BIODIVERSITY OF MEDICINAL PLANTS IN VELLAYANI

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THESIS

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I hereby declare that this thesis entitled **Biodiversity of medicinal plants in Vellayani'** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the bas s for the award of any degree diploma associateship fellowship or other similar title of any other university or society

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CERTIFICATE

Certified that this thesis entitled **Biodiversity of medicinal plants in Vellayani** is a record of research work done independently by **Ms Jyothilekshmi L** under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her

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INTRODUCTION

INTRODUCTION

India has one of the oldest richest and diverse cultural traditions associated with the use of medicinal plants The plant wealth of India comprises of many species of therapeutic value specified in the pharmacopoeias of various countries In India around 8 900 plant species of ethno botanical importance are available on which around 70 per cent population depends for their health care Herbal drugs are popular for their safety efficacy cultural acceptability and less side effects (Mandal and Ghosh 2000)

Our country is floristically very rich and is counted among the twelve mega biodiversity centers of the world About 400 plants are used in Ayurveda Unani Siddha and Tibetan medicines Around 70 per cent of India s medicinal plants are found in her tropical forests and less than 30 per cent are found in the temperate region (Shankar *et al* 1997) Micro studies show that a larger percentage of medicinal plants occur in the dry and moist deciduous forests as compared to the evergreen or temperate forests These medicmal plants are seen in their natural state of growth as weeds in many parts of the country Throughout the warm humid tropics the growth of natural vegetation is rapid and vigorous The lush natural flora of weed species growing in different habitats are widely used in indigenous system of medicine and folklore medicine Different habitats like dry and moist area harbour many weed species which have medicinal properties

FRLHT (Foundation For Revitalisation of Local Health Traditions) report on first red listed medicinal plants of South India shows that 74 species are under

rare endangered and threatened category Over 70 per cent of the plant collection involves destructive harvesting because of the use of parts like roots bark wood stem and whole plant This causes a definite threat to the genetic stocks and to the diversity of medicinal plants Floristic investigations help the conservationist to take adequate protective measures against rare and threatened plant species in time lest they get wiped out from the face of earth

Vellayani watershed is one of the botanically less explored area in Thiruvananthapuram district of Kerala and no concerted efforts have been made in the past Hence a study of the medicinal plants in Vellayani area can be helpful in the present context of scarcity of medicinal plants Further the study of growth behaviour of selected medicinal plants available in the area will give a clue whether such plants can be commercially cultivated in the area This view can be authenticated by the chemical investigations of active ingredient in these plants Such a study will enlighten the feasibility of cultivation of medicinal plants in this area which in turn will help to increase the income per unit area

With these considerations the following were set out as major object ves of the present study

(1) Identification and cataloguing of plants from among the existing natural flora in and around Vellayam lake

(2) Study of growth behaviour of selected medicinal plants

(3) Chemical investigations of active constituents of the selected medicinal plants

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2 1 Medicinal plant resources in India

The humid tropical forest of our country is a treasure chest of biodiversity w th different agro climatic conditions and India naturally hosts a large variety of plants India is the home of about 15 000 to 18 000 flowering plants of which about 7 000 plants are recognized as medicinal plants and are being used by various traditional systems of medicine

Since ancient period of civilization medicinal plants are known as one of the gifts of nature to cure a number of diseases of human beings The knowledge of Ayurveda has led to the discovery of many potent bioactive agents in modern drug development (Devsukh 1997) India is one of the richest countries for medicinal and aromatic plant genetic resources in the world It apportions 11 per cent of total known world flora though its total land mass is only 2 per cent of the whole world (Botanical Survey of India 1997) of which about 30 per cent are endemic to India (Jain 1990)

According to another estimate on marketing and trades of medicinal plants around 1 500 plants are currently being exploited under traditional systems of medicine *viz* Ayurveda Sidha and Unani (Bhatnagar 1997) According to Kumar *et al* (1997) the number of medicinal and aromatic plants constituted the viable component of human health care at one time or the other in different world cultures over millennia is enormously large They occur most preponderantly in tropical and subtropical countries

India is one of the world s top twelve megadiversity centers containing about 45 000 species of plants It is floristically one of the richest countries in the world ranking 10^{h} on global basis and 4^{h} among Asian nations (Natesh 1998) Two out of the 18 hot spots in the world are in India – Eastern Himalayas and Western Ghats both with high degree of endemism (Swaminathan 1993)

According to Vedprakash (1998) around 3 000 plant species are known for their medicinal value in India The total number of plants used by village communities for human and veterinary health care is about 6 500 to 7 000 species for the last 5 000 years Another estimate states that there are more than 7 500 species of medicinal plants in India, which are being used by various ethnic communities for human and veterinary health care (Vijayalakshmi 1999) Acording to Sharma (1999) India is one of the richest countries for medicinal and aromatic plant genetic resources in the world

2 2 Biodiversity of medicinal plants

Biodiversity can be defined as the sum total of plants animals and micro organisms existing as an interacting system in the biosphere It can be auto sustainable and self regenerating if there are no natural and man made perturbations Biodiversity depends mainly on two functions Firstly it depends on the stability of the biosphere which leads to the stability of climate water soil and health of the biosphere Secondly the species on which the human race depends for food fuel fibre and medicine (Khoshoo 1991)

According to Singh *et al* (1994) the very basis of human survival and economic well being is the biodiversity as it provides food medicine and industrial raw material and offers potential for providing many more unknown benefits for future generations

Biodiversity refers to the variety and variability of all plants animals and micro organisms on earth and is considered at three levels such as genetic diversity species diversity and ecosystem diversity (Haeruman 1995)

2 2 1 Biodiversity in forests

The humid tropical evergreen forests of Kerala are rich in plant wealth with considerable diversity The Western Ghats comprise of different forest types *viz* wet evergreen semi evergreen dry deciduous moist deciduous scrub jungles shoalas and montane grasslands Silent valley and Agasthyamala regions in the Western Ghats comprise ra n forests Thus Kerala is rich in biodiversity because of these varied forest types

The pioneer work on the medicinal plants n and around Cochin province of Kerala state was the Hortus Malabaricus written by Hendrick Van Rheede (1678 1693) This twelve volume monumental work gave description of 742 plants including their medicinal properties Manilal (1984) attempted rediscovery of the medicinal plants mentioned in Hortus Malabaricus

The medicinal plant wealth of the Western Ghats is very rich A descriptive list of the medicinal plants of Kerala forest was prepared by Nambiar *et al* (1985) Nair and Daniel (1986) published a list of about 46 species of important medicinal plants in Kerala forests The evergreen forests consist of distinct storeys of trees and a ground layer of shrubs and herbs All these layers contain several medicinal species (Nair and Dan el 1986)

According to Sasidharan (1991) among the medicinal plants of Kerala forests about 150 species are used for the manufacture of Ayurvedic medicines on a commercial scale while others are used by traditional vaidyas and tribals Bhat and Padmaja (1991) described 25 vulnerable medicinal plants of Munnar forest region

India as a center of genetic diversity has many wild relatives of crop plants which are potentially useful sources of genes for plant breeding and biotechnology Medicinal plants one such genetic resource available both wild and cultivated offer new pharmaceutical products (Chandel *et al* 199?) Many of the wild medicinal and aromat c plants are highly habitat specific found only in forests and occupied highly specialized ecological niches with restricted distribution (Pushpangadan 1992)

Sharma and Hore (1993) observed a wide diversity of medicinal plants in north eastern India Kinghorn and Balandrin (1993) described about the tropical forest biodiversity and the potential for new medicinal plants biological and chemical diversity and the search for new pharmaceuticals and other bioactive natural products

India though rich in biodiversity with about 45 000 plant species is now under threat of partial extinction of several species mainly due to human intervention (Damodaran 1996) The humid tropical forests of India have a remarkable diversity of medicinal plants Almost every major types of habitat are found here Ecosystem wise India has 42 vegetation types 26 major forest types 10 geographical zones and 25 hotspots of endemic centers (Nayar 1996) It is the sum total of such remarkable diversity which has made India a gene bank for a number of medicinal and aromatic plants Younes (1996) discussed about the contributions of tropical biodiversity to the world's medicine cabinets along with lists of plants in use

A macro analysis of the distribution of medicinal plants by Shankar *et al* (1997) 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 temperate forests and higher altitudes Micro studies showed that a larger percentage of medicinal plants occur in their dry and moist deciduous forests as compared to the evergreen or temperate forests

In a floristic diversity study of the Agasthyamala area of the Western Ghats Mohanan *et al* (1997) located 124 highly important medicinal plants which demand active conservation measures to save them from commercial over exploitation

A study conducted by Raveendran and Pandurangan (1997) in the Kerala Western Ghats on floristic diversity of Triveni Medicinal Plant Conservation Area (MPCA) revealed that 46 per cent of the flora contained known medicinal plants and 149 medicinal plants were collected from this area

Habit and habitat analysis of selected medicinal plants in native and domestic environment of Peechi hills was done by Miniraj (1997) and enabled to locate 226 medicinal plants distributed over 73 families of which 64 per cent were from moist deciduous forest and 25 per cent from the semi evergreen forest In the regional assessment there were altogether 25 rare endangered or threatened species

Vegetation characteristics of southern secondary moist deciduous forest in the Agasthyamala area of Kerala were assessed by random sampling through census quadrat method A total of 694 individuals belonging to 49 species and spreadmg over 29 families were recorded (Varghese and Menon 1998)

In a study on the status dynamics of a few sacred groves of Kerala, a number of medicinal plants that are economically important were collected and identified (Radha *et al* 1998) But in the present day context due to exposure of sacred groves to outside community and ruthless forest exploitation sacred groves are being disturbed and in some cases destroyed beyond reversible limits

Sasidharan (1999) conducted a study on the flora of Chinnar wild life sanctuary one of the 12 sanctuaries in Kerala This sanctuary is a treasure house of medicinal plants with 335 species of angiosperms recorded as medicinal

Tropical Botanic Garden and Research Institute (TBG&RI) with support from Kerala Forest Department carried out the floristic studies of Eravikulam Nat onal Park Idukki resulted emphasis to the rare and endemic species (Biju and Manojkumar 1999)

An extensive survey covering the forest ranges and homesteads of Kerala vas carried out to assemble the available variability of the four medicinal plants *Adhatoda beddomei Plumbago rosea Kaempferia galanga* and *Asparagus racemosus* (Kurian and Augustin 2000) The collected types were documented catalogued and evaluated as pure crop and intercrop in coconut garden

2 2 2 Biodiversity in plantations

The cocunut plantations and rubber plantations cover the majority of area under plantation crops in Kerala The interspaces of these crops allow the growth of natural vegetation The vicinity of these plantations to forests also promotes the luxuriant gro vth of numerous plant species under their canopy

Pushparajah and Woo (1971) reported several weeds such as *Axonopus compresses Paspalum conjugatum Elusine indica Cyperus* sp and *Borreria alata* in rubber plantations of Malaysia

Raghavan (1992) catalogued the medicinal plants in Vellanikkara rubber estate He catalogued 50 plants growing as undergrowths in rubber plantations Quantification of medicinal plants identified m rubber plantations of Vellanikkara was done by Ramabhadran (1993) He described 34 species of medicinal plants and quantified the availab lity of officinal parts of important medicinal plants

In a study on Biodiversity of medicinal plants conducted at the Oil palm Plantations Kulathupuzha Kollam by (Sarada 2000) a total of 85 plant species were identified belonging to 79 genera and 36 families None of the plants were endem c There were 74 indigenous and 10 exotic or naturalized plants Ten important medicinal plants species were selected for detailed study and their growth behavior was mon tored for one year

2 3 Ethno medicinal investigations

Investigations m the Western Ghats among the primitive tribes were done by Pushpangadan and Atal (1984) Medicinal herbs used by the tribes were identified and described 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 constituent in the plant

Medicinal uses of 93 plants of 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 tribes of Agasthyamala area for the plant *Trichopus zeylanicus* that induces evergreen health and vitality

A study among the tribes of Wynad Kerala was conducted by Mathur (1987 a) and presented data on their etiology treatment and traditional curing techniques A detailed account of the ethno medicine of the Irular tribe of Attapady along with the etiology of illness and treatment was prepared by Mathur (1987 b)

Ethno botany of medicinal plants used by tribes in Kerala was studied by Sudhadevi (1992) The study included the documentation of ethnomedicines used by the Malayan tribes of Thrissur district their botanical description and propagation methods from Chimminy area 73 plants from Marottichal 93 from Sholayar 125 from Vazhachal 108 and from Vazhani forests 73 were reported She had listed the plants *Alstonia venenata Coscinium fenestratum Habenaria latilabris Rotula aquatica* and *Woodfordia fruticosa* as rare in the forests of Thrissur

Radhakrishnan *et al* (1996) had listed some lesser known plant species which were traditionally used by different tribal communities of Kerala for treating various ailments He had also arranged those plant species alphabetically with family name followed by local name with therapeutical details

2 3 Conservation of biodiversity

Conservation of biodiversity is attempted principally through two methods *in situ* and *ex situ* *In situ* conservation involves conservation under natural conditions *Ex situ* approach aims at conservation of complete organisms or their relevant parts outside their natural habitat (Khoshoo 1991) Revival of interest in herbal drugs necessitates that the plants should be conserved from extinction documented and catalogued (Panicker 1993)

Simpson *et al* (1996) defined biodiversity prospecting as a mechanism for both discovering new pharmaceutical products and saving endangered ecosystem

Rajashekharan *et al* (1996) reported that biodiversity conservation has recently received attention all over the world and its various aspects have been debated at different platforms by scientific communities policy makers and administrators

Ved *et al* (1998) reported that many of the therapeutically useful plants are no longer available from the wild in quantities required Nonavailability of quality raw material is not only because of the population pressure and increase in demand but also because of the fact that 70 per cent of the plant drugs involve destructive harvesting of roots (29 per cent) rhizomes (4 per cent) whole plant (16 per cent) bark (14 per cent) wood (3 per cent) and stem (6 per cent)

2 4 1 Endemism and RET plants

Endemism and RET (Rare Endangered and Threatened) plants are the common terms used in biodiversity studies India has many endemic plants and vertebrate species Among plant species endemism is estimated at 33 per cent w th 140 endemic families (Botanical Survey of India 1983)

Areas rich in endemism are North East India the Western Ghats and north western and eastern Himalayas A small pocket of local endemism also occurs in the Eastern Ghats (Mackinnon and Mackinnon 1986) Amalraj *et al* (1991) enumerated four endangered and eight threatened medicinal plant species from Western Ghats

The features uses and distribution and status of *Coscinium* sp *Embelia ribes Helminthostachys zeylanica Heracleum candolleanum Holostema adakodian* and *Rauvolfia serpentina* were studied by Dan and Shavanakshan (1991) and these were found becoming potentially rare in Southern Western Ghats due to over exploitation

Ram (1991) reported that conservation of endangered plant species through *in vitro* micropropagation techniques is a method of recent origin which holds great promises for the conservation of endangered plant species such as *Picorhiza kurroa Valeriana wallichii Podophyllum hexandurm Saussurea lappa and Coptis teeta*

