
	July	29.8	1.8	9.8	668.8
	Sept	27.2	1.6	9.8	685.2
	Nov	26.8	1.6	9.0	684.8
	Jan	20.6	1.2	1.8	136.9
AK	May	30.8	1.2	5.6	442.5
	July	37.4	1.4	7.4	586.5
	Sept	95.8	1.6	11.0	891.3
	Nov	122.6	2.0	14.8	1199.1
	Jan	118.4	1.0	7.4	599.5
Mean for the natural habitat (MDF)					
	May	46.8	1.3	7.0	498.4
	July	54.6	1.5	8.7	647.0
	Sept	86.4	1.7	10.8	826.7
	Nov	97.9	1.6	11.6	901.8
	Jan	52.3	1.2	4.3	318.9

PNV

Increment in plant height was linear starting from 20.8 cm in May reaching 61.6 cm in November. After November it declined. Number of branches remained more or less the same during the peak growth period. Number of leaves and total leaf area also showed a linear increase upto November and then it decreased.

KP-1

The initial plant vigour was comparatively high in this habitat, as is evident from the data. Here also upto November all the characters exhibited a progressive increase and after November a sudden decrease. There was 57 per cent increase in plant height and 39 per cent increase in total leaf area by November. Branching nature was not prominent in this habitat also. Period from September-November recorded the maximum growth increment.

KP-2

Initial vigour was very high in this habitat. All the biometric parameters revealed an increasing trend upto November and after that a decreasing trend. The almost non-branching nature of the species was evident here also. Leaves were comparatively larger in size with a total leaf area of 1178.9 cm^2 by November. Vines were almost defoliated by January. Maximum growth occurred during the period July-September.

KC-1

Plants were moderately vigorous at the start of the observations in May, and the vines attained their maximum growth by September. Plant height increased by 57 per cent, number of leaves by 48 per cent and total leaf area by 47 per cent. July-September recorded the maximum growth, September-November was almost static with respect to the above ground growth, and after November there was only a short decrease in all the parameters recorded. Vines remained fresh even in January.

KC-2

Vines were with an average of three branches in this habitat. Maximum growth occurred during July-September. Upto November it remained almost static and there was a sudden decline after November. The total leaf area fell down by 82 per cent in January.

VK-1

In general, the growth was very slow in this habitat. Branching pattern was not conspicuous. September-November was apparently a no growth period. Vines entered into the senescence phase by January.

VK-2

In this habitat also Piper appeared to grow only very slow. Active growth was observed only upto July after which upto November vines remained almost stunted in appearance. Senescence was evident from January onwards.

M-1

Active growth in Piper was recorded only upto July here. July-November did not show any apparent increment in any of the biometric characters. After November the vines started drying up.

M-2

In general a stunted growth was observed in this habitat. All the vines remained stunted upto November after which they started withering.

AK

The data show that there was a progressive increase in all the biometric characters upto November. There was 75 per cent increase in plant height, 40 per cent increase in number of branches, 62 per cent increase in number of leaves and 63 per cent increase in the total leaf area by November. The senescence phase, though initiated after November, vines remained fresh even in January.

General growth pattern of *Piper*

Perusal of the data pertaining to the growth parameters of piper shows that the growth pattern differed in different habitats. Habitats KP-1, KP-2, KC-1, KC-2 and AK appeared to favour the natural growth of *Piper*. Period of maximum growth varied in different habitats. After November vines showed symptoms of withering. However, senescence was late in the habitats KC-1 and AK. The plants did not exhibit a conspicuous branching pattern in any of the natural habitats.

Growth analysis

Result of the growth analysis carried out in different natural habitats is presented in Appendix 1. Both LGR and CGR were maximum in the habitats AK and KC-1 with respect to plant height, number of leaves and total leaf area. Lowest growth rate was observed in M-2.

Yield and yield parameters

Total dry matter production, dry yield of root, root:shoot ratio and harvest index of *Piper longum* in different habitats are furnished in Table 14.

Total dry matter production ranged from 30.2 to 49.9 gram per plant. It was maximum in the habitat KC-1, followed by KC-2, M_1 and KP-2.

As in the case of total dry matter production, root yield also was maximum in KC-1 (17.4 kg). The habitat AK stood almost close with a single plant root yield of 17.0 g. Lowest yields were recorded in PNV, M-2, VK-1 and VK-2 (10.8, 11.1 and 11.2 g respectively). Root : shoot ratio was minimum in AK followed by VK-2 and it was maximum in KP-2. Harvest index ranged from 0.32-0.43 and the highest value again was recorded in AK (0.43).

From the parameters it could be inferred that the habitats AK and KC-1 favoured the growth of *Piper* to its maximum since the yield and related attributes recorded maximum values in these habitats.

Table 14. Yield and yield parameters of *Piper longum* in different habitats in the forest

Habitat	Total dry matter production (gram per plant)	Dry yield of root (gram per plant)	Root:shoot ratio	Harvest index
PNV	30.2	10.8	1 : 1.9	0.36
KP-1	36.1	11.6	1 : 2.1	0.32
KP-2	41.6	13.2	1 : 2.1	0.32
KC-1	49.9	17.4	1 : 1.8	0.35
KC-2	45.2	15.9	1 : 1.8	0.35
VK-1	33.1	11.1	1 : 1.9	0.33
VK-2	30.6	11.2	1 : 1.7	0.36
M-1	42.2	14.6	1 : 1.8	0.35
M-2	30.1	10.5	1 : 1.8	0.35
AK	39.2	17.0	1 : 1.3	0.43
Mean for the natural habitat (MDF)	38.5	13.4	1 : 1.9	0.35

4.2.6.2 *Naravelia zeylanica*

This herbaceous climber was present in all the 10 habitats and the biometric observations recorded are presented in Table 15.

PNV

Plants appeared to be moderately vigorous in May. There was slight increase in growth upto July, from July-November there was practically no growth. Growth showed a declining trend after November.

KP-1

In general Naravelia plants in this habitat exhibited poor growth. However, there was slight increment in all the growth parameters from May-November.

KP-2

In this nearby habitat also general growth of *Naravelia* was not satisfactory. Upto November there was a slight increase in growth and plants started drying up after November.

KC-1

This habitat had fairly good growth of Naravelia as the data indicate. Plants attained maximum growth in November with 60 per cent increase in plant height (234.7 cm); 33 per cent in number of branches (2.2); 38 per cent in number of leaves and 37 per cent in total leaf area (2962.9 cm^2). In January even though all

Table 15. Biometric observations of *Naravelia zeylanica* in different habitats in the forest

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
PNV	May	98.3	1.8	23.5	762.0
	July	112.8	1.8	27.8	916.9
	Sept	112.8	1.8	28.6	915.6
	Nov	130.7	1.6	27.9	913.8
	Jan	71.3	1.3	6.6	218.1
KP-1	May	49.4	1.0	15.8	505.6
	July	56.3	1.2	18.6	604.5
	Sept	61.8	1.2	20.4	677.2
	Nov	74.8	1.2	25.6	844.8
	Jan	50.6	1.0	10.2	312.1
KP-2	May	34.6	1.0	11.4	369.6
	July	39.4	1.0	14.6	474.5
	Sept	56.4	1.1	16.8	547.6
	Nov	68.4	1.1	20.9	639.5
	Jan	50.4	0.8	8.6	264.8
KC-1	May	95.7	1.7	53.5	1874.3
	July	154.0	1.7	56.5	1966.0
	Sept	206.5	2.2	62.0	2158.0
	Nov	234.7	2.2	86.2	2962.9
	Jan	212.2	2.0	58.7	2018.2
KC-2	May	103.5	1.5	33.5	1072.4
	July	113.2	1.5	40.2	1288.5
	Sept	110.6	2.2	45.6	1296.8
	Nov	110.6	1.5	44.8	1300.6
	Jan	43.7	1.2	8.0	232.2
VK-1	May	53.6	1.0	15.6	500.7
	July	82.0	1.4	21.4	689.4
	Sept	87.4	1.6	20.8	688.4
	Nov	88.0	1.8	20.0	680.0
	Jan	77.8	1.8	0	0

Contd.

Table 15. Continued

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
	May	36.4	1.2	16.0	529.9
	July	40.2	1.2	17.4	592.4
VK-2	Sept	46.8	1.2	18.6	590.6
	Nov	45.0	1.4	17.6	586.0
	Jan	20.4	1.2	2.2	69.8
	May	41.7	1.2	15.0	510.0
	July	58.0	1.2	20.5	705.1
M-1	Sept	73.0	1.5	25.0	780.6
	Nov	73.0	1.5	25.0	775.4
	Jan	42.7	1.0	3.5	108.5
	May	42.2	1.2	18.5	592.5
	July	57.5	1.2	20.7	667.1
M-2	Sept	86.4	2.0	20.2	788.6
	Nov	111.7	1.7	24.2	907.6
	Jan	44.2	1.5	8.2	306.9
	May	120.1	2.0	38.1	1292.4
	July	129.0	2.0	46.0	1564.6
AK	Sept	132.6	2.0	62.6	2170.6
	Nov	132.4	2.0	68.4	2190.6
	Jan	97.2	1.8	21.0	672.5
Mean for the natural habitat (MDF)					
	May		67.5	24.0	800.5
	July		84.2	28.3	946.5
	Sept		97.4	32.1	1060.9
	Nov		106.9	36.0	1180.1
	Jan		71.0	12.7	419.9

the parameters recorded lower values, the rate of decrease was less. Plants remained fresh for a longer period.

KC-2

Even though initial vigour of the plants was high in this habitat there was no significant improvement in growth afterwards. By January plants were almost reduced to stumps.

VK-1

There was progressive increase in all the biometric parameters upto September and period from September-November did not show any apparent increase in growth. Maximum growth occurred during May-July. Plants were reduced to mere stumps in January with apparently no leaves.

VK-2

The same pattern of growth as that of VK-1 was observed in this habitat also.

M-1

The natural growth of *Naravelia* was moderate in this habitat. There was an increase of 63 per cent in plant height, 40 per cent in the number of leaves and 35 per cent in total leaf area by September. After November all the parameters started declining and in January there were only few leaves on the plant. Maximum growth occurred during May-July and the period September-November did not show any significant growth.

M-2

Here also the growth was comparatively good for *Naravelia*. Growth was almost equally distributed upto November. There was 63 per cent increase in plant height, 24 per cent in number of leaves and 35 per cent in the total leaf area by November. Plants entered the senescence phase after November.

AK

Initial growth was high in this habitat. In the month of May itself plants were 120 cm tall with two branches, 38 leaves and a total leaf area of 1292.4 cm^2. November recorded maximum values for all these parameters. Maximum growth occurred during July-September. Eventhough there was only 10 per cent increase in plant height, total leaf area increased by 40 per cent by September. During September-November plants did not grow much. After November plants showed symptoms of ageing.

General growth pattern of *Naravelia*

From the data it could be seen that all the habitats did not favour the natural growth of this species. The plants preferred the habitats AK, KC-1, M-1 and M-2. No definite period could be identified which promoted maximum growth of this plant. Branching also was less in all the habitats.

Growth analysis

Growth analysis values are presented in Appendix 2. With respect to plant height, maximum LGR and CGR values were recorded in the habitat M-2

followed by KC-1. Regarding number of leaves and total leaf area maximum values of LGR and CGR were for the habitat AK.

Yield and yield parameters

Data regarding yield and its related attributes of *Naravelia* are given in Table 16.

The biological yield was maximum in AK followed by KC-1. It ranged from 20.8 g to 47.4 g. Lowest value was recorded in KP-1. Economic yield also followed an almost similar pattern (15.6 g in KC-1 and 15.4 g in AK). Root : Shoot ratio ranged from 1:1.8 to 1:2.9 and harvest index from 0.25 to 0.35. Lowest root : shoot ratio was recorded in KC-1, followed by AK and highest harvest index in KC-1, followed by AK, KP-1 and KP-2.

Biological and economic yields recorded highest values in the habitats KC-1 and AK. So, the conditions in these habitats seemed to favour both above and below ground growth of *Naravelia*.

4.2.6.3 *Sida rhombifolia* ssp. retusa

This species was present in five habitats viz., KC-1, VK-2, M-1, M-2 and AK and there were totally 35 experimental plants (Table 9). Biometric observations are furnished in Table 17.

KC-1

After the receipt of early pre-monsoon showers in April, *Sida* plants were 42 cm high in this habitat at the first observation. Upto November the plants

Table 16. Yield and yield parameters of *Naravelia zeylanica* in different habitats in the forest

Habitat	Total dry matter production (gram per plant)	Dry root yield (gram per plant)	Root:shoot ratio	Harvest index
PNV	35.0	9.6	1 : 2.6	0.27
KP-1	20.8	6.4	1 : 2.2	0.31
KP-2	22.1	6.8	1 : 2.2	0.31
KC-1	45.0	15.6	1 : 1.8	0.35
KC-2	29.2	7.3	1 : 2.9	0.25
VK-1	35.3	10.3	1 : 2.4	0.29
VK-2	32.8	8.8	1 : 2.6	0.27
M-1	37.9	11.2	1 : 2.3	0.30
M-2	35.1	10.4	1 : 2.3	0.30
AK	47.4	15.4	1 : 2.0	0.32
Mean for the natural habitat (MDF)	34.0	10.2	1 : 2.4	0.30

Table 17. Biometric observations of *Sida rhombifolia* ssp. *retusa* in different habitats in the forest

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
KC-1	May	42.0	2.0	27.5	111.5
	July	50.5	2.0	31.0	131.8
	Sept	64.5	2.0	38.0	156.6
	Nov	67.5	2.5	45.0	197.5
	Jan	65.4	2.5	39.5	173.3
KC-2	May	70.5	4.0	45.0	181.7
	July	76.5	5.0	50.0	201.7
	Sept	91.5	5.5	60.0	243.6
	Nov	95.5	5.5	58.5	243.4
	Jan	92.0	2.5	26.0	109.5
M-1	May	59.2	2.8	36.7	153.9
	July	66.5	3.5	43.7	183.8
	Sept	80.7	4.1	53.2	223.8
	Nov	102.7	4.1	70.7	297.0
	Jan	85.5	2.5	31.2	131.4
M-2	May	24.0	1.0	5.5	20.7
	July	27.5	1.0	6.8	29.7
	Sept	30.1	1.0	6.8	25.8
	Nov	31.1	1.0	10.3	38.6
	Jan	29.3	1.0	6.17	23.4
AK	May	17.5	1.0	11.0	44.6
	July	22.5	1.0	13.5	58.2
	Sept	48.0	3.0	21.0	87.6
	Nov	72.0	3.0	69.0	297.5
	Jan	72.0	2.0	0	0
Mean for the natural habitat (MDF)					
	May	42.6	2.1	25.1	102.4
	July	48.7	2.5	29.0	121.0
	Sept	62.9	3.1	35.8	147.5
	Nov	73.7	3.2	50.7	214.8
	Jan	68.8	2.1	20.5	87.5

grew actively. Period September-November recorded maximum growth. Decrease in growth was evident after November, however the plants remained fresh in January also.

VK-2

Sida plants exhibited moderate growth here. There were 5.5 branches on an average in September, which recorded the maximum growth. Increase in plant height was 26 per cent; number of leaves 25 per cent and total leaf area 26 per cent by September. Plants showed symptoms of ageing after November.

M-1

In general *Sida* exhibited good growth in this habitat. Growth pattern was linear upto November. There was 42 per cent increase in plant height, 48 per cent each in number leaves and total leaf area by November. September-November recorded maximum growth. There was on an average 4.1 branches per plant at full growth. As in other habitats, here also plants entered the senescence phase after November.

M-2

In general, *Sida* plants in this habitat had a stunted appearance. Initial growth itself was poor and after seven months there was only slight increase. All the plants were single stemmed with few leaves.

AK

Eventhough the initial vigour of the plants was less in this habitat, upto November, plants exhibited very good growth. There was 75 per cent increase in plant height and 85 per cent increase in total leaf area by November. September-November period recorded the maximum growth.

In January all the plants were completely defoliated.

General growth pattern of *Sida*

It is obvious from the data that growth pattern was dissimilar in different habitats. However, growth appeared better in M-1, AK and VK-2. Period from September to November recorded maximum growth in these habitats. Ageing commenced from November onwards in all the habitats.

Growth analysis

Data on the growth analysis are furnished in Appendix 3. Maximum values for LGR and CGR with respect to all parameters were recorded for the habitat AK followed by M-1.

Yield and yield paramters

Information on yield and yield parameters of *Sida* are given in Table 18.

As in the case of biometric characters yield and yield parameters also showed a similar trend.

Table 18. Yield and yield parameters of *Sida rhombifolia* ssp. retusa in different habitats in the forest

Habitat	Total dry matter production (gram per plant)	Dry root yield (gram per plant)	Root:shoot ratio	Harvest index
KC-1	80.0	10.5	1 : 6.6	0.13
VK-2	84.2	14.2	1 : 4.9	0.17
M-1	89.0	16.8	1 : 4.3	0.11
M-2	69.3	7.7	1 : 8.0	0.11
AK	83.5	12.0	1 : 5.9	0.14
Mean for the natural habitat (MDF)	81.2	12.2	1 : 5.9	0.15

Total biological yield ranged from 69.3 g to 89.0 g. It was maximum in M-1 followed by KC-1, VK-2 and AK, with almost the same yield. Yield of root, which is the economic part ranged from 7.7 g to 16.8 gram per plant. Maximum was in M-1, closely followed by VK-2 and then AK. Root:shoot ratio was comparatively high in this species and it ranged from 1:1.4 to 1:8.0. Lowest value was in M-1 followed by VK-2. Harvest index, which ranged from 0.11-0.19 also showed a similar trend.

Overall scrutiny of the data revealed that the habitat M-1 was most congenial for the natural growth of *Sida*. Next best was VK-2 and then AK.

4.2.6.4 *Desmodium velutinum*

The habitats KC-1, VK-1, VK-2, M-1, M-2 and AK had the natural population of *Desmodium* and there were totally 31 experimental plants (Table 9). Habitat-wise data on the biometric characters are presented in Table 19.

KC-1

Desmodium appeared growing very good in this habitat. Initial vigour of the plants itself was high here. Upto November, plants exhibited a progressive increase in growth. By November there was 30 per cent increase in plant height, and 52 per cent increase in total leaf area. Increase in plant height was maximum during September-November whereas maximum increase in leaf area was from September-November. After November senescence started.

Table 19. Biometric observations of *Desmodium velutinum* in different habitats in the forest

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
KC-1	May	72.0	2.0	23.0	2185.0
	July	81.3	2.0	25.3	2415.5
	Sept	98.5	2.0	35.6	3394.9
	Nov	104.3	2.0	48.6	4617.0
	Jan	94.1	2.0	7.3	696.3
VK-1	May	40.0	1.6	14.2	1306.4
	July	47.2	1.6	17.6	1657.9
	Sept	47.6	1.4	19.2	1804.8
	Nov	48.0	1.2	18.0	1710.0
	Jan	37.2	0.4	6.8	639.2
VK-2	May	42.2	1.4	7.8	648.3
	July	46.0	1.4	8.8	750.3
	Sept	47.6	1.6	10.2	846.7
	Nov	50.8	1.6	11.6	994.3
	Jan	50.4	1.6	4.0	342.8
M-1	May	54.0	3.0	18.5	1715.3
	July	67.0	3.0	25.2	2340.6
	Sept	82.7	3.7	39.0	3650.1
	Nov	99.0	2.5	39.5	3600.4
	Jan	62.2	2.0	10.0	911.4
M-2	May	31.0	1.4	10.2	937.1
	July	35.6	1.4	12.6	1154.4
	Sept	40.2	1.4	13.4	1186.4
	Nov	46.6	1.4	13.8	1206.8
	Jan	43.6	1.0	4.1	358.5
AK	May	42.0	3.0	19.0	1697.8
	July	45.5	3.0	20.5	1832.5
	Sept	46.5	3.0	20.5	1836.4
	Nov	47.0	3.0	19.0	1678.1
	Jan	46.0	2.5	4.0	352.2
Mean for the natural habitat (MDF)					
	May	46.8	2.0	15.4	1414.6
	July	53.7	2.0	18.3	1691.3
	Sept	65.9	2.1	22.9	2119.3
	Nov	65.9	1.9	25.0	2300.8
	Jan	55.6	1.5	6.0	549.6

VK-1

In general, growth of *Desmodium* appeared to be poor in this habitat. Plants showed symptoms of withering after November.

VK-2

Here also the growth of *Desmodium* was not good as revealed by the data.

M-1

Conditions prevailing in this habitat seemed to enhance the growth of *Desmodium*. There was a progressive increase in all the biometric parameters up to November. There was about 46 per cent increase in plant height and 55 per cent increase in total leaf area by November. Maximum growth occurred during July-September. Growth pattern showed a declining trend after November.

M-2

The growth of *Desmodium* was not satisfactory in this habitat as is evident from the data. There was only 32 per cent increase in plant height and 22 per cent increase in total leaf area by November.

AK

General growth was moderate here. Though plants were shorter in appearance, they had more branches and leaves and a high total leaf area. Initial vigour was high, but afterwards there was no significant improvement in growth.

General growth pattern of *Desmodium*

Among the different habitats two viz. KC-1 and M-1 were congenial for the growth of *Desmodium*. July-September recorded maximum growth in this species. In all the habitats plants started drying up after November.

Growth analysis

Data given in Appendix 4 gives a picture of the growth rate of *Desmodium* in the natural habitat. With respect to plant height, LGR and CGR were maximum in M-1 followed by KC-1. LGR and CGR with respect to number of leaves and total leaf area were highest in KC-1 followed by M-1.

Yield and yield parameters

Table 20 explains the data pertaining to yield and yield related characters of *Desmodium*. The data revealed that the biotic as well as abiotic conditions of the habitat KC-1 appeared to favour the growth of *Desmodium* to its best. Next best was M-1.

The total dry matter production ranged from 48.2 to 168.3 g; root yield from 17.1 to 80.5 gram per plant; root:shoot ratio from 1:1.0 tp 1:2.0 and harvest index from 0.32 to 0.48. Optimum values of all these parameters were recorded in the habitats KC-1 and M-1.

4.2.6.5 *Baliospermum solanifolium*

Out of 10 habitats, only 5 had the natural population of *Baliospermum* (Table 9). Habitat-wise details of biometric parameters are presented in the Table 21.

Table 20. Yield and yield parameters of *Desmodium velutinum* in different habitats in the forest

Habitat	Total dry matter production (gram per plant)	Dry root yield (gram per plant)	Root:shoot ratio	Harvest index
KC-1	168.3	80.5	1 : 1.0	0.48
VK-1	53.0	17.1	1 : 2.0	0.32
VK-2	76.4	27.3	1 : 1.7	0.36
M-1	140.5	64.7	1 : 1.1	0.46
M-2	48.2	18.9	1 : 1.5	0.39
AK	119.2	52.2	1 : 1.2	0.44
Mean for the natural habitat (MDF)	100.9	43.5	1 : 1.4	0.41

Table 21. Biometric observations of *Baliospermum solanifolium* in different habitats in the forest

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
KP-1	May	35.8	1.3	5.8	1074.3
	July	40.3	1.3	7.3	1360.3
	Sept	50.5	1.3	9.8	1819.7
	Nov	50.0	1.3	9.9	1837.3
	Jan	26.2	0.3	3.75	755.0
KP-2	May	37.4	1.4	8.2	1431.9
	July	43.4	1.4	10.0	1777.6
	Sept	42.8	1.4	10.2	1786.4
	Nov	54.0	1.4	10.0	1860.6
	Jan	46.0	1.4	3.8	707.0
KC-1	May	71.6	1.3	12.3	2331.8
	July	79.8	1.3	14.0	2659.5
	Sept	93.6	1.3	16.0	3008.4
	Nov	117.1	1.3	15.1	3000.0
	Jan	110.7	1.3	7.0	1384.3
KC-2	May	55.5	1.5	11.5	2170.7
	July	60.5	1.5	13.2	2534.0
	Sept	68.6	1.5	14.5	2782.8
	Nov	69.3	1.5	14.0	2733.2
	Jan	65.7	1.5	5.0	976.1
VK-2	May	33.6	1.2	4.6	897.6
	July	38.7	1.2	5.2	1019.2
	Sept	39.9	1.2	5.3	1003.6
	Nov	42.4	1.2	8.8	1689.6
	Jan	34.4	1.2	3.0	570.8
Mean for the natural habitat (MDF)					
	May	46.8	1.34	8.49	1369.0
	July	52.5	1.34	9.96	1869.8
	Sept	58.9	1.34	11.16	2417.4
	Nov	66.5	1.34	11.57	2223.8
	Jan	56.6	1.14	4.51	878.4

KP-1

Baliospermum plants exhibited moderate growth in this habitat. Growth occurred upto November and the maximum growth was recorded during July-September. There was 30 per cent increase in plant height and 42 per cent increase in total leaf area by September. During September-November there was practically no growth. After November plants started drying up.

KP-2

Natural growth of *Baliospermum* was not good here as revealed by the data.

KC-1

In general, the growth of *Baliospermum* was good in this habitat. There was progressive increase in all the biometric parameters upto November after which it decreased. There was 38 per cent increase in plant height and 22 per cent increase in total leaf area. Maximum growth was recorded during July-September.

KC-2

Baliospermum exhibited good growth in this habitat also. An almost similar trend as that of KC-1 was observed here also but the maximum growth occurred during May-July.

VK-2

Data revealed that in this habitat growth of *Baliospermum* was poor.

General growth pattern

Regarding the best season of growth no definite pattern was evident. In all the habitats studied, the plants had only very few branches (1.2-1.5). In general, habitats KP-1, KC-1 and KC-2 appeared best for the natural growth of *Baliospermum*.

Growth analysis

Result of the growth analysis carried out in this species is given in Appendix 5. With respect to plant height, maximum values of LGR and CGR were recorded in the habitat KC-1 followed by KP-2. Regarding number of leaves and total leaf area, highest values were recorded in KP-1 followed by KC-1.