Handa (1992) published a list of 19 threatened or endangered medicinal plants in India Many of the medicmal plant species have become rare endangered or threatened due to various factors Due to over exploitation several medicinal plants such as *Rauvolfia serpentina Dioscorea deltoidea Aconitum deinrrhizeum Atropa acuminata* and *Gentiana kurroa* (Western Himalayas) *Coptis teeta* (Arunachal Pradesh) *Nardostachys grandiflora* and *Picorhiza kurroa* (Alpine Himalayas) have become endangered (Arora 1983 Thakur 1993)

A red data list of South Indian medicinal plants published recently by FRLHT (Foundation for Revitalisation of Local Health Traditions) listed 73 medicinal plants under different categories as vulnerable rare critically endangered endangered extinct, low risk, data deficient and extinct in wild (Shankar *et al* 1997) Based on recent ethnobotanical surveys 2500 endemic plants are also now known to have varied and novel medicmal uses m India (Vedprakash 1998)

2 5 Vegetative parameters in biodiversity study

The important vegetative parameters used in biodiversity study are frequency density abundance and important value index The distribution pattern of different species was studied using the ratio of abundance to frequency (Whiteford, 1949) because the relation between the frequency and abundance indicates the nature of species distribution (Curtis and Cottam 1956)

Quantitative characteristics *viz* frequency density and abundance were studied following Curtis and Mc Intosh (1950) The relative values were determined The values were summed to obtain Importance Value Index (IVI) of individual species (Curtis 1959)

Diversity Index and concentration of dominance were calculated using Shannon Wiener Information Function (Shannon and Wiener 1963) and Simpson s Index (Simpson 1949) respectively

The species richness diversity and concentration of dominance of species in the plant stands were computed to extract more information about the structure and composition The species richness is simply the number of species per unit area (Whittaker 1972) The natural regeneration of different plant species was studied by adopting quadrat method suggested by Kersham (1973)

A study of the relationship between disturbances and community phenomenon aimed to enquire the patterns of change in plant diversity along the disturbance gradient (Pandey and Shukla 1999) The Important Value Index (IVI) for different species was calculated as the sum of relative frequency relative density of each species These values for different species of common habitat were summed to compare the species group with in the same stand and those of different stands The grand sum of frequency and density of all the species constituting different communities were also derived

Studies were undertaken in ten and twenty year old pure stands of *Acacia auriculiformis* along with twenty year old mixed stand with dominance of *Enterolobium cyclocarpum* in Auroville South Arcot district Tamil Nadu Vegetative parameters like relative density relative frequency abundance and diversity index were recorded (Buveneswaran *et al* 1999)

Plant biodiversity of dry deciduous forest of Sandur was assessed by establishing twenty transects totaling 2 ha (Seetharam *et al* 1999) Biomass and diversity of community were also enumerated The diversity of forest is 1 73 (Shannon) 0 697 (Evenness) Simpson s Index showed 0 749(1 D) 3 984 (1/D) The floristic richness was made using Margalef Index (24 75) and Mechinicks Index (3 00)

A survey on the weed flora of coconut gardens in the southern agroclimatic zone of Kerala was conducted by Abraham and Abraham (2000) Average specieswise count of the weeds from 33 randomly selected coconut gardens were recorded and the relative frequency relative density and Summed Dominance Ratio (SDR) of each weed spec es were calculated Among the 28 weed species recorded *Axonopus compressus Ischaemum indicum Borreria hispida Mimosa pudica Desmodium triflorum* and *Vernonia cinerea* were top ranking ones accounting more than 50 per cent of the total SDR values

2 6 Chemical constituents and medicinal properties

Chopra *et al* (1958) found that the plants generally owe their virtues as medicinal agents to characteristic constituents like alkaloids glycosides sapon ns

flavanoids tannins volatile oil steroids or terpenoids resin and mucilage present n them The synthesis of these compounds takes place during their metabolic process when the plant grows The amount of active substances present in plants is dependent upon several factors such as the nature of the soil the climate the season the stage of growth of a plant the nature and intensity of light and cultivation

Jain and Puri (1984) published a list of 100 species of ethno medicinal plants with description of their medicinal uses Methods of preparation of crude drugs were given and the active ingredients were indicated

Antipyretic activity of some Indian plants in traditional medicines was revealed by Anis and Iqbal (1986) based on a survey of the Gwalior forest region in Central India fifteen preparations made with seventeen plant species were found to be used by Sharon tribe against pneumonia malaria typhoid and other fevers

According to Mossa *et al* (1987) glycosides are much wider in occurance than alkaloids and they are sugar containing compounds They constitute major classes of drugs like digitalis glycosides sennosides rutin etc

At least 121 chemical substances of known structure are still extracted from plants that are useful as drugs throughout the world (Farnsworth and Soejarto 1988) Santhosh and Bharadwaj (1996) reported that plant cells are highly sophisticated chemical factories where a large variety of chemical compounds are manufactured with

great precision and ease from simple raw materials Plants are thus a very important renewable source of raw materials for the production of a variety of chemicals and drugs

2 6 1 ***Bacopa monnieri***

The drug from *Bacopa monnieri* enhances memory and facilitates learning by enhancement of protein kinase activity and new protein synthesis The effect is mainly due to the plant saponin known as bacoside A (Chatterjee *et al* 1963)

Brahmi (*Bacopa monnieri*) has been clinically tried in 35 cases of anxiety neurosis One month treatment with this drug provides significant relief in symptoms besides a quantitative reduction in the level of anxiety Thus this drug appears to be an anti anxiety agent and has adaptogenic effect (Singh and Singh 1980)

The plant extract of *Bacopa monnieri* is also known to cure leprosy anaemia and epilepsy and has shown to possess anticancerous activity (Shanmugasundaram *et al* 1991)

A spectrophotometric method for estimation of bacoside A was reported by Pal and Sarin (1992) A saponin mixture (bacoside) obtained from *Bacopa monnieri* conta ns mainly bacoside A minor amount of bacoside B along with unidentified compounds of minor quantity Bacoside A rf 0 52 and bacoside B rf 0 11 in solvent BuOH EtOAC H_2O 4 1 5

A minor triterpene saponin was obtained from *Bacopa monnieri* Its structure was elucidated as 3 O {alpha L arabino furanosyl (1 3) alpha 2 arabinopyranosyl} jujubogenin by chemical and spectral studies (Jain and Kulshreshtha 1993)

A new triterpenoid saponin bacoside A3 a constituent of bacosides the saponin mixture of *Bacopa monnieri* (brahmi) was isolated and characterized (Rastogi *et al* 1994 a) Studies were carried out to find the seasonal variation of chemical constituents especially bacosides in *Bacopa monnieri* by Rastogi *et al* (1994 b) It was observed that there was a marked change in the content of different constituents

A new dammarane type triterpenoid saponins bacosaponins A B and C of biological interest have been isolated from *Bacopa monnieri* and identified as 3 O alpha L arabinopyranosyl 20 O alpha L arabinopyranosyl jujubogenin by spectrophotometric method and some chemical transformations (Garai *et al* 1996)

Structure of bacosine isolated from the aerial parts of *Bacopa monnieri* was elucidated as lup 20 (29) ene 3 alpha ol 27 oic acid by Uohora *et al* (1997) Bacosine exhibited moderate analgesic effects

A simple quick and accurate high performance thin layer chromatography method for the determination of memory enhancing drug bacoside A in *Bacopa monnieri* was described by Gupta *et al* (1998) The combines separation and visualization of

bacoside A colour and scanning of the blue coloured spot on the silica gel 60 F 254 high performance thin layer plate by dual wave lengh absorption reflection mode using a TLC scanner Using this technique it has been demonstrated that *Bacopa monnieri* harvested shoots dried to 80^0 C for 30 minutes helps in the retention of higher amounts of bacoside A in the dried plant material

2 6 2 *Andrographis paniculata*

The drug of *Andrographis paniculata* has been included in the Indian pharmacopoe a Andrographolide is the main active bitter principle of Kalmegh *(Andrographis paniculata)* The gravimetric method of estimation is described in the Indian Pharmacopoeial List (1946) and subsequently incorporated in the Indian Pharmacopoeia was found to give high results due to some yellow colouring substance other than andrographolide which is soluble in ethyl acetate (Pharmacopoeia of India 1955) *Andrographis paniculata* Nees (Fa Acanthacea) popularly known as Kalmegh is a well known drug in the Hindu system of medicine and is widely cultivated in Ind a The extract of this plant is used to relieve griping irregular stools and loss of appetite It has also the reputation of being febrifuge tonic alterative and antihelmmthic (Chopra 1958)

The colorimetric method of estimation of andrographolide was proposed by Maiti *et al* (1959) The disadvantage of this method is that the red colour formed with the

addition of alcoholic potassium hydroxide to the solution of andrographolide is unstable and fades always quickly

Rao (1962) suggested a chemical method involving a lactone titration for the estimation of andrographolide from *Andrographis paniculata* but the method had been reported to be not suitable for detecting quantities less than 100 mg

A spectrophotometric method of assay of andrographolide in Kalmegh (*Andrographis paniculata*) by measuring absorption at 226 nm has been described by Gaind *et al* (1963) The method was found to be more rapid and more accurate than the official method and other methods so far reported Samples containing 0 02 mg or less of andrographolide content can be satisfactorily estimated by this method

An ion pair HPLC method for the separation and determination of various water soluble andrographolide derivatives from *Andrographis paniculata* was reported by Xianglin *et al* (1981)

Two new glucosides *viz* 14 deoxy andrographolide 19 B glucoside and andrographolide 19 B glucoside have been isolated from *Andrographis paniculata* and characterized (Hu and Zhou 1982)

According to Handa and Sharma (1990) andrographolide is the major active principle present in *Andrographis paniculata*

Andrographohde a diterpene isolated from *Andrographis paniculata* exhibited a strong choleractic action when administrated intraperitineally to albino rats This substance induced an increase in bile flow together with a change in the physical properties of the bile secretion (Tripathi and Tripathi 1991)

Visen *et al* (1991) found that andrographohde the active antihepatotoxic principle isolated from the plant *Andrographis paniculata* showed a s gnificant anticholestatic effect against galactosamine induced hepatic damage Andrographohde was found to be more potent than silymarine a known hepatoprotective drug

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study on the biodiversity of medicinal plants in Vellayani was carried out in and around Vellayani lake of Thiruvananthapuram district The period of study was January 1999 to March 2000 Studies were undertaken under the following major heads

3 1 Study of site selected and mapping of the area
3 2 Collection of plant samples
3 3 Study of growth phases of selected medicinal plants
3 4 Chemical analysis of officinal part

3 1 Study of site selected and mapping of the area

3 1 1 Study site

Table 1 Geographical and weather parameters of the site selected for study

Location	In and around Vellayani lake Thiruvananthapuram
Latitude	8 5 ^{0} North
Longitude	76 9 ^{0} East
Altitude	29 35 m above mean sea level
Average annual Rainfall during the study	2046 mm
Temperature	23 2 30 64 ^{0}C
Average annual relative humidity	82 25%

The study area comprises of four categories

1) Dry land
2) Garden land
3) Paddy field
4) Lake area

In each strata, nature of soil varies In dry land soil is loamy laterite and in garden land, soil is well drained sandy loam and in paddy field soil is clayey and lake area with clayey soil and water

3 1 2 Mapping of the area

Mapping of the study site was done and maps were prepared (Fig 1)

3 2 Collection of plant samples

3 2 1 Sampling technique

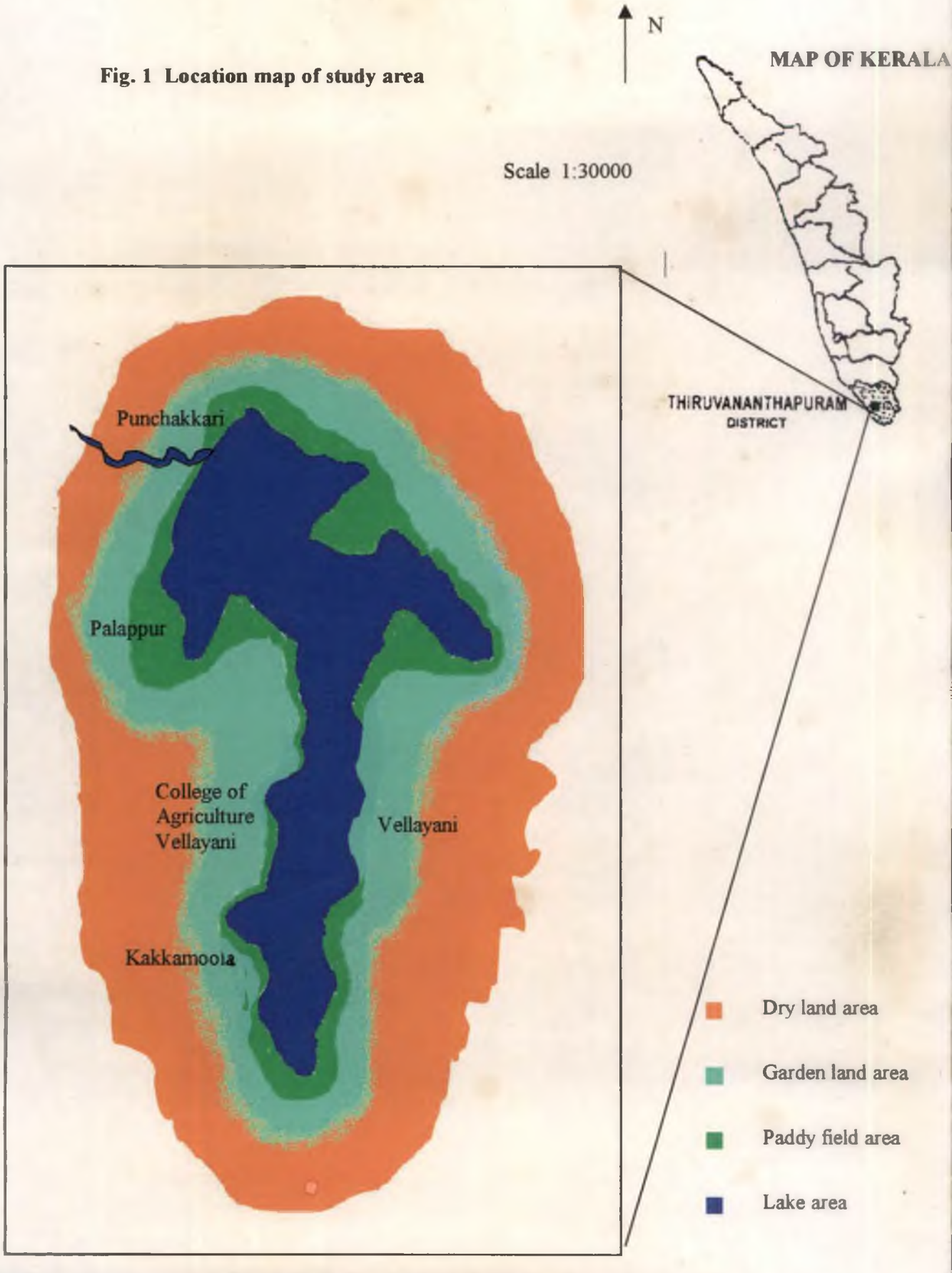
For collection of plant samples stratified random sampling technique was adopted the strata being dry land (D) garden land (G) paddy field (P) and lake area (L)

The medicmal plants in these stratas were collected and quantified by random sampling technique using 1 0 m^2 metallic frame The frame was thrown at random and all the plants in each quadrat were collected and sorted A total of 80 such sampling units were taken randomly giving sufficient representation to the area covered

3 2 2 Identification of flora

A large number of herbs and shrubs of annual or perennial nature are growing in the four different stratas in and around Vellayani lake Every plant species contained

Fig. 1 Location map of study area



Study area – Vellayani lake and its surroundings

within a sampling unit was identified Identified plants were categorized under respective botanical families with vernacular or common name and scientific name and were listed in alphabetic sequence (Table 2)

3 2 3 Observations recorded

Observations were recorded for each plant species in a quadrat

3 2 3 1 Number of plants

Total number of plants of each species was counted and recorded

3 2 3 2 Fresh and dry weight

Fresh weight of the total number of plants of each species was recorded and expressed in gram (g) Fresh samples of shoot and root of the plants each weighing 100g were collected and dried in hot air oven at 70^0 C till a constant weight obtained Dry weight of the samples was then recorded Shoot root ratios were also calculated

3 2 3 3 Shoot weight

Weight of the stem and leaves of all the plants of a species was recorded and expressed in g

3 2 3 4 Root weight

Weight of root of all the plants of a species was recorded and expressed in g

3 2 4 Study of vegetation parameters

3 2 4 1 List or Census quadrat method

Analytical characters were determined by means of list or census quadrat method In th s method the plant species were listed and a number of individuals of each species were counted The following vegetation parameters were calculated (Kandasamy 1996)

$$\text{Absolute density (D)} = \frac{\text{The total number of plants of a given species in all quadrats}}{\text{Total number of quadrats used}}$$

$$\text{Relative density (Rd)} = \frac{\text{Absolute density for a species (D)}}{\text{Total number of plants for all species}} \times 100$$

$$\text{Absolute frequency (F)} = \frac{\text{The number of quadrats in which a given species occurs}}{\text{Total Number of quadrats used}}$$

$$\text{Relative frequency (Rf)} = \frac{\text{Absolute frequency for a species (F)}}{\text{Total of the absolute frequencies for all species}} \times 100$$

$$\text{Importance value (IV)} = \text{Relative density (Rd)} + \text{Relative frequency (Rf)}$$

$$\text{Summed Dominance Ratio (SDR)} = \text{IV}/2$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species}}{\text{Number of quadrats of occurance}}$$

3 2 5 Plant vegetation analysis

3 2 5 1 Co efficient of community

When comparing two communities or the vegetation stands of two regions a mathematical expression of the similarity of the list of species can be used If community x is compared to y the number of species common to both expressed as per cent of the total number of x plus y has been termed the co efficient of community (Publ co and Moody 1983)

Us ng the quantitative data such as IV or SDR for the various species pairs of communities may be compared by calculating a co efficient of similarity (C) using the equation

$$\text{Similarity co efficient (C)} - \frac{2 \times (w \times 100)}{(a+b)}$$

Where w sum of the lower IV s or SDR s of species shared by the two communities

a sum of the IV s or SDR s of all species in the first community

b sum of the IV s or SDR s of all species in the second community

The similarity co efficient value varies from zero for communities hav ng no species in common to 100 per cent for communities having identical species composit on and quantitative value for the species

3 2 5 2 Simpson s Index (C)

The Simpson s Index is a measure of the concentration of dominance and can be used to determine the degree of diversity in a community (Whittaker 1965) This was determined using the following equation

Simpson s Index (C) – $\sum (Y/N)^2$

Where Y – IV or SDR of a given species

N = the sum of IV s or SDR s for all species in the sample

3 2 5 3 Species diversity

Species diversity of each study site was calculated using a formula given by Magurran (1988)

$$H - \sum P_i \ln P_i$$

Where P_i is the proportional abundance of the ith species – (ni/N)

The distribution of individuals among the species is called species evenness Evenness Index (J) was calculated by the formula

$$J - H / H \max$$

Where $H \max - \log_2 S$

H max Species diversity under conditions of maximal equitability

S Number of species in the community

$$\log_2 S \quad \frac{\log_0 S}{\log_0 2}$$

(Brower and Zar 1977)

3 2 5 4 Site similarity

Similarities of any two given study sites in terms of number of plant species encountered in both sites were quantitatively measured using Sorenson s similarity index (Bray and Curtis 1957) quoted by Nambiar *et al* (1985)

$$C_N - \frac{2N_j}{Na + Nb}$$

Where C_N Sorenson quantitative index

Nj Number of species common to both sites

Na – Number of species found in site 1

Nb – Number of species found in site 2

3 2 5 5 Total biomass production of medicinal plants

From the fresh weight and dry weight of shoot and root of plants in each strata driage and shoot root ratio were calculated as follows

$$\text{Driage (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{Shoot root ratio} = \frac{\text{Dry weight of shoot}}{\text{Dry weight of root}}$$

3 2 6 Statistical analysis

Vegetation parameters like Absolute density Relative density Absolute frequency Relative frequency Importance value Summed dominance ratio and Abundance were determined statistically

3 3 Study of growth phases of selected medicinal plants

Ten important medicinal plants were selected which were common to atleast two stratas The growth behaviour of the selected plants was monitored for one year at three different stages of growth *viz* pre flowering flowering and seed set

3 3 1 Observations recorded

3 3 1 1 Height of the plant

The height of the plant was measured from the ground level to the growing tip of the plant and expressed in cm

3 3 1 2 Number of branches

The total number of branches in a plant was counted and recorded

3 3 1 3 Plant spread

The distance occupied by the plant was measured in North South and in the east west direction from it s axis The area occupied was obtained by multiplying the two values and expressed in cm^2

3 3 1 4 Height at which first branch is produced

The height at which first branch is produced was measured from the ground level to the position from where the branch is produced and expressed in cm

3 3 1 5 Number of leaves

The total number of leaves produced in a plant was counted and recorded

3 3 1 6 Season of flowering

The month in which flowering occurred was noted

3 3 1 7 Root length

The length of the longest root was measured and expressed in cm

3 3 1 8 Number of roots

The total number of roots were counted and recorded

3 3 1 9 Inter nodal length

The distance between successive nodes was measured and the mean value was expressed in cm

3 3 1 10 Stem girth

The average girth of the stem was measured and expressed in mm

3 3 1 11 Fresh and dry weight of officinal part

The fresh weight of the medicinally important part was taken and expressed in g The dry weight of the off cinal part was calculated after drying 100 g of the spec men in hot a r oven at 70^0 C till a constant weight was obtained and expressed in g

3 3 1 12 Fresh and dry weight of non officinal part

The fresh weight of the non officinal part was taken and expressed in g The dry weight of the non officinal part was calculated after drying 100 g of the specimen in hot air oven at 70^0 C till a constant weight was obtained and expressed in g

3 3 1 13 Shoot root ratio

Shoot root ratio is a ratio between the dry weight of the shoot and the dry weight of the root and was calculated by the following formula

Shoot root rat o – Dry weight of shoot / Dry weight of root

3 4 Chemical analysis of officinal part

3 4 1 Experimental material

Bacopa monnieri L (brahmi) and *Limnophila repens* Benth L collected from the paddy field and lake area were analysed for their chemical constituents *Limnophila repens* which is used by the local people of Vellayani as a substitute to *Bacopa monnieri* Whole plant material of *Limnophila repens* and *Bacopa monnieri* were used for the determination of bacoside which is responsible for memory enhancing in brahmi

The aerial parts of *Andrographis paniculata* Burm f collected from two different stratas around the Vellayani lake were analysed for andrographohde content

3 4 2 Methods

3 4 2 1 *Bacopa monnieri* and *Limnophila repens*

The whole plant material of *Bacopa monnieri* and *Limnophila repens* were washed off mud and dried in shade for two weeks Then the plant material was powdered using a grinder Two g of each species were taken and to this 30 ml of distilled Dichloro methane was added and then stirred using a magnetic stirrer for two hours Then filtered to a round bottom flask by Whatman 20 filter paper Then the filtrate was concentrated using a rotavapor and again defatted with hexane (Harborne 1973)

Then the material was dissolved in 5 ml of methanol and spotted on TLC plates and TLC (Thin Layer Chromatography) was performed in two different solvents Samples were spotted on TLC plates (silica gel plates) using capillaries in a horizontal line about 2 cm from the lower end By a mere gentle touch of the capillary the sample solutions were transferred to the plates The plates were then transferred to a chamber containing the solvent system Rectangular glass jars with airtight lid was used as TLC chamber The solvent was poured directly into the chamber The solvent migrated up and when it

reached the upper end the plates were taken out and allowed to dry in the air (Daniel 1991) Two different solvent systems were used for both species The solvent systems used were the following

a) EtOAc MeOH H_2O (60 14 10)

Chromatography was carried out for about one hour with the mobile phase of solvent mixture of EtOAc MeOH H_2O (60 14 10) and the plates were developed to a height of 8 cm (Gupta *et al* 1998)

b) BuOH EtOAc H_2O (4 1 5)

Chromatography was carried out for about one hour with the mobile phase of solvent mixture of BuOH EtOAc H2O (4 1 5) and the plates were developed to a height of 8 cm Bacoside A has an rf (Retention Factor) in this solvent system (Pal and Sarin 1992)

Spots were visualized by spraying the vanillin sulphuric acid reagent and then heating the plates with heating mantle at 110^0 C for 15 minutes to visualize a blue coloured bacos de A spot (Gupta *et al* 1998)

3 4 2 2 *Andrographis paniculata*

A spectrophotometric method of assay of andrographolide was suggested by Gaind *et al* (1963) The stem and leaves of *Andrographis paniculata* was dried under shade for one week and in oven for 24 hours at 70^0 C Then the plant material was finely powdered From the finely powdered drug 0 5 g was accurately weighed was refluxed with 25 ml of benzene on a rotavapor for one hour It was kept for three to four hours and then filtered The residue was washed with cold benzene two or three times till no more of green colouring matter was extracted The residue was again treated with hot benzene and filtered to ensure complete removal of the chlorophyll It was dried in hot air oven to remove the traces of benzene Then the residue was extracted in a soxhlet apparatus with pure chloroform for four to five hours The chloroform was completely distilled off and

the residue was dissolved in 25 ml of methyl alcohol Further dilution was made so that the optical density of the resulting solution falls within the range of the standard curve The methyl alcoholic solution of plant extract was then subjected to spectrophotometric analysis and the percentage of andrographolide was calculated from the standard curve Spectrophotometric analysis was done at a wavelength of 223 nm The determination of optical densities was therefore made at this wavelength using methyl alcohol as blank This wavelength is characteristic to andrographolide content

RESULTS

RESULTS

The present study on biodiversity of medicinal plants in Vellayani was carried out in and around the Vellayani lake of Thiruvananthapuram district from January 1999 to March 2000 The results of this study are presented in this chapter

4 1 Identification of flora and vegetation analysis

4 1 1 Flora

A total of 135 plant species belonging to 120 genera and 57 families were identified in the four different strata *viz* dry land area (D) garden land area (G) paddy field area (P) and lake area (L) (Table 2) There were 118 indigenous and 17 exotic or naturalized plants The plants identified were categorized under respective botanical families with vernacular or common name and scientific name and were listed in alphabetic sequence The strata of occurance of each plant species is also shown

Analytical characters like absolute frequency relative frequency absolute density relative density importance value summed dominance ratio and abundance were determined by means of List or Census quadrat method

Table 2 Stratawise distribution of medicinal plants

Sl No	Scientific Name	Vernacular Name	Family	Strata				
				D	G	P	L	GO
1	*Abrus precatorius* L	Kunni	Fabaceae	√	√			I
2	*Abutilon indicum* L	Ooram	Malvaceae	√				I
3	*Acalypha indica* L	Kuppamem	Euphorbiaceae	√	√			I
4	*Achyranthes aspera* L	Kadaladi	Amaranthaceae	√		√		I
5	*Adiantum pedatum* L	Maiden hair fern	Adiantaceae				√	I
6	*Adenia palmata* Lam	Palmothakku	Passifloraceae	√				I
7	*Aerva lanata* (Gaertn)de Wilde	Balipoovu	Amaranthacea	√	√			I
8	*Alternanthera sessilis*(L)R Br	Vayalcheera	Amaranthaceae			√		I
9	*Alysicarpus vaginalis* (L)DC	NA*	Fabaceae	√	√			I
10	*Andrographis paniculata* Burm f	Kiryathu	Acanthaceae	√	√			I
11	*Aniseia martinicensis* Jacq	NA*	Convolvulaceae		√			I
12	*Aristolochia indica* L	Garudakodi	Aristolochiaceae	√				I
13	*Asparagus racemosus* Willd	Shathavari	Liliaceae		√			I
14	*Asystasia coromandeliana* (L) T And.	Murikoottipacha	Acanthaceae	√	√			I
15	*Atylosia scarabaeoides* (L)Benth	NA*	Fabaceae	√	√			I
16	*Bacopa monnieri* L	Neerbrahmi	Scrophulariaceae				√	I
17	*Boerhaavia diffusa* L	Thazhuthama	Nyctaginaceae	√				I
18	*Borreria alata* (Aubl)DC	Vellatharavu	Rubiaceae	√	√	√		I
19	*Biophytum sensitivum* (L)DC	Mukkutti	Oxalidaceae	√	√			I
20	*Blepharis medaraspatensis* L	NA*	Acanthaceae	√				I
21	*Bulbostylis barbata* (Rottb) Clarke	Suryan	Cyperaceae			√		I
22	*Cactus dilleni* Icer Gawl	Nagathali	Cactaceae	√				E/N
23	*Capparis brevispina* DC	Thudali	Capparaceae		√			E/N
24	*Cardiospermum helicacabum* L	Valliuzhinja	Sapindaceae	√				I
25	*Carissa conjesta* Wt	Mully	Apocynaceae	√	√			I
26	*Cassia occidentalis* L	Ponnionthakara	Fabaceae	√	√			I

Table 2 Contd

27	*Cassytha filiformis* L	Moodillathali	Cassythaceae	√				I
28	*Catharanthus roseus* var *alba* L	Nithyakalyani	Apocynaceae		√			E/N
29	*Catharanhus roseus* var *roseus* L	Nithyakalyani	Apocynaceae		√			E/N
30	*Cayratia pedata* (Lame) Juss	Tripadi	Vitaceae		√			I
31	*Centella asiatica* L	Kudangal	Apiaceae	√	√	√	√	I
32	*Centrosema pubescens* Benth	Butterfly pea	Fabaceae	√	√			E/N
33	*Chromolaena odorata* King&Robinson	Communistpacha	Asteraceae	√				E/N
34	*Chrysopogon aciculatus* Trin	Lovegrass	Poaceae	√	√	√		I
35	*Cissampelos pareira* L	Malathangi	Menispermaceae	√				I
36	*Cleome rutidosperma* L	Kattukaduku	Cleomaceae	√	√	√		I
37	*Cleome viscosa* L	Naikaduku	Cleomaceae	√	√			I
38	*Clerodentrum viscosum* Vent	Peruvalam	Verbenaceae	√	√			I
39	*Clitoria ternatea* L	Sankupushpam	Fabaceae	√				I
40	*Commelina bengalensis*	Vazhapadathi	Commelinaceae	√	√	√		I
41	*Crassocephalum crepioides* (Benth.)	NA*	Asteraceae			√		I
42	*Coldenia procumbens* L	Thekkada	Boraginaceae			√		I
43	*Croton sparsiflorus* Baill	NA*	Euphorbiaceae		√			E/N
44	*Cryptocorine retrospiralis* Reiz	NA*	Boragmaceae			√	√	I
45	*Curculigo orchioides* Gaertn	Nilappana	Hypoxidaceae	√	√			I
46	*Cyclea peltata* Hook f &Thoms	Padakizhangu	Memspermaceae	√	√			I
47	*Cynodon dactylon* (L) Pers	Karuka	Poaceae	√	√	√		I
48	*Cyperus deformis* L	Thalekkettan	Cyperaceae	√	√	√		I
49	*Cyperus iria* L	Manjakora	Cyperaceae			√	√	I
50	*Cyperus killinga* Endl	Muthanga	Cyperaceae	√	√	√		I
51	*Cyperus rouendus* L	Karimuttan	Cyperaceae	√	√	√		I
52	*Dactyloctenium aegyptium*	Kakkakalan	Poaceae	√	√			I
53	*Desmodium gangeticum* (L) DC	Orila	Fabaceae	√				I
54	*Desmodium triflorum* DC	Nilamparanda	Fabaceae	√	√	√		I
55	*Desmodium velutinum* Willd	Orila	Fabaceae	√	√			I