Yield and yield parameters

Data on the yield and yield parameters of *Baliospermum* are furnished in Table 22.

In this species, it was observed that, the fleshy storage roots grew proportionately more compared to the stem. Root:shoot ratio was very low and it ranged from 1:0.56 to 1:0.89. Lowest value was recorded in KP-1 followed by VK-2 and KP-2. Harvest index ranged from 0.54 to 0.65. This also followed the same trend. The root yield per plant ranged from 120.60 to 222.2 g and maximum values for biological as well as economic yields were recorded in KP-1 and KC-1 respectively.

Table 22. Yield and yield parameters of *Baliospermum solanifolium* in different habitats in the forest

Habitat	Total dry matter production (gram per plant)	Root yield (gram per plant)	Root:shoot ratio	Harvest index
KP-1	348.0	222.2	1 : 0.56	0.65
KP-2	201.5	120.6	1 : 0.69	0.60
KC-1	401.0	215.3	1 : 0.89	0.54
KC-2	358.8	207.5	1 : 0.73	0.58
VK-2	220.6	134.6	1 : 0.64	0.61
Mean for the natural habitat (MDF)	305.0	180.0	1 : 0.70	0.60

In general, the habitats KP-1, KC-1 and KC-2 appeared to be congenial for the natural growth and yield of *Baliospermum*.

4.2.6.6 *Barleria prattensis*

Barleria was present only in two habitats ie., VK-2 and KC-1. The performance of the species in these habitats is given in Table 23 (biometric characters) and Table 24 (yield and yield parameters).

VK-2

In general, a linear growth pattern was observed upto November. Increment in growth was almost same during different periods. There was only 25 per cent increase in plant height and 13 per cent increase in total leaf area by November. After November, plants entered the senescence phase and about 50 per cent leaves fell down. On an average plants had five branches at maximum growth stage.

KC-1

The growth parameters recorded high values in this habitat. A linear growth pattern was observed upto November. There was about 44 per cent increase in plant height and total leaf area. There were 6.1 branches at the maximum growth of the plant. Ageing commenced after November and there was 65 per cent decline in the total leaf area. Growth increment was almost uniform upto November.

Growth analysis

Data presented in Appendix 6 gives the growth rate of this species. It is

Table 23. Biometric observations of *Barleria prattensis* in different habitats in the forest

Habitat	Month	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm^2)
VK-2	May	44.0	4.0	54.0	1080.5
	July	49.0	5.0	59.5	1240.0
	Sept	55.0	5.0	50.0	1260.6
	Nov	58.6	4.5	61.6	1250.8
	Jan	46.4	4.5	21.0	426.4
KC-1	May	40.4	4.0	60.5	1219.6
	July	50.6	5.6	70.1	1412.7
	Sept	65.9	6.1	100.0	2036.9
	Nov	71.4	5.9	109.8	2176.8
	Jan	63.6	4.7	38.7	767.2
Mean for the natural habitat (MDF)					
	May	42.2	4.0	57.2	1150.0
	July	49.8	5.3	64.8	1326.3
	Sept	60.4	5.5	80.3	1648.7
	Nov	65.0	5.2	85.7	1713.8
	Jan	55.0	4.6	29.8	596.5

Table 24. Yield and yield parameters of *Barleria prattensis* in different habitats in the forest

Habitat	Total dry matter production (gram per plant)	Root yield (gram per plant)	Root:shoot ratio	Harvest index
KC-1	80.8	31.1	1 : 1.5	0.39
VK-2	66.0	22.0	1 : 2.0	0.33
Mean for the natural habitat (MDF)	73.4	26.6	1 : 1.8	0.36

evident that between the two habitats, KC-1 recorded the maximum values for LGR and CGR with respect to plant height, number of leaves and total leaf area.

Yield and yield parameters

Data presented in Table 24 indicate that the biological yield of *Barleria* was maximum in KC-1 (80.8 g), followed by VK-1 (66.0 g). Root yield also showed the same trend. It was 31.1 g in KC-1 and 22 g in VK-2. Root:shoot ratio and harvest index were 1:1.2 and 0.39 respectively in KC-1 and 1:1.5 and 0.33 respectively in VK-1.

It is clear from the tables that out of the two habitats where *Barleria* grew naturally in abundance, KC-1 was better. In general, growth showed a linear increase upto November. Plants on an average had 5.5 primary branches and senescence set in after November.

4.2.6.7 Flowering period of select species in the natural habitat

Information on the flowering time in the select species is given in Table 25.

In the forest, flowering in all the species was comparatively early. Peak flowering in *Desmodium, Barleria* and *Sida* was from October-November, whereas in *Baliospermum* it extended upto January. None of the experimental plants of *Piper* and *Naravelia* flowered during the period of study.

4.2.6.8 Regeneration

Study plots in the habitats KP-1, KP-2, KC-1, VK-1, M-1, M-2 and AK

Table 25. Flowering period of select species in different habitats in the forest

Habitat	Species					
	Desmodium	*Piper*	*Naravelia*	*Sida*	*Baliospermum*	*Barleria*
PNV	NP	NF	NF	NP	NP	NP
KP-1	NP	NF	NF	NP	Dec-Jan	NP
KP-2	NP	NF	NF	NP	Dec-Jan	NP
KC-1	Oct-Nov	NF	NF	Oct-Nov	Oct-Nov	Oct-Nov
KC-2	NP	NF	NF	NP	Oct-Nov	NP
VK-1	Dec-Jan	NF	NF	NP	NP	NP
VK-2	Oct-Nov	NF	NF	Oct-Nov	Oct-Nov	Oct-Nov
M-1	Oct-Nov	NF	NF	Oct-Nov	NP	NP
M-2	Oct-Nov	NF	NF	Oct-Nov	NP	NP
AK	Oct-Nov	NF	NF	Oct-Nov	NP	NP

NP - Plant not present
NF - Not flowered

Table 26. Regeneration pattern of select species in different habitats in the forest

Habitat	Occurrence of fire	*Piper*		*Naravelia*		*Sida*		*Desmodium*		*Baliosp-permum*		*Barleria*		% regeneration in the habitat
		IC	RC	IC	RC	IC	RC	IC	RC	IC	RC	IC	RC	
PNV	NB	10	8	8	6	NP		NP		NP		NP		77
KP-1	B	8	2	1	0	NP		NP		8	5	NP		41
KP-2	B	8	4	3	1	NP		NP		8	5	NP		53
KC-1	B	20	10	8	7	5	0	8	6	8	8	20	26	83
KC-2	NB	18	9	7	6	NP		NP		5	4	NP		63
VK-1	B	10	4	6	3	NP		7	6	NP		NP		56
VK-2	NB	6	0	5	7	5	0	6	6	1	0	15	10	60
M-1	B	10	25	10	15	13	25	6	3	NP		NP		152
M-2	B	12	6	6	9	10	8	7	6	NP		NP		74
AK	B	22	26	6	8	5	0	5	3	NP		NP		97
Total		124	94	61	62	38	33	39	30	30	22	35	36	
% regeneration of the species		76		102		87		77		73		103		

B - Burnt
NB - Not burnt
IC - Initial count
RC - Regenerated count
NP - Not present

were completely burnt in forest fire in March 1995. Fire did not occur in PNV, KC-2 and VK-2. After the summer showers, in the first week of May all the plots were re-enumerated to find out the regeneration pattern of select species and the data are furnished in Table 26 (Figs.12, 13).

A close scrutiny of the data reveal that *Barleria* and *Naravelia* had the maximum regeneration pecentage (103 and 102 per cent respectively). They were followed by *Sida* (87%). *Baliospermum, Desmodium* and *Piper* had almost similar pattern of regeneration.

Amongst the habitats, M-1 recorded the highest percentage of regeneration (152%) followed by AK (97%). Lowest regeneration was in KP-1 (41%).

In general it could be inferred that fire was not a limiting factor in the regeneration of these species. Both the burnt and unburnt plots had satisfactory regeneration in all the species. Taking the total regeneration percentage of six species together, the burnt plots recorded higher regeneration than the unburnt ones.

4.2.6.9 Plant associations

The data on plant associations were tabulated using different criteria. Two way tables were made for all the species by taking fifteen dominant species in each case. There was no definite pattern of association noticeable in any of the select species. Occurrence of the species appeared to be random.

4.3 Experiment III. Domestic Environment Analysis

The domestic crop was raised in the month of June after bringing the planting material from the forest (Plates 9, 10). Bimonthly observations were

Plate 9. Select species in the domestic environment

9a *Baliospermum solanifolium* with flowers
9b *Barleria prattensis* with flowers
9c *Piper longum* with female spike

Plate 9. Select species in the domestic environment

Plate 10. Select species in the domestic environment - continued

10a *Sida rhombifolia* ssp. retusa with flowers
10b *Naravelia zeylanica* with flowers
10c *Desmodium velutinum* with flowers

Plate 10. Select species in the domestic environment

recorded in July. September, November and January. Crop was harvested in March.

Mean values of biometric observations and yield parameters of the six species are presented in Tables 27 and 28, respectively. Estimates of growth rates are furnished in Appendix 7.

4.3.1 *Piper longum*

Growth of *Piper* showed a linear pattern throughout the growth period. Plant height increased by 80 per cent and total leaf area by 82 per cent. Branching was conspicuous in the domestic crop. Maximum dry matter production recorded was 80.1 g and the dry weight of roots 22.8 gram per plant. Root:shoot ratio and harvest index were 1:2.5 and 0.28 respectively.

4.3.2 *Naravelia zeylanica*

Naravelia grew well in the domestic field, flowered and seeded. Growth pattern was linear with respect to all characters, plant height was increased by 49 per cent, number of branches by 66 per cent, number of leaves by 73 per cent and total leaf area by 61 per cent. A biological yield of 32.8 g and economic yield of 8.2 g were recorded with a root:shoot ratio of 1:3 and a harvest index of 0.25.

4.3.3 *Sida rhombifolia* ssp. retusa

Sida grew above 2.2 m in the domestic plot, branching and leafing profusely with 93 per cent increase in plant height and total leaf area. Per plant biological yield recorded was 400.6 g and economic yield 55.4 g giving a root:shoot ratio of 1:6.23 and harvest index of 0.14.

Table 27. Biometric observations of select species in the domestic environment

Character	Month	Species					
		Piper	*Naravelia*	*Sida*	*Desmodium*	*Baliospermum*	*Barleria*
Plant height (cm)	Jul	25.8	43.6	96.0	53.2	38.0	24.0
	Sept	89.6	58.0	135.0	125.6	50.0	35.0
	Nov	126.6	74.0	185.0	181.6	64.0	44.0
	Jan	132.2	89.0	225.0	192.4	99.0	55.0
Number of branches per plant	July	4	4	14	12	4	20
	Sept	8	7	29	28	7	36
	Nov	13	11	49	10	10	52
	Jan	16	12	65	52	11	63
Number of leaves per plant	Jul	4	25	15,000	90	34	46.4
	Sept	13	36	1,35,000	196	46	76.4
	Nov	18	76	1,85,000	290.8	59	89.8
	Jan	22	90	2,25,000	366.4	88	100.9
Total leaf area (cm^2)	Jul	344.1	878.6	75,000	8550.8	6392.6	928.6
	Sept	1107.9	1296.4	6,75,000	19208.6	8694.6	1604.6
	Nov	1555.6	2664.6	9,25,000	27916.8	11092.4	1975.6
	Jan	1870.6	3060.4	11,25,000	35408.2	16544.6	2018.2

Table 28. Time of flowering, yield and yield parameters of select species in the domestic envrionment

Character	Species					
	Piper	*Naravelia*	*Sida*	*Desmodium*	*Baliospermum*	*Barleria*
Flowering period	Dec	Dec	Dec	Dec	Dec	Dec
Total dry matter production (gram per plant)	80.1	32.8	400.6	420.6	420.6	85.0
Dry root yield (gram per plant)	22.8	8.2	55.4	150.4	290.9	35.0
Root:shoot ratio	1:2.51	1:3	1:6.23	1:1.8	1:0.45	1:1.43
Harvest index	0.28	0.25	0.14	0.36	0.69	0.41

4.3.4 *Desmodium velutinum*

Growth appeared luxurious in the domestic environment with a linear pattern. Increase in plant height was to the tune of 73 per cent, number of branches 77 per cent and total leaf area 76 per cent. Biological and economic yields recorded were 420.6 and 150.4 g respectively.

4.3.5 *Baliospermum solanifolium*

There was very good growth in this species in the fully open field. There was about 62 per cent increase in all the growth parameters. Secondary branches were also present at the maximum growth stage. Total dry matter production was as high as 420.6 g and dry root yield 290.9 gram per plant with a root:shoot ratio of 1:0.45 and harvest index of 0.69.

4.3.6 *Barleria prattensis*

This species also successfully completed its life cycle in the domestic environment with an evidently linear growth pattern. There was an increase of 44 per cent in plant height and 64 per cent in total leaf area. Branching pattern was profuse with secondary and tertiary branches giving the plant a bushy appearance. Total dry matter production was 85 g with a root yield of 35 g giving a root:shoot ratio of 1:1.4 and harvest index of 0.41.

4.3.7 Flowering of select species in the domestic environment

All the species flowered in the domestic environment and produced seeds. Irrespective of the species, December was the peak flowering time in the domestic environment (Table 28).

4.3.8 Comparison of the performance of the select species in the wild as well as domestic environments

A general comparison is made with the performance of the species in the domestic environment to that of the most suitable habitat in the forest and to the overall performance in the MDF and the data on important parameters are furnished in Table 29.

4.3.8.1 *Piper longum*

Physical habit of the species differed slightly in the domestic and natural environments. Branching was not conspicuous in the wild whereas it was prominent in the domestic crop. Vegetative growth was more in the domestic environment and upto January growth pattern was linear. In the wild plants after November growth started declining. None of the plants in the wild flowered while those in the domestic environment flowered during December.

Dry root yield per vine was slightly higher in the domestic crop (24%) than the yield in the most suitable habitat (KC-1) and it was about 41 per cent higher than the overall MDF yield (Fig.6). Root:shoot ratio was 1:1.2 for the domestic crop where as it was 1:1.8 for KC-1 and 1:1.9 for the general MDF.

4.3.8.2 *Naravelia zeylanica*

Compared to the wild plants, domestic crop produced more branches. Growth pattern was linear upto January in domestic environment whereas senescence set in by November in the wild population. In this species also flowering was not recorded in the wild plants whereas domestic crop flowered in December-January.

Table 29. Performance of select species in the wild and domestic environments

Species	Most congenial habitat in the wild		Mean value for the entire MDF		Domestic environment	
	Total dry matter production (gram per plant)	Dry root yield (gram per plant)	Total dry matter production (gram per plant)	Dry root yield (gram per plant)	Total dry matter production (gram per plant)	Dry root yield (gram per plant)
Piper longum	49.9 (KC-1)	17.4 (KC-1)	38.5	13.4	80.1	22.8
Naravelia zeylanica	47.4 (AK)	15.6 (KC-1)	34.0	10.2	32.8	8.2
Sida rhombifolia ssp. retusa	89.0 (M-1)	16.8 (M-1)	81.2	12.2	400.6	55.4
Desmodium velutinum	168.3 (KC-1)	80.5 (KC-1)	100.9	43.5	420.6	150.4
Baliospermum solanifolium	401.0 (KC-1)	222.2 (KP-1)	305.0	180.0	420.6	290.9
Barleria prattenis	80.8 (KC-1)	31.1 (KC-1)	73.4	26.6	85.0	35.0

The total plant yield was slightly high in the wild samples (27%) than the yield in KC-1 and it was almost the same as that of the overall yield for MDF (Fig.7). Root yield was also high in the wild (47 per cent than KC-1 and 19 per cent than the overall yield in MDF). Root:shoot ratio was 1:2.4, 1:1.8 and 1:3 in the domestic environment, KC-1 and in the general MDF.

4.3.8.3 *Sida rhombifolia* ssp. retusa

There was drastic difference in both the growth and yield of *Sida* in the forest and in the domestic environment. The vegetative growth was luxurious in the domestic crop with more secondary and tertiary branches. Both the wild and domestic plants flowered, but flowering was early in the forests.

Root yield was also high in the domestic crop (Fig.8). It was more than three times to the yield in M-1 and more than 4.5 times to the overall yield in the MDF. Root:shoot ratio was 1:6.2, 1:4.3 and 1:5.9 in the domestic environment, M-1 and general MDF.

4.3.8.4 *Desmodium velutinum*

In this species also vegetative growth was more in the domestic crop compared to the wild plants. There was profuse branching and flowering was late by one month in the domestic crop.

Root yield was almost double in the domestic crop (150.4 g) than the yield in KC-1 and 3.45 times more than the yield in the general MDF (Fig.9). Root:shoot ratio was 1:1.8 in domestic environment whereas it was 1:1.0 and 1:1.4 in KC-1 and general MDF.

4.3.8.5 *Baliospermum solanifolium*

Domesticated plants were slightly vigorous than the naturally growing plants in the wild. Growth pattern was linear except the early setting of senescence in the wild plants. Root yield was also high under domestication (290.9 g) whereas it was 222.2 g in KP-1, the most congenial habitat and 180.0 g in the overall MDF (Fig.10). Root:shoot ratio was 1:0.45 in the domestic environment, 1:0.56 in KP-1 and 1:0.7 in the general MDF.

4.3.8.6 *Barleria prattensis*

In the domestic environment, plants were profusely branching compared to the forest growth. Domestic plants also flowered and seeded but little late. Root yield recorded only a slight increase in domestic crop (35.0 g) whereas in the most suited habitat (KC-1) it was 31.1 g and in the general MDF, 26.6 g (Fig.11). Root:shoot ratio was 1:1.5 in KC-1, 1:1.8 in general MDF and 1:1.4 in the domestic crop.

4.4 Experiment IV. Biochemical analysis

Results of the biochemical analysis carried out in the wild as well as domestic plants of the select species are presented here. Pooled samples were taken for analysis.

4.4.1 Selection of suitable solvent for extraction

Percentage recovery of crude extractables and number of siphonings obtained in different solvents in soxhlet extraction are presented in Table 30.

Table 30. Extraction efficiency of different solvents in the select species

Solvent	Parameters	Species					
		Piper	*Naravelia*	*Sida*	*Desmodium*	*Baliospermum*	*Barleria*
Petroleum ether (60-80°C)	% recovery of crude extractables	6.1	2.7	3.36	6.3	5.9	3.2
	Number of siphonings in 10 hrs	55	46	48	49	49	58
	Efficiency factor	0.11	0.06	0.07	0.13	0.12	0.06
Hexane	% recovery of crude extractables	3.3	2.9	3.1	5.9	5.8	3.3
	Number of siphonings in 10 hrs	52	50	53	50	51	53
	Efficiency factor	0.06	0.06	0.06	0.12	0.11	0.06
Chloroform	% recovery of crude extractables	4.3	2.7	3.0	5.9	5.7	2.9
	Number of siphonings in 10 hrs	45	47	45	48	46	45
	Efficiency factor	0.10	0.06	0.07	0.12	0.12	0.06
Ethyl acetate	% recovery of crude extractables	6.1	2.5	2.8	5.9	5.2	2.9
	Number of siphonings in 10 hrs	42	41	45	42	43	42
	Efficiency factor	0.15	0.06	0.06	0.14	0.12	0.06
Acetone	% recovery of crude extractables	7.6	3.5	4.0	6.1	5.7	4.1
	Number of siphonings in 10 hrs	39	38	40	40	40	39
	Efficiency factor	0.19	0.09	0.10	0.15	0.14	0.11
Methanol	% recovery of crude extractables	9.6	8.8	7.1	10.2	8.7	8.9
	Number of siphonings in 10 hrs	19.5	17	18	18	19	20
	Efficiency factor	0.49	0.52	0.39	0.57	0.46	0.45

In all the species more number of siphonings were obtained with Petroleum ether (60-80°C) in an extraction time of 10 hrs. It was least in the case of Methanol. Percentage recovery of crude extractables and extraction efficiency were high in Methanol irrespective of the species. Next efficient solvent was Acetone. There was not much difference in the extraction efficiency of the solvents - Petroleum ether, Ethylacetate, Hexane and Chloroform.

In all the species Methanol extracts were turbid due to the presence of plant waxes. Acetone extracts also precipitated after keeping for a short period. Petroleum ether extracts were very clear in all the species and it could directly be used for further analysis.

4.4.2 Estimation of crude extractables

Results of the soxhlet extraction with Petroleum ether (60-80°) are presented in Table 31.

It is evident from the table that in the case of *Desmodium, Baliospermum, Naravelia* and *Piper* wild samples gave a hgher percentage of crude extractables. Reverse trend was observed in the case of *Sida* and *Barleria*. There was a difference of up to 15 per cent in *Desmodium*, 26 per cent in *Baliospermum*, 53 per cent in *Naravelia*, 14 per cent in *Piper*, 46 per cent in *Barleria* and 41 per cent in *Sida*.

4.4.3 Soluble sugars

Soluble sugar content given in Table 32 shows that in *Desmodium,*

Table 31. Percentage of crude extractables in the wild and domestic plants

Species	Percentage of crude extractables	
	Wild	Domestic
Desmodium	5.50	4.70
Baliospermum	4.90	3.60
Barleria	2.95	5.31
Sida	2.25	3.79
Naravelia	2.43	1.15
Piper	6.50	5.60

Table 32. Soluble sugar content of select species in the wild and domestic environments

Species	Habitat	Soluble sugar content (%)
Desmodium	Wild	5.07
	Domestic	3.31
Baliospermum	Wild	3.94
	Domestic	2.54
Sida	Wild	2.03
	Domestic	11.01
Piper	Wild	3.30
	Domestic	5.96
Naravelia	Wild	3.41
	Domestic	2.36
Barleria	Wild	7.58
	Domestic	14.72

Baliospermum and *Naravelia* the wild plants contained more soluble sugars than the domestic plants. On the contrary in *Sida, Piper* and *Barleria* the domestic plants contained more soluble sugars. In *Sida* it was more than five times high and in *Barleria* and *Piper* almost double.

4.4.4 Starch

Starch content of the wild and domestic plants is given in Table 33. In *Sida* and *Barleria* wild plants contained more starch compared to the domestic plants whereas in the remaining four species domestic plants contained more starch. In *Barleria* and *Sida* it was almost double the quantity. In *Naravelia* there was no difference in starch content between the wild and domestic plants.

4.4.5 Total free amino acids

Data presented in Table 34 reveal that irrespective of the species all the domestic plants contained more total free amino acids compared to the wild plants. In *Sida* there was a difference of 72 per cent whereas in the remaining species the difference was not so drastic.

4.4.6 Qualitative tests for alkaloids

Fresh plant samples from the wild were subjected to preliminary tests for alkaloids and the results are presented in Table 35.

A scrutiny of the table reveals that *Desmodium* gave positive results in all the three reagents in all the solvents tried. Presence of alkaloids can hence be confirmed in this species. *Baliospermum* gave positive tests for alkaloids with Dragendorffs and Wagners reagents, in Petroleum ether, Acetone or Methanol

Table 33. Starch content of select species in the wild and domestic environments

Species	Habitat	Starch content (%)
Desmodium	Wild	23.56
	Domestic	27.04
Baliospermum	Wild	73.30
	Domestic	84.08
Sida	Wild	20.87
	Domestic	8.97
Piper	Wild	20.95
	Domestic	30.18
Naravelia	Wild	24.17
	Domestic	24.17
Barleria	Wild	18.69
	Domestic	9.22

Table 34. Total free amino acid content of select species in the wild and domestic environments

Species	Habitat	Total free amino acids (%)
Desmodium	Wild	0.012
	Domestic	0.014
Baliospermum	Wild	0.006
	Domestic	0.008
Sida	Wild	0.006
	Domestic	0.022
Piper	Wild	0.014
	Domestic	0.020
Naravelia	Wild	0.004
	Domestic	0.005
Barleria	Wild	0.006
	Domestic	0.007

Table 35. Priliminary tests for alkaloids

Species	Solvents	Mayers reagent	Dragendorff's reagent		Wagner's reagent	
			Alone	After acidification	Alone	After acidification
Desmodium	Petroleum ether (60-80°C)	+	+	+	+	+
	Hexane	+	+	+	+	+
	Chloroform	-	+	+	+	+
	Ethyl acetate	+	+	+	+	+
	Acetone	+	+	+	+	+
	Methanol	+	+	+	+	+
Baltospermum	Petroleum ether (60-80°C)	-	+	+	+	+
	Hexane	-	-	-	-	-
	Chlorform	-	-	-	-	-
	Ethyl acetate	-	-	-	-	-
	Acetone	-	+	+	+	+
	Methanol	-	+	+	+	+
Sida	Petroleum ether (60-80°C)	-	-	-	-	-
	Hexane	-	-	-	-	-
	Chloroform	-	-	-	-	-
	Ethyl acetate	-	-	-	-	-
	Acetone	+	+	+	-	+
	Methanol	-	+	+	-	-
Naravelia	Petroleum ether (60-80°C)	-	+	+	+	+
	Hexane	-	+	+	+	+
	Chloroform	-	-	-	-	-
	Ethyle acetate	-	-	-	-	-
	Acetone	-	+	+	-	-
	Methanol	-	+	+	+	+
Barleria	Petroleum ether (60-80°C)	-	-	-	-	-
	Hexane	-	-	-	-	-
	Chloroform	-	-	-	-	-
	Ethyle acetate	-	+	+	+	+
	Acetone	-	+	+	-	-
	Methanol	-	+	+	-	-
Piper	Petroleum ether (60-80°C)	-	+	+	+	+
	Hexane	-	+	+	+	+
	Chloroform	-	+	+	-	-
	Ethyle acetate	-	+	+	+	+
	Acetone	+	+	+	+	+
	Methanol	+	+	+	+	+

'-' absent
'+' present

extracts. In *Sida*, the test was positive only in Acetone and Methanol extracts. Except in Chloroform and Ethylacetate, *Naravelia* also gave positive tests for alakaloids with Dragendorffs and Wagners reagents. Ethylacetate, Acetone and Methanol extracts of *Barleria* gave positive results with Dragendorffs reagent. In *Piper* all the solvent extracts gave positive results for alkaloids in almost all the reagents.

Among the 6 species, *Piper* and *Desmodium* responded well to the tests and confirmed the presence of alkaloids.

4.4.7 Thin layer chromatography

Results of the TLC carried out in the wild as well as domestic plants are presented in the following tables crop-wise.

4.4.7.1 *Desmodium velutinum*

Spray reagent: Conc. H_2SO_4

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
8	8	0.33	0.33	Light orange	Light orange
		0.41	0.41	Dark orange	Dark orange
		0.46	0.46	Yellow	Yellow
		0.61	0.61	Light orange	Light orange
		0.65	0.65	Reddish orange	Reddish orange
		0.79	0.79	Light orange	Light orange
		0.88	0.88	Reddish orange	Reddish orange
		0.93	0.93	Dark blue	Dark blue

Spray reagent : Dragendorffs reagent followed by Sodium nitrite 5%

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
		0.20	0.20	Light orange	Light orange
		0.30	0.30	Light orange	Light orange
9	9	0.39	0.36	Light orange	Light orange
		0.42	0.42	Light orange	Light orange
		0.47	0.47	Dark orange	Dark orange
		0.61	0.61	Dark orange	Dark orange
		0.66	0.66	Yellow	Yellow
		0.78	0.78	Light yellow	Light yellow
		0.86	0.84	Yellow	Yellow

Spray reagent: Carr-price reagent

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
1	1	0.92	0.92	Purple	Purple

From the above three tables it is clear that in the wild and domestic plants the number of spots and pattern of spot development did not vary in the three reagents (Plate 11, Fig.16).

Development with Conc. H_2SO_4 produced eight distinct spots, seven of which were different shades of yellow or orange and the last spot (Rf = 0.93) blue in colour. Out of the eight spots the one with Rf = 0.65 was the most intense one and this could be the major component. The blue coloured spot with Rf = 0.93 could be a terpenoid and the remaining seven phenols, alkaloids etc.

Spraying with Dragondorffs reagent followed by Sodium nitrite (5%) resulted in nine distinct spots of yellow or orange. This is a confirmatory test for alkaloids and these nine spots could be alkaloids. Out of the nine alkaloids the one

with Rf = 0.66, was the most intense and large spot and hence this could be the major alkaloid.

After spraying with the Carr-price reagent, only one purple spot with Rf = 0.92 was visible. This along with the result of H_2SO_4 confirms that it is a terpenoid.

An overall assessment of the results indicates that *Desmodium velutinum* contains nine alkaloids and one terpenoid. The major alkaloid was with the Rf = 0.66. The number of alkaloids/terpenoids did not vary in the wild and domestic plants.

4.4.7.2 *Baliospermum solanifolium*

Spray reagent: Conc. H_2SO_4

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
5	5	0.35	0.35	Dark brown	Dark brown
		0.53	0.53	Faint brown	Faint brown
		0.57	0.57	Fain brown	Faint brown
		0.72	0.72	Lilac	Lilac
		0.96	0.96	Dark brown	Dark brown

Spray reagent: Dragendorffs reagent followed by 5% Sodium nitrite

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
3	3	0.36	0.36	Yellow	Yellow
		0.93	0.93	Yellow	Yellow
		0.97	0.97	Light yellow	Light yellow

Spray reagent: Carr-price reagent

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
1	1	0.72	0.72	Purple	Purple

A perusal of the three tables indicates that the wild and domestic plants had the same number of spots in all the three reagents.

In the conc. H_2SO_4 spray five components were detected and except for the spot of Rf = 0.72 (lilac) all other were brown in colour. Spot with the Rf = 0.35 was very prominent and it was clearly evident from the chromatogram that the wild plants contained maximum quantity of this component compared to the domestic plants (Plate 11, Fig.16). The lilac spot with Rf = 0.72 could be a terpenoid.

Spray with Dragendorffs reagent followed by Sodium nitrite produced three yellow spots, first and last of which (Rf : 0.36 and 0.97) coincided with the spots obtained in conc. H_2SO_4 spray. These three could be alkaloids. Colour intensity was very high in the wild compared to domestic plants.

Only one compound was detected in the chromotogram developed with the Carr-price reagent. It was purple in colour with an Rf = 0.72 and it clearly coincided with the 4th spot in conc. H_2SO_4 spray. Hence this could be a terpenoid.

The above results point to the fact that the *Baliospermum* roots contains three alkaloids and one terpenoid. The major alkaloid could be the compound with Rf = 0.36 and its content appeared to be high in the wild plants.

Plate 11. Thin Layer Chromatogram (TLC) of the wild and domestic plants

11a TLC of *Desmodium* showing alkaloids
11b TLC of *Baliospermum* showing alkaloids
11c TLC of *Sida* showing alkaloids and terpenoids
11d TLC of *Sida* showing alkaloids
11e TLC of *Piper* showing alkaloids

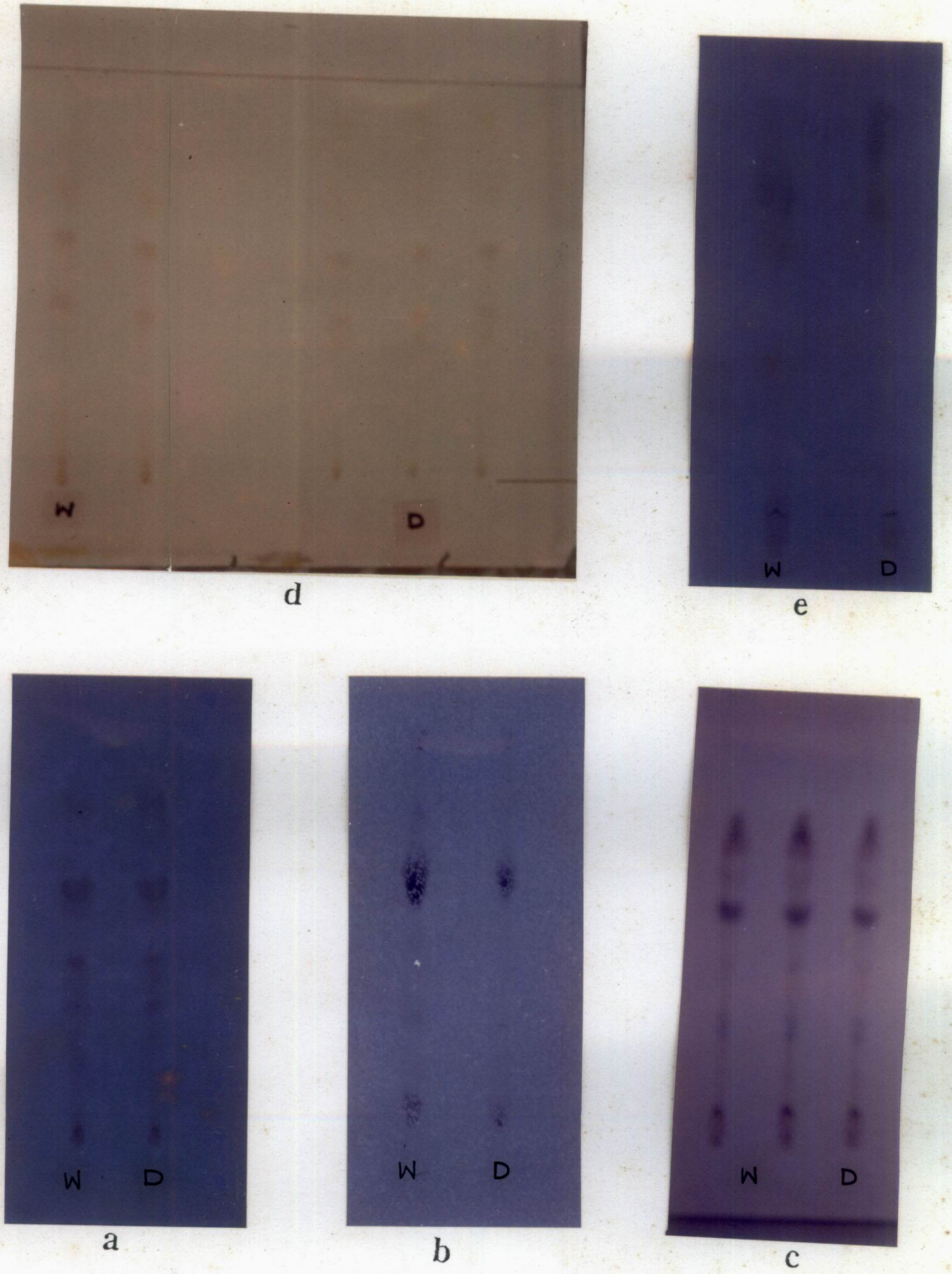


Plate 11. TLC of the wild and domestic plants

4.4.7.3 *Sida rhombifolia* ssp. *retusa*

Developing reagent: Conc. H_2SO_4

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
6	8	0.17	0.17	Light brown	Light brown
		0.45	0.35	Dark blue	Dark blue
		ab	0.48	ab	Light blue
		ab	0.61	ab	Yellow
		0.70	0.70	Lilac	Lilac
		0.83	0.83	Yellow	Yellow
		0.93	0.93	Yellow	Yellow
		0.98	0.98	Dark brown	Dark brown

ab - absent

Developing reagent: Dragendorffs reagent followed by 5% Sodium nitrite

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
2	2	0.68	0.17	Light yellow	Light yellow
		0.88	0.93	Dark yellow	Light yellow

Spray reagent: Carr-price reagent

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
2	3	0.35	0.35	Purple	Purple
		ab	0.48	ab	Light pink
		0.70	0.70	Pink	Dark pink

From the above said results of the TLC it could be inferred that there was difference in the qualitative components in the wild and domestic plants.

There were only six components in the wild plants upon development with conc. H_2SO_4 whereas there were eight in the domestic plants. Those of Rf = 0.48 and 0.61 were absent in the wild plants. All other components were the same with respect to the Rf as well as the intensity of colour. There were three lilac/blue spots (Rf = 0.35, 0.48 and 0.70) and these probably could be terpenoids (Plate 11, Fig.16).

Development with Dragendorffs reagent produced entirely different results for the wild and domestic plants. In both, two yellow components could be detected but these were with different Rf values indicating that they were different alkaloids. In the domestic plants these coincided with the components in the H_2SO_4 spray. In the wild plants it was not so and instead two other alkaloids could be detected (Plate 11, Fig.16).

Reaction with Carr-price reagent confirmed the presence of terpenoids, three in the domestic samples and two in the wild plants.

It may be concluded that there was difference in quality of the *Sida* roots from the forest as well as the domestic environment with respect to number of alkaloids, terpenoids etc. The domestic plants indicated the presence of two alkaloids of Rf = 0.17 and 0.93 and three terpenoids where as the wild plants contained two other alkaloids of Rf = 0.68 and 0.88 and only two terpenoids.

4.4.7.4 *Piper longum*

Spray reagent : Conc. H_2SO_4

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
5	5	0.12	0.12	Light brown	Light brown
		0.49	0.49	Light brown	Light brown
		0.61	0.61	Light brown	Light brown
		0.89	0.89	Light brown	Light brown
		0.98	0.98	Dark brown	Dark brown

Spray reagent : Dragendorffs reagent followed by Sodium nitrite (5%)

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
4	4	0.16	0.16	Light yellow	Light yellow
		0.34	0.34	Light yellow	Light yellow
		0.40	0.40	Light yellow	Light yellow
		0.77	0.62	Dark yellow	Dark yellow

Spray reagent : Carr-price reagent

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
3	3	0.11	0.11	Brown	Brown
		0.76	0.76	Orange	Orange
		0.83	0.83	Green	Green

Results point out that the wild and domestic plants of *Piper* differed in their quality components like alkaloids, terpenoids etc. five components were detected in the H_2SO_4 spray both in wild and domestic plants.

In the test for alkaloids four alkaloids could be detected in the chromatogram but the last one was different in the wild and domestic plants. In wild it was with an Rf = 0.77 and domestic with an Rf of 0.62 (Plate 11, Fig.16).

Three terpenoids also made their presence on developing the plate with the Carr-price reagent.

Since the extracts contained parts of stem also there was interference of chlorophyll in the chromatogram and hence column chromatography was carried out with Silica gel using Methanol extract of the sample.

Results of TLC of the column fractions

Pet - ether fraction

Reagent : Dragendorffs reagent with Sodium nitrite 5%

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
3	3	0.31 0.39 0.49	0.39 0.49 0.63	Yellow Yellow Yellow	Yellow Yellow Yellow

Methanol fraction

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
1	1	0.44	0.44	Yellow	Yellow

In the Pet-ether fraction three alkaloids could be detected in the wild as well as domestic plants out of which two were the same and one was different. In

the Methanol fraction only one alkaloid was detected. It was the same in both samples.

It could be inferred that in the chlorophyll free extract also there were four alkaloids. But the Rf values did not tally with the previous results of TLC.

4.4.7.5 *Naravelia zeylanica*

Both the roots and whole plant were analysed separately.

Reagent: Conc. H_2SO_4

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
Root					
7	7	0.23	0.23	Brown	Brown
		0.28	0.28	Brown	Brown
		0.34	0.34	Brown	Brown
		0.39	0.39	Dark brown	Dark brown
		0.63	0.63	Brown	Brown
		0.88	0.88	Dark brown	Dark brown
		0.96	0.96	Brown	Brown
Whole plant					
2	2	0.39	0.39	Brown	Brown
		0.63	0.63	Brown	Brown

Spray reagent: Dragendorffs reagent followed by 5% Sodium nitrite

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
Root					
4	4	0.15	0.15	Light brown	Light brown
		0.33	0.33	Light brown	Light brown
		0.58	0.58	Light brown	Light brown
		0.85	0.85	Yellow	Yellow
Whole plant					
1	1	0.33	0.33	Yellow	Yellow

Spraying reagent: Carr-price reagent

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
Root					
4	4	0.12	0.12	Brown	Brown
		0.43	0.43	Brown	Brown
		0.69	0.69	Brown	Brown
		0.80	0.80	Brown	Brown
Whole plant					
2	2	0.78	0.78	Green	Green
		0.95	0.95	Green	Green

Results reveal that both wild and domestic plants of *Naravelia* did not show any variation in the qualitative components like alkaloids, terpenoids etc. Four alkaloids and four terpenoids could be detected in the root while only one alkaloid and two terpenoids were detected in whole plant samples (Fig.16).

4.4.7.6 *Barleria prattensis*

Spray reagent: Conc. H_2SO_4

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
7	7	0.05	0.05	Deep purple	Deep purple
		0.13	0.13	Light blue	Light blue
		0.18	0.18	Light blue	Light blue
		0.38	0.38	Brown	Brown
		0.61	0.61	Brown	Brown
		0.74	0.74	Brown	Brown
		0.82	0.82	Brown	Brown

Spray reagent: Dragendorffs reagent followed by 5% Sodium nitrite

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
7	10	0.05	0.05	Dark red	Dark red
		0.10	0.10	Light brown	Light brown
		0.15	0.15	Light brown	Light brown
		0.48	0.36	Light brown	Light brown
		0.55	0.45	Light brown	Light brown
		0.68	0.52	Light brown	Light brown
		0.88	0.59	Light brown	Dark brown
			0.68	Light brown	
			0.78	Dark brown	
			0.88	Light brown	

Spraying reagent: Carr-price reagent

No. of spots		Rf value		Colour of the spot	
Wild	Domestic	Wild	Domestic	Wild	Domestic
2	2	0.05	0.05	Dark red	Dark red
		0.93	0.93	Faint brown	Faint brown

Detection of iridoids

Solvent system	Rf value/colour of spot			
	Carr-price reagent		Anisaldehyde H_2SO_4	
Isopropanol: water	0.75	Blue fluorescence oval spot	0.72	Orange flourescence oval spot
BAW	0.13	Blue fluorescence oval spot with a tail	0.13	Orange fluorescence oval spot

The wild and domestic plants of *Barleria* differed with respect to the number of alkaloids. There was an anthocyanin group of pigment in all the samples (Rf = 0.05). Seven alkaloids could be detected in the wild plants while there were

10 in the domestic plants. Rf values also differed with respect to two alkaloids (Fig.16). There were only two terpenoids in both the samples.

Another component detected was an iridoid and it could be detected in both the samples (Fig.16).

Discussion

DISCUSSION

Results of the four experiments of the project 'Habit and habitat analysis of select medicinal plants in native and domestic environments' are discussed in this chapter. First and fourth experiments are discussed separately while second and third are discussed together. A general discussion is given at the end which concludes the chapter.

5.1 Experiment I. Survey of the area

5.1.1 Ethnomedicine

Over 4000 species of vascular plants are found in South India of which nearly 2000 are used in classical health systems as well as in folk medicine traditions followed by thousands of ethnic communities.

In folk medicine, the traditional use of plants is eco-system and ethnic community specific, with each ethnic community having developed its own traditional remedies based on plants and other natural resources found in the surrounding forests (Thayil, 1997b).

In the present study, an attempt has been made to document the ethnomedicines practiced by 'Malayans', the inhabitants of Peechi forests. In spite of their fairly good knowledge on the native medicinal plants, the dependence of the folk on these plants was only partial. In their traditional migratory habits (Iyer, 1987), the surrounding forests might have provided the micro-environment and the natural resources (in the form of plants, animals and minerals) necessary for their typical health needs. But now, the developmental activities have forced them to live in

permanant huts in the forest boundary which naturally is open to all sorts of interventions and perturbations. The over powering intrusion of extraneous cultures practically have wiped out their irreplaceable life style diversity. The vast treasure of indigenous knowledge was some thing precious they had to compromise in the name of development. Only the older generation had some knowledge on the traditional curing practices and that too for minor ailments.

The degradation of the MDFs due to several reasons has led to the distruction and disappearance of many native medicinal plants. Majority of the plants used by this tribe were from the MDFs. Due to their settled nature, collection of plants from the far away semi evergreens is risky. All these factors might have contributed to the partial dependence of the tribe on native medicinal flora.

Ironically, these tribal people by and large do not appear to be aware of the seriousness of the threat, inspite of the fact that there is a custom among them of excercising utmost care in avoiding damage to plants while collecting them. Eventhough some of the elder women expressed their anxieties about the shortage of plants, there is lack of concern about securing long term availability of the plants on which the sustainability of the tradition so critically rests.

Among the list of plants used by this jungle tribe, a few have been accepted widely by the Ayurveda physicians (*Wrightia* for psoriasis, *Entada* seeds for rheumatism etc.) and the properties of some have been clinically proved also (*Holarrhena* seeds for amoebiasis).

The knowledge of Indian people about plants and plant products is based on a sophisticated indegenous knowledge category called "Dravya Gun Shastra"

(Thayil, 1997a) and not based on the western catagories of knowledge and approaches like Chemistry and Pharmacology. At present, we lack an accepted methodology to integrate both these approaches. Probably that would be a worth while excercise to establish the utility and efficacy of these plants in therapeutics.

5.1.2 Medicinal flora of Peechi hills

The moist deciduous and semi evergreen forests harboured 226 medicinal plants which were spread over 73 families (Table 3, Fig.2). The preponderance of the families Euphorbiaceae and Acanthaceae could probably be explained to their evolutionary preferance to comparatively dry and stressed habitats. This patch of forests are continuously subjected to disturbances which might have led to the dominance of these families which have developed adaptive mechanisms to the stresses. An excercise to find out the dominant families of South Indian medicinal plants also revealed the dominance of Fabaceae and Euphorbiaceae (Shankar *et al.*, 1997).

What makes a plant medicinal is the unique quality it possesses. Components which impart quality are synthesized in different organs, and in certain plants it may be translocated from the site of synthesis for accumulation elsewhere. It may either be concentrated in certain organs or be distributed uniformely through out the plant. The habit - habitat interactions probably, may play an important role in the formation and accumulation of these medicinal principles. Fig.3 shows the part used in different plants to be different. In majority, it was the roots followed by stem bark and then the whole plant. Apart from the primary functions, in many species roots have special functions which are advantageous to the plants. Synthesis of alkaloids and other substances of therapeutic value in several medicinal plants is

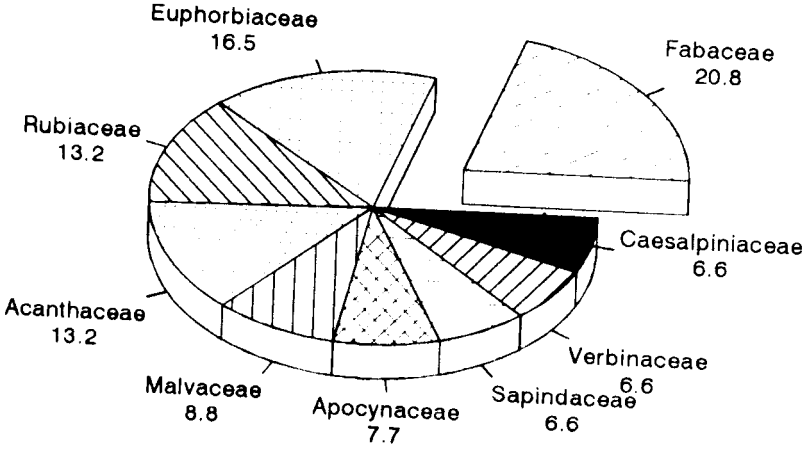


Fig.2. Major families of distribution of medicinal plants

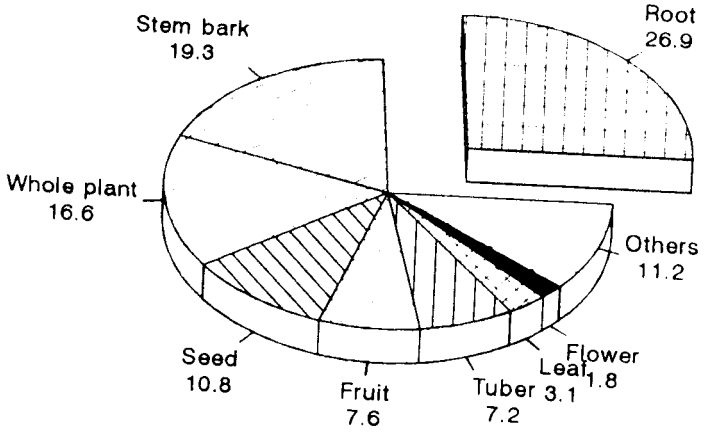


Fig.3. Categorisation of medicinal plants by part used

one among them (Salam and Wahid, 1993). Various treatise in Ayurveda also enlist roots to be the medicinal part used in majority of the plants.

There exists many controversial drugs in Ayurveda. Lack of proper botanical identity, use of different local names for the same plant etc. only add to their ambiguity. In the ancient health traditions, the practice was to utilise the locally available plants. India, being an epitome of diverse climates and ecosystems, it may be possible that genetically related plants growing in similar ecosystems possess more or less similar properties. In Kerala there are about 16 plants used as the source of the drug "Sahachara" or "Kurinji" and the physicians in different parts of Kerala are quite confident about the genuinity of the drug used by them. When Ayurveda became centralised, drugs needed to be collected in plenty which naturally led to the mixture of different plants as the source of the same drug.

In the present study, there were many plants extracted as the source of 'Sahachara', but *Nilgirianthus ciliatus*, an SEG species constituted the major source of "Karimkurinjii". *Strobilanthus asperrimus*, the species used widely in the southern districts was abundant in the forests, but the tribes were totally unaware of its medicinal properties. The MDF herb, *Barleria prattensis* was collected and sold as "Madhurakurinji". It is in the Badagara region of North Kerala that this plant is used as the source of 'Sahachara'.

Similarly, the generally accepted source of 'Orila' or 'Prsniparni' is *Desmodium gangeticum* in India and Kerala. This species is not at all present in Peechi. *Desmodium velutinum* which is abundant here is extracted instead.

Dispute about the source of these two drugs have been pointed out by Sivarajan and Balachandran (1994) also. Vaidya (1982) has given a list of controversial drugs in Indian medicine. Bhat and Nesamony (1992) have reported about the use of *Balanophora fungosa* ssp. indica as the source of 'gajapippali' by Kerala physicians, whereas *Scindapsus officinalis* is considered as the source plant in various ayurvedic nighantus. As stated earlier, an interdisciplinary approach from the botanists, biochemists and pharmacologists would be a feasible solution to clarify these controversies.

In a macrolevel habitat allocation, the MDF accounted for more number of medicinal plants than the SEG (Fig.4). Compared to the MDF, the SEG forests are a more advanced state of forest formation. Nameer (1993) opined that the MDFs, if left undisturbed may become an SEG in course of time. The fully developed non-defoliating canopy of the SEG and the subdued illumination do not permit much undergrowth. The MDF on the other hand are exposed to periodic stresses, both biotic and abiotic and since it allows more light to penetrate inside, the undergrowth is also more. This is also supported by the finding that majority of the MDF species were shrubs, herbs or herbaceous climbers. On the contrary majority of SEG species were trees. At certain pockets, a transition zone existed between the MDF and the SEG and in such areas both the species were seen growing together.