Table 2 Contd

56	*Diplocyclos palmatus* Chakr	Neyyunni	Cucurbitaceae				√	I
57	*Eclipta alba* L	Kythonni	Asteraceae		√	√		I
58	*Elephantopus scaber* L	Anachuvadi	Asteraceae		√			I
59	*Eleusine indica* (L) Gaertn	Muthangapullu	Poaceae	√	√			I
60	*Emilia sonchifolia* L	Muyalchevian	Asteraceae	√	√	√		I
61	*Euphorbia hirta* L	Chithirapala	Euphorbiaceae	√	√		√	I
62	*Evolvulus alsinoides* (L) L	Vishnukranhi	Convolvulaceae		√	√		I
63	*Fimbristylis aestivalis* Retz	Kora	Cyperaceae			√		I
64	*Gloriosa superba* L	Menthonni	Liliaceae	√	√			I
65	*Grangea medaraspatana* Poir	Nilampala	Asteraceae		√			I
66	*Heliotropium indicum* L	Venalpacha	Boraginaceae		√	√		E/N
67	*Hemidesmus indicus* R Br (L)	Narunanti	Asclepiadaceae	√	√			I
68	*Hyptis suaveolens* Poit (L)	Nattapoochedi	Lamiaceae	√	√			E/N
69	*Hydrilla verticellata* L f	Mullanpayal	Hydrocharitaceae				√	I
70	*Indigofera tinctoria* L	Neelaymari	Fabaceae	√	√			I
71	*Ionodium suffruticosum* L	Orilathamara	Violaceae	√	√			I
72	*Ipomoea mauritiana* Jacq	Palmuthukku	Convolvulaceae			√		I
73	*Ixora coccinea* L	Kattuthetty	Rubiaceae	√	√			I
74	*Jasminum rottlerianum* Wall	Vellakattumulla	Oleaceae		√			I
75	*Justicia japonica* Thunb	NA*	Acanthaceae	√	√			I
76	*Kalanchoe pinnata* Lam	Murikoodi	Crassulaceae	√	√			I
77	*Knoxia mollis* W &A		Rubiaceae	√				I
78	*Lantana camara* L	Poochedi	Verbenaceae	√	√			E/N
79	*Leucas aspera* (Roth) Spreng	Thumba	Lamiaceae	√	√			I
80	*Lindernia antipoda* L	NA*	Scrophulariaceae			√	√	I
81	*Limnophila repens* Benth	Manganari	Scrophulariaceae				√	I
82	*Ludwigia parviflara* Roxb	NA*	Onagraceae			√		I
83	*Lycopodium flexeosus* L	NA*	Lycopodiaceae		√			I
84	*Marsilea marscens* L	Nalilakodiyan	Marsileaceae			√	√	I
85	*Melochia cochorifolia* L	NA*	Sterculiaceae		√			E/N
86	*Mimosa pudica* L	Thottavadi	Mimosaceae	√	√			E/N
87	*Mitracarpus verticellata*	NA*	Rubiaceae	√		√		I
88	*Mollugo pentaphylla* L	Parpadakapullu	Molluginaceae		√	√		I
89	*Monochoria vaginalis* Burm f	Karinkoovalam	Pontederiaceae			√	√	I
90	*Morinda citrifolia* L	Manjanathi	Rubiaceae	√				I
91	*Nelumbo nucifera* Gaertn	Thamara	Nelumbonaceae				√	I
92	*Nymphea nouchali* Burm f	Vellampal	Nymphaeceae				√	I

Table 2 Contd

93	*Ocimum sanctum* L	Thulasi	Lamiaceae	√				I
94	*Hedyotis corymbosa* L	Monganampullu	Rubiaceae	√	√			I
95	*Hedyotis diffusa* (Willd)Roxb	NA*	Rubiaceae			√		I
96	*Hedyotis herbaceae* L	Monganampullu	Rubiaceae		√			I
97	*Hedyotis umbellate* L	NA*	Rubiaceae		√			I
98	*Oxalis corniculata* L	Puliyarila	Oxalidaceae	√		√		I
99	*Phyllanthus amarus* Schum	Kizhanelli	Euphorbiaceae	√	√	√		I
100	*Phyllanthus urinaria* L	Hazarmani	Euphorbiaceae	√				I
101	*Panicum repens* L	Inchipullu	Poaceae	√	√	√		I
102	*Polygala javana* DC	NA*	Polygalaceae	√				I
103	*Polygonum glabrum* Willd	Kozhivalan	Polygonaceae			√		I
104	*Portulaca oleraceae* L	Kozhuppa	Portulacaceae			√		I
105	*Psidium guajava* L	Pera	Myrtaceae	√				E/N
106	*Rungia parviflora* Nees	NA*	Acanthacaea			√		I
107	*Rauvolfia serpentina* (L)Benth.	Sarpagandhi	Apocynaceae	√				I
108	*Salvinia molesta* L	African payal	Salviniaceae				√	I
109	*Scoparia dulcis* L	Kallurikki	Scrophulariaceae	√	√	√		E/N
110	*Sebastiana chamelea* (L) Muell	Cheriyarnanka	Euphorbiaceae	√	√			I
111	*Sesamum indicum* L	Ellu	Pedaliaceae	√				I
112	*Sida acuta* Burm f	Cheruparuva	Malvaceae	√	√			I
113	*Sida rhombifolia* L	Kurunthotti	Malvaceae	√	√			I
114	*Solanum indicum* Lam	Putharichunda	Solanaceae	√	√			I
115	*Solanum nigrum* L	Manithakkali	Solanaceae			√		I
116	*Limnophila heterophyllus* Benth.	NA*	Scrophulariaceae				√	I
117	*Stachytarpeta urticaefolia* Sims	Kudapananth	Verbenaceae	√	√			E/N
118	*Struchium sparganophorum* L	NA*	Asteraceae		√	√		E/N
119	*Synedrella nodiflora* Gaertn	Mudianpacha	Asteraceae	√	√	√		I
120	*Tinospora cordifolia* Willd	Sithamruthu	Menespermaceae		√			I
121	*Tephrosia purpurea* Pers	Kozhingil	Fabaceae	√				I
122	*Tiliacora acuminata* Hook f &Thoms	NA*	Menispermaceae	√	√			I

Table 2 Contd

123	*Toddalia asiatica* L	Kakkathudali	Rutaceae	√				I
124	*Thunbergia mysorensis* Wight	NA*	Acanthaceae		√			E/N
125	*Tragia involucrata* L	Kodithuva	Euphorbiaceae	√				I
126	*Trianthema portulacastrum* L	Pasalikeera	Aizoaceae	√				I
127	*Trichodesma indicum* Banerjee	Kattuthumba	Boraginaceae		√			I
128	*Tridax procumbens* L	Thalavetti	Asteraceae	√	√			I
129	*Trichosanthes cucumerina* L	Kattupadavalam	Cucurbitaceae		√			I
130	*Urena lobata* L	Vatturam	Malvaceae	√	√			I
131	*Utricularia aurea* Lour	NA*	Lentibulariaceae				√	I
132	*Vernonia cinerea* (L) Less	Poovankurunthal	Asteraceae	√	√	√		I
133	*Lindernia crustaceae* F	NA*	Scrophulariaceae			√		I
134	*Vigna trilobata* Verdc	Kattupayar	Fabaceae		√			I
135	*Zizyphus oenoplia* (L) Mill	Mulli	Rhamnaceae	√				I

NA* Not Available
D Dry land area
G Garden land area
P Paddy field area
G O Geographical origin
I Indigenous
E/N Exotic / Naturalised

4 1 2 Study of vegetative parameters of medicinal plants

4 1 2 1 Vegetative parameters in dry land area

A total of 30 sampling units were taken using 1 0 m^2 frame in dry land area (Table3) The dominant species are *Emilia sonchifolia* having highest relative density (13 83 %) followed by *Cyperus rotundus* (7 91 %) and *Panicum repens* (6 52 %) The rare species are *Blepharis medaraspatensis Cactus dilleni Carissa congesta Mor nda tinctoria Stachytarpheta urticaefolia* with relative density of 0 05 % followed by *Rauvolfia serpentina* and *Abrus precatorius* (0 10 %) High relative frequency was observed in *Phyllanthus amarus* (3 44 %) *Chrysopogon aciculatus Eleusine indica* and *Synedrella nodiflora* (3 05 %) It was lower for *Abrus precatorius Aerva la iata Aristolochia indica Blepharis medaraspatensis Cactus dilleni Carissa congesta Cassia occidentalis Centella asiatica Clitoria ternatea Cyperus killinga Desmodium gangeticum Gloriosa superba* with 0 38 % *Emilia sonchifolia* is the most abundant species in dry land area with high Importance value index (16 12) and Abundance (46 33)

4 1 2 2 Vegetative parameters in garden land area

A total of 27 sampling units were taken using 1 0 m^2 frame in garden land area (Table 4) The dominant species are *Centella asiatica* having high relative density (7 31 %) followed by *Scoparia dulcis* (5 98 %) The rare species are *Acalypha indica Aniseia martinicensis Capparis brevispinus Cayratia pedata Catharanthus roseus* var *alba*

Table 3 Vegetative parameters of medicinal plants in dry land area around Vellayani lake

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
1	*Abrus precatorius*	2	0 10	3 33	0 38	0 48	0 24	2 0
2	*Abutilon indicum*	6	0 30	6 67	0 76	1 06	0 53	3 0
3	*Acalypha indica*	13	0 65	6 67	0 76	1 41	0 71	6 5
4	*Achyranthes aspera*	21	1 04	20 00	2 29	3 33	1 67	3 5
5	*Adina palmata*	2	0 10	6 67	0 76	0 86	0 43	1 0
6	*Aerva lanata*	15	0 75	3 33	0 38	1 13	0 57	15 0
7	*Alysicarpus vaginalis*	48	2 39	23 33	2 67	5 06	2 53	6 86
8	*Andrographis paniculata*	26	1 29	20 0	2 29	3 58	1 79	4 33
9	*Aristolochia indica*	3	0 15	3 33	0 38	0 53	0 27	3 0
10	*Asystasia coromandeliana*	13	0 65	6 67	0 76	1 41	0 71	6 5
11	*Atylosia scarabaeoides*	7	0 35	10 0	1 15	1 50	0 75	2 33
12	*Boerhaavia diffusa*	12	0 60	6 67	0 76	1 36	0 68	6 0
13	*Borreria alata*	18	0 90	13 33	1 53	2 43	1 22	4 5
14	*Blepharis medaraspatensis*	1	0 05	3 33	0 38	0 43	0 22	1 0
15	*Biophytum sensitivum*	12	0 60	6 67	0 76	1 36	0 68	6 0
16	*Cactus dillenii*	1	0 05	3 33	0 38	0 43	0 22	1 0
17	*Cardiospermum helicacabum*	10	0 50	13 33	1 53	2 03	1 02	2 5
18	*Carissa congesta*	1	0 05	3 33	0 38	0 43	0 22	1 0
19	*Cassia occidentalis*	8	0 40	3 33	0 38	0 78	0 39	8 0
20	*Cassytha filiformis*	4	0 20	6 67	0 76	0 96	0 48	2 0

Table 3. Contd.

Sl. No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
21	*Centella asiatic.*	10	0.50	3.33	0.38	0.43	0.22	10.0
22	*Centrosema pubescens*	7	0.35	6.67	0.76	1.11	0.56	3.5
23	*Chromolaena odorata*	16	0.80	16.67	1.91	2.71	1.36	3.2
24	*Chrysopogon aciculatus*	47	2.34	26.67	3.05	5.39	2.70	5.8
25	*Cissampelos pereira*	6	0.30	10.0	1.15	1.45	0.73	2.0
26	*Cleome rutidosperma*	3	0.15	3.33	0.38	0.53	0.27	3.0
27	*Cleome viscosa*	22	1.10	20.0	2.29	3.39	1.70	3.67
28	*Clerdendrum viscosum*	15	0.75	13.33	1.53	2.28	1.14	3.75
29	*Clitoria ternatea*	2	0.10	3.33	0.38	0.48	0.24	2.0
30	*Commelina clavata*	44	2.20	13.33	1.53	3.73	1.87	11.0
31	*Curculigo orchioides*	12	0.60	6.67	0.76	.36	0.68	6.0
32	*Cyclea peltata*	15	0.75	16.67	1.91	2.66	1.33	3.0
33	*Cyperus deformis*	78	3.88	10.0	1.15	5.03	2.52	26.0
34	*Cyperus killinga*	15	0.75	3.33	0.38	1.13	0.57	15.0
35	*Cyperus rotundus*	159	7.91	20	2.29	10.2	5.10	26.5
36	*Cynadon dactylon*	30	1.50	16.67	1.91	3.41	1.71	6.0
37	*Dactyloctenium aegyptium*	23	1.14	6.67	0.76	1.9	0.95	11.5
38	*Desmodium gangeticum*	5	0.25	3.33	0.38	0.63	0.32	5.0
39	*Desmodium triflorum*	44	2.19	6.67	0.76	2.95	1.48	22.0
40	*Desmodium velutinum*	98	4.88	20.0	2.29	7.17	3.59	16.33

Table 3. Contd.