In the ongoing evolutionary process, certain species may get adapted to specialised niches. *Ensete, Malaxis, Bigonia, Costus* and *Curcuma* are rhizomatous fleshy species without a tap root system. All these grow well on the superficial organic matter on the rocks or in the shallow soil in the crevices. These are probably 'drought evaders'. Anatomical peculiarites help them store sufficient water during

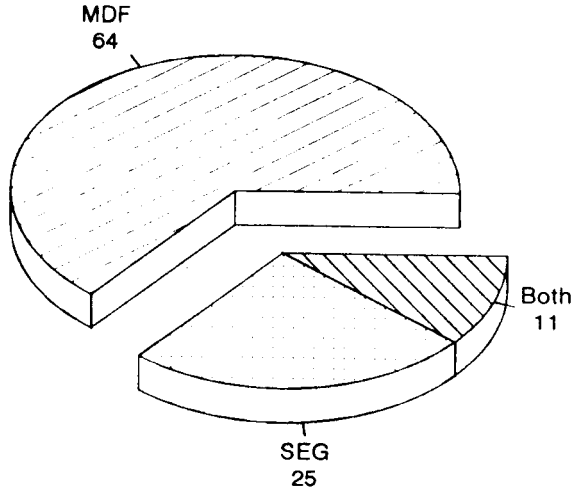


Fig.4. Habitat wise distribution of medicinal plants

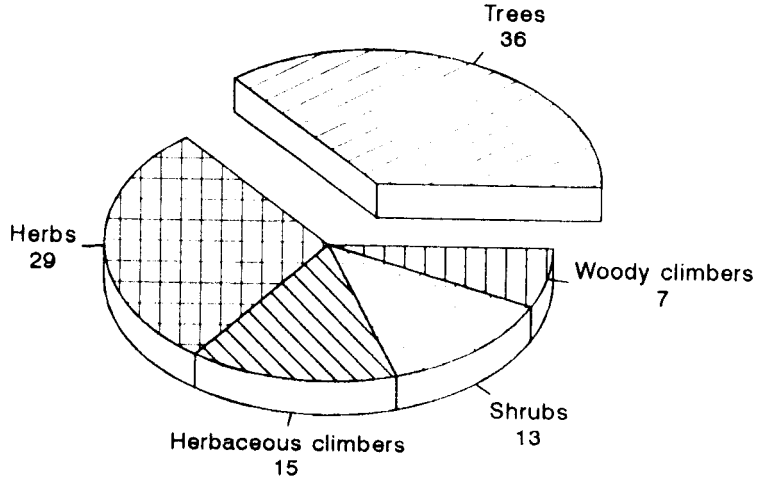


Fig.5. Habit wise distribution of medicinal plants

rains for use in the lean season. There may be other ecological reasons also for the spatial isolation of these vegetatively propagated fragile species.

Embelia tsjeriam-cottam is a plant with a sturdy tap root which could even penetrate light rocks.

The natural tendancy of the creepers to grow downwards upon gravitational pull was evident in the luxuriant growth of *Piper longum* on slopes. Abundance of *Piper longum* in the borders of streams has also been reported by Viswanathan (1995).

The endemic flora in Kerala is a palaeotropic one, a part of the peninsular Indian endemic flora of the Gondwana land region (Nayar, 1997). Twenty two endemic medicinal plants are reported to occur in Peechi hills (Table 4). Various floristic surveys conducted in Western Ghats have listed these species as endemics (Nayar, 1997). The reasons for high percentage of endemism in Western Ghats have been reported to be due to a multiple of physical, climatological and geological changes that have occurred during the evolution of the flora as well as peninsular Indian region (Sastry and Sharma, 1991).

Endemic species once lost is lost for ever and hence these species need to be conserved on a priority basis.

Many authors have described the present era as an era of species extinctions. International Union for Conservation of Nature and Natural resources (IUCN) recognised five status catagories of rare plants (Maheswari, 1977) as endangered, rare, depleted and indeterminate. The word "threatened" has been used for either rare or depleted species.

In the regional assessment in Peechi hills, 25 medicinal plants were found to be either rare, endangered or threatened (Table 5). Each species has got its own specific reasons for the specific status. As pointed out by Swarupanandan (1991), the causes of rarity may be evolutionary status of the species, its reproductive in-efficiency, shrinkage of ecological niches, anthropogenic reasons or paucity of studies. Strict compartmentalization of the cause is not possible as one kind may be triggering or leading to the other.

Major reasons behind the RET status of these species are over exploitation in the case of *Rauvolfia, Holostemma, Saraca, Trichosanthes, Asparagus, Coscinium, Nervilia, Adenia, Pseudarthria* and *Symplocos* and destructive harvesting in the case of *Canarium, Cinnamomum, Persea, Myristica, Phyllanthus emblica* and *Acacia concinna.*

The big spurt in the manufacture of indigenous medicines especially during the last decade, has also increased the demand of various drug plants. *Rauvolfia* is an example and now the export of *Rauvolfia* is restricted or banned by the Government of India inorder to prevent further genetic erosion (Amalraj *et al.*, 1991).

Among the RET species, except *Coscinium* all are MDF species. As discussed earlier, the MDF in this tract are subjected to all sorts of perturbations. Apart from the climatic changes, anthropogenic problems like entry of non-tribals for plant extraction, recurrent forest fires, cattle grazing, charcoal making, illicit cutting of wood for props, spread of alien weeds etc. have led to clearance of the

forest; disturbing the natural habitat of many species. This, coupled with the over collection of the survivors might have contributed to the rarity of these species.

Coscinium fenestratum, a woody climber of the SEG is said to have a long pre-bearing period. The plant is found to regenerate asexually also. However, due to its over exploitation even the young vines are being cut away without allowing it to mature for sexual or asexual reproduction. In their exhaustive floristic survey conducted in Thrissur forest division, Sasidharan and Sivarajan (1996) could not locate flower bearing plants in this species. It is in high demand in the market and if the plant continues to be extracted like this it is quite certain to become exinct.

The delicate ground orchid, *Nervilia aragoana* would be another species which may suffer from the habitat changes without being able to tide over it.

Regeneration of tuberous plants like *Adenia, Asparagus, Holostemma* etc. were well ensured by the tribes by leaving a portion of the tuber unharvested. However, younger generation of the tribes as well as the non-tribal drug collectors do not seen to care this aspect very much.

Steep increase in demand for *Acacia concinna, Adenia hondala* and *Persea macrantha* for non-medicinal uses might be another reason for their rarity.

Recent reports by Amalraj *et al.*, (1991), Sasidharan (1991), Sudhadevi (1992), Kumar and Bhandari (1994), Bhadula *et al.* (1996) and Shankar *et al.* (1997) also highlighted the reasons for the rarity of many medicinal plants including some of the species mentioned in the present study.

Loss of diversity has implications beyond the extinction of species. As species disappear, the intricate links between species - their biological and behavioural associations are sundered. We cannot replicate the complex dynamic natural milieu for any species and without the natural complex of interactive environmental conditions, the evolution of the species would not continue in the normal course.

Not all the medicinal plants of Peechi hills are extracted by the tribes. Only 43 are collected regularly (Table 6). The major factor which decides what to be extracted is market demand. As and when there is order for a particular drug, it is collected. For the past few years there has been high demand for *Adenia, Persea* and *Acacia concinna* and these are the ones extracted in maximum quantities from Peechi hills for the last 2-3 years. A recent study by the Kerala Forest Research Institute at Peechi in the monitoring of MFPs from Peechi forests supports this (Anil *et al.*, 1996).

A record of the flowering and extraction period of the major species was made (Table 6). Almost all the annuals flowered during October-January after attaining sufficient vegetative growth. It was obvious that the flowering and extraction periods of most of the species coincided, without giving time for seed development for the regeneration.

July-December period coincided with the peak time of extraction of roots and whole plants and the reason is evidently the wet and loose soil during the period and hence the easyness in pulling out the roots. Stem and root barks are extracted during sunny periods for quick drying. The resin yield of *Canarium* is high during

summer, however, the tree is tapped year round. Shallow rooters like *Adenia*, *Ipomoea mauritiana* and *Malaxis* are also harvested throughout the year.

Destructive harvesting was observed in certain drugs which led to low quality drugs besides making the regeneration of the plants difficult. All these plants have either become rare, endangered or threatened due to the unscientific extraction practices.

After the appropriate processing methods, the produces are packed in their traditional artistic ways and taken to market.

After all these efforts, when the produce reaches the market (Thrissur), its value is decided only based on the weight and not the worth. The whole risk behind the process of extraction, man hours spent, distance travelled, the energy expended and the genuinity and quality of the drug are factors which never get consideration. Even though the trade involves no middle men, they never get a reasonable price for the effort, what so ever. Acacia pods, Coscinium vines, Holostemma tubers and Canarium resin (black dammer) are a few, which fetch them a some what reasonable price. Often, these people who lack the bargaining capacity are forced to sell their produce at damn cheap rates. A recent study conducted among 'Malayans' by the KFRI, Peechi has also come to similar conclusions (Anil *et al.*, 1996).

As discussed earlier, controversy over certain drugs regarding its source has led to the practice of substitution/adulteration (Table 7). It may be possible that plants of the same genus or family found in a habitat possess similar properties so that they may be substituted. But mixing of genetically distant plants with only

171255

similarity in physical appearance can be viewed with scepticism only. Entry of the non-tribal population for collection of drugs and the willingness of market to accept spurious drugs also favours adulteration. Adulteration of *Saraca asoca* with *Polyalthia longifolia, Shorea robusta* etc. and substitution of *Berberis aristata* with *Coscinium fenestratum* have been reported by Vaidya (1982). Nambiar *et al.* (1985) have cautioned about the use of various species of *Sida*, a drug which is consumed in maximum quantity by the South Indian Pharmacies. Even though it is not proper to confirm the genuinity of a drug only based on physical observations, at least in a few cases, deliberate adulteration is suspected. Probably only pharmacological studies can prove it.

5.2 Experiment II and III - Natural and domestic environment analysis

Results of the natural and domestic environment analysis are combined and a common, species-wise dicussion is attempted.

5.2.1 General habit

The selection of species was such that they represent all habits and organs used in medicine.

On the basis of physical appearance, the select spp. fall into four catagories as

1. herb - *Barleria, Sida, Baliospermum*
2. shrub - *Desmodium*
3. climber - *Naravelia*
4. creeper - *Piper*

KERALA AGRICULTURAL UNIVERSITY
THRISSUR
680 654

Grouping of these species based on the part used in medicine will be as

1. root - *Desmodium, Barleria, Sida*
2. storage root - *Baliospermum*
3. stem and root - *Piper*
4. whole plant - *Naravelia*

Density, abundance and percentage frequency values of these species are given in Table 10. The creeper *Piper* was the most dispersed among the six. Though less dense, the climber *Naravelia* was also evenly distributed through out the forest. Capacity to explore far and high for the resources by virtue of their creeping and climbing habits probably would have made their distribution even. Another reason may be the comparatively lesser extent of extraction of these two species. Among the herbs, *Sida* and *Baliospermum* were moderately dispersed and *Barleria* was the least dispersed species. *Sida*, well known for its abundant growth in marginal lands naturally is a more adaptable species and *Baliospirmum*, with its long storage roots probably might have adapted to the varying situations, to some extent. On the other hand, *Barleria* with its shallow, fibrous root system and soft stem may be more specific in its requirements. The only shrub, *Desmodium*, with a woody stem and a sturdy penetrating root system had a higher even distribution than the herbs.

In terms of numerical strength, however, *Piper* was the most abundant species. As discussed earlier fast growing nature, rapid vegetative regeneration and comparatively lesser extent of extraction may be some of the important factors contributing to its high density.

Habit of a plant includes its morphological and physiological development, environmental adaptations, longevity, quality aspects etc. More simply it is the result of genotype + environment.

The adaptations of a plant include all the physical and biochemical mechanisms of the plant inorder to acquire the resources it needs from the environment, to transform these resources into useful products and to full fill other necessities of life such as growth and reproduction. Other adaptions may improve the survival of the plant in other ways such as conferring resistance to physical stresses through various biochemical or behavioural adaptations or by protecting the plant through different defence machanisms.

All these adaptions are species specific which ultimately decides its habit. The species puts each effort to maintain its uniformity in structure, function, reproduction, growth and development, by preservation of its genetic pool. However, species may exhibit 'plastic' response to get itself adjusted structurally and physiologically to the changing environment (Franz, 1981).

In the present study, although the test species exhibited a more or less uniform physical habit throughout the forest, in each habitat there were differences. It would be discussed in detail in the species-wise discussion. However, certain very general observations could be made irrespective of the habitat and they are discussed here under:

Duration or longevity of the species is one among them. As the pre-monsoon showers were early, all the species sprouted in April itself and the growth rate was linear in all the species upto November (Appendices 1-6) after which it

declined. In the domestic crop however, strictly linear growth pattern was observed upto January (Appendix 7). The deciduous habit of the forest, preferably evolved as a drought avoidance mechanism and the resultant leaf shedding during summer months, the strong winds to which the tract is exposed to after November (Table 1), higher amount of solar radiation, water stress etc. offer a plausible explanation for this arrest of active growth of the under growth after November. Drastic reduction in the number of branches, leaves and total leaf area were observed which might end up in reduced rate of carbohydrate synthesis.

On the other hand all the resources were in plenty throught out in the domestic field so that plants could grow uninterrupted resulting in a strictly linear growth pattern for a longer period.

With respect to flowering also, a general trend could be observed. The forest plants started flowering in October and it was prolonged upto January depending upon the habitat. Moisture stress is one of the factors which favour the initiation of flowering. Also, by flowering early, fruiting, seeding and dispersal would occur during the summer months itself. Gopakumar (1994) has opined that the peak flowering of few tropical trees in summer may be an adaptive mechanism to avoid risking flowers in rain and thereby losing in competition. This, along with other stresses might have contributed to the early deferentiation into the reproductive phase in the natural habitat.

In the domestic crop, however, amidst the comparatively plentiful resources, flowering was little late, but synchromised. The specificities of flowering in each species would be discussed later.

5.2.2 Habitat analysis

Habit and habitat influence each other and it is often difficult to partition the two. However, in the following paragraphs, the habitat-wise performance of the test species is discussed taking into account their performance in the natural as well as domestic environments.

5.2.2.1 *Piper longum*

Being the most widely dispersed species, it was present in all the habitats and the pattern of growth differed with the habitat (Table 13). A striking observation was its viny non-branching growth habit in the forest. The plants exhibited a slight branching tendency in three habitats only, where they produced hardly two branches per vine whereas in other habitats it grew single vined. A scrutiny of Table 12 reveals that the available light percentage in different habitats ranged from 23 to 58. Light, being a major factor affecting plant growth, it may be inferred that in the forest, the vines might have spread more in search of light without the production of laterals. The undulating terrain of the natural habitat was also in favour of the downward movement of vines upon the gravitational pull.

In the domestic crop, there were as many as sixteen laterals per vine (Table 27). In comparison to plants growing in shade, those developing in full sun-light usually exhibit shorter internodes and more frequent branching (Sharma, 1996).

The branching habit of this species needs also to be viewed along with the gender differences exhibited by it. Chance extraction of female plants of this dioecious creeper might have resulted in the colonisation of male plants. The higher energy associated with masculinity may be a factor responsible for the

faster growth, regeneration and spread of male vines especially on undulating terrains. All the energy would be utilised for horizontal growth and no energy for vertical growth.

In *Piper peepuloides*, Arora (1983) has reported that intensive collection from the natural habitat has resulted in the imbalance in natural populations of male and female bushes.

In *Piper*, flowers are produced on lateral shoots. In the natural habitat none of the experimental plants flowered, eventhough some of the nearby vines were seen flowering. In the domestic crop however, most of the plants produced flowers, this may be due to the production of more laterals, which later bear the spikes.

'Pippali' is one of the drugs in which high morphological variability is reported (Viswanathan, 1995). 'Kattuthippali', 'Cheruthippali' and 'Thippali' are treated as the same plant now. From the present study it may be concluded that the type found in Peechi forests is an 'ecad'. An ecad of a plant species is a population of individuals which although belong to the same genetic stock, differ markedly in vegetative characters such as size, shape, number of leaves, stems etc. (Sharma, 1996). These variations are simply environmentally induced, and thus are temporary or reversible; ie. one type of 'ecad' may change into another with the change in its habitat.

Coming to the growth pattern of this species in the natural habitat; the performance varied at different sites. When the habitats KP-1, KP-2, KC-1, KC-2, M-1 and AK recorded good vegetative growth, the root yield was better only in KC-1, AK and KC-2 (Table 14). Both the environmental and soil characteristics

would have influenced the top and root growth. In the habitats KP-1 and KP-2, the above ground growth was good, but the root production was low resulting in a low dry matter production. The light intensity in these habitats was around 23 per cent only which might be the major limiting factor for carbohydrate synthesis and then for its utilisation in the root formation. In general, the soil condition was good in these habitats (Table 11). The reduced root production may also be due to ultimate factors apart from the well established proximate factors. In the habitat KC-2, the total dry matter production was high because of more laterals, leaves and total leaf area, but the root yield was not high giving a lower root : shoot ratio compared to KC-1 and AK. One factor contributing to the low yield may be the rockiness of this habitat. Deletang (1973) have noticed growth restrictions imposed by hard pans in tobacco. In terms of root yield, KC-1 and AK recorded highest values. The available light percentage, moisture content, organic carbon content, litter cover, canopy cover and other vegetation characters of these two were entirely different as is evident from the Tables 8, 11 and 12. Light availability was low in KC-1 (30%) whereas it was high (50%) in AK. All other parameters recorded high values in KC-1. Population of *Piper* was high in AK resulting in intra species competition whereas in KC-1 the herb and shrub diversity and number were more resulting in inter species competition. Another significant factor was that AK was burnt during previous season's fire. Since the fires are almost a recurring phenomena here, the plants might have adjusted to it and it has been reported that species that fortunately survive fires generally increase in abundance at the expense of those killed by fires (Sharma, 1996). Some like Lemon grass are even stimulated by fire. The growth analysis values also support the best performance of the species in the habitat KC-1 (Appendix 1).

Ecological factors affecting the growth and development of a species, under natural conditions, operate in conjunction, and not in isolation as they interact one another and it becomes very difficult some times to say as which of the individual factor is actually responsible for the marked effect.

However, considering the parameters other than the quality, it may probably be concluded that at an elevation of around 200 M above MSL, the MDF with gentle slope, without any hard pan with an organic carbon content of around 2.3 per cent, pH of 5.7, sufficient quantities of macro and micro nutrients, 30 per cent light intensity and a moisture content of 14 per cent during summer was an ideal habitat for *Piper longum*.

In the domestic environment the species performed well responding to the added manures and fertilizers and irrigation, enjoying the fully open condition. Physical habit changes were discussed earlier. Both biological and economic yields were slightly high in domestic crop compared to the most ideal habitat KC-1 and very high when compared to general MDF yield (Table 29, Fig.6). The increase in productivity may be attributed to the more or less controlled environmental conditions without any stresses and competition.

A gradation of the habitats based on the performance of the species will be as KC-1 ≋ AK > domestic > KC-2 > M-1 > KP-2 > KP-1 ≋ VK-1 ≋ VK-2 > PNV ≋ M-2.

5.2.2.2 *Naravelia zeylanica*

This herbaceous climber was present in all the natural habitats. Being a

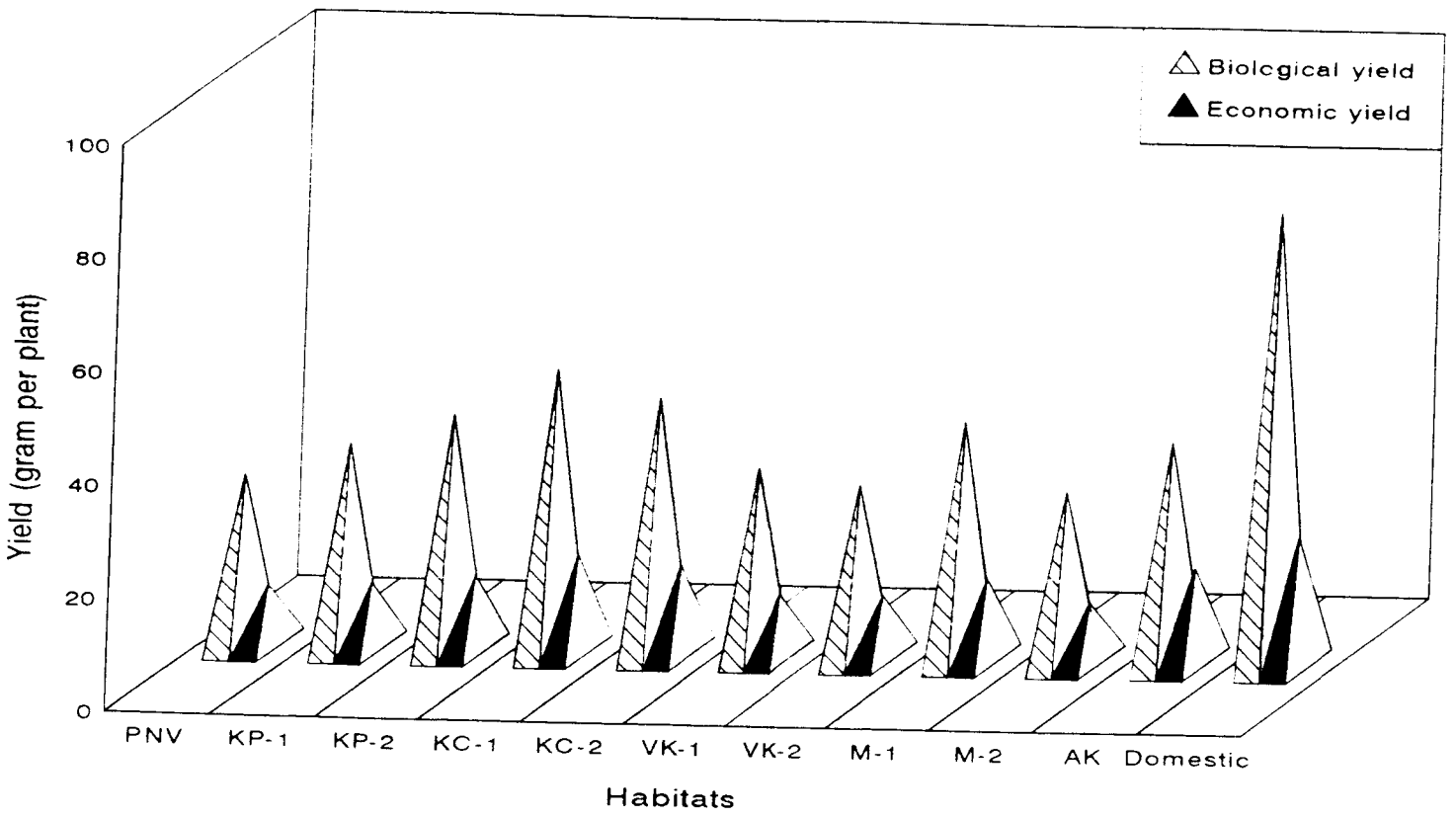


Fig.6. Biological and economic yield of *Piper longum* in the natural and domestic environments

tendril climber, until it gets a firm catch over a support, the plant is subjected to all sorts of physical stresses. Initially the plants were vigorous with long internodes and tendrils to catch hold of a support and many a times the main vine was cut away due to physical stresses. New flushes were formed in such cases and so most of the time the vines appeared young. All the available energy would be utilised for vegetative growth alone for a long period. Only a few plants get a chance to grow uninterrupted to differentiate into the natural course of reproductive phase. It may be noted that none of the experimental plants in the natural habitat flowered.

In the fully open conditions in the domestic environment, the unsupported vines grew uninterrupted, developed sufficient infrastructure to bear flowers, fruits and seeds profusely.

Among the ten habitats, only five (AK, KC-1, M-1, M-2 and VK-1) supported very good growth of this species (Tables 15, 16). Increased initial vigour of this species in the habitat AK which was burnt in the previous season's forest fire may be specially noted. It could be due to the resurgence of the species after the ground fire. Certain MDF species have been found to grow vigorously immediately after fire. It could also be a fire tolerant species like *Piper*. Similar was the situation in another burnt habitat M-2.

Some what uninterrupted growth of this species was observed in KC-1 and M-2 only. The ground vegetation was high in these habitats (Table 8) and that could be a factor responsible for it. It is also supported by the high LGR and CGR values for plant height (Appendix 2). In AK and M-1, ground vegetation was poor and higher values of LGR and CGR for total leaf area was recorded in KC-1 and AK and this resulted in high biological and economic yield in these habitats.

It may also be noted that the habitat M-2 which did not favour the growth of any other species appeared to be good for the growth of this species. It may be because of the fire tolerant nature of this species and its wider adaptability. Similarly in VK-1 with 57 per cent light and 5.03 per cent soil moisture, subjected to all sorts of physical stresses also, the plant's performance was average.

Being a plant valued as such, both shoot and root growth are important in this species. In general, it could be inferred that in the MDF with low intensity of physical stresses the growth of this species was fairly good.

On domestication, the species performed well and completed its life cycle with a strictly linear growth pattern (Tables 27, 28, Fig.7). In spite of the controlled conditions, the productivity was low in the domestic environment especially in the case of root yield, as is evident in the low root : shoot ratio in the forest compared to the domestic crop. The reproductive phase in the domestic crop where large quantities of energy will be consumed and the fire tolerant nature of the species might be factors responsible for the better development of root system in the forest conditions - an adaptive strategy for its very survival.

An observation made by Singh *et al.*,(1993) in field grown tobacco was that topping of the tobacco plants resulted in increased root growth by increase in the dry matter from 20 to 40 per cent. It is also postulated that the apex has some inhibitory action on root growth and removal of the apex release the block for development of roots (Deletang, 1973). Chance for the natural 'topping' is more in the forest and this might be another factor contributing to the higher yield of this climber in the natural habitat.