Sl. No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
41	*Eleusine indica*	77	3.33	26.67	3.05	6.88	3.44	9.6
42	*Emila sonchiflia*	278	13.83	20.0	2.29	16.12	8.06	46.33
43	*Euphorbia hirta*	10	0.50	10.0	1.15	1.65	0.83	3.33
44	*Gloriosa superba*	3	0.15	3.33	0.38	0.53	0.27	3.0
45	*Hedyotis corymbosa*	9	0.45	6.67	0.76	1.21	0.61	4.5
46	*Hemidesmus indicus*	63	3.13	16.67	1.91	5.04	2.52	12.6
47	*Hiptis sauveolens*	14	0.70	16.67	1.91	2.61	1.31	2.8
48	*Indigofera tinctoria*	9	0.45	10	1.15	1.6	0.80	3
49	*Ionidium suffruticosum*	30	1.5	6.67	1.91	3.41	1.71	6.0
50	*Ixora coccinea*	7	0.35	6.67	0.76	1.11	0.56	3.5
51	*Justicia japonica*	47	2.34	23.33	2.67	5.01	2.51	6.7
52	*Kalanchoe pinnata*	10	0.50	3.33	0.38	0.88	0.44	10.0
53	*Knoxia mollis*	24	1.20	13.33	1.53	2.73	1.37	6.0
54	*Lantana camara*	9	0.45	16.67	1.91	2.36	1.18	1.8
55	*Leucas aspera*	9	0.30	3.33	0.38	0.68	0.34	6.0
56	*Mimosa pudica*	13	0.65	16.67	1.91	2.56	1.28	2.6
57	*Mitracarpus verticellata*	11	0.55	13.33	1.53	2.08	1.04	2.75
58	*Morinda citrifolia*	1	0.05	3.33	0.38	0.43	0.22	1.0
59	*Ocimum basilicum*	2	0.10	3.33	0.38	0.48	0.24	2.0
60	*Oxalis corniculata*	3	0.15	3.33	0.38	0.53	0.27	3.0
61	*Panicum repens*	131	6.52	20.0	2.29	8.81	4.41	21.83
62	*Phyllanthus amarus*	115	5.72	30.0	3.44	9.16	4.58	12.78

Table 3 Contd

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
63	*Phyllanthus urinaria*	5	0 25	6 67	0 76	1 01	0 51	2 5
64	*Polygala javana*	8	0 40	3 33	0 38	0 78	0 39	8 0
65	*Psidium guajava*	1	0 05	3 33	0 38	0 43	0 22	1 0
66	*Rauvolfia serpentina*	2	0 10	3 33	0 38	0 48	0 24	2 0
67	*Scoparia dulcis*	17	0 85	10 0	1 15	2 0	1 0	5 6
68	*Sebastiana chamalea*	8	0 40	6 67	0 76	1 16	0 58	4 0
69	*Sesamum indicum*	7	0 35	6 67	0 76	1 11	0 56	3 5
70	*Sida acuta*	27	1 34	10 0	1 15	2 49	1 25	9 0
71	*Sida rhombifolia*	2	0 10	3 33	0 38	0 48	0 24	2 0
72	*Solanum indicum*	6	0 30	10 0	1 15	1 45	0 73	2 0
73	*Stachytarpheta urticaefolia*	1	0 05	3 33	0 38	0 43	0 22	1 0
74	*Synedrella nodiflora*	54	2 69	26 67	3 05	5 74	2 87	6 7
75	*Tephrosia purpurea*	3	0 15	6 67	0 76	0 91	0 46	1 5
76	*Tiliacora acuminata*	3	0 15	6 67	0 76	0 91	0 46	1 5
77	*Toddalia asiatica*	3	0 15	10 0	1 15	1 30	0 65	1 0
78	*Tragia involucrata*	14	0 70	3 33	0 38	1 08	0 54	14
79	*Trianthema portulacastrum*	10	0 50	16 67	1 91	2 41	1 21	2 0
80	*Tridax procumbens*	49	2 44	20 0	2 29	4 73	2 37	8 17
81	*Urena lobata*	2	0 10	6 67	0 76	0 86	0 43	1 0
82	*Vernonia cinerea*	41	2 04	23 33	2 67	4 71	2 36	5 8
83	*Zyzyphus oenoplia*	1	0 05	6 67	0 76	0 81	0 41	1 0

Table 4 Vegetative parameters of medicinal plants in garden land area around Vellayani lake

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative	Importance Value	Summed Dominance Ratio	Abundance
1	*Abrus precatorius*	3	0 28	3 70	0 59	0 87	0 44	3 0
2	*Acalypha indica*	1	0 09	3 70	0 59	0 87	0 44	1 0
3	*Aerva lanata*	12	1 14	3 70	0 59	1 73	0 87	12 0
4	*Alysicarpus vaginalis*	5	0 47	7 41	1 18	1 65	0 83	2 5
5	*Aniseia martinicensis*	1	0 09	3 70	0 59	0 68	0 34	1 0
6	*Asparagus racemosus*	5	0 47	7 41	1 18	1 65	o 83	2 5
7	*Andrographis paniculata*	12	1 14	14 81	2 35	3 49	1 75	3 0
8	*Asystasia cormandeliana*	20	1 90	3 70	0 59	2 49	1 25	20 0
9	*Atylosia scarabaeoides*	9	0 85	7 41	1 18	2 03	1 02	4 5
10	*Borreria alata*	26	2 47	14 81	2 35	4 82	2 41	6 5
11	*Biophytum sensitivum*	40	3 80	3 70	0 59	4 39	2 20	40 0
12	*Capparis brevispina*	1	0 09	3 70	0 59	0 68	0 34	1 0
13	*Cassia occidentalis*	6	0 57	7 41	1 18	1 75	0 88	3 0
14	*Carissa congesta*	4	0 38	3 70	0 59	0 97	0 49	1 0
15	*Cayratia pedata*	1	0 09	3 70	0 59	0 68	0 34	1 0
16	*Catharanthus alba*	1	0 09	3 70	0 59	0 68	0 34	1 0
17	*Catharanthus roseus*	3	0 28	3 70	0 59	0 87	0 44	3 0
18	*Centella asiatica*	77	7 31	18 52	2 94	10 25	5 13	15 4
19	*Centrosema pubescens*	2	0 19	3 70	0 59	0 78	0 39	2 0
20	*Chrysopogon aciculatus*	30	2 85	18 52	2 94	5 79	2 90	6 0

Table 4 Contd

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative	Importance Value	Summed Dominance Ratio	Abundance
21	*Cleome rutidosperma*	16	1 52	7 41	1 18	2 70	1 35	8 0
22	*Clerodentrum viscosum*	10	0 95	7 41	1 18	2 13	1 07	5 0
23	*Commelina bengalensis*	1	0 09	3 70	0 59	0 68	0 34	1 0
24	*Croton sparsiflorus*	1	0 47	7 41	1 18	1 65	0 83	2 5
25	*Curculigo orchioides*	15	1 42	7 41	1 18	2 60	1 30	7 5
26	*Cyceia peltata*	7	0 66	14 81	2 35	3 01	1 51	1 75
27	*Cynodon dactylon*	31	2 94	14 81	2 35	5 29	2 65	7 75
28	*Cyperus deformis*	30	2 85	3 70	0 59	3 44	1 72	30 0
29	*Cyperus kallinga*	11	1 04	11 11	1 76	2 80	1 40	3 67
30	*Cyperus rotundus*	17	1 61	18 52	2 94	4 55	2 28	33 4
31	*Dactyloctenium aegyptium*	45	4 27	18 52	2 94	7 21	3 61	9 0
32	*Desmodium triflorum*	1	0 09	3 70	0 59	0 68	0 34	1 0
33	*Desmodium velutinum*	40	3 80	14 81	2 35	6 15	3 08	10 0
34	*Elephantopus scaber*	20	1 90	3 70	0 59	2 49	1 25	20 0
35	*Eleusine indica*	23	2 18	18 52	2 94	5 12	2 56	4 6
36	*Emilia sonchifolia*	5	0 47	7 41	1 18	1 65	0 83	2 5
37	*Euphorbia hirta*	17	1 61	7 41	1 18	2 79	1 40	8 5
38	*Evolvulus alsinoides*	4	0 38	3 70	0 59	0 97	0 49	4 0
39	*Gloriosa superba*	8	0 76	14 81	2 35	3 11	1 56	2 0
40	*Grangea medaraspatana*	3	0 28	3 70	0 59	0 87	0 44	3 0
41	*Hedyotis corymbosa*	4	0 38	3 70	0 59	0 97	0 49	4 0
42	*Hedyotis herbacea*	21	1 99	3 70	0 59	2 58	1 29	21 0

Table 4 Contd

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative	Importance Value	Summed Dominance Ratio	Abundance
43	*Hedyotis umbellata*	51	4 84	7 41	1 18	6 02	3 01	25 5
44	*Hemidesmus indicus*	7	0 66	7 41	1 18	1 84	0 92	3 5
45	*Heliotropium indicum*	3	0 28	3 70	0 59	0 87	0 44	3 0
46	*Hiptis sauveolens*	40	3 80	11 11	1 76	5 56	2 78	13 33
47	*Indigofera tinctoria*	2	0 19	3 70	0 59	0 78	0 39	2 0
48	*Ionidium suffruticosum*	2	0 19	7 41	1 18	1 37	0 69	1 0
49	*Ixora coccinea*	15	1 42	11 11	1 76	3 18	1 59	5 0
50	*Justicia japonica*	22	2 09	14 81	2 35	4 44	2 22	5 5
51	*Jasminum rottlerianum*	8	0 76	3 70	0 59	1 35	0 68	8 0
52	*Kalanchoe pinnata*	2	0 19	3 70	0 59	0 78	0 39	2 0
53	*Leucas aspera*	21	1 99	14 81	2 35	4 34	2 17	5 25
54	*Lycopodium flexeosus*	2	0 19	3 70	0 59	0 78	0 39	2 0
55	*Lantana camara*	1	0 09	3 70	0 59	0 68	0 34	1 0
56	*Melochia corchorifolia*	1	0 09	3 70	0 59	0 68	0 34	1 0
57	*Mimosa pudica*	1	0 09	3 70	0 59	0 68	0 34	1 0
58	*Mollugo pentaphylla*	3	0 28	3 70	0 59	0 87	0 44	3 0
59	*Panicum repens*	20	1 90	18 52	2 94	4 84	2 42	4 0
60	*Phyllanthus amarus*	34	3 23	14 81	2 35	5 58	2 79	8 5
61	*Phyllanthus urinaria*	3	0 28	3 70	0 59	0 87	0 44	3 0
62	*Sebastiana chamaelea*	39	3 70	14 81	2 35	6 05	3 03	9 75
63	*Scoparia dulcis*	63	5 98	25 93	4 12	10 10	5 05	9 0
64	*Sida rhombifolia*	19	1 80	7 41	1 18	2 98	1 49	9 5

Table 4 Contd

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative	Importance Value	Summed Dominance Ratio	Abundance
65	*Solanum indicum*	3	0 28	7 41	1 18	1 46	0 73	1 5
66	*Stachytarpheta urticaefolia*	2	0 19	3 70	0 59	0 78	0 39	2 0
67	*Strichium sparganophorum*	3	0 28	3 70	0 59	0 87	0 44	3 0
68	*Synedrella nodiflora*	39	3 70	18 52	2 94	6 64	3 32	7 8
69	*Tenospora cordifolia*	3	0 28	7 41	1 18	1 46	0 73	1 5
70	*Thunbergia mysorensis*	1	0 09	3 70	0 59	0 68	0 34	1 0
71	*Tiliacora acuminata*	4	0 38	7 41	1 18	1 56	0 78	2 0
72	*Trichodesma indicum*	2	0 19	3 70	0 59	0 78	0 39	2 0
73	*Trichosanthes cucumerina*	1	0 09	3 70	0 59	0 68	0 34	1 0
74	*Tridax procumbens*	4	0 38	3 70	0 59	0 97	0 49	4 0
75	*Urena lobata*	2	0 19	3 70	0 59	0 78	0 39	2 0
76	*Vernonia cinerea*	36	3 42	25 93	4 12	7 54	3 77	5 1
77	*Vigna trilobata*	1	0 09	3 70	0 59	0 68	0 34	1 0

Commelina bengalensis Desmodium triflorum Lantana camara Melochia corcorifolia Mimosa pudica Thunbergia mysorensis and *Trichosanthes cucumerina* with relative density of 0 09 per cent High relative frequency was observed for *Scoparia dulcis* (4 12 %) and *Vernonia cinerea* (4 12 %) Lowest relative frequency was observed in all the rare plant species The most abundant species in the garden land area are *Hedyotis umbellata* with abundance 25 5 and importance value index 6 02 and *Centella asiatica* with abundance 15 4 and importance value index 10 25

4 1 2 3 Vegetative parameters in paddy field area

A total of 13 sampling units were taken using 1 0 m^2 frame in paddy field area (Table 5) The dominant species are *Centella asiatica* having high relative density (32 99 %) and *Oxalis corniculata* with a relative density of 8 80 % The rare species are *Borreria alata Coldenia procumbens Emilia sonchifolia* and *Portulaca oleraceae* with a relative density of 0 15 % High relative frequency of 5 81 % was observed for *Centella asiatica* and *Eclipta alba* Lower relative frequency of 1 16 % was observed for *Alternanthera sessalis Achyranthes aspera Borreria alata Chrysopogon aciculatus Cryptocorine retrospiralis Cyperus deformis Cyperus killinga Crassocephalum crepioides Desmodium triflorum Emilia sonchifolia Leucas aspera Lindernia crustaceae Hedyotis diffusa Polygonum glabrum Portulaca oleraceae* and *Rungia parviflora Centella asiatica* is the most abundant species in paddy field area as is evident from its high importance value index (38 80) and abundance (45 00)

Table 5 Vegetative parameters of medicinal plants in paddy field area around Vellayani lake

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
1	*Achyranthes aspera*	3	0 44	7 69	1 16	1 60	0 80	3 0
2	*Adiantum pedatum*	18	2 64	23 08	3 49	6 13	3 07	6 0
3	*Alternanthera sessalis*	3	0 44	7 69	1 16	1 60	0 80	3 0
4	*Borreria alata*	1	0 15	7 69	1 16	1 31	0 66	1 0
5	*Bulbostylis barbata*	18	2 64	15 38	2 33	4 97	2 49	9 0
6	*Centella asiatica*	225	32 99	38 46	5 81	38 80	19 40	45
7	*Chrysopogon aciculatus*	4	0 59	7 69	1 16	1 75	0 88	4 0
8	*Cleome rutidosperma*	31	4 55	30 76	4 65	9 20	4 60	7 75
9	*Coldenia procumbens*	1	0 15	7 69	1 16	1 31	0 66	1 0
10	*Commelina bengalensis*	25	3 67	23 08	3 49	7 16	3 58	8 33
11	*Crassocephalum crepioides*	2	0 29	7 69	1 16	1 45	0 73	2 0
12	*Cryptocoryne retrospiralis*	4	0 59	7 69	1 16	1 75	0 88	4 0
13	*Cynodon dactylon*	5	0 73	15 38	2 33	3 06	1 53	2 5
14	*Cyperus deformis*	4	0 59	7 69	1 16	1 75	0 88	4 0
15	*Cyperus iria*	4	0 59	15 38	2 33	2 92	1 46	2 0
16	*Cyperus kyllinga*	5	0 73	7 69	1 16	1 89	0 95	5 0
17	*Cyperus rotundus*	9	1 32	23 08	3 49	4 81	2 41	3 0
18	*Desmodium triflorum*	20	2 93	7 69	1 16	4 09	2 05	20 0
19	*Eclipta alba*	22	3 23	38 46	5 81	9 04	4 52	4 4
20	*Emilia sonchifolia*	1	0 15	7 69	1 16	1 31	0 66	1 0
21	*Evolvulus alsinoides*	6	0 88	15 38	2 33	3 21	1 61	3 0

Table 5 Contd

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
22	*Hedyotis diffusa*	3	0 44	7 69	1 16	1 60	0 80	3 0
23	*Heliotropium indicum*	5	0 73	23 08	3 49	4 22	2 11	1 6
24	*Ipomoea mauritiana*	5	0 73	15 38	2 33	3 06	1 53	2 5
25	*Leucas aspera*	2	0 29	7 69	1 16	1 45	0 73	2 0
26	*Limnophila repens*	25	3 67	15 38	2 33	6 0	3 0	12 5
27	*Lindernia antipoda*	17	2 49	15 38	2 33	4 82	2 41	8 5
28	*Lindernia crustaceae*	3	0 44	7 69	1 16	1 60	0 80	3 0
29	*Ludwigia parviflora*	27	3 96	23 08	3 49	7 45	3 73	9 0
30	*Marselia marsescens*	18	2 64	15 38	2 33	4 97	2 49	9 0
31	*Mitracarpus verticellata*	4	0 59	15 38	2 33	2 92	1 46	2 0
32	*Mollugo pentaphylla*	9	1 32	15 38	2 33	3 65	1 83	4 5
33	*Monochorea vaginalis*	7	1 03	23 08	3 49	4 52	2 26	2 3
34	*Oxalis corniculata*	60	8 80	15 38	2 33	11 13	5 57	30 0
35	*Panicum repens*	9	1 32	15 38	2 33	3 65	1 83	4 5
36	*Phyllanthus amarus*	10	1 47	15 38	2 33	3 80	1 90	5 0
37	*Polygonum glabrum*	3	0 44	7 69	1 16	1 60	0 80	3 0
38	*Portulaca oleraceae*	1	0 15	7 69	1 16	1 31	0 66	1 0
39	*Rungia parviflora*	14	2 05	7 69	1 16	3 21	1 61	14 0
40	*Scoparia dulcis*	13	1 91	15 38	2 33	4 24	2 12	6 5
41	*Solnum nigrum*	4	0 59	15 38	2 33	2 92	1 46	2 0
42	*Struchium sparganophorum*	4	0 59	15 38	2 33	2 92	1 46	2 0
43	*Synedrella nodiflora*	13	1 91	15 38	2 33	4 24	2 12	6 5
44	*Vernonia cinerea*	15	2 20	23 08	3 49	5 69	2 85	5 0

4 1 2 4 Vegetative parameters in lake area

A total of 10 sampling units were taken from the lake area In the lake area it was difficult to throw 1 0 m^2 frame So sampling was done by assuming 1 0 m^2 area in the lake (Table 6) The dominant species are *Limnophila repe is* having high relative density (18 15 %) followed by *Bacopa monnieri* (14 11 %) and *Hydrilla ver ticellata* (12 10 %) The rare species are *Diplocyclos palmati s* (0 20 %) *Monochorea vagi inalis* (0 60 %) and *Trichosanthes cucumer ina* (0 60 %) High relative frequency of 9 76 % was observed for *Cyperus iria* and *Nymphea nouchali* Lower relative frequency of 2 44 % was observed for *Diplocyclos palmatus Fimbristylis aestivalis* and *Trichosa ithes cucumerina Limnophila repens* is the most abundant species in the lake area as it is evident from its high importance value index (23 03) and abundance (45 0 0) followed by *Bacopa monnieri* with importance value index of 18 99 and abundance of 35 00

4 1 2 5 Medicinal plant vegetation pair wise analysis

Parameters used for medicinal plant vegetation pair wise analysis are given in Table 7 When the vegetation stands of pairs of sites are compared dry land and garden land has a high co efficient of community (33 12) Sorrenson s similarity index is also high for dry land and garden land (0 663) Co efficient of community is lower for dry land and lake area (1 0) and Sorrenson s similarity index is also lower for dry land andlake area (0 02) The similarity co efficient value calculated using the importance value is high for dry land and garden land (50 18) and it is low for dry land and lake area (0 22)

Table 6 Vegetative parameters of medicinal plants in Vellayani lake area

Sl No	Scientific Name	Absolute Density	Relative Density	Absolute Frequency	Relative Frequency	Importance Value	Summed Dominance Ratio	Abundance
1	*Bacopa monnieri*	70	14 11	20 0	4 88	18 99	9 50	35 0
2	*Centella asiatica*	25	5 04	20 0	4 88	9 92	4 96	12 5
3	*Cryptocorine retrospiralis*	17	3 43	20	4 88	8 31	4 16	8 5
4	*Cyperus iria*	27	5 44	40	9 76	15 20	7 60	6 7
5	*Diplocyclos palmatus*	1	0 20	10 0	2 44	2 64	1 32	1 0
6	*Fimbristylis aestivalis*	10	2 02	10 0	2 44	4 46	2 23	10 0
7	*Hydrilla verticellata*	60	12 10	30 0	7 32	19 42	9 71	0 0
8	*Limnophila heterophyllus*	25	5 04	20	4 88	9 92	4 96	12 5
9	*Limnophila repens*	90	18 15	20 0	4 88	23 03	11 52	45 0
10	*Lindernia antipoda*	20	4 03	20 0	4 88	8 91	4 46	10 0
11	*Marselia marsescens*	60	12 10	20	4 88	16 98	8 49	30 0
12	*Monochoria vaginalis*	3	0 60	20 0	4 88	5 48	2 74	1 5
13	*Nelumbo nucifera*	6	1 21	30 0	7 32	8 53	4 27	2 0
14	*Nymphea nouchali*	24	4 84	40 0	9 76	14 60	7 30	6 0
15	*Salvinia molesta*	10	2 02	30 0	7 32	9 34	4 67	3 33
16	*Trichosanthes cucumerina*	3	0 60	10 0	2 44	3 04	1 52	3 0
17	*Utricularia aurea*	15	3 02	20 0	4 88	7 90	3 95	7 5

Table 7 Pair wise indices of medicinal plant vegetation analysis in different strata in and around Vellayani lake

STRATA	Co efficient of community	Similarity coefficient	Sorrenson s s milarity ndex
Dry land and Garden land	33 12	50 18	0 663
Dry land and Paddy field	15 74	23 04	0 315
Dry land and Lake area	1 0	0 22	0 020
Garden land and Paddy field	18 18	30 85	0 364
Garden land and Lake area	2 13	5 48	0 043
Paddy field and Lake area	9 18	17 14	0 196

Table 8 Strata wise vegetation analysis indices in and around Vellayani lake

STRATA	Simpson s index (C)	Shannon s index (H)	Evenness index (J)
Dry land	0 0259	4 07	0 64
Garden land	0 0228	3 83	0 61
Paddy field	0 0586	3 25	0 60
Lake area	0 0804	2 42	0 59

4 1 2 6 Stratawise vegetation analysis indices

Parameters used for stratawise vegetation analysis are given in Table 8 The concentration of dominance as expressed by Simpson s index (C) is high in lake area (0 0804) and least in garden land area (0 0228) The species diversity H is h ghest in dry land area (4 07) and least in lake area (2 42) The distribution of individuals among the species is g ven by Evenness index (J) which is maximum in dry land area (0 64) and least in lake area (0 59)

4 1 3 Total biomass production of medicinal plants

The fresh weight and dry weight of shoot and root of plants in each strata were found and from this driage and shoot root ratio were calculated

4 1 3 1 Total biomass production in dry land area

A total of 30 sampling units were taken using 1 0 m^2 frame in dry land area The fresh weight of each plant species was obtained by taking the mean values from all the quadrats in which it occurs The data on the biomass production of the plant species in dry land area are given in Table 9

Plants like *Adenia palmata* (175 0 g) *Morinda tinctoria* (145 0 g) *Carissa congesta* (80 0 g) *Solanum indicum* (77 49 g) *Abrus precatorius* (75 0 g) and *Cassytha filiformis* (69 2 g) produced higher biomass when compared to other species identified in

Table 9 Total biomass production of medicinal plants in dry land area around Vellayani lake

Sl No	Scientific Name	Fresh weight (g)			Dry weight (g)			Drnage (%)			Shoot Root ratio
		Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	
1	*Abrus precatorius*	45 0	30 0	75 0	25 43	20 25	45 67	56 5	67 5	60 9	1 25 1
2	*Abutilon indicum*	10 83	3 33	14 16	3 55	1 23	4 78	32 75	36 94	33 76	2 89 1
3	*Acalypha indica*	2 31	1 15	3 46	0 77	0 38	1 15	33 33	33 04	33 24	2 03 1
4	*Achyranthes aspera*	7 19	2 33	9 52	1 79	0 78	1 57	24 90	33 48	16 50	2 29 1
5	*Adenia palmata*	95 0	80 0	175 0	23 75	19 04	42 79	25 0	23 80	24 45	1 25 1
6	*Aerva lanata*	5 0	2 0	7 0	1 76	1 18	2 94	35 20	59 0	42 0	1 5 1
7	*Alysicarpus vaginalis*	4 66	1 89	6 55	1 47	0 63	2 10	31 55	33 33	32 06	2 3 1
8	*Andrographis paniculata*	7 0	1 65	8 65	1 91	0 65	2 56	27 29	39 39	29 60	2 9 1
9	*Aristolchia indica*	12 0	5 5	17 5	4 5	2 0	6 5	37 5	36 36	37 14	2 25 1
10	*Asystasia coromandeliana*	2 08	1 77	3 85	0 44	0 52	0 96	21 15	29 38	24 94	1 1 18
11	*Atylosia scarabaeoides*	21 43	4 29	25 72	7 14	1 53	8 67	33 32	35 66	33 71	4 67 1
12	*Boerhaavia diffusa*	28 0	10 60	38 60	8 48	4 70	13 18	30 29	44 34	34 15	1 80 1
13	*Borreria alata*	2 0	0 78	2 78	0 57	0 19	0 76	28 5	24 36	27 34	3 1
14	*Blepharis medaraspatensis*	7 0	3 0	10 0	2 0	1 60	3 60	28 57	53 33	36 0	1 25 1
15	*Biophytum sensitivum*	1 08	0 42	1 50	0 36	0 12	0 48	33 33	28 57	32 0	3 1
16	*Cactus dillenii*	50 0	10 0	60 0	36 67	6 0	42 67	73 34	60 0	71 11	6 1 1
17	*Cardiospermum helicacabum*	34 50	4 50	39 0	7 79	0 66	8 45	22 58	14 67	21 67	11 8 1
18	*Carissa congesta*	70 0	10 0	80 0	34 06	5 43	34 49	48 66	54 30	49 36	6 27 1
19	*Cassia occidentalis*	12 50	5 0	17 50	3 01	2 72	5 73	24 08	54 40	32 74	1 11 1
20	*Cassytha filiformis*	58 75	10 50	69 20	12 16	2 31	14 47	20 70	22 0	20 91	5 26 1
21	*Centella asiatica*	3 50	4 0	7 50	0 53	0 80	1 33	15 14	20 0	17 73	1 1 51

Table 9 Contd

22	*Centrosema pubescens*	5 71	2 14	7 85	1 41	0 96	2 37	24 69	44 85	30 19	1 47 1
23	*Chromolaena odorata*	23 13	10 63	33 76	5 13	3 15	8 28	22 18	29 63	24 53	1 47 1
24	*Chrysopogon aciculatus*	4 20	4 0	8 20	0 53	0 50	1 03	12 62	12 50	12 56	1 06 1
25	*Cissampelos pereira*	13 33	2 50	15 83	3 79	1 40	5 19	28 43	56 0	32 78	2 7 1
26	*Cleome rutidosperma*	10 0	5 0	15 0	0 89	0 72	1 61	8 90	14 40	10 73	1 24 1
27	*Cleome viscosa*	1 27	1 0	2 27	0 19	0 17	0 36	14 80	17 30	15 90	1 08 1
28	*Clerodendrum viscosum*	5 86	3 46	9 32	2 05	1 60	3 65	34 98	46 24	39 16	1 28 1
29	*Clitoria ternatea*	15 0	10 0	25 0	4 73	4 10	8 83	31 53	41 0	35 32	1 15 1
30	*Commelina bengalensis*	3 48	1 61	5 09	0 42	0 19	0 61	12 07	11 80	11 98	2 2 1
31	*Curculigo orchioides*	1 83	1 92	75	0 16	0 63	0 79	8 74	32 81	21 07	1 3 94
32	*Cyclea peltata*	25 0	12 66	37 66	6 75	4 49	11 24	27 0	35 47	29 85	1 5 1
33	*Cynodon dactylon*	2 33	2 33	4 66	0 91	1 30	2 29	39 06	55 79	49 14	1 1 43
34	*Cyperus deformis*	0 41	1 71	2 12	0 12	0 39	0 51	29 27	22 77	24 06	1 3 25
35	*Cyperus killinga*	8 0	5 0	13 0	1 13	1 15	2 28	14 13	23 0	17 54	1 1 02
36	*Cyperus rotundus*	0 72	2 44	3 16	0 18	1 22	1 40	25 0	50 0	39 0	1 1 67
37	*Dactyloctenium aegyptium*	0 52	0 35	0 87	0 10	0 07	0 17	19 23	20 0	19 54	1 43 1
38	*Desmodium triflorum*	2 16	1 14	3 30	0 72	0 57	1 29	33 19	50 0	39 0	1 26 1
39	*Desmodium velutinum*	74	1 21	2 95	0 58	0 51	1 09	33 33	42 15	36 95	1 14 1
40	*Desmodium gangeticum*	6 0	6 0	12 0	1 38	2 34	3 72	23 0	39 0	31 0	1 1 7
41	*Eleusine indica*	2 73	2 08	4 81	0 68	0 52	1 20	24 91	25 0	24 95	1 31 1
42	*Emilia sonchifolia*	1 35	0 42	1 77	0 17	0 05	0 22	12 59	11 90	12 43	3 4 1
43	*Euphorbia hirta*	1 50	0 50	2 0	0 45	0 13	0 58	30 0	26 0	29 0	3 46 1
44	*Gloriosa superba*	60 0	30 0	90 0	6 66	11 08	17 74	11 10	36 93	19 71	1 1 66
45	*Hedyotis corymbosa*	1 22	0 44	1 66	0 27	0 09	0 36	22 13	20 45	21 69	3 0 1
46	*Hemidesmus indicus*	2 06	1 03	3 09	0 71	0 45	1 16	34 46	43 69	37 54	1 58 1