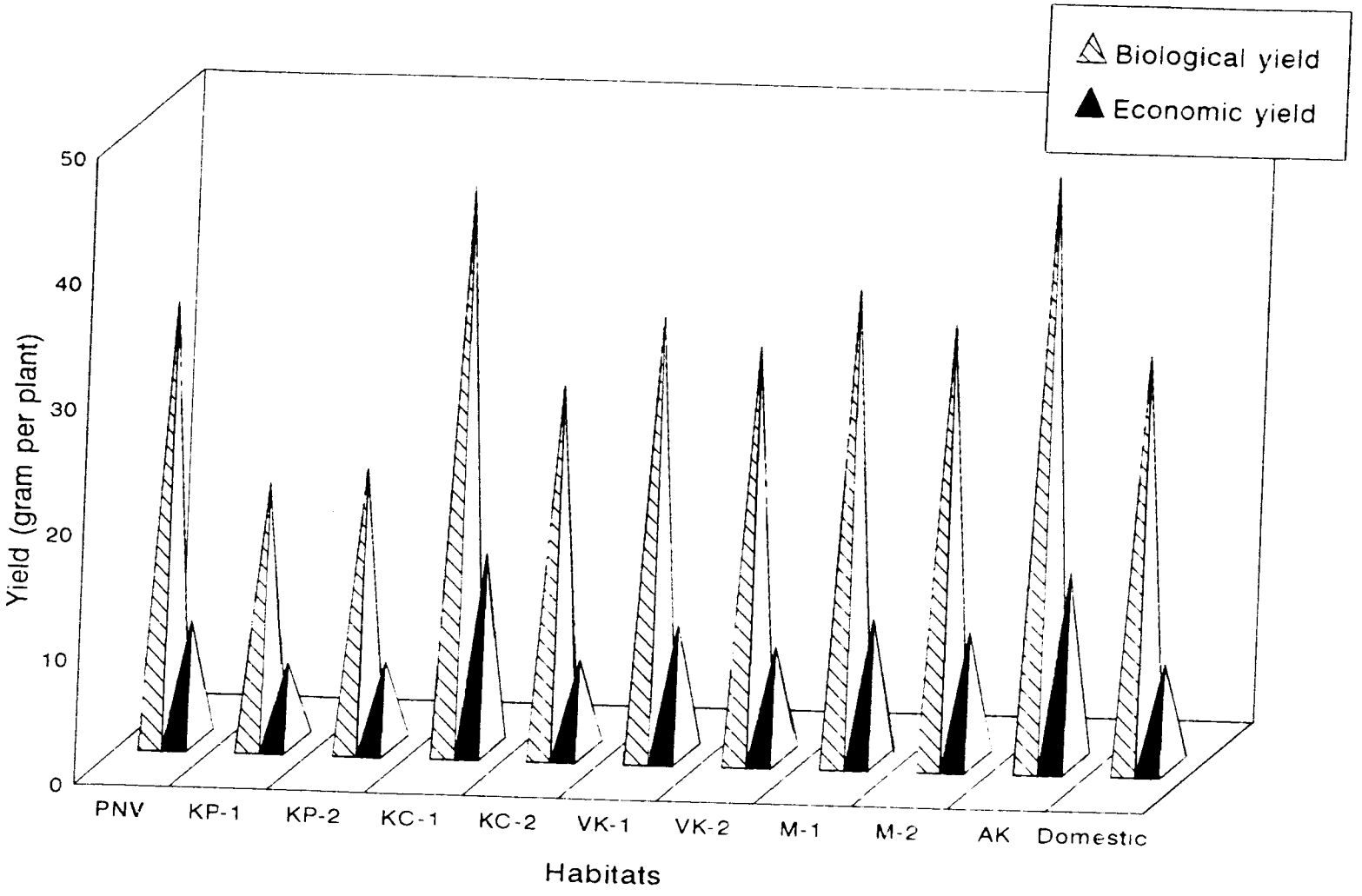


Fig.7. Biological and economic yield of *Naravelia zeylanica* in natural and domestic environments

Gradation of different habitats based on the growth will be as KC-1 ≅ AK > M-1 > M-2 ≅ VK-1 > PNV > VK-2 > KC-2 > KP-1 ≅ KP-2 > domestic.

5.2.2.3 *Sida rhombifolia* ssp. retusa

Well known for its antirheumatic properties, this plant is held in great reputation in Ayurveda. The genus *Sida* comprises of many species, sub-species and ecotypes and different species are used in different parts of the country. The species present in Peechi forests has been identified as *Sida rhombifolia* ssp. retusa.

The population of *Sida* was more on the way to forest than in the interior. In spite of being a profuse seed bearer, the population was very low inside.

In the forest, the five *Sida* habitats were situated in the foraging route of the tribes and in general, the growth was good except in M-2 (Tables 17, 18, Appendix 3). In areas of 30-58 per cent light intensity the crop grew well and the highest yield was in VK-2, the plot with maximum light intensity, low moisture content and maximum disturbances. This habitat was nearer to the settlement also. Plants, in general exhibited a lanky growth with only 4-5 branches and they flowered by September-November.

The root yield was very low in all the habitats as indicated by the low root : shoot ratio. The tap root was strong, but laterals were only few in number. The restricted root system may be due to the surface feeding nature of the species.

The performance of this species in the domestic environment was strikingly different (Tables 27, 28, Fig.8). From a herb, it attained the status of a shrub with woody stem, primary, secondary and tertiary branches and numerous leaves. By December, flowering occurred. Root : shoot ratio was higher than the wild plants. To support the luxuriant top growth, there was a strong tap root with more laterals.

Rooting pattern of this species as studied by Viswanathan (1993) indicated that under field conditions, the root spread was around 15 cm laterally and down to 40 cm vertically from the plant. Average root weight ranged from 5-13 g and the root : shoot ratio was 1:9.7.

At Vellanikkara, Viswanathan (1991) has reported a dry root yield of 437 kg ha^{-1} in *Sida rhombifolia* under fully open condition without any fertilizer application.

That environmental factors could contribute to the change in the status of a species from a herb to shrub is evident here. A slender herb in the MDF grew to a shrub in the domestic field. Taking into view the profuse growth of *Sida* on waterlands and roadsides (Viswanathan, 1993), it would not be an over statement that this early, naturally domesticated species again might have entered the forest by some means and is again getting adapted to the conditions there. Or more precisely this species may be in its route of secondary evolution. Growth analysis and bio-chemical analysis also support this.

Considering all these aspects the gradation of habitats could be as domestic > KC-1 ≋ VK-2 ≋ M-1 ≋ AK > M-2.

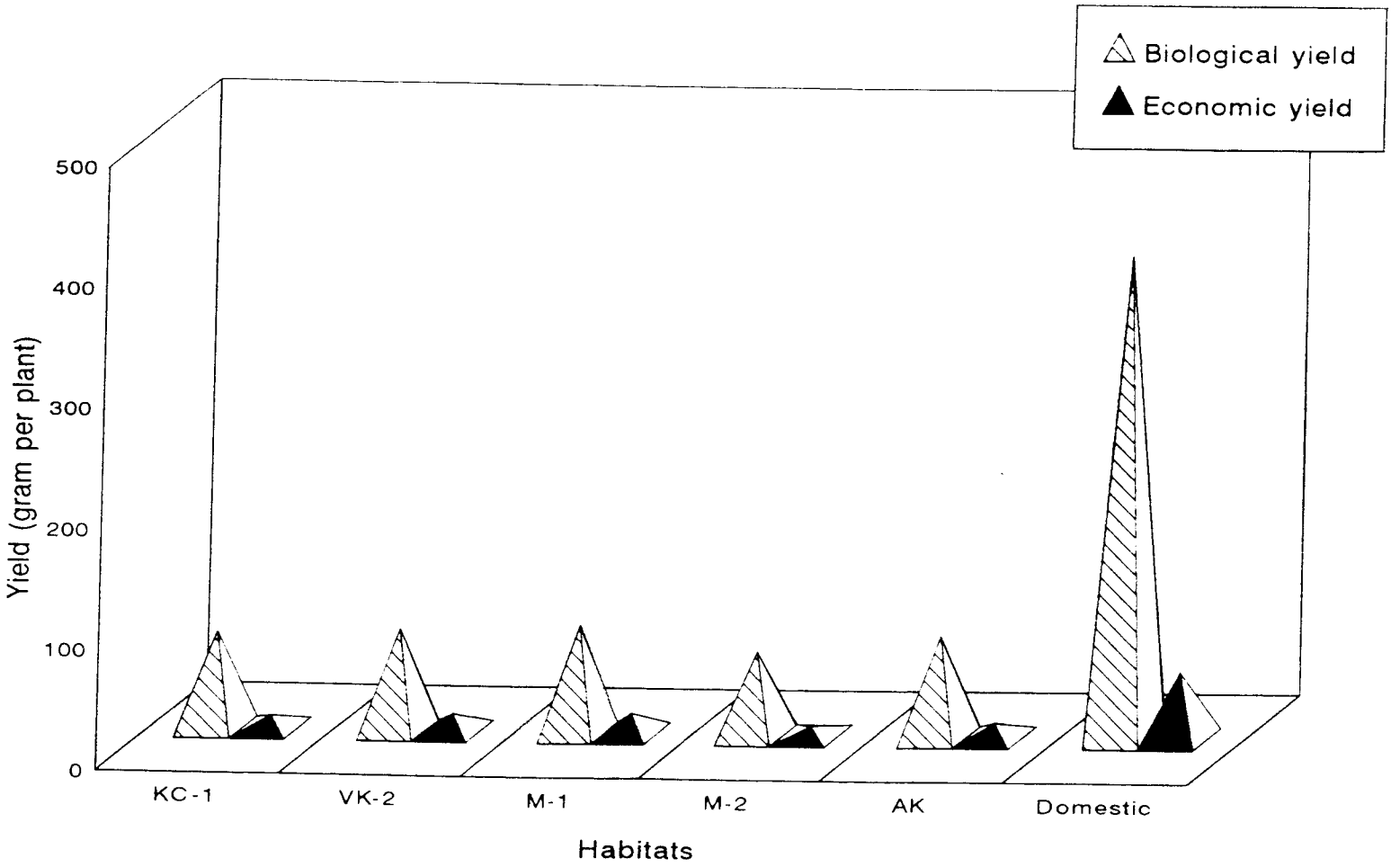


Fig.8. Biological and economic yield of *Sida rhombifolia* spp. retusa in natural and domestic environments

5.2.2.4 *Desmodium velutinum*

"Adharva Veda" states that 'Orila' was the first medicinal plant used by man (Adharva Veda Sooktha 25/2, quoted by Sankunni, 1988). It is one of the members of the "dasamoola" group. Mainly, the roots are used in various medicines.

A shrub by nature, the MDFs harbour a very good population of this species, even though it is not well distributed.

In the present study, six habitats had the natural population of *Desmodium*. All the plants flowered and produced seeds. Highest vegetative growth and root yield were obtained in KC-1 and M-1 with 30-40 per cent available light (Tables 19, 20). Soil status and vegetation status of these two habitats were discussed earlier and taking the root yield alone, the habitat KC-1 appeared to be the most suitable habitat. The more opened up and disturbed habitats of VK-1, VK-2 and M-2 did not favour the growth of this species. However, in the burnt habitat, AK, initial growth was very good. It may be because of the resurgence of the species from the underground roots. But later, the environmental factors might not have favoured further growth. *Desmodium* also may be a fire tolerant species. Estimates of LGR and CGR values also support the performance of this species in different habitats.

The species also responded well to the inputs supplied in the domestic field under fully open condition. More branches, leaves etc. resulted in a high total dry matter production (Tables 27, 28, Fig.9). Root system was well developed with

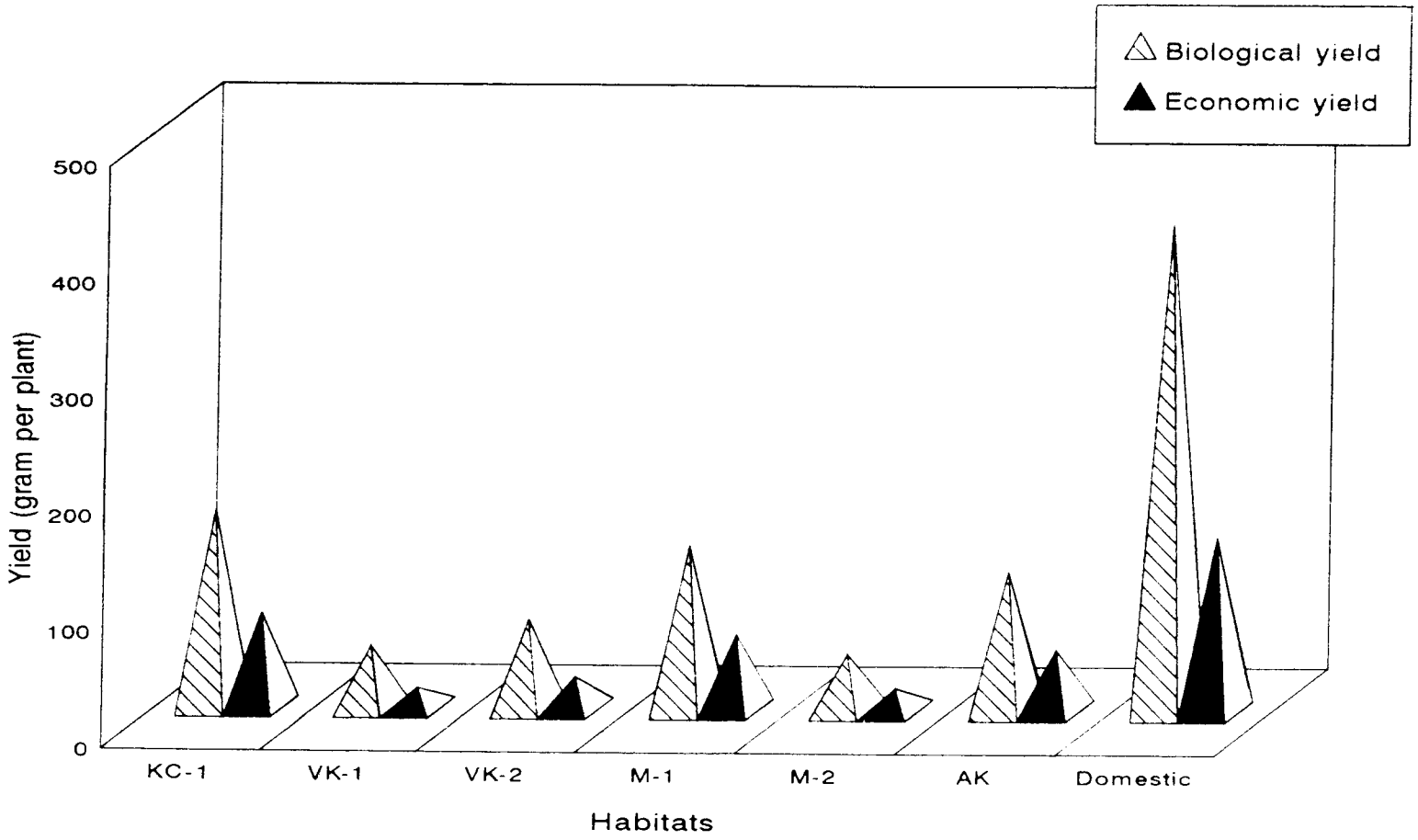


Fig.9. Biological and economic yield of *Desmodium velutinum* in natural and domestic environments

an extra long strong taproot. Another observation was the vertical orientation of leaf blades in the domestic field. This probably might have reduced the light injury in the field conditions.

In the natural condition, there was drastic differences in the growth and yield of this species and in the domestic crop almost double the yield was obtained. Gradation of habitats may be as domestic > KC-1 > M-1 > AK > M-2 > VK-1 ≋ VK-2.

5.2.2.5 *Baliospermum solanifolium*

The fleshy long unbranched storage root of this species is used in Ayurveda. As an unbranched herb, it was seen in five habitats; KC-1, KC-2, KP-1, KP-2 and VK-2, all with SE slope facing the reservoir (Tables 21, 22). Poor performance in KP-2 was due to the physical disturbance due to the fall of a huge tree. A scrutiny of the data reveals that the available light was below 50 per cent in all these habitats. In KP-2, the best habitat, it was only 23 per cent. Soil moisture (24%) and organic carbon (1.42%) contents were also high in KP-2. This is the only one species which recorded more growth of roots compared to top. The average root:shoot ratio was 1:0.50. In the most ideal habitat KP-1, there were only 10 leaves per plant and it produced a root weight of 222 g. The factor, leaf area duration, becomes relevant here. All the leaves might have remained functional till November, resulting in maximum carbohydrate production. After flowering and seeding, all the leaves withered off and only the stem remained. After this period whatever food synthesised would have been transported to the roots for storage or for the synthesis of quality components. In the domestic field, on the contrary, there were 88 leaves per plant and the root yield was 290 g. The productivity in the forest,

in spite of the competition and stresses was not comparable with the domestic environment, even though the yield was high in the latter (Tables 27, 28, Fig.10).

In the domestic roots slight branching was noticed. It may be because of reduced root competition in the field compared to the natural habitat where there were enough undergrowth.

The LGR and CGR values also supports its performance in KP-1 and KC-1.

Viewing together the performance of the species under 23 per cent light and 95 per cent light, it may be concluded to be a facultative heliophyte which although grow best at lower light intensives, can grow well in full sunlight also by some adaptive slrategies (Sharma, 1996).

A gradation of the habitats would be as domestic > KP-1 > KC-1 > KC-2 > KP-2 > VK-2.

5.2.2.6 *Barleria prattensis*

An under shrub of the Acanthaceae family, this forms the source of the drug "Madhurakurinji" in the Peechi hills with only restricted distribution. The species was found only in two habitats. It produced several flowers and seeds, a general character of the family, Acanthaceae (Nayar, 1997).

Between the two habitats, KC-1 supported very good growth of this species (Tables 23, 24, Appendix 6). Being a surface feeder with a shallow soft root system this species preferred to grow under shade and high moisture conditions in fertile loose soil. VK-2 was a disturbed habitat.

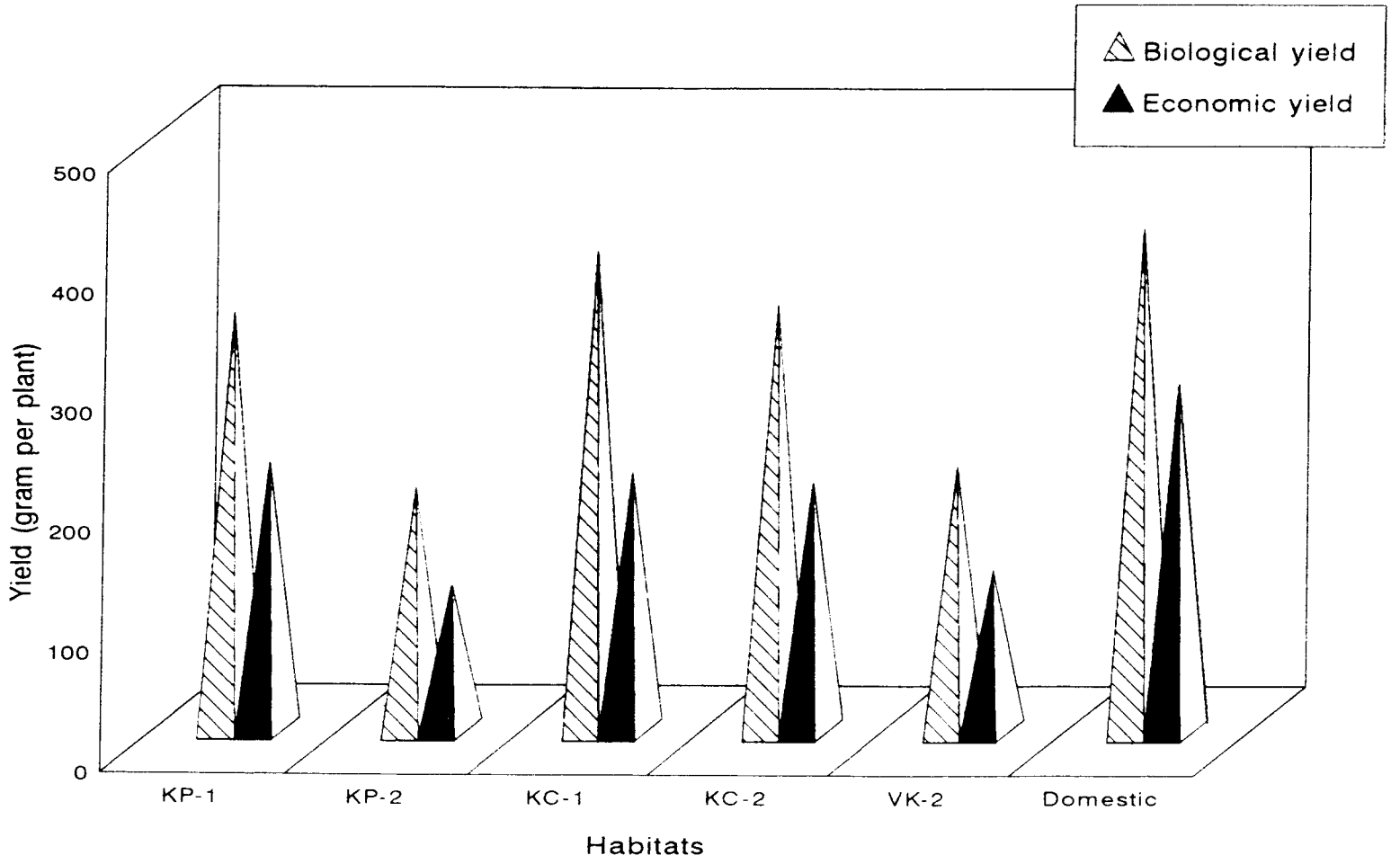


Fig.10. Biological and economic yield of *Baliospermum solanifolium* in natural and domestic environments

Under domestication, the response was good with respect to root and top growth (Tables 28, 29, Fig.11). The plant was more spreading with profuse branching compared to the straight growth in natural habitat. Stems were more pigmented than the natural habitat. The increase in root and top yields were only marginal.

As there were only a few experimental plants no conclusive inference could be made regarding its vegetative growth and yield.

In general, the habitat KC-1 appeared to be the most congenial one for the natural growth and productivity of *Piper, Naravelia, Barleria* and *Desmodium*. The growth of *Baliospermum* and *Sida* were also satisfactory in this habitat.

In spite of the heavy competition by herbs, shrubs, trees and tree seedlings (Table 8) for the resources, the biomass production recorded maximum values here. This habitat was situated 200 M above MSL with a medium slope with SE aspect; available light of 30.52 per cent, canopy, and litter cover of 80 and 90 per cent respectively having a loose soil of pH 5.74, organic carbon content of 2.3 per cent, moisture 14.52 per cent with sufficient macro and micro nutrients.

Eventhough the yield was high in the domestic environment; it is not comparable with the forest yields. The major reason for higher yields would be its previlaged position as monocrop amidst the plentiful resources in the fully open condition.

Higher yield in the open condition than the natural habitat for both the above and below ground portions has been reported by Khamiodkhodzhaev (1980) in *Ungerina vitoris* and Ost rogradski and Chernystu (1992) in the medicinal plant *Aralia continentalis*.

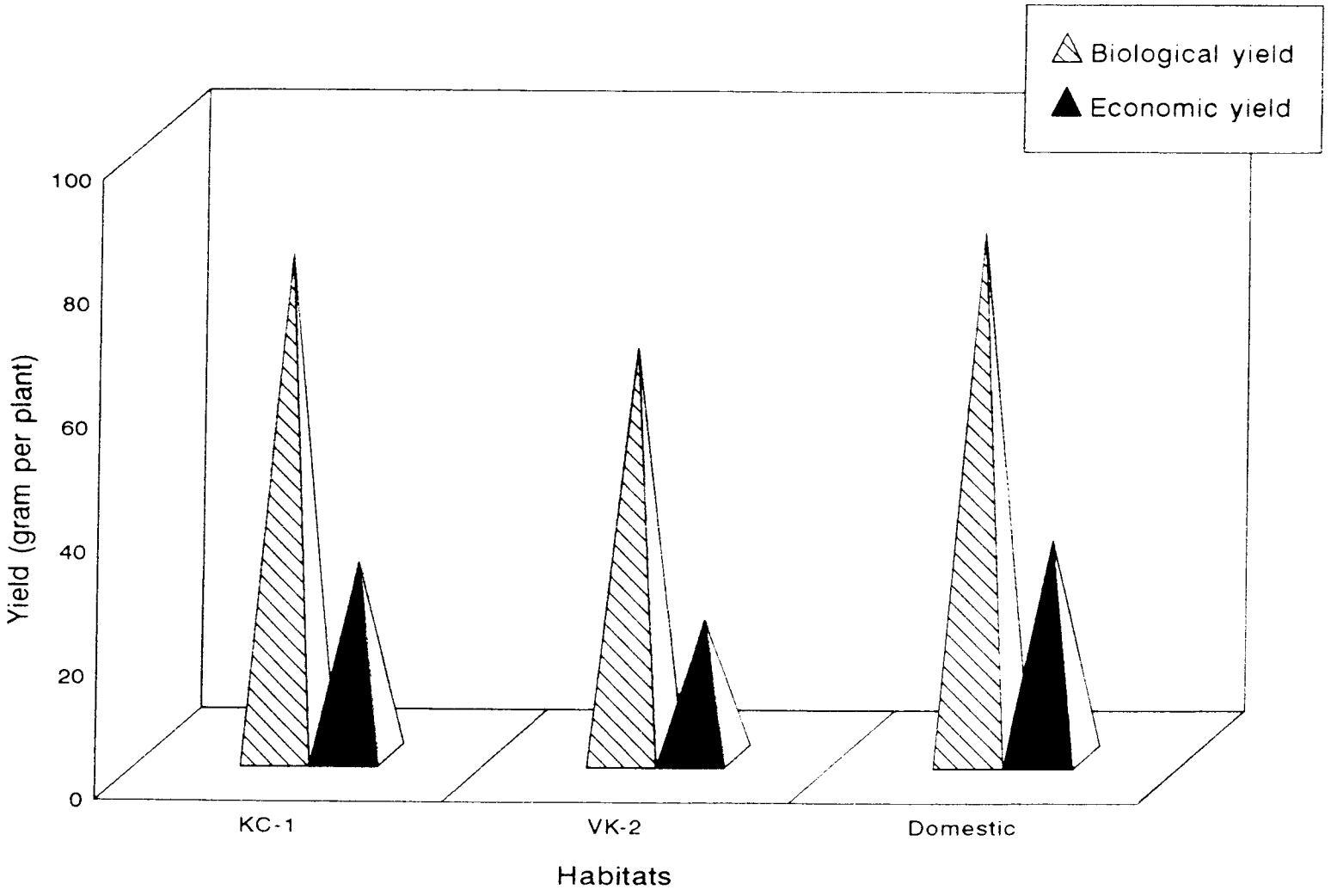


Fig.11. Biological and economic yield of *Barleria prattensis* in natural and domestic environments

5.2.3 Regeneration

Regeneration pattern of the select species showed that *Barleria* and *Naravelia* had the maximum regeneration percentage (Table 26, Fig.12). Being a member of Acanthaceae family, Barleria produces flowers and seeds profusely. The seeds may be able to withstand the ground fires. This, coulpled with the vegetative regeneration might have contributed to high percentage of regeneration. Some fire-tolerant plants have a unique property of completing their life cycles within a short period of time by virtue of their rapid rate of growth and development (Sharma, 1996). Another adaptation to survive the fire is the production of seeds in large numbers and presence of hard seed coats.

Next fire tolerant species was *Naravelia*. This plant also has got both sexual and asexual methods of reproduction.

The type of fire occurring in this forest may be classified as surface fire which sweeps over the ground surface rapidly and their flames consume the litter, living herbaceous vegetation and shrubs and also scorch the tree bases if come in contact.

Surface fires are totally man made. Even though the regeneration pattern of the burnt plots was higher than the unburnt plots (Table 26, Fig.13), it is with respect to the select species only. The fire sensitive species might have been wiped out totally and only the fittest might have survived. Stand composition of the habitat AK which was burnt during previous seasons fire reveal that the diversity and strength of shrubs and tree seedlings was low (Table 8). In a forest ecosystem the total diversity is more important than the individual member. Loss of a single

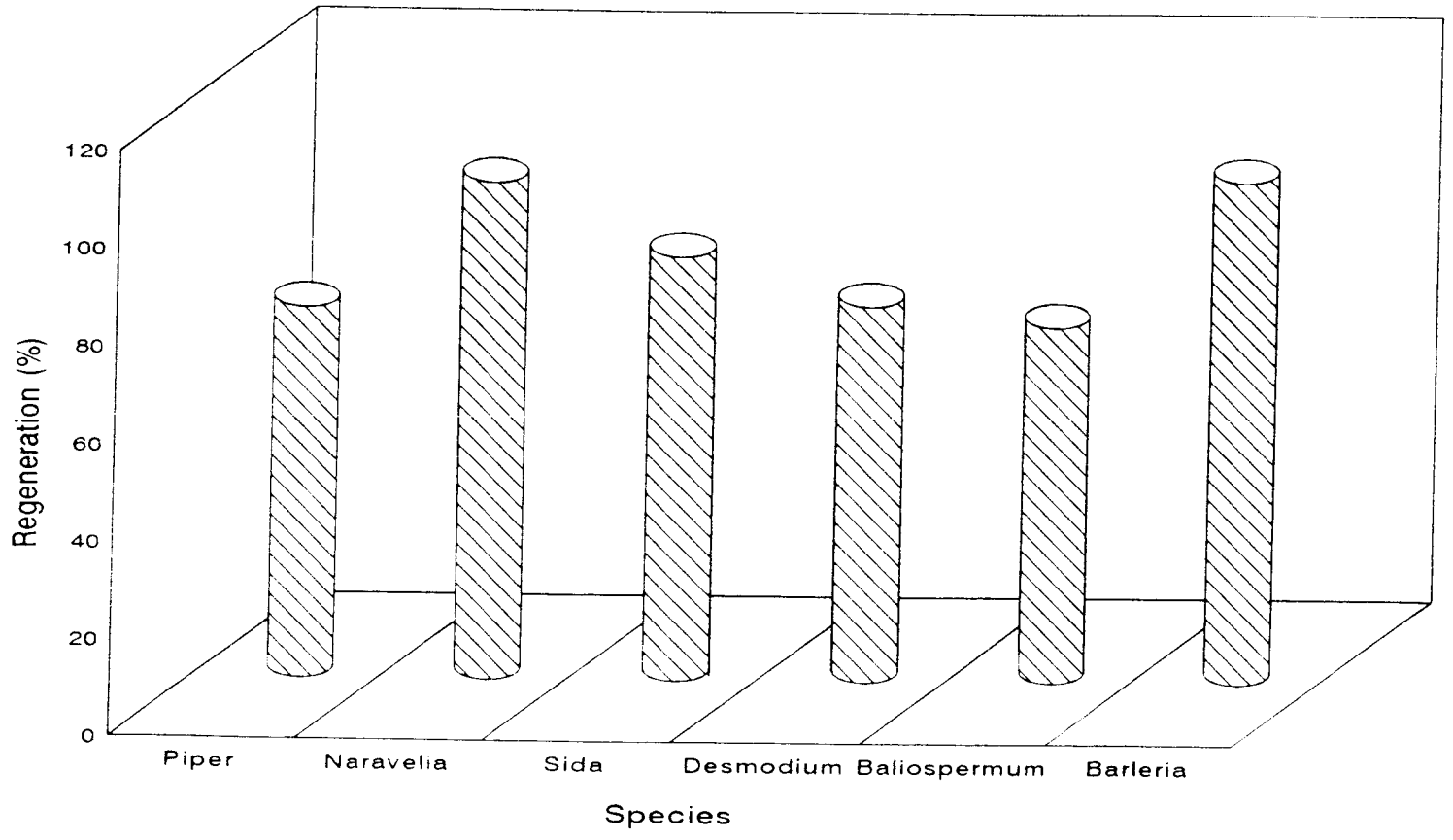


Fig.12. Regeneration pattern of select species in the natural habitat

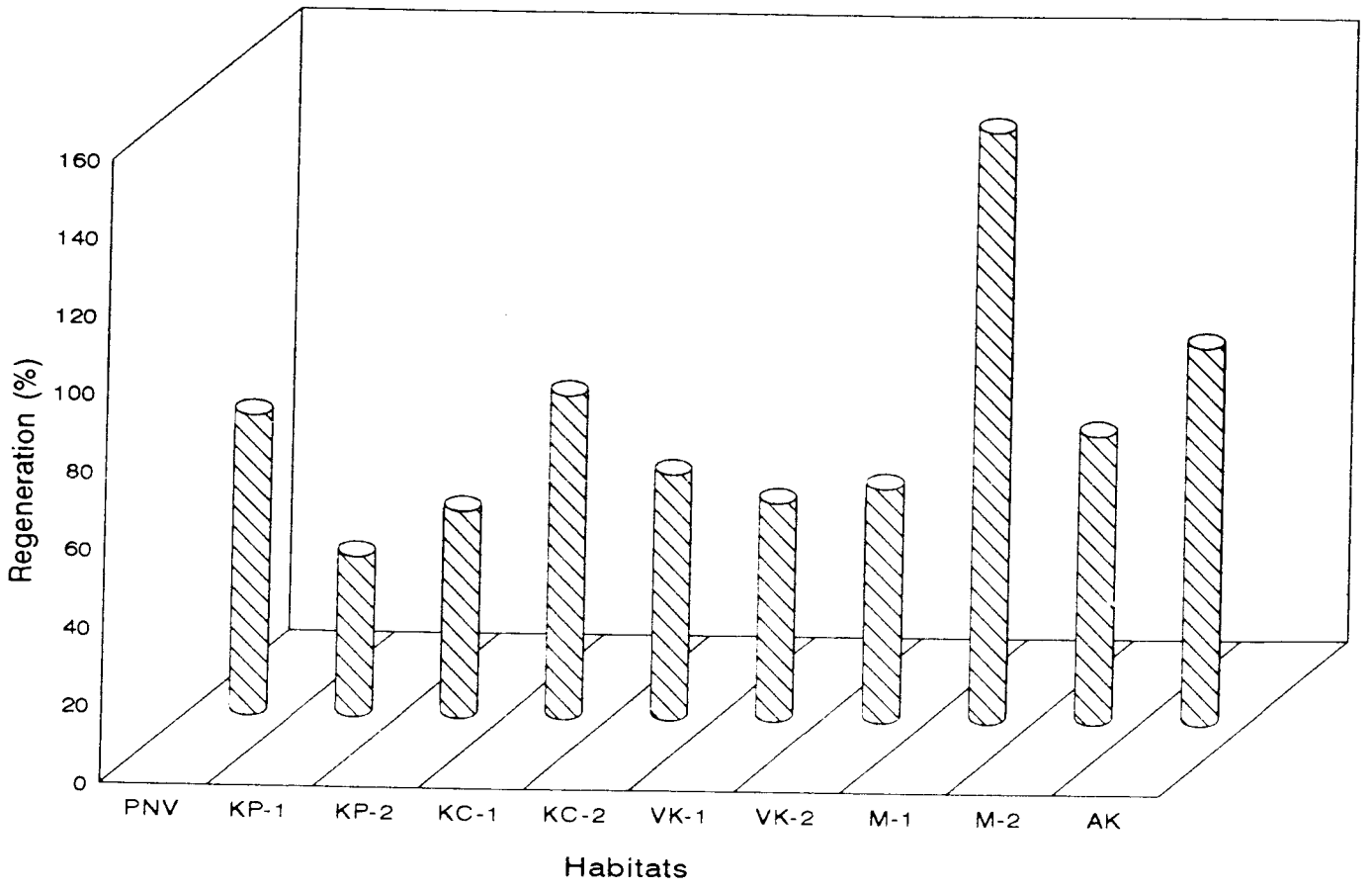


Fig.13. Regeneration pattern of different natural habitats

species can alter the ecosystem functions and hence fire is a major limiting factor to the biodiversity.

5.3 Experiment II. Biochemical analysis

Results of the biochemical analysis carried out in the wild and domestic plants are discussed hereunder:

5.3.1 Selection of suitable solvent for extraction

The extraction medium was standardised using six solvents (Table 37). Number of siphonings obtained in each solvent also followed a similar trend as that of their position in the eluotropic series. Extraction efficiency was maximum in the polar solvent, Methanol, followed by Acetone. But all the Methanol and Acetone extracts were turbid. This may be due to the presence of plant waxes, gums, pigments etc. However, these could not be used for calorimetry or TLC without purification which again was suspected to result in a loss or change of some of the components. At the same time Petroleum ether (60-80°C) extracts were very clear in all the species, its extraction efficiency was also on the average. Moreover, this solvent has also been reported to be used in some of the related species. So finally, Petroleum ether (60-80°C) was chosen as the extraction solvent in all the species.

5.3.2 Primary and secondary metabolites

Pattern of variation in the primary and secondary metabolites indicated that it varied with the species and habitat (Tables 31, 32, 33, 34, Figs. 14, 15, 16). Relative content of the metabolites in the wild and domestic plants is furnished in Table 36.

Table 36. Pattern of variation in the primary and secondary metabolites in the wild and domestic plants

Species	Total soluble sugars		Starch		Total free amino acids		Crude extractables		Alkaloids			Terpenoids			Other compounds
	W	D	W	D	W	D	W	D	No.	Rf	Size of the spot	No.	Rf	Size of the spot	
Piper	L	H	L	H	L	H	H	L	S	D	-	S	S	S	
Naravelia	H	L	S	S	L	H	H	L	S	S	S	S	S	S	
Sida	L	H	H	L	L	H	L	H	S	D	-	D	D	-	
Desmodium	H	L	L	H	L	H	H	L	S	S	S	S	S	S	
Baliospermum	H	L	L	H	L	H	H	L	S	S	D	S	S	S	
Barleria	L	H	H	L	L	H	L	H	D	D	-	S	S	S	Iridoid; anthocyanin pigment

L - low; H - high; S - same; D - different

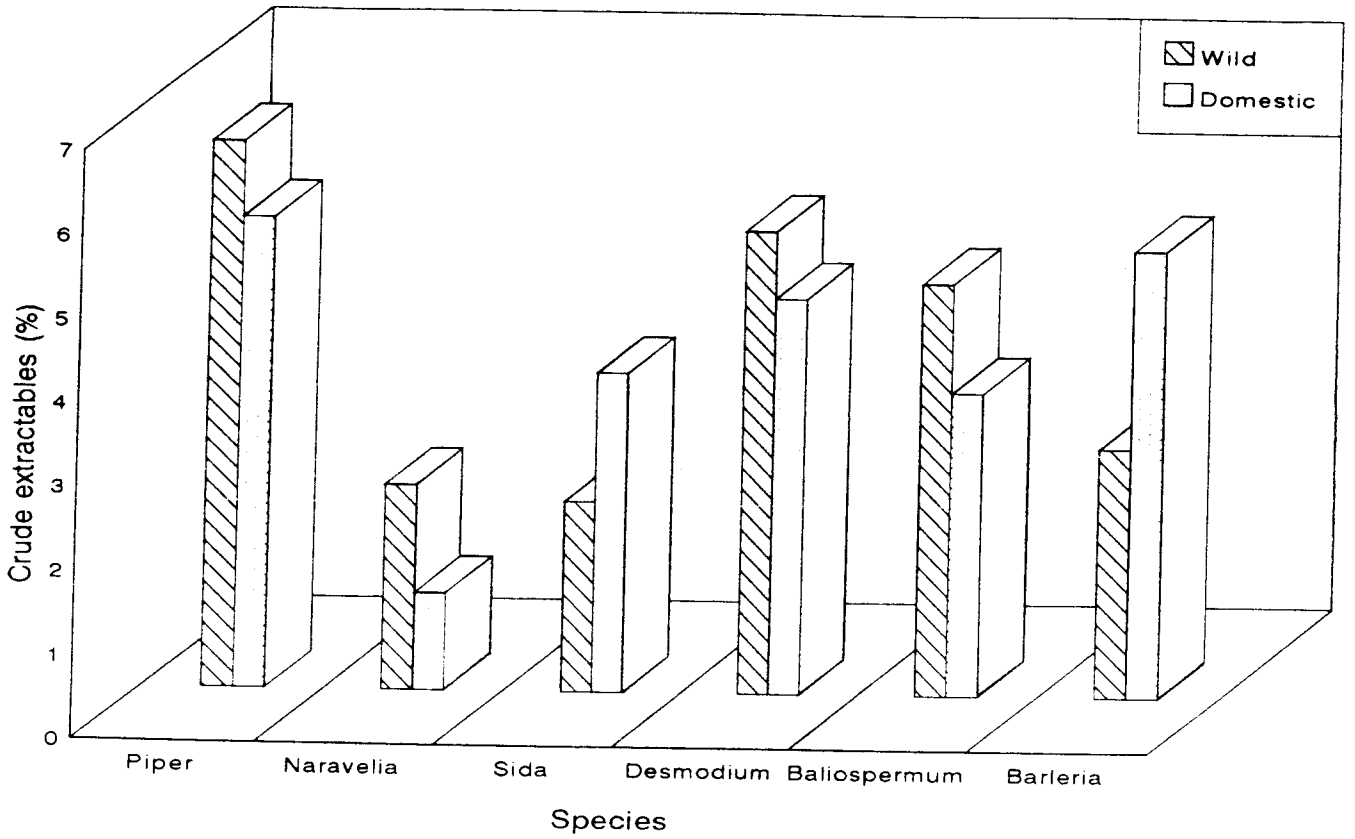


Fig.14. Percentage of crude extractables in the wild and domestic plants

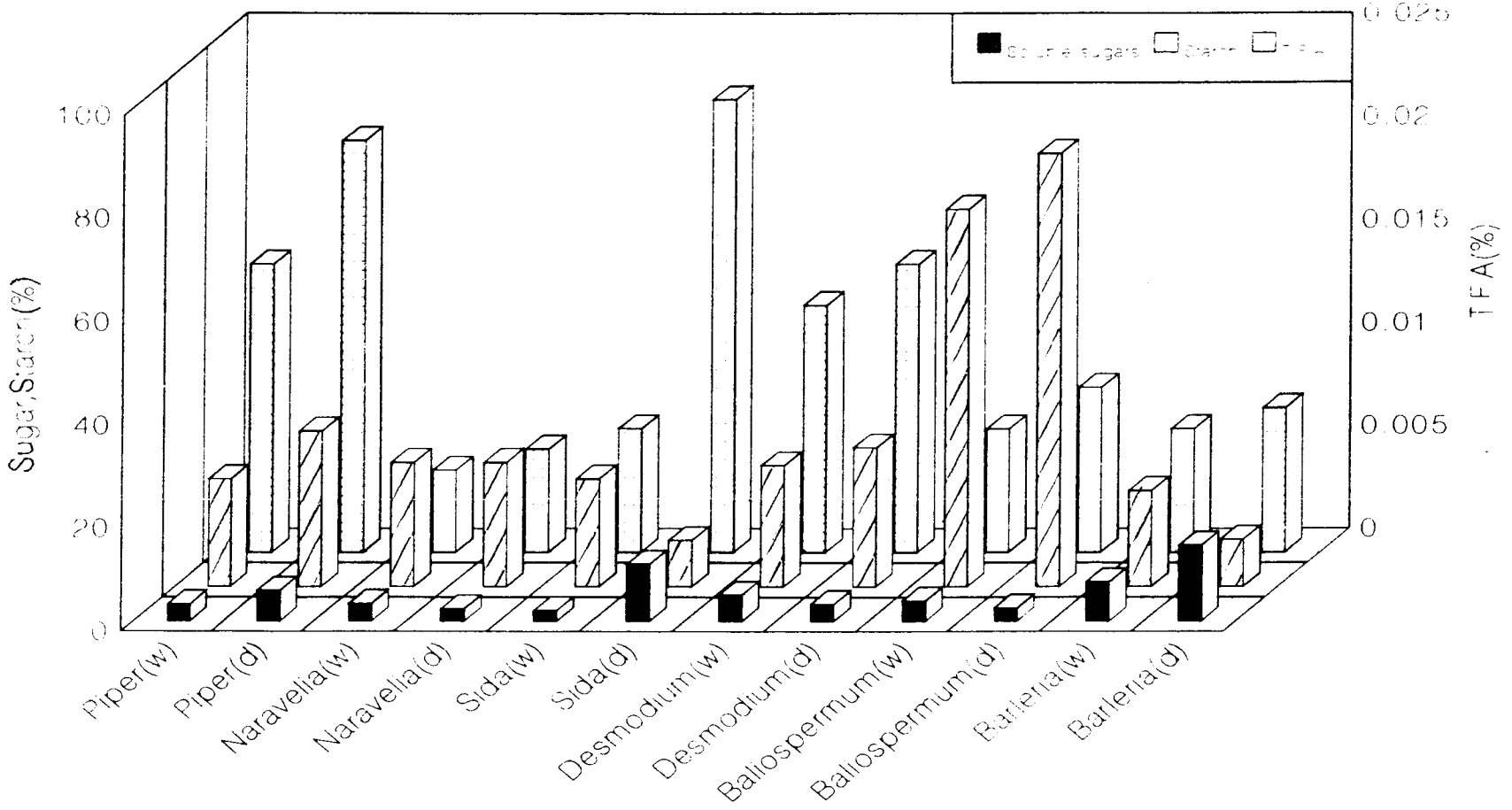


Fig.15. Total soluble sugars, starch and total free amino acid content of wild and domestic plants

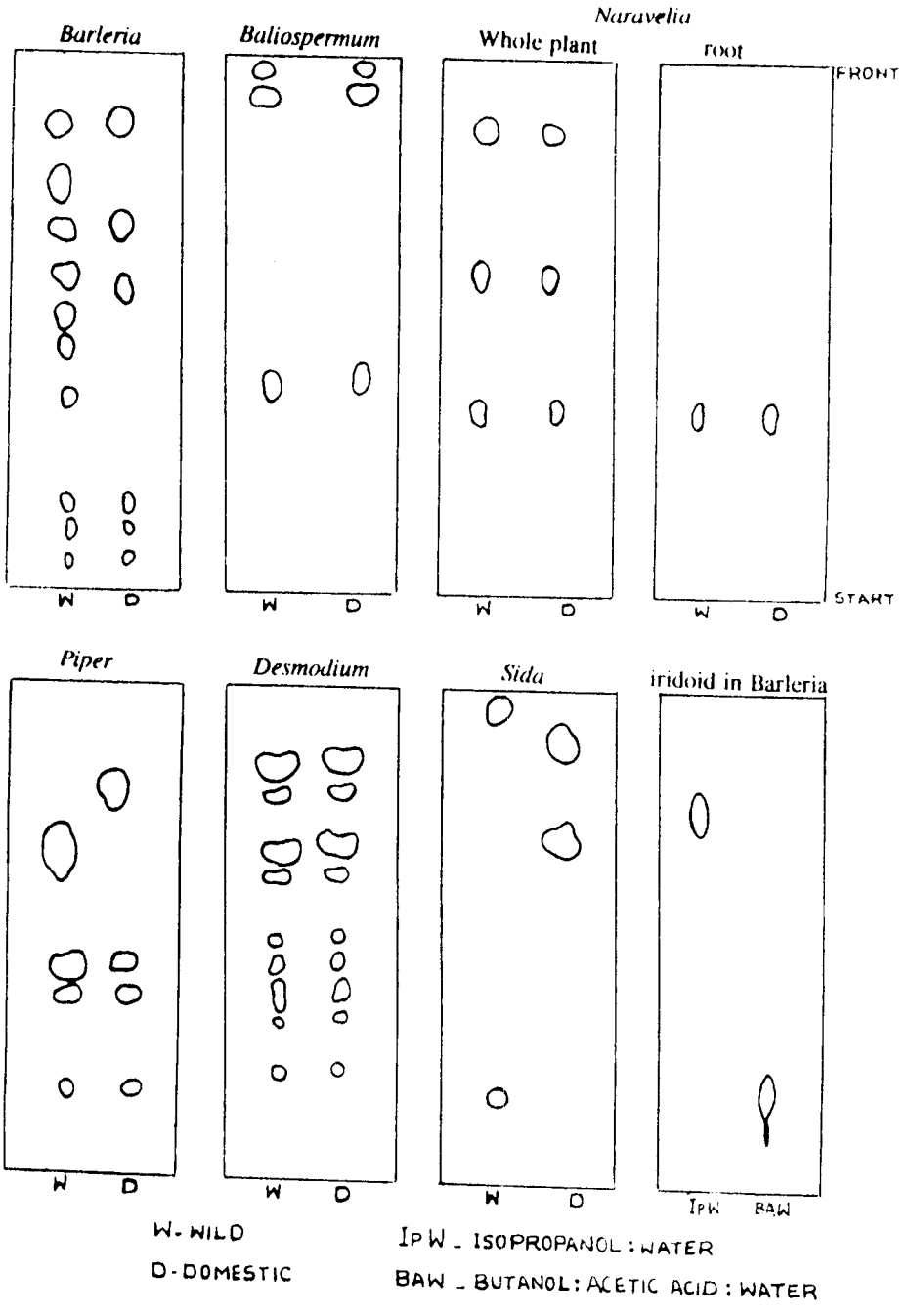


Fig.16 Scale diagram of the TLCs in the wild and domestic plants

Soluble sugars are the initial products in photysynthesis. Plants always maintain an equilibrium of soluble sugars in the source and whenever the concentration exceeds it is either converted to the polysaccharide - starch or interconverted to other primary products or translocated to other organs for the synthesis of secondary products. Once it is in the form of starch, further transformations are slow or limited.

A higher production of primary metabolites can normally be expected in the fully open conditions. In the present study, domestic plants of *Barleria* and *Sida* contained higher amounts of soluble sugars than the wild. The crude extractables was also high in the domestic plants of these two species. They might have synthesised more secondary products from primary metabolites. This is again supported by the low starch content.

In *Piper*, both the sugar and starch contents were high in the domestic plants, but the crude extractables was low. It is possible that the mechanism of sugar convertion to secondary products in this species might be regulated by many factors. The sugars might have been converted to starch and not to secondary products.

In *Naravelia, Desmodium* and *Baliospermum* domestic plants contained low sugars and crude extractables than the wild, but the starch content was high. The favourable conditions for the normal metabolism in the domestic environment might have resulted in high starch accumulation.

Higher content of total free aminoacids in the domestic plants of all the species could again be due to the favourable conditions that prevailed in the domestic

field for primary metabolite production. In the forest, on the contrary, competition for resources and the prevailing abiotic stresses might have influenced negatively, the synthesis of aminoacids or positively, the conversion of aminoacids to secondary products.

Aminoacids are the precursors of majority of the secondary products. Kudesia and Jetley (1995) have reported that precursors for the biosynthesis of alkaloids are am inoacids such as ornithine, lysine, phenylalanine, tyrosine and tryptophan. Hence, high content of free amino acids is advantageous in medicinal plants, if they are utilised in the production of valuable secondary products.

Based on these results, the select species may be grouped into three.

Group I 1. *Piper*	Species in which the primary metabolite production is high and secondary metabolite production are low in the domestic environment compared to the wild condition
Group II 1. *Sida* 2. *Barleria*	Species in which the primary and secondary metabolite production are high in the domestic environment compared to the wild condition
Group III 1. *Desmodium* 2. *Baliospermum* 3. *Naravelia*	Species in which the primary and secondary metabolite production are low in the domestic environment compared to the wild condition

In group I species, the status of a monocrop in the fully open condition with plentiful resources might have contributed to high production of primary metabolites. But, conditions for secondary product synthesis did not exist or the excess primary products themselves became the inhibitors of secondary metabolism.

In group II species, the favourable conditions produced more primary products. Secondary product synthesis also occurred simultaneously. May be, the

secondary metabolism in these species is more under genetic control. It may be noted that higher content of primary products can make the plant susceptible to pests and diseases. So, this could be an adaptive mechanism also.

In group III species, both primary and secondary products were low in the domestic plants.The maximum potential for secondary metabolism in these species was expressed in the wild condition.

5.3.3 Pattern of variation in the quality components

Changes in the pattern of alkaloids, terpenoids and other compounds are discussed here under, group-wise and species-wise.

Group I - *Piper*

Roots along with the thicker part of stem were used for analysis. Out of the two alkaloids, one was different in Rf value in the domestic plants. Size of the spots was the same. There was no change in the number and spot size of the terpenoids.

Three alkaloids viz. piperine, piperlongumine and piperlonguminine have been reported from *Piper* roots by Chatterjee and Datta (1967).