Table 9 Contd

47	*Hiptis sauveolens*	16 79	3 57	20 36	4 28	1 45	5 73	25 49	40 62	28 14	2 95 1
48	*Indigofera tinctoria*	12 22	5 55	17 77	2 73	1 30	4 03	22 34	23 42	22 68	2 1 1
49	*Ionidium suffruticosum*	1 62	0 62	2 24	0 78	0 31	1 09	48 15	50 0	48 66	2 52 1
50	*Ixora coccinea*	22 86	17 14	40 0	6 90	9 59	16 49	30 18	55 95	41 23	1 1 39
51	*Justicia japonica*	3 26	0 98	4 24	0 65	0 21	0 86	19 94	21 43	20 28	3 1 1
52	*Kalanchoe pinnata*	13 50	4 0	17 50	6 78	0 87	7 65	50 22	21 75	43 71	7 79 1
53	*Knoxia mollis*	3 75	0 42	4 17	1 25	0 15	1 40	33 33	35 71	33 57	8 33 1
54	*Lantana camara*	37 77	4 44	42 21	12 54	1 62	14 16	33 20	36 49	33 55	7 74 1
55	*Leucas aspera*	5 0	2 50	7 50	1 28	0 98	2 26	25 60	39 20	30 13	1 31 1
56	*Mimosa pudica*	20 23	3 23	23 46	5 96	1 36	7 32	29 46	42 10	31 20	4 38 1
57	*Mitracarpus verticellata*	6 27	0 82	7 09	0 85	0 28	1 13	13 56	34 15	15 94	1 79 1
58	*Morinda citrifolia*	75 0	70 0	145 0	25 73	26 37	52 10	34 31	37 67	35 93	1 1 02
59	*Ocimum basilicum*	7 50	2 50	10 0	2 0	0 98	2 98	26 67	39 20	29 80	2 04 1
60	*Oxalis corniculata*	1 33	0 33	1 66	0 30	0 07	0 37	22 51	19 51	21 99	4 62 1
61	*Panicum repens*	1 64	1 26	2 90	0 41	0 32	0 73	25 0	25 40	25 17	1 28 1
62	*Phyllanthus amarus*	0 93	0 32	1 25	0 18	0 12	0 30	19 35	37 50	24 0	1 5 1
63	*Phyllanthus urinaria*	17 0	7 0	24 0	3 29	1 54	4 83	19 35	22 0	20 13	2 08 1
64	*Polygala javana*	2 50	1 25	3 75	1 0	0 75	1 75	40 0	60 0	46 67	1 33 1
65	*Psidium guajava*	20 0	25 0	45 0	8 30	10 0	18 30	41 50	40 0	40 67	1 1 20
66	*Rauvolfia serpentina*	10 0	7 0	17 00	3 33	3 50	6 83	33 30	50 0	40 17	1 1 05
67	*Scoparia dulcis*	5 82	2 12	7 94	1 33	0 71	2 04	22 85	33 49	25 69	1 87 1
68	*Sebastiana chamalea*	1 0	1 5	2 5	0 37	0 51	0 88	37 0	34 0	35 2	1 1 38
69	*Sesamum indicum*	20 0	4 28	24 28	2 82	0 90	3 72	14 10	21 03	15 32	3 13 1
70	*Sida acuta*	7 04	2 04	9 08	2 26	0 85	3 11	32 10	41 67	34 25	2 66 1
71	*Sida rhombifolia*	10 0	2 50	12 50	0 37	0 51	0 88	37 0	34 0	35 2	1 1 38

Table 9 Contd

72	*Solanum indic um*	65 66	11 83	77 49	14 25	3 08	17 33	21 70	26 04	22 36	4 63 1
73	*Stachytarpheta urticaefolia*	20 0	5 0	25 0	5 08	1 95	7 03	25 4	39 0	28 12	2 61 1
74	*Synedi ella nodiflora*	5 46	1 23	6 69	1 17	0 46	1 63	21 42	37 39	24 36	2 5 1
75	*Tephi osia pui purea*	25 0	10 0	35 0	13 65	6 80	20 45	54 60	68 0	58 43	2 01 1
76	*Tiliacora acuminata*	48 33	8 33	56 66	16 63	3 99	20 62	34 41	47 89	36 39	4 17 1
77	*Todalia asiatica*	48 33	18 33	66 66	16 97	11 61	28 58	35 11	63 33	42 87	1 46 1
78	*Tragia involucrata*	5 36	1 07	6 43	1 39	0 45	1 84	25 93	42 05	28 62	3 09 1
79	*Trianthema portulacastrum*	5 0	3 0	8 0	2 25	1 25	3 50	45 0	41 66	43 75	1 80 1
80	*Tridax procumbei s*	4 47	0 84	5 31	0 36	0 11	0 47	8 05	13 09	8 85	3 27 1
81	*Urena lobata*	40 0	20 0	60 0	18 0	6 89	24 89	45 0	34 45	41 48	2 61 1
82	*Vernonia cinerea*	1 83	0 63	2 46	0 30	0 14	0 44	16 39	22 22	17 89	2 61 1
83	*Zyzyphus oenoplia*	15 0	5 0	20 0	5 0	25	6 25	33 33	25 0	31 25	4 1

the strata Lower biomass production was observed in *Dactyloctenium aegyptium* (0 87 g) *Phyllanthus amarus* (1 25 g) *Biophytum sensitivum* (1 50 g) *Oxalis corniculata* (1 66 g) *Hedyotis corymbosa* (1 66 g) and *Emilia sonchifolia* (1 77 g) The proportion of shoot was much higher than the root in the case of *Cardiospermum helicacabum* (11 8 1) *Knoxia mollis* (8 33 1) *Kalanchoe pinnata* (7 79 1) *Lantana camara* (7 74 1) and *Carissa congesta* (6 27 1) This was confirmed by their higher shoot root ratio In the case of *Curculigo orchioides* (1 3 94) *Cyperus deformis* (1 3 25) and *Cyperus rotundus* (1 6 78) the proportion of the root was higher than shoot which can be observed from the shoot root ratio

4 1 3 2 Total biomass production in garden land area

A total of 27 sampling units were taken using 1 0 m^2 frame in garden land area The fresh weight of each plant species was obtained by taking the mean values from all the quadrats in which it occurs The data on the biomass production of the plant species in the garden land area are given in Table10

Plants like *Cayratia pedata* (305 0 g) *Tinospora cordifolia*(113 33 g) *Thunbergia mysorensi* (125 0 g) and *Urena lobata* (250 0 g) produced higher biomasswhen compared to other species identified Lower biomass production was bserved in *Biophytum sensitivum* (0 38g) *Hedyotis herbacea* (1 19g) *Hedyotis umbellata* (0 68g) *Centella asiatica* (1 69g) *Dactyloctenium aegyptium* (1 67g) and *Mimosa pudica* (1 60g) From the shoot root ratio it is evident that the proportion of shoot was much higher than the

Table 10 Total biomass production of medicinal plants in garden land area around Vellayani lake

Sl No	Scientific Name	Fresh weight (g)			Dry weight (g)			Drage (%)			Shoot Root ratio
		Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	
1	*Abrus precatorius*	30 0	6 66	36 66	16 95	4 5	21 45	56 50	67 57	58 51	3 77 1
2	*Acalypha indica*	4 0	1 0	5 0	1 08	0 30	1 38	27 0	30 0	27 60	3 6 1
3	*Aerva lanata*	12 0	2 50	14 50	4 23	1 48	5 71	35 25	59 20	39 38	2 86 1
4	*Alysicarpus vaginalis*	4 80	2 20	7 0	1 52	0 73	2 25	31 67	33 18	32 14	2 08 1
5	*Andrographis paniculata*	17 75	4 75	22 50	4 85	1 76	6 61	27 38	37 05	9 38	2 75 1
6	*Aniseia martinicensis*	25 0	15 0	40 0	6 06	3 75	9 81	24 24	25 0	24 53	1 62 1
7	*Asparagus racemosus*	19 0	50 0	69 0	6 51	22 25	28 76	34 26	44 50	41 68	1 3 42
8	*Asystasia coromandiliana*	8 25	5 0	13 25	1 73	1 48	3 21	20 97	29 60	24 23	1 17 1
9	*Atylosia scarabaeoides*	5 22	2 0	7 22	2 0	0 95	2 95	38 31	47 5	40 85	2 11 1
10	*Biophytum sensitivum*	0 25	0 13	0 38	0 10	0 07	0 17	40 0	53 84	44 74	1 43 1
11	*Borreria alata*	7 62	1 04	8 66	1 28	0 14	1 42	16 80	13 46	16 39	9 14 1
12	*Capparis brevispina*	10 0	5 0	15 0	5 0	2 75	7 75	50 0	55 0	51 66	1 81 1
13	*Carissa congesta*	35 0	30 0	65 0	17 03	16 30	33 33	49 66	54 33	51 28	1 04 1
14	*Cassia occidentalis*	15 83	4 17	20 0	3 81	2 27	6 08	24 07	54 44	30 40	1 68 1
15	*Catharanthus roseus*	25 0	5 0	30 0	9 13	3 70	12 83	36 52	74 0	30 43	2 47 1
16	*Cathqranthus roseus*	6 67	1 67	8 34	1 60	0 77	2 37	23 99	46 11	28 42	2 08 1
17	*Cayratia pedata*	65 0	240 0	305 0	12 35	33 84	46 19	19 0	14 10	15 14	1 2 74
18	*Centella asiatica*	1 17	0 52	1 69	0 18	0 10	0 28	15 38	20 0	16 80	1 73 1
19	*Centrosema pubescens*	30 0	10 0	40 0	15 6	4 5	20 10	52 0	45 0	50 25	3 47 1
20	*Chrysopogon aciculatus*	4 10	4 44	8 54	1 35	2 22	3 57	32 93	50 0	41 8	1 1 64

Table 10 Contd

21	*Cleome rutidosperma*	13 56	1 13	14 69	1 20	0 16	1 36	8 85	14 16	9 26	7 5 1
22	*Cleome viscose*	6 31	2 44	8 75	0 93	0 42	1 35	14 74	17 21	15 43	2 21 1
23	*Clerodendrum viscosum*	15 0	5 0	20 0	4 50	2 40	6 90	30 0	48 0	34 50	1 88 1
24	*Commelina bengalensis*	4 0	1 0	5 0	0 48	0 12	0 60	12 0	12 0	24 0	4 0 1
25	*Croton sparsiflorous*	9 0	3 0	12 0	2 84	1 70	4 54	31 56	56 67	37 83	1 67 1
26	*Curculigo orchioides*	1 40	5 13	6 53	0 41	1 67	2 08	29 29	32 55	31 85	1 4 07
27	*Cyclea peltata*	18 57	12 14	30 71	5 01	4 31	9 32	26 98	35 50	30 34	1 16 1
28	*Cynodon dactylon*	3 77	1 87	5 64	0 56	0 37	0 93	15 01	19 79	16 59	1 53 1
29	*Cyperus deformis*	0 66	1 66	2 32	0 16	0 83	0 99	24 24	50 0	42 67	1 5 19
30	*Cyperus killinga*	1 27	0 82	2 09	0 18	0 19	0 37	14 17	23 17	17 70	1 1 06
31	*Cyperus rotundus*	3 21	2 08	5 29	0 64	0 77	1 41	19 94	37 02	26 65	1 1 20
32	*Dactyloctenium aegyptium*	1 0	0 67	1 67	0 25	0 22	0 47	25 0	32 8	28 14	1 14 1
33	*Desmodium triflorum*	1 95	0 18	2 13	0 45	0 07	0 52	23 08	38 89	24 41	6 43 1
34	*Desmodium velutinum*	3 0	2 0	5 0	0 99	1 0	1 99	33 0	50 0	39 0	1 1 01
35	*Elephantopus scaber*	6 0	4 0	10 0	3 12	1 43	4 55	52 0	35 75	45 50	2 18 1
36	*Eleusine indica*	6 43	5 52	11 95	2 75	2 0	4 75	42 76	36 23	39 75	1 38 1
37	*Emilia sonchifolia*	1 2	0 6	1 8	0 15	0 08	0 23	12 50	12 50	12 50	2 0 1
38	*Euphorbia hirta*	1 65	0 41	2 06	0 49	0 11	0 60	29 70	26 83	29 13	4 45 1
39	*Evolvulus alsinoides*	2 0	0 5	2 50	0 88	0 23	1 11	44 0	45 0	44 20	3 91 1
40	*Grangea medaraspatana*	5 0	1 66	6 66	0 90	0 11	1 01	18 0	6 63	15 17	8 18 1
41	*Hedyotis corymbosa*	3 0	2 0	5 0	0 66	0 40	1 06	22 0	20 0	21 20	1 65 1
42	*Hedyotis herbacea*	0 95	0 24	1 19	0 21	0 05	0 26	22 11	20 0	21 68	4 38 1
43	*Hedyotis umbellata*	0 29	0 39	0 68	0 06	0 08	0 14	22 07	20 0	20 88	1 1 22
44	*Heliotropium indicum*	20 0	6 66	26 66	3 64	1 07	4 71	18 20	16 07	17 67	3 40 1
45	*Hemidesmus indicus*	0 71	1 14	1 85	0 25	0 51	0 76	35 0	44 74	40 99	1 2 04

Table10 Contd

46	*Hiptis sauveolens*	3 63	1 63	5 26	0 93	0 67	1 60	25 62	41 10	30 42	1 39 1
47	*Indigofera tinctoria*	2 50	2 50	5 0	0 56	0 58	1 14	22 40	23 20	22 80	1 1 04
48	*Ionidium suffruticosum*	3 50	1 50	5 0	1 68	0 75	2 43	48 0	50 0	46 0	2 24 1
49	*Ixora coccinea*	8 66	5 66	14 32	2 62	3 17	5 79	30 25	56 0	40 43	1 1 21
50	*Jasminum rottlerianum*	1 88	2 50	4 38	0 94	1 49	2 43	50 0	59 60	55 48	1 1 59
51	*Justicia japonica*	3 0	1 09	4 09	0 60	0 23	0 83	20 0	21 10	20 29	2 61 1
52	*Kalanchoe pinnata*	40 0	10 0	50 0	20 08	2 18	22 26	50 20	21 80	45 20	9 21 1
53	*Lantana camara*	25 0	20 0	45 0	8 3	7 3	15 6	33 2	36 5	34 67	1 14 1
54	*Leucas aspera*	9 0	1 24	10 24	2 30	0 49	2 79	25 56	39 52	27 25	4 69 1
55	*Lycopodium flexeosus*	10 0	25 0	35 0	4 25	17 75	22 0	42 50	71 0	62 86	1 4 18
56	*Melochia corchorifolia*	40 0	5 0	45 0	20 0	2 0	22 0	50 0	40 0	48 88	10 1
57	*Mimosa pudica*	1 50	0 10	1 60	0 44	0 04	0 48	29 33	42 0	30 13	10 47 1
58	*Mollugo pentaphylla*	1 67	1 67	3 34	0 37	0 33	0 70	22 16	19 76	20 95	1 12 1
59	*Panicum repens*	9 85	6 15	16 0	3 28	2 0	5 28	33 33	26 15	33 0	1 64 1
60	*Phyllanthus amarus*	1 32	0 59	1 91	0 25	0 22	0 47	18 94	37 29	24 61	1 14 1
61	*Phyllanthus urinaria*	5 0	1 67	6 67	1 30	0 25	1 55	26 0	14 97	23 24	5 2 1
62	*Scoparia dulcis*	4 52	1 46	5 98	1 03	0 49	1 52	22 79	33 56	25 42	2 10 1
63	*Sebastiana cl amaelea*	2 03	0 49	2 52	0 75	0 17	0 92	36 95	34 69	36 51	4 41 1
64	*Sida rhombifolia*	7 89	2 11	10 0	3 37	1 24	4 61	42 71	58 77	46 10	2 72 1
65	*Solanum indicum*	61 66	18 33	79 99	13 39	4 77	18 16	21 72	26 02	22 70	2 81 1
66	*Stachytarpheta urticaefolia*	65 0	15 0	80 0	16 52	5 85	22 37	25 42	39 0	27 96	2 82 1
67	*Struchium sparganophorum*	25 0	3 33	28 33	7 14	0 95	8 09	28 56	28 53	28 56	7 52 1
68	*Synedrella nodiflora*	3 33	0 89	4 22	0 72	0 33	1 05	21 62	37 08	24 88	2 18 1
69	*Thunbergia mysorensis*	110 0	15 0	125 0	25 30	4 80	30 10	23 0	32 0	24 08	5 27 1
70	*Tiliacora acuminata*	25 0	8 75	33 75	8 6	4 2	12 8	34 40	48 0	37 93	2 05 1