Group II - *Sida*

Rf values of the two alkaloids were different in the wild and domestic plants and an additional terpenoid was present in the domestic plants.

Eventhough the alkaloids of *Sida rhombifolia* have been reported by Prakash *et al.* (1981), in the present study, *Sida* did not give positive tests for

alkaloids in Petroleum ether extract (Table 35). The quantity may be too low to make its presence as also reported by Gunatilaka *et al.* (1980).

Barleria

Perhaps, this is the first report of the phyto constituents of this species. The anthocyanin pigment was more in the domestic plants. Alkaloids also were more in domestic plants. There was an iridoid, quantity of which was found to be the same in the wild and domestic plants.

Purushothaman *et al.* (1986) have reported three iridoids from *Barleria prionitis*. Iridoids often occur in plants, associated with sugar and glucoside is the stable compound (Harborne, 1973). It may be noted that the soluble sugar content was also high in this species in the domestic environment.

Group III - *Desmodium*

This may be the first report of the phytochemical aspects of this species. There was no difference in the number and quantity of alkaloids and terpenoids in the wild and domestic plants. Stability of this species in this aspect is a positive factor for recommending the same for cultivation.

Medicinal quality of *Desmodium gangeticum*, another source of the drug has been attributed to its 12 alkaloids by Ghosal and Bhattacharya (1972). Since *D. velutinum* also contained nine alkaloids, it could well be a substitute for *D. gangeticum*, the widely accepted source plant.

Baliospermum

Roots contain high starch (83%). Three alkaloids and a terpenoid were located both in the wild and domestic plants. But the spot size of the major alkaloid was bigger in the wild samples (Plate 11) indicating the high content of that alkaloid.

The alkaloids could probably be montanin, 12-deoxy phorbol 13-palmitate and baliospermin as reported by Ogura *et al.* (1978).

Naravelia

Phyto constituents are reported for the first time in this species. Four alkaloids and four terpenoids were observed in the roots while only one alkaloid and two terpenoids were located in the whole plant samples. Rf value of the root alkaloid was same as that of one of the alkaloids of the whole plant, indicating its presence in the roots.

The synthesis and accumulation of the secondary metabolites in various organs differ in each species.

In general, these results confirm the finding of Mika (1962) that the biosynthesis of secondary compounds although controlled genetically, their heritability and expression are greatly affected by the environmental factors.

Reports on the variation, type and quantity of the chemical constituents with change of phase, season, habitat, light and water availability, manuring etc. are plenty (Mckee and Street, 1978; Banerjee and Datta, 1991; Rao *et al.*, 1991; Bilia *et al.*, 1992; Samuel *et al.*, 1993; Thakur, 1993; Narayanan, 1993; Menon, 1994; Menon, 1996 etc.). However, since more than one factor is involved, partioning of the total effect often becomes impossible.

From the point of view of domestication/cultivation, it may be concluded that the group II species viz. *Sida* and *Barleria* are more adaptable to the open condition. But, since the finer components varied on domestication, the cultivation package has to be modified based on the natural habitat analysis to get optimum quality.

Group I and III species viz. *Piper, Desmodium, Baliospermum* and *Naravelia* are less adaptable to open conditions with respect to quality. So, the cultivation package for these species need thorough modification.

5.4 General discussion

Moist tropical forests with their unusual assemblage of species are the richest expression of life on earth with the highest biomass production potential, structural and functional complexity, stability and species diversity (Nair, 1994). Yet these are currently the most threatened of all ecosystems on earth. Habitat destruction, excessive exploitation and a host of other factors have practically wiped out the biological diversity which include a variety of plants which possess curative properties also.

'Malayans', the inhabitants of Peechi forests seem to have only limited knowledge on ethno-medicine and the present situation gives serious cause for concern. Tribal communities are factually and historically the custodians of forest biodiversity. They have no other vocations other than the MFP collection. However, the present study points to the need for excercising some regulations in the collection of medicinal plants. Foraging area may be demarcated for each settlement to avoid competition and collection of immature drugs. Entry of non-tribals for collection

should be strictly prevented and destructive harvesting methods totally banned. Drug collection should be allowed only in proper seasons, also to protect young and immature plants. RET species may be declared as national treasure and exempted from collection by legal measures. Measures to check forest fire, grazing, spread of exotic weeds, ellicit cutting of wood etc. will help prevent the habitat destruction and protection of habitat would be the best way of conserving these plants.

The demand on medicinal plants goes on increasing. Any conservation policy that fails to promote measures to meet the immediate demand on plant resources is bound to fail in the long term. So we have to have domestication/cultivation efforts also along with the in-situ conservation measures.

Habitat analysis and the domestication trial conducted with select species indicate the possibility of cultivating these plants in the field, even though the pattern of growth and development varied to a great extent. Though the photosynthesis appeared to be high in the open condition, the enzymatic reactions which decides the quality of the plant seemed to be associated with shade and so many other factors. The content of the secondary compounds in each species which is affected by the rate of biosynthesis and catabolism seemed to be a function of the environment and soil factors.

Any how, by providing conditions similar to that of its natural habitat and with proper management, these species can be cultivated successfully with out compromising for the quality. Organic farming, mixed/intercropping, rainfed farming etc. are some of the practices where the natural habitat conditions can be mimiced to get optimum quality.

On a broader perspective, these species may also be taken as just test plants and not medicinal plants and the result may be extrapolated to other crop plants also.

Summary

SUMMARY

The present investigation, "Habit and habitat analysis of select medicinal plants in native and domestic environments" was undertaken at the Department of Plantation Crops and Spcies during the period 1994-97. There were four separate experiments. First experiment was a survey of the Peechi hills to document the ethno-medicines practiced by the native 'Malayans'; the native medicinal plants of the area and the extraction procedures of various drugs. Based on the results of the survey, six species were selected viz., *Piper longum*, *Naravelia zeylanica*, *Sida rhombifolia* ssp. retusa, *Desmodium velutinum*, *Baliospermum solanifolium* and *Barleria prattensis* for detailed habitat analysis which formed the second experiment. Third experiment was a domestic environment analysis in which the select species were grown under fully open condition following adhoc agronomic management practices. Biochemical analysis of both the wild and domestic plant samples formed the fourth experiment.

Results of these experiments are summarised below.

Minor forest produce collection, mainly medicinal plants is the chief vocation of the 'Malayans' of the area. The dependence of the tribe on the native medicinal herbs for their health problems was only partial. Only twenty eight ethno-medicines could be documented. Majority of the plants were used in skin disorders and rheumatism. Single plant remedies were also there.

A total of 226 medicinal plants were identified from Peechi forests which included both Moist Deciduous Forests (MDF) and Semi Evergreen Forests (SEG).

These plants were distributed over 73 plant families and the families which were well represented were Fabaceae, Euphorbiaceae, Rubiaceae and Acanthaceae. Root was the part used in majority of the plants.

Eight different species were considered as the source of the drug "Sahachara" or "Kurinji" and four different species for 'prsniparni' or 'orila'.

Habitat wise, 64 per cent of the plants were from the MDF and 25 per cent from the SEG forests. Remaining 11 per cent were present both in the MDF and SEG forests.

Habit wise, 36 per cent were trees, 29 per cent herbs, 15 per cent herbaceous climbers, 13 per cent shrubs and seven per cent woody climbers.

Twenty two endemic plants spread over 18 plant families were reported.

In the regional assessment, there were all together 25 RET species out of which ten were endangered, six rare and nine threatened with respect to Peechi forests.

Out of the 226 medicinal plants, only 43 plants were collected by the tribes in large quantities on a regular basis. In annuals, the flowering and extraction period often overlapped whereas no trend could be noticed in perennials. In general, roots and tubers were collected during the wet months and stem bark and seeds during the dry months.

Extraction methods varied, depending on the part harvested. Destructive harvesting was noticed in the case of canarium resin, cinnamon bark, phyllanthus fruits, persea bark, acacia pods, myristica fruits, coscinium vines etc. which resulted in low quality drug, at the same time making their regeneration difficult.

A close monitoring of the drugs extracted revealed the practice of substitution/adulteration in certain cases.

In the natural habitat analysis, ten habitats were selected and they were characterised by recording the physiographic, environmental, edaphic and biotic variables.

Cluster analysis revealed that there were nine clusters based on climatic and vegetation characteristics and only two clusters based on soil characteristics.

Phytosociological analysis showed that *Piper* and *Naravelia* were the most dispersed species and *Barleria*, the least dispersed. The most abundant species was *Piper*.

Species-wise growth analysis indicated that the growth pattern was almost linear upto November in all the species and estimates of LGR and CGR with respect to plant height, number of leaves and total leaf area confirmed this.

The creeper *Piper* was non-branching in the natural habitat and none of the plants flowered during the entire period of study. Out of the ten habitats, KC-1 favoured the growth of *Piper* to the maximum, justified by the maximum values recorded with respect to yield and yield contributing attributes.

The climber *Naravelia* was also present in all the habitats and maximum yield was recorded in the habitat KC-1.

The root herb *Sida*, was present only in five habitats out of which M-1 appeared most congenial for its natural growth. Root:shoot ratio was very high in this species.

Out of the six habitats in which the shrub *Desmodium* was present, growth and yield was maximum in KC-1.

Storage root was the part used in *Baliospermum* and out of the five habitats, KP-1 appeared to be congenial for its growth in the forest. Root:shoot ratio was very low in this species.

Barleria, the least dispersed of the six species was present only in two habitats and between these two, KC-1 recorded higher values of growth and yield.

Regeneration pattern revealed that among the six species, *Barleria* and *Naravelia* had the maximum regeneration. Among the habitats, M-1 recorded highest regeneration percentage with respect to the select species. Forest fire was not a limiting factor in the regeneration of these species.

In the domestic environment, all the species grew well and exhibited a strictly linear growth pattern up to January. Flowering occurred in all the species in December.

In *Piper*, branching was higher in the domestic plants as compared to the forest plants. Dry root yield was also higher in the domestic crop.

Both the biological and economic yields were slightly low in the domestic environment compared to forest plants in the species *Naravelia*.

Sida grew vigorously in the domestic environment, attaining the status of a shrub. Root yield was high in the domestic crop.

Desmodium also recorded almost double the yield in the domestic crop.

In *Baliospermum*, branching was conspicuous in the domestic crop and root yield was high in the domestic environment.

In *Barleria*, plants were profusely branching in the domestic environment with a slightly higher root yield.

In the biochemical analysis, based on the extraction efficiency and nature of the extract, Petroleum ether (60-80°C) was selected as the solvent for extraction.

Among the select species, in the case of *Desmodium*, *Baliospermum*, *Naravelia* and *Piper* wild plants contained more crude extractables whereas in *Sida* and *Barleria*, domestic plants contained more crude extractables.

In the priliminary tests for alkaloids, eventhough all the species responded to one or other of the tests, only *Piper* and *Desmodium* confirmed the presence of alkaloids by giving positive response to all the tests.

In *Naravelia*, *Desmodium* and *Baliospermum*, wild plants contained more total soluble sugars and in *Piper*, *Sida* and *Barleria* domestic plants contained more total soluble sugars.

With respect to the starch content, *Barleria* and *Sida* contained maximum starch in the wild plants whereas *Piper*, *Desmodium* and *Baliospermum* contained maximum starch in the domestic plants. In *Naravelia*, there was no differences in the content of starch between the wild and domestic plants.

Irrespective of the species, the content of total free aminoacids was high in the domestic plants compared to the wild, but the variation was drastic only in *Sida*.

TLC results indicated the presence of nine alkaloids and one terpenoid in *Desmodium*. Major alkaloid was with an Rf of 0.66. Both the nature and quantity of the components appeared to be same in the wild and domestic plants.

In *Baliospermum*, there were three alkaloids and one terpenoid. Major alkaloid was with an Rf of 0.36. Quantity appeared to be more in the wild plants.

There were two alkaloids each in the wild and domestic plants of *Sida*, but they were with different Rf values. Two terpenoids in the wild, and three in the domestic plants were also located.

In *Piper*, there were four alkaloids each in wild and domestic plants out of which one was different and three were the same. Three terpenoids could be located both in the wild and domestic plants.

There were four alkaloids and four terpenoids in *Naravelia* roots whereas in the whole plant samples only one alkaloid and two terpenoids could be located. Both the nature and quantity did not vary between the wild and domestic plants.

Barleria roots contained seven alkaloids and two terpenoids in the wild plants and ten alkaloids and two terpenoids in the domestic plants. There was an anthocyanin pigment, content of which appeared to be high in the domestic plants. One iridoid glucoside was located both in the wild and domestic plants.

Results of the domestic environment and biochemical analysis indicated the possibility of cultivating these species by providing conditions similar to that of its natural habitat; thereby assuring the quality of the drug.

The study also pointed to the need for excersising some regulations in the collection of medicinal plants from Peechi forests.

References

REFERENCES

Ahmedullah, M. and Nayar, M.P. 1986. *Endemic Plants of the Indian Region. Vol. I.* Peninsular India Botanical Survey of India, Calcutta, p.246

Amalraj, V.A., Velayudhan, K.C. and Abraham, Z. 1991. Threatened medicinal plants of Western ghats. *Proc. Symp. Rare, endangered and endemic plants of the Western Ghats*, Kerala Forest Department, p.215-219

Ambasht, R.S., Srivastava, A.K. and Ambasht, N.K. 1994. Conserving the biodiversily of India. An ecological approach. *Indian Forester.* **9**:791-97

Anil, P.C., Mohan, V., Harinarayanan, M.K., Amrith, M. and Sankar, S. 1996. 'Malayarude geevanopaadhiyaya vanavibhavangal' (Malayalam). *Jananeethi.* 3(4):31-35

Arora, R.K. 1983. Threatened plants of India. Some considerations on native genetic resources. *An Assessment of Threatened Plants of India* (Ed. Jain, S.K. and Rao, R.R.). Botanical survey of India. Howrah. p.296

Aslanov, S.M. 1983. Dynamics of the alkaloid contents in *Physochaina orientalis* G. *Don. Fil. Rastit. Resur.* **19**(1):658

Babu, C.R., Joshi, A. and Sardesai, N. 1993. Biodiversity : A genetic treasure. *Indian Fmg.* **43**(7):25-35

Balyan, S.S., Sobti, S.N., Pushpangadan, P., Singh, A. and Atal, C.K. 1982. *Cultivation and Utilization of Aromatic Plants* (Eds. Atal, C.K. and Kapur, B.M.). Regional Research Lab, Jammu, p.559

Banerjee, D. and Datta, P.C. 1991. Effect of seasons, age, phase and hormones on the medicinal compound accumulation in plants. *Recent Advances in Medicinal, Aromatic and Spice Crops* (Ed. Roy Chaudhuri, S.P.), Today and Tomorrow's Printers and publishers, New Delhi, p.436

Batisse, M. 1982. The biosphere reserve. A tool for environmental conservation and management. *Envir. Conserv.* **9**:101-114

Behari, M. and Varshney, A. 1986. 5 - sterols from the *Desmodium* species. *Indian Drugs*. **23**:434-435

Benjamin, P.K. and Anderson, R.C. 1985. Influences of collecting on the reproductive capacity of wild ginseng (*Panax quinquefolius*) in Illinois. *Bull. Ecol. Soc. Am.* **66**(2):140-141

Bhadula, S.K., Sing, A., Lata, H., Huniyal, C.P. and Purohit, A.N. 1996. Genetic resources of *Podophyllum hexandrum* Royle, an endangered medicinal species from Garhwal Himalaya, India. *Pl. Gen. Res. Newsl.* **106**:26-29

Bhakuni, D.S., Goel, A.K., Jain, S., Mehrotra, B.N., Patnaik, G.K. and Prakash, V. 1988. Screening of Indian plants for biological activity Part VIII. *Ind. J. Exp. Biol.* **26**:883-904

Bhat, A.V. and Nesamany, S. 1992. Botanical source of Gajapippali in Kerala. *B.M.E.B.R.* **12**(3-4):108-113

Bhat, A.V. and Padmaja, B. 1991. Vulnerable medicinal plants of Munnar forest region, Idukky district, Kerala. *Proc. Symp. Rare, endangered and endemic plants of the Western ghats*. Kerala Forest Department. p.248-255

Bilia, A.R., Cioni, P., Morelli, I., Coppi, A., Lippi, A. and Tomei, P.E. 1992. Essential oil of *Satureja montana* L. ssp. montana. Composition and yields of plants grown under different environmental conditions. *J. essential oil Res.* **4**:563-568

Bisen, S.S., Choudhury, K.C., Giri, V. and Gogate, M.G. 1993. Medicinal plant potential in Melghat. *Indian J. Trop. Biod.* 1:37-51

Biswas, K. 1955. Cultivation of *Rauvolfia serpentina* in West Bengal. *Indian J. Pharm. Sci.* **10**(6):227-232

Blank, F. 1958. '*Encyclopaedia of Plant Physiology* Vol. 10, (Ed. Ruhland, W.) Springer verlag, Berlin, p.353

Champion, H.G. and Seth, S.K. 1968. *A Revised Survey of the Forest Types of India*. Govt. of India Press, New Delhi, p.358

Chandrasekharan, I., Amalraj, V.A., Khan, H.A. and Ghanim, A. 1984. Scopalamine from *Datura innoxia*. *Transactions of the Indian Society of Desert Technology and University Centre for Desert Studies*. 9(2):23-25

Chatfield, C. and Collins, A.J. 1980. *Introduction to Multivariate Analysis*. Chapman and Hall, London, p.430

Chatterjee, A. and Dutta, C.P. 1967.Alkaloids of *Piper longum*. I. Structure and synthesis of piper longumine and piper longuminine. *Tetrahedron*. 23:1769-81

Chunekar, K.C. 1982. *Bhavaprakasha nighantu of Sri Bhavamisra*. Commentary, Varanasi (in Hindi). p.256

Dan, M. and Shanavakshan, A.E. 1991. A glance to some rare medicinal plants of Western ghats. *Proc. Symp. Rare, Endangered and Endemic Plants of the Western Ghats*. Kerala Forest Department. p.221-225

Daniel, M. 1991. *Methods in Plant Chemistry and Economic Botany*. Kalyani Publishers, New Delhi. p.332

Dastur, J.F. 1970. *Piper longum. Medicinal Plants of India and Pakisthan*. Dr. Taraporevala Sons and Co. Pvt. Ltd., Bombay. p.372

* Deletang, J. 1973. *Enracinement du tabac et travail du sol. Seita Ann. Sect.* 2(10):31-59

Dey, A.C. 1980. *Indian Medicinal Plants*. Dehra Dun. p.259

Dhawan, B.N., Pantnaik, G.K., Rastogi, R.P., Singh, K.K. and Tandon, J.S. 1977. Screening of Indian plants for biological activity. Part VI. *Indian J. Exp. Biol.* 15:208-218

Dutta, T. 1963. Investigation on Balas I. *Bull. Reg. Res. Lab*, Jammu, India. 1:178-182

Ehrlich, P.R. and Daily, G.C. 1993. Quoted from Purushothaman, S. and Viswanath, S. 1993. Preserving biological diversity : An operational model to compare and contrast. *Indian J. Trop. Biod.* 1: 161-166

Evenari, M. 1960. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolites of medicinal and aromatic plants - a review. *Cultivation and Utilisation ofMedicinal Plants* (Ed. Atal, C.K. and Kapur, B.M.). RRL, CSIR, Jammu and Tawi, p.559

* Fing, Y.Z. 1982. Cultivated multistorey and multispecific association of tropical crop plants and beneficial effect of these communities on light intensity, soil fertility and soil moisture. Collected research papers on tropical botany. *Academia Sinica* :42-45

Franz, E.H. 1981. A general formulation of stress phenomena in ecological system. *Stress Effects on Natural Ecosystems.* (Ed. Barrett, G.W. and Rosenberg, R.) John Wiley and Sons, p.454

Gamble, J.S. 1935. *Flora of the Presidency of Madras*. Vol. 1-3. Adlard and Son Ltd., W.C. p.2017

George, E.B. 1992. Evaluation of ginger cultivars for shade tolerance. M.Sc. (Ag.) thesis. Kerala Agricultural University, Thrissur, Kerala.

Gershinzon. 1978. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolites of medicinal and aromatic plants - a review. *Cultivation and Utilisation of Medicial Plants* (Ed. Atal, C.K. and Kapur, B.M.). RRL, CSIR, Jammu and Tawi, p.559

Ghanim, A., Chandrasekharan, I., Amalraj, V.A. and Khan, H.A. 1984. Studies on diosgenin content of fruits of *Balanites roxburghii. Transactions of the Indian Society of Desert Technology and University Centre for Desert Studies*. 9(2):21-22

Ghosal, S. and Bhattacharya, S.K. 1972. *Desmodium* alkaloids. II. Chemical and pharmacological evaluation of *Desmodium gangeticum. Planta Med.* :434-40

Ghosal, S., Banerjee, P.K., Rathore, R.S. and Bhattacharya, S.K. 1972. Alkaloids of *Desmodium gangeticum* - chemistry and pharmacology. *4th Int. Symp. Biochem. Physiol. Alkaloide* :107-11

Ghosal, S., Dutta, S.K., Sanyal, A.K. and Bhattacharya, S.K. 1969. *J. Med. Chem.* 12:480

Gopakumar, S. 1994. Pheno-morphological studies of selected tree species in a tropical forest ecosystem. M.Sc. (Forestry) thesis. Kerala Agricultural University, Thrissur, Kerala.

Gopalakrishnan, S., Sthanusubramanian, R. and Venkateswara, P. 1984. Chemical examination of the roots of*Barleria buxifolia* - structure of barleria - quinone. *Chem. Pharm. Bull.* 32:4137-9

GSI, 1976. *Geology and Mineral Resources of the States of India Part XI. Kerala.* Miscellaneous Publication No.30. Geological Survey of India, Government of India.

Gunatilaka, A.A.L., Sotheeswaran, S., Balasubramanyan, S., Chandrasekhara, A.I. and Sriyani, H.T.B. 1980. Studies on medicinal plants of Srilanka. III. Pharmacologically important alkaloids of some *Sida* species. *Planta Med.* 39:66-72

Gupta, H.M. and Saxena, V.K. 1984. A new acylated luteolin-7-0-ß-D glucoside from the roots of *Barleria prionitis. Natl. Acad. Sci. Lett.* (India) 7(6):187-9

Handa, S.S. 1992. Medicinal plant based drug industry and emerging plant drugs. CSIR foundation day lecture delivered at CIMAP, Lucknow on 26th September 1992

Harborne, J.B. 1973. *Phytochemical Methods,* Chapman and Hall, London, p.416

Harborne, J.B. 1977. *Introduction to Ecological Biochemistry.* Academic Press, London, p.449

Indrayanto, G., Cholies, N. and Wahyudi. 1985. Influence of fruit size of *Solanum wrightii* on its solasodine content. *Planta Med.* 5:470

Iyer, I.K.A.K. 1987. *Tribes and Castes of Cochin*, Cosmo Publications, New Delhi, p.516

Jackson, M.L. 1958. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, p.498

Jain, S.K. and Sastry, A.R.K. 1980. *Threatened plants of India.* A State of the Art report, New Delhi

Jensen, H.F.W., Jensen, S.R. and Nielsen, B.J. 1988. Chemotaxonomy of the Acanthaceae. Iridoids and quarternary amines. *Phytochemistry* 27:2581-89

John, D. 1984. One hundred useful raw drugs of the Kani tribe of Trivandrum forest division, Kerala India. *Int. J. Crude Drug Res.* 22(1):17-39

Kamathy, R.V. 1983. Rare and endemic species of Indian Commelinaceae. *An assessment of threatened plants of India* (Ed. Jain, S.K. and Rao, R.R.). Botanical Survey of India, Howrah, p.349

Kapoor, S.L. and Mitra, R. 1979. *Herbal Drugs in Indian Pharmaceutical Industry*, Lucknow, p.572

Karnick, C.R. 1977. Ethnobotanical, pharmacognostical and cultivation studies of *Hemidesmus indicus. Herba Hung.* 16(2):7-16

* Kasahara, Y. and Hikino, H. 1983. Cultivation conditions and antiemetic activity of *Pinellia ternata. Hort. Abstr.* 1986. 56(1):62

KAU. 1986. *Final report of the co-ordinated research project on restoration of degraded environment in Champakkad tribal colony area.* KAU, Vellanikkara, Thrissur, Kerala, p.2-12

* Khamidkhodzhaev, S.A. 1980. *Ungerina vitoris* and other species under cultivation. *Uzbekskii-Biol. Zhurnal.* 1:42-44

* Kona, R.J. and Kushari, D.P. 1989. Effect of leaf leachate of four species on sprouting behaviour of rhizomes, seedling growth and diosgenin content of *Costus speciosus. Bull. Torrey Bot. Club.* 116:339-348

Kudesia, V.P. and Jetley, U.K. 1995. *Environmental and Biochemistry*, Pragati Prakashan, Meerut, p.574

Kumar, M. and Bhandari, M.M. 1994. *Commiphora wightii* - a threatened medicinal plant of the Thar pradesh. *Ethnobiology in human welfare: Abstr. IVth Int. Cong. ethnobiology, Lucknow,* U.P., India, p.307

Kurup, P.N.V., Ramdas, V.N.K. and Joshi, P. 1979. *Handbook on Medicinal plants*, New Delhi, p.400

Longenhein, J.H., Stubblebine, W.H. and Foster, C.E. 1979. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolites of medicinal and aromatic plants - a review. *Cultivation and Utilisation of Medicinal Plants*. (Ed. Atal, C.K. and Kapur, B.M.) RRL, CSIR, Jammu & Tawi, p.1-11

Maheswari, J.K. 1977. Conservation of rare plants - Indian scene vis-a-vis world scene. *Bull. Bot. Surv. India.* **13**:167-173

Manilal, K.S. 1984. *Hortus malabaricus* and the enthnobotanical knowledge of ancient Malabar. *Anc. Sci. Life* **4**(2):96-99

Martinez, P.H. 1995. Commercialization of wild medicinal plants from South west Puebla, Mexico. *Econ. Bot.* **49**:197-206

Mathrubhoomi. 1994. "Aarogyappacha" (Malayalam). Mathrubhoomi daily dated 4-8-1994

Mathur, P.R.G. 1987a. Anthropology of tribal medicine, disease and curing techniques among the tribals of North Wynad (Kerala). Paper presented at the National workshop on tribal health and medicine in forest environment. KIRTADS, Kozhikode

Mathur, P.R.G. 1987b. The ethnomedicine of the Irular of Attappady, Kerala. Paper presented at the National workshop on Tribal health and medicine in forest environment. KIRTADS, Kozhikode

Mc Kee, C.G. and Street, D.F. 1978. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolites of medicinal and aromatic plants - a review. *Cultivation and Utilization of Medicinal Plants*. (Ed. Atal, C.K. and Kapur, B.M.). RRL, CSIR, Jammu & Tawi, p.559

Meera, N. 1994. Standardisation of propagation and stage of harvest in Adakodien (*Holostemma annulare* K. (Schum). M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, Kerala

Menon, J.S. 1994. Influence of methods of planting and shade on growth, yield and plumbagin content of 'Chethikoduveli' (*Plumbago rosea* Linn.). M.Sc.(Hort) thesis, Kerala Agricultural University, Thrissur, Kerala

Menon, M.V. 1996. Effect of different inputs on productivity and quality relations in Njavara (*Oryza sativa*). Ph.D thesis, Kerala Agricultural University, Thrissur, Kerala

Mika, E.S. 1962. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolites of medicinal and aromatic plants - a review. *Cultivation and Utilization of Medicinal Plants*. (Ed. Atal, C.K. and Kapur, B.M.). RRL, CSIR, Jammu & Tawi, p.559

Mohanan, N., Rajkumar, G. and Shaju, T. 1997. Floristic diversity of Agasthyamala, Western ghats. *Proc. 9th Kerala Sci. Cong.* State Committee on Science, Technology and Environment, Government of Kerala, p.444-448

Moitra, S.K., Ganguli, A.N., Chakravarti, N.N. and Adhya, R.N. 1970. Chemical investigation of *Barleria prionitis*. *Bull. Calcutta Sch. Trop. Med.* **18**(1):7

Mothes, K. 1978. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolites of medicinal and aromatic plants - a review. *Cultivation and Utilization of Medicinal Plants*. (Ed. Atal, C.K. and Kapur, B.M.). RRL, CSIR, Jammu & Tawi, p.559

Naderuzzaman, A.J.M. 1983. Role of flavanoids in the taxonomy of Desmodium. *Bangl. J. Bot.* 12:2732

Nair, G.S., Sudhadevi, P.K. and Kurien, A. 1991. Introduction of medicinal and aromatic plants as intercrops in coconut plantations. *Recent Advances in Medicinal, Aromatic and Spice crops. Vol.I.* (Ed. Raychaudhuri, S.P.). Today's and Tomorrows Printers & Publishers, New Delhi, p.436

Nair, K.U., Nair, A.R. and Nair, C.P.R. 1992. Techno/economic data and cultivation preservation of some south Indian medicinal plants. *Aryavaidyan* 5:238-240

Nair, N.C. and Daniel, P. 1986. The floristic diversity of the western ghats and its conservation: A review. *Proc. Indian Acad. Sci. (Anim. Sci./Plant Sci.) Suppl*, p.127-163

Nair, S.C. 1991. *The Southern Western ghats*. INTACH, New Delhi, p.92

Nair, S.C. 1994. Conserving the forest: Conserving the value system. *Biodiversity conservation. Whose resources? Whose knowledge?* (Ed. Shiva, V.). Indian National Trust for Art and Cultural Heritage, New Delhi, p.35-49

Nair, V.N. 1985. Tribal health and medicine in Kerala - A study of interrelationship between habitat, health, medicine, society and culture. Ph.D. thesis, University of Calicut, Calicut, Kerala

Nambiar, K.V.P., Sasidharan, N., Renuka, C. and Balagopalan, M. 1985. Studies on the medicinal plants of Kerala forests. *KFRI Research Report No.42.* Kerala Forest Research Institute, Peechi, Kerala

Nameer, P.O. 1993. Ecophysiological studies in disturbed forest ecosystem: A case study at Pattikad. M.Sc.(Forestry) thesis, Kerala Agricultural University, Thrissur, Kerala

Narayanan, A.K. 1993. Collection, cataloguing and evaluation of Rauvolfia spp. M.Sc.(Ag) thesis, Kerala Agricultural University, Thrissur, Kerala

Narayanan, I. 1988. Regeneration status of some important moist deciduous forest trees in the Thrissur forest division. M.Sc.(Forestry) thesis, Kerala Agricultural University, Thrissur, Kerala

Nayar, E.V.G. 1992. Domestication of wild medicinal plants of ayurvedic importance - Need of the day. *Aryavaidyan* 6:47-48

Nayar, M.P. 1996. *Hotspots of endemic plants of India, Nepal and Bhutan*. Tropical Botanic Garden and Research Institute, Thiruvananthapuram, p.252

Nayar, M.P. 1997. Biodiversity challenges in Kerala and science of conservation biology. *Biodiversity and tropical forests. The Kerala Scenario* (Ed. Pushpangadan, P. and Nair, K.S.S.), STEC, Kerala, p.212

Nigam, K.B., Chaurasia, M.C., Jamley, N.R., Agarwal, B.P. and Rawat, G.S. 1984. Effect of Nitrogen, Phosphorus and Potassium on Opium seed yield and morphine strength. *Indian J. Agron.* **29**(1):87-89

Oguntimein, B.O. and Elakovich, S.D. 1991. Allelopathic activity of the essential oils of Nigerian medicinal plants. *Int. J. Pharma* **29**(1):39-44

Ogura, M., Kazerhiro, K., Geoffrey, C.A. and Norman, F.R. 1978. Potential anticancer agents. VIII. Constituents of *Baliospermum montanum* (Euphorbiaceae). *Planta Med.* **33**:128-43

* Ostrogradskii, P.P. and Chernyshev, V.D. 1992. A trial on photo-culture of *Aralia continentalis* Kitag. *Rastitel'nye-Resursy*. **28**(1):55-61

Page, A.L. 1982. *Methods of soil analysis. Part II. 2nd ed.* American Society of Agronomy. Inc. Madison, Wisconsin, USA, p.356

Pandita, K., Bhatia, M.S., Tappu, R.K., Agarwal, S.G., Dhar, K.L. and Atal, C.K. 1983. Seasonal variation of alkaloids of *Adathoda vasica* and detection of glycosides and N-osides of vascine and vasicinone. *Planta Med.* **48**:81-82

Penka, M. 1978. Quoted from Yaniv, Z. and Palevitch, P. 1982. Effect of drought on the secondary metabolite s of medicinal and aromatic plants - a review. *Cultivation and Utilization of Medicinal Plants*. (Ed. Atal, C.K. and Kapur, B.M.). RRL, CSIR, Jammu Tawi, p.1-11

Pillai, R.R. 1990. Quality of oil of clocimum (*Ocimum gratissimum* L.) as influenced by stages of harvest and shade. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, Kerala

Prakash, A., Varma, R.K. and Ghosal, S. 1981. Alkaloidal constituents of *Sida acuta, S. humilis, S. rhombifolia* and *S. spinosa*. *Planta Med.* **43**:384-388

Purushothaman, K.K. and Narayanaswamy, V. 1974. Isolation of gangetin from the roots of *Desmodium gangeticum*. *Indian Drugs*. **140**:367

Purushothaman, K.K., Chandrasekharan, S., Balakrishna, K. and Connolly, J.D. 1975. Gangetinin and desmodin, two minor pterocarpanoids of *Desmodium gangeticum*. *Phytochemistry*. **14**:1129-1130

Purushothaman, K.K., Saraswathy, A., Sarada, A. and Sasikala, E. 1988. Structural studies of iridoids from *Barleria prionitis* L. *Indian Drugs*. **26**:97-100

Purushothaman, S. and Viswanath, S. 1993. Preserving biological diversity: An operational model to compare and contrast. *Indian J. Trop. Biol.* **1**:161-166

Pushpangadan, P. 1986. Aarogyappacha (*Trichopus zeylanicus*). The ginseng of Kani tribe of Agasthya hills (Kerala) for evergreen health and vitality. *Anc. Sci. Life*. **8**(1):13-16

Pushpangadan, P. 1992. On conservation biology, domestication and commercial cultivation of wild medicinal and aromatic plants. *Recent Advances in Medicinal, Aromatic and Spice crops* Vol.2 (Ed. Raychaudhury, S.P.). Today and Tomorrow's Printers & Publishers, New Delhi, p.436

Pushpangadan, P. and Atal, C.K. 1984. Ethno-medico-botanical investigations in Kerala. I. Some primitive tribals of western ghats and their herbal medicine. *J. Ethnopharmacol.* **11**(1):59-77

Pushpangadan, P. and Rajasekharan, S. 1987. Scientific approach and methodology for domestication and commercial cultivation of medicinal plants. *B.M.E.B.R.* Vol.III. No.1-2:85-90

Raghunathan, S. and Mitra, R. 1982. *Pharmacognosy of Indigenous Drugs*, New Delhi, p.616

Rajagopalan, A. 1983. Standardisation of propagation method, time of planting, time of harvest and phytochemical analysis of *Kaempferia galanga*. M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, Kerala

Rajithan, K.S. 1997. Cultivation of medicinal plants for primary health care, self employment and ecological balance. *Proc. 9th Kerala Science Congress*. State Committee on Science, Technology and Environment, Govt. of Kerala, p.247-248

Rao, A.S. 1993. Role of rural communities in conserving biodiversity. *Indian Fmg.* **43**(7):47-54

Rao, B.R.R., Singh, K., Kaul, P.N. and Bhattacharya, A.K. 1991. Influence of nitrogen on yield, nutrient uptake and quality of davana (*Artemesia pallens*). *Indian J. Agron.* **36**(3):395-397

Raveendran, M. and Pandurangan, A.G. 1997. A study on the vegetation and floristics of Triveni MPCA, Kerala. *Proc. 9th Kerala Sci. Cong.* State Committee on Science, Technology & Environment, Government of Kerala, p.66-68

Sadasivam, S. and Manickam, A. 1992. *Biochemical Methods*. New Age International Publishers and Tamil Nadu Agricultural University, Coimbatore, p.373

Sadhale, A. 1991. Studies on some rare and endangered medicinal plants of western ghats of Maharastra. *Proc. Symp. Rare, Endangered and Endemic plants of the Western ghats*. Kerala Forest Department, p.237-275

Salam, M.A. and Wahid, P.A. 1993. *Rooting Patterns of Tropical Crops*. Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, p.331

Samuel, S., Nair, E.V.G., Kumar, D.K.V. and John, R. 1993. Domestication of high value medicinal plants for ayurvedic formulations - needs of the society. *Trad. Med. Systems*. **3**(3):17-21

Sankar, S., Thomas, T.P., Mary, M.V., Balagopalan, M. and Alexander, T.G. 1987. Properties of soils (profiles) in natural forests of Trichur Forest division. Kerala Forest Research Institute (Unpublished)

Sankunni, L. 1988. "*Vaidyasastra Charithram - Ayurvedam*" (Malayalam). Kerala Bhasha Institute, Thiruvananthapuram, Kerala, p.297

Sasidharan, N. 1991. Conservation of rare and threatened medicinal plants in the forest of Kerala. *Proc. Symp. Rare, Endangered and Endemic plants of the Western ghats*. Kerala Forest Department, p.227-229

Sasidharan, N. and Sivarajan, V.V. 1996. *Flowering plants of Thrissur Forests*. Scientific Publishers, Jodhpur, p.916

Sastry, A.R.K. and Sharma, B.D. 1991. The significance of the western ghats in plant conservation. *Proc. Symp. on Conservation Strategy of Rare, Endangered and Endemic plants of Western ghats*, Kerala Forest Department, p.116-119

Sen, S. and Datta, P.C. 1986. Alkaloid quantity of some Apocyanaceous leaf drugs in relation to season. *Acta Hort.* **138**:177-186

Shankar, D., Ved, D.K., Tandon, V., Remesh, S.R., Kareem, A. and Singh, P. 1997. Conserving a national resource - Need for a national policy and national programme on medicinal plant conservation. *Biodiversity and Tropical Forests. The Kerala Scenario*. (Ed. Pushpangadan, P. and Nair, K.S.S.), STEC, Kerala, p.212

Sharma, P.D. 1996. *Ecology and Environment*. Rastogi Publications, Meerut, p.418

Shibata, T., Hatakeyama, Y., Anetai, M. and Kaneshima, H. 1992. The trial cultivation of *Coptis japonica* Makino under unshaded (open) condition in northern Hokkaido. *Shoyokugaku zasshi*. **46**(4):317-321

Singh, B.G. and Subramanyan, K.N. 1991. Endemic plants of Kerala and need for its conservation. *Proc. Symp. Rare, Endangered and Endemic plants of the Western ghats*. Kerala Forest Department, p.314-329

Singh, K.D., Rao, S.V. and Chari, M.S. 1993. Tobacco. *Rooting Patterns of Tropical Crops*. (Ed. Salam, M.A. and Wahid, P.A.). Tata Mc Graw Hill Publishing Company Ltd., New Delhi, p.313

Singh, S.P., Rao, B.R. and Rajeshwara, B.R. 1983. Variability in the total pyrethrin content in Pyrethrum. *Indian Drugs* **20**:365-367

Sivarajan, V.V. and Balachandran, I. 1994. *Ayurvedic Drugs and their Plant Sources*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, p.666

* Skurzova, Z.V. and Shnyakina, G.P. 1985. Dynamics of cardenolides in the aerial parts of *Adonis amurensis*. *Hort. Abstr.* 1986. **56**(4):288

Soldati, F. and Tanaka, O. 1984. *Panax ginseng*. Relation between age of plant and content of ginsengosides. *Planta Med.* **50**:351-352

Subramanyan, S. and Nair, A.G.R. 1972. Flavanoids of *Ruellia prostrata* and *Barleria cristata*. *J. Indian Chem. Soc.* **49**(8):825-6

Subramanyan, K. and Nayar, M.P. 1974. Vegetation and phytogeography of the western ghats. *Ecology and Biogeography of India* (Ed. Mani, M.S.). The Hagur, Netherlands, p.326

Sudhadevi, P.K. 1992. Ethnobotany of medicinal plants used by the tribes of Kerala. Ph.D. thesis, Kerala Agricultural University, Thrissur, Kerala

Sulochana, C.B. 1959. Indian species of *Rauvolfia serpentina*. *J. Indian Bot. Soc.* **18**:575-594

Swarupanandan, K. 1984. Asclepiadaceae of Kerala. Ph.D. thesis, University of Calicut, Calicut, Kerala

Swarupanandan, K. 1991. An analysis of physical basis and causes of rarity in the Asclepiadaceae of Kerala. *Proc. Symp. Rare, Endangered and Endemic plants of the Western ghats*. Kerala Forest Department, p.230-235

Swarupanandan, K. and Sasidharan, N. 1992. Regeneration studies on some important trees in a natural moist deciduous forest ecosystem. *KFRI research report No.88*. Kerala Forest Research Institute, Peechi

Thakur, R.S. 1993. Plant drugs: emerging areas of modern drug research. *Glimpses in Plant Research Vol.XI*. (Ed. Govil, J.N., Singh, V.K. and Hashmi, S.). Today and Tomorrow's Pinter & Publishers, New Delhi, p.427

Thayil, S. 1997a. Medicinal plants of India - Guidelines for national policy and multi-dimensional conservation programmes. *Amruth* 1(8):19

Thayil, S. 1997b. Under seige. The nattivaidya's craft. *Amruth* 1(8):3-8

* Tilihominov, A.A., Zolutukhin, J.C. and Yasid'ko, F. 1976. Effect of light regime on productivity and quality of the harvest of radish. *Soviet Pl. Physiol.* 23:27-31

Tiwari, D.N. 1993. Conservation of biodiversity. *Indian J. Trop. Biod.* 1:1-7

Tiwari, L.C. and Pandey, G. 1992. Quality control of indegenous pharmaceutical products. *Aryavaidyan.* 6(1):49-53

Vaidya, B. 1982. *Some Controversial drugs in Indian Medicine.* Chankhambha Orientalia, Varanasi, Delhi, p.219

Varughese, S. 1989. Screening of varieties of ginger and turmeric for shade tolerance. M.Sc.(Ag) thesis, Kerala Agricultural University, Thrissur, Kerala

Viswanathan, T.V. 1975. Cytogenetic studies on some medicinal plants of the genus *Solanum* utilised by the tribals of Kerala and Tamil Nadu. Ph.D. thesis, University of Calicut, Calicut, Kerala

Viswanathan, T.V. 1991. Root and seed yield estimation in selected *Sida* spp. Progress report of AICRP on M & AP, Trichur Centre presented at the IXth All India Workshop of AICRP on M & AP. Gujarat Agricultural University, Anand

Viswanathan, T.V. 1993. Bala and Long Pepper. *Rooting Pattern of Tropical crops.* (Ed. Salam, M.A. and Wahid, P.A.). Tata Mc-Graw Hill Publishing Company Ltd., New Delhi, p.313

Viswanathan, T.V. 1995. Long peppper. *Advances in Horticulture Vol.II. Medicinal & Aromatic Plants.* (Ed. K.L.Chadha). Malhotra Publishing House, New Delhi, p.383

Appendices

Appendix 1. Growth rate of *Piper longum* in different habitats in the forest

Habitat	Growth rate (%)	Plant height	Number of leaves	Total leaf area
PNV	LGR	96.4	16.6	34.4
	CGR	230.1	92.7	154.6
KP-1	LGR	106.6'	19.2	25.5
	CGR	241.1	91.8	117.7
KP-2	LGR	91.9	37.5	92.8
	CGR	293.5	159.4	411.6
KC-1	LGR	128.2	58.9	54.0
	CGR	380.8	248.3	238.0
KC-2	LGR	104.0'	44.3	44.1
	CGR	348.7	180.5	180.5
VK-1	LGR	8.8'	8.9'	11.1'
	CGR	49.6	55.2	69.4
VK-2	LGR	7.6'	144.9	60.3
	CGR	46.2	144.9	60.3
M-1	LGR	12.6'	9.1'	14.0'
	CGR	175.7	64.0	86.6
M-2	LGR	0'	3.5'	8.2'
	CGR	3.2	26.4	48.5
AK	LGR	-*	164.2	188.9
	CGR	1032.4	394.3	417.6

LGR - Linear growth rate
CGR - Compound growth rate

* LGR is not given due to negative intercept
' Values not significant

Appendix 2. Growth rate of *Naravelia zeylanica* in different habitats in the forest

Habitat	Growth rate (%)	Plant height	Number of leaves	Total leaf area
PNV	LGR	10.8	5.9'	5.9'
	CGR	51.7	35.8	35.8
KP-1	LGR	12.6	6.3	6.6
	CGR	48.4	36.7	38.4
KP-2	LGR	15.6	7.6	8.1
	CGR	50.2	42.6	50.6
KC-1	LGR	84.7'	26.8'	25.1'
	CGR	358.1	98.1	92.7
KC-2	LGR	1.6'	12.5	6.4'
	CGR	10.4	69.0	38.3
VK-1	LGR	21.4'	7.7'	10.6'
	CGR	133.3	53.8	68.2
VK-2	LGR	9.5'	3.7'	3.1'
	CGR	50.3	21.8	18.8
M-1	LGR	32.0	27.5	18.3'
	CGR	170.3	151.1	107.9
M-2	LGR	156.9	10.0'	22.5
	CGR	404.6	45.2	100.4
AK	LGR	3.2'	39.2	33.7
	CGR	18.0	173.5	160.6

LGR - Linear growth rate
CGR - Compound growth rate
' - Values not signfiicant

Appendix 3. Growth rate of *Sida rhombifolia* spp. retusa in different habitats in the forest

Habitat	Growth rate (%)	Plant height	Number of leaves	Total leaf area
PNV	LGR	27.0	29.0	35.9
	CGR	130.1	122.8	146.6
VK-1	LGR	14.7	12.3	14.8
	CGR	70.2	63.6	73.3
M-1	LGR	35.0	43.7'	4.0'
	CGR	137.6	144.3	145.4
M-2	LGR	10.9	18.4	16.9
	CGR	56.3	50.9	59.1
AK	LGR	-*	-*	-*
	CGR	976.4	1358.8	1484.8

LGR - Linear growth rate
CGR - Compound growth rate
- * - LGR not given due to negative intercept
' - Values not significant

Appendix 4. Growth rate of *Desmodium velutinum* in different habitats in the forest

Habitat	Growth rate (%)	Plant height	Number of leaves	Total leaf area
PNV	LGR	18.8	-*	5.9'
	CGR	90.1	1385.9	33.3
VK-1	LGR	6.1'	9.2'	0.8'
	CDG	35.8	56.3	5.6
VK-2	LGR	6.8	20.0	21.5
	CGR	33.9	90.9	97.2
M-1	LGR	39.6	67.4	64.1
	CGR	196.1	292.6	186.3
M-2	LGR	20.1	12.0	9.2'
	CGR	91.4	66.7	53.1
AK	LGR	3.8	0'	0'
	CGR	20.7	3.2	1.8

LGR - Linear growth rate
CGR - Compound growth rate
-* - LGR not given due to negative intercept
' - Values not significant

Appendix 5. Growth rate of *Baliospermum solanifolium* in different habitats in the forest

Habitat	Growth rate (%)	Plant height	Number of leaves	Total leaf area
KP-1	LGR	3.5	12.0	18.6
	CGR	21.0	68.2	100.9
KP-2	LGR	15.3	6.8	9.3
	CGR	67.4	41.5	53.1
KC-1	LGR	28.3	8.9	10.8
	CGR	115.2	49.2	57.3
KC-2	LGR	9.6	7.8	9.3
	CGR	48.9	44.2	51.7
VK-2	LGR	2.1	10.8	11.7
	CGR	14.6	36.6	48.6

LGR - Linear growth rate
CGR - Compound growth rate

Appendix 6. Growth rate of *Barleria pratensis* in different habitats in the forest

Habitat	Growth rate (%)	Plant height	Number of leaves	Total leaf area
KC-1	LGR	36.0	43.9	41.7
	CGR	167.3	184.4	179.2
VK-2	LGR	12.7	4.4	4.9'
	CGR	61.8	23.5	28.8

LGR - Linear growth rate
CGR - Compound growth rate
' - Values not significant

Appendix-7

Growth rate of select species in the domestic environment

Species	Growth rate (%)	Plant height	Number of branches	Number of leaves	Total leaf area
Piper	LGR	13.88	-*	-*	-*
	CGR	69.04	27.05	33.35	52.76
Naravelia	LGR	-*	-*	12.10	-*
	CGR	36.45	31.21	59.23	45.55
Sida	LGR	24.16	1.01	-*	-*
	CGR	67.11	62.93	40.28	46.22
Desmodium	LGR	9.59	19.05	0	-*
	CGR	72.18	58.13	132.81	58.49
Baliospermum	LGR	-*	-*	1.17	0.71
	CGR	36.46	28.23	71.79	56.31
Barleria	LGR	0	0	0	-*
	CGR	132.80	58.85	36.14	28.82

LGR - Linear growth rate

CGR - Compound growth rate

-* - LGR is not given due to negative intercept

HABIT AND HABITAT ANALYSIS OF SELECT MEDICINAL PLANTS IN NATIVE AND DOMESTIC ENVIRONMENTS

By

N. MINI RAJ

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirements for the degree

Doctor of Philosophy in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Plantation Crops and Spices
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 654
KERALA, INDIA

1997

ABSTRACT

Investigations on 'Habit and habitat analysis of select medicinal plants in native and domestic environments' was undertaken at the Department of Plantation Crops and Spices, College of Horticulture, Vellanikkara 680 654, Kerala, during the period 1994-97. The first two experiments viz., survey and natural habit at analysis were carried out in the Peechi forests and the last two viz., domestic environment analysis and biochemical analysis in the College of Horticulture.

Ethno-medicines practiced by the 'Malayans' of the Peechi forests were documented. The floristic survey identified 226 medicinal plants distributed over several habits, habitats, plant families etc. There were 22 endemic, ten endangered, six rare and nine threatened species. Extraction procedures of the drugs were documented which varied with the plant and the part used. Practice of substitution/adulteration was noticed in a few drugs.

Based on the survey, six species were chosen for detailed habitat analysis. They were *Piper longum, Naravelia zeylanica, Sida rhombifolia* ssp. retusa, *Desmodium velutinum, Baliospermum solanifolium* and *Barleria prattensis*.

Ten different habitats were selected in the MDF and they were characterised by physiographic, climatic, edaphic and biotic variables. Habitats were also grouped by cluster analysis.

The growth pattern of the select species in the forest showed that it was almost linear upto November in all the habitats. Among the ten habitats, KC-1 appeared to be congenial for the natural growth and productivity of *Piper*,

Naravelia, Desmodium and *Barleria*. The habitat, KP-1 appeared to support maximum growth of *Baliospermum* and the habitat M-1 for *Sida*. *Piper* and *Naravelia* did not flower in the forest whereas in the remaining species, flowering occurred during October-January. Among the six species, *Barleria* and *Naravelia* recorded maximum regeneration and forest fire was not a limiting factor for the regeneration of these species.

In the domestic environment, all the species grew flowered and seeded well with a strictly linear growth pattern upto January. The plant habit changed in the domestic environment in all the species. Except *Naravelia* all the species recorded higher biological and economic yields in the domestic environment.

Phytoconstituents of *Desmodium velutinum, Barleria prattensis* and *Naravelia zeylanica* were reported for the first time.

The nature and content of the primary and secondary metabolites of all the species varied with the change of habitat.

The study indicated the possibility of cultivating these species by providing conditions similar to that of the natural habitat; thereby assuring the quality of the drug.

Necessity for regulating the collection of medicinal plants from the Peechi forests was also highlighted.

171255