Table 10 Contd

71	*Tinospora cordifolia*	70 0	43 33	113 33	25 67	24 05	49 72	36 67	55 50	43 87	1 07 1
72	*Trichodesma indicum*	30 0	32 50	62 50	10 75	11 97	22 72	35 83	36 83	36 35	1 1 11
73	*Trichosanthes cucumerina*	45 0	15 0	60 0	6 30	2 80	9 10	14 0	18 67	15 17	2 25 1
74	*Tridax procumbens*	6 25	1 25	7 50	0 54	0 16	0 70	8 64	12 80	9 33	3 38 1
75	*Urena lobata*	150 0	100 0	250 0	67 5	34 44	101 94	45 0	34 44	40 78	1 96 1
76	*Vernonia cinerea*	1 69	0 53	2 22	0 28	0 12	0 40	16 33	22 64	17 84	2 3 1
77	*Vigna trilobata*	4 0	1 0	5 0	1 04	0 15	1 19	26 0	15 0	23 80	6 93 1

root in case of *Borreria alata* (9 14 1) *Kalaonchoe pinnata* (9 21 1) *Melochia corcorifolia* (10 1) and *Mimosa pudica* (10 47 1) In *Asparagus racemosus* (1 3 42) *Curculigo orchioides* (1 4 07) and *Cyperus deformis* (1 5 19) the proportion of root was much h gher than shoot which is evident from the shoot root rat o

4 1 3 3 Total biomass production in paddy field area

A total of 13 sampling units were taken using 1 0 m^2 frame in the paddy f eld area The fresh weight of each plant species was obtained by taking the mean value from all the quadrats in which it occurs The data on biomass production of the plant species in paddy field area are given in Table 11

Higher biomass production was observed in *Heliotropium indicum* (86 00 g) *Polygonum glabrum* (58 33 g) *Monochorea vaginalis* (39 99 g) *Ipomoea maurittiana* (40 g) *Struchium sparganophorum* (40 g) and *Solanum nigrum* (75 00 g) Plants like *Desmodium triflori m* (2 25 g) *Lindenia crustacea* (1 66 g) *Oxalis corniculata* (? 17g) and *Phyllanthus amarus* (1g) produced lower biomass compared to other plant species The proportion of shoot was much higher than root in the case of *Alternanthera sessalis* (6 58 1) *Lindernia antipoda* (8 98 1) *Struchium sparganophorum* (5 42 1) *Solanum nigrum* (4 81 1) and *Vernonia cinerea* (5 1) which can be understood from the shoot root ratio In the case of *Adiantum pedatum* (1 1 52) *Emilia sonchifolia* (1 1 95) *Chrysopogon aciculatus* (1 1 67) and *Ipomoea mourittiana* (1 3 21) the proportion of root was higher than the shoot

Table 11 Total biomass production of medicinal plants in paddy field area around Vellayani lake

Sl No	Scientific Name	Fresh weight (g)			Dry weight (g)			Drnage (%)			Shoot Root ratio
		Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	
1	*Achyranthes aspera*	18 33	5 0	23 33	6 11	1 72	7 83	33 33	34 40	33 56	3 55 1
2	*Adiantum pedatum*	8 06	6 94	15 0	1 37	2 08	3 45	16 99	29 97	23 0	1 1 52
3	*Alternanthera sessalis*	25 0	3 33	28 33	6 25	0 95	7 20	25 0	28 53	25 41	6 58 1
4	*Borreria alata*	4 0	1 0	5 0	1 13	0 24	1 37	28 25	24 0	27 40	4 71 1
5	*Bulbostylis barbata*	2 50	3 0	5 50	1 0	1 25	2 25	40 0	41 67	40 90	1 1 25
6	*Centella asiatica*	2 06	0 96	3 02	0 31	0 19	0 50	15 05	19 79	16 56	1 63 1
7	*Chrysopogon aciculatus*	2 50	5 0	7 50	1 50	2 5	4 0	60 0	50 0	53 33	1 1 67
8	*Cleome rutidosperma*	6 19	0 90	7 0	0 55	0 13	0 68	8 89	14 49	9 71	4 23 1
9	*Coldenia procumbens*	7 0	3 0	10 0	1 56	0 75	2 31	22 29	25 0	23 10	2 08 1
10	*Commelina bengalensis*	10 0	3 0	13 0	1 2	0 36	1 56	12 0	12 0	12 0	3 33 1
11	*Crassocephalum creptoides*	3 50	2 80	6 30	1 5	1 0	3 5	42 85	35 71	55 55	1 5 1
12	*Cryptocorine retrospiralis*	2 50	2 50	5 0	0 83	0 86	1 69	33 32	34 4	33 86	1 1 03
13	*Cynodon dactylon*	4 80	2 20	7 0	1 88	1 23	3 11	39 17	55 91	44 43	1 53 1
14	*Cyperus deformis*	8 75	7 50	16 25	1 23	1 73	2 96	14 06	23 07	18 22	1 1 41
15	*Cyperus iria*	3 0	2 50	5 50	1 0	0 75	1 75	33 33	30 0	31 82	1 33 1
16	*Cyperus kyllinga*	4 0	2 0	6 0	0 56	0 46	1 02	14 0	23 0	17 0	1 22 1
17	*Cyperus rotundus*	5 33	3 55	8 88	1 32	1 78	3 10	24 77	50 14	34 91	1 1 35
18	*Desmodium triflorum*	1 50	0 75	2 25	0 50	0 32	0 82	33 33	42 67	36 44	1 56 1
19	*Eclipta alba*	3 50	1 50	5 0	0 77	0 23	1 0	22 0	15 33	20 0	3 35 1
20	*Emilia sonchifolia*	3 0	2 0	5 0	0 38	0 74	1 12	12 67	37 0	22 40	1 1 95
21	*Evolvulus alsinoides*	4 50	1 33	5 83	1 98	0 60	2 58	44 0	45 11	44 25	3 30 1

Table 11 Contd

22	*Hedyotis diffusa*	11 66	3 33	14 99	2 56	0 67	3 23	21 96	20 12	21 55	3 82 1
23	*Heliotropium indicum*	44 0	42 0	86 0	8 0	6 72	14 72	18 18	16 0	17 12	1 19 1
24	*Ipomoea mauritiana*	19 0	21 0	40 0	2 13	6 83	8 96	11 21	32 52	22 40	1 3 21
25	*Leucas aspera*	5 0	2 50	7 50	1 28	0 98	2 26	25 60	39 20	30 13	1 31 1
26	*Limnophila repens*	5 8	1 80	7 60	0 83	0 18	1 01	14 12	10 0	13 29	4 61 1
27	*Lindernia antipoda*	3 82	0 59	4 41	0 53	0 06	0 59	13 87	10 0	13 36	8 98 1
28	*Lindernia crustaceae*	1 33	0 33	1 66	0 11	0 07	0 18	8 27	20 0	10 60	1 67 1
29	*Ludwigia parviflora*	12 59	3 15	15 74	2 32	0 79	3 11	18 43	25 08	19 76	2 94 1
30	*Marselia marsescens*	2 50	1 39	3 89	0 48	0 28	0 76	19 20	20 14	19 54	1 71 1
31	*Mitracarpus verticellata*	14 50	2 75	9 25	1 97	1 61	3 58	13 59	33 89	18 59	1 22 1
32	*Mollugo pentaphylla*	8 66	0 78	9 44	1 92	0 17	2 09	22 17	21 79	22 14	11 29 1
33	*Monochorea vaginalis*	27 85	12 14	39 99	1 81	1 20	3 01	6 50	9 88	7 53	1 51 1
34	*Oxalis corniculata*	1 25	0 92	2 17	0 28	0 18	0 46	22 40	19 57	21 19	1 56 1
35	*Panicum repens*	3 88	4 44	8 32	0 83	1 06	1 89	21 39	23 87	22 72	1 1 28
36	*Phyllanthus amarus*	0 60	0 40	1 0	012	0 15	0 27	20 0	37 50	27 0	1 1 25
37	*Polygonum glabrum*	50 0	8 33	58 33	16 20	3 77	19 97	32 40	45 26	34 24	4 30 1
38	*Portulaca oleraceae*	7 0	3 0	10 0	2 80	1 20	4 0	40 0	40 0	40 0	2 33 1
39	*Rungia parviflora*	4 29	3 21	7 50	1 43	1 07	2 50	33 33	33 33	33 33	1 34 1
40	*Scoparia dulcis*	11 85	3 15	15 0	2 70	1 05	3 75	22 78	33 33	25 0	2 57 1
41	*Solanum nigrum*	65 0	10 0	75 0	8 66	1 80	10 46	13 32	18 0	13 95	4 81 1
42	*Struchium sparganophorum*	33 75	6 25	40 0	9 64	1 78	11 42	28 56	28 48	28 55	5 42 1
43	*Synedrella nodiflora*	4 62	1 15	5 77	0 99	0 43	1 42	21 43	37 39	24 61	2 30 1
44	*Vernonia cinerea*	11 33	1 66	12 99	1 85	0 37	2 22	16 33	22 29	17 09	5 0 1

4 1 3 4 Total biomass production in lake area

A total of 10 sampling units were taken from the lake area assuming 1 0 m^2 as it is difficult to throw the metallic frame inside the lake The fresh weight of each plant species was obtained by taking the mean values from all the quadrats of occurance The data on the biomass production of the plant species in the lake area are given in Table 12

Higher biomass production was observed in *Monochoria vaginalis* (239 99 g) and *Nelumbo nucifera* (161 66 g) In the case of *Marsilea marsecens* (2 50 g) and *Hydrilla verticellata* (1 00 g) the biomass production was lower compared to other species From the shoot root ratio it is evident that proportion of shoot was higher than root in *Limnophila repens* (4 45 1) and *Nymphea nouchali* (5 09 1) The proportion of root was higher than shoot in *Monochoria vaginalis* (1 1 45) *Cyperus iria* (1 2) and *Salvinia molesta* (1 2)

4 2 Growth phases of selected medicinal plants

Ten important medicinal plant species were selected as candidate species which were common to at least two stratas (Table 13) The growth behaviour of the selected plants was monitored for one year at three different growth stages *viz* pre flowering flowering and seed set stage From the lake area none of the species was selected

Table 12 Total biomass production of medicinal plants in Vellayani lake area

Sl No	Scientific Name	Fresh weight (g)			Dry weight (g)			Drage (%)			Shoot Root ratio
		Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	Shoot	Root	Shoot + Root	
1	*Bacopa monnieri*	5 43	4 14	9 57	1 07	0 69	1 76	19 71	16 67	18 39	1 55 1
2	*Centella asiatica*	3 50	1 50	5 0	0 53	0 30	0 83	15 14	20 0	6 60	1 77 1
3	*Cryptocorine retrospiralis*	2 80	3 0	5 80	0 90	1 10	2 0	32 14	36 67	34 48	1 1 22
4	*Cyperus iria*	3 0	3 50	6 50	1 0	2 0	3 0	33 33	57 14	46 15	1 2
5	*Diplocyclos palmatus*	20 0	10 0	30 0	7 5	3 5	11 0	37 5	35 0	36 67	2 14 1
6	*Fimbristylis aestivalis*	2 50	1 50	4 0	1 25	0 75	2 0	50 0	50 0	50 0	67 1
7	*Hydrilla verticellata*	0 5	0 5	1 0	0 10	0 10	0 20	20 0	20 0	20 0	1 1
8	*Limnophila heterophillus*	1 50	1 0	2 50	0 15	0 10	0 25	10 0	10 0	10 0	1 5 1
9	*Limnophila repens*	6 33	2 0	8 33	0 89	0 20	1 09	14 06	10 0	13 09	4 45 1
10	*Lindernia antipoda*	6 05	2 0	8 05	1 02	0 56	1 58	16 86	28 0	19 63	1 82 1
11	*Marsilea marsecens*	1 50	1 0	2 50	0 20	0 11	0 31	13 33	11 0	12 40	1 81 1
12	*Monochoria vaginalis*	123 3	116 66	239 99	9 25	13 42	22 67	7 50	11 50	9 45	1 1 45
13	*Nelumbo nucifera*	105 0	56 66	161 66	18 38	9 58	27 96	17 50	16 91	17 29	1 92 1
14	*Nymphea nouchali*	20 41	7 91	28 32	2 65	0 52	3 17	12 98	6 57	11 19	5 09 1
15	*Salvinia molesta*	2 0	2 80	4 80	0 50	1 0	1 50	25 0	35 71	31 25	1 2
16	*Trichosanthes cucumerina*	10 0	10 0	20 0	1 40	1 87	3 27	14 0	18 70	16 35	1 34 1
17	*Utricularia aurea*	3 50	3 0	6 50	1 5	1 0	2 5	42 85	33 33	38 46	1 5 1

Table 13 List of medicinal plants selected for studying growth phases

Sl No	Scientific name	Vernacular name	Family
1	*Andrographis paniculata* Burm f	Kiryathu	Acanthaceae
2	*Cyclea peltata* Hook f & Thoms	Padathali	Menispermaceae
3	*Desmodium velutinum* L	Oarila	Fabaceae
4	*Eclipta alba* L	Kythonni	Asteraceae
5	*Gloriosa superba* L	Menthonni	Liliaceae
6	*Hemidesmus indicus* R Br	Narunanti	Asclepiadaceae
7	*Phyllanthus amarus* Schum	Kizhanelli	Euphorbiaceae
8	*Scoparia dulcis* L	Kallurukki	Scrophulariaceae
9	*Sida rhombifolia* L	Kurunthotti	Malvaceae
10	*Solanum indicum* Lam	Chunda	Solanaceae

Plate 1: *Andrographis paniculata*

Plate 2: *Cyclea peltata*

Plate 3: *Desmodium velutinum*

Plate 4: *Eclipta alba*

Plate 5: *Gloriosa superba*

Plate 6: *Hemidesmus indicus*

Plate 7: *Phyllanthus amarus*

Plate 8: *Scoparia dulcis*

Plate 9: *Sida rhombifolia*

Plate 10: *Solanum indicum*

4 2 1 Plant height

The data on plant height of the selected species are given in Table 14 It is evident that the height of the plant increases from the pre flowering to the seed set stage for all the ten species Plant height also differs among the different strata In case of *Andrographis paniculata* and *Solanum indicum* plant height was more in dry land area than garden land area In *Cyclea peltata Desmodium vel tini m Gloriosa superba Hemidesmus indicus* and *Sida rhombifolia* plant height was more n garden land area than dry land area In *Eclipta alba Phyllanthus amarus Scoparia dulcis* plant height was more in paddy field area compared to other stratas The difference in plant height among the strata was greater for *Gloriosa superba* especially in the seed set stage

4 2 2 Number of branches

The data on number of branches of selected species are given in Table 15 For all the ten plant species number of branches was found to increase from the pre flowering to seed set stage

More number of branches were produced under dry land condition in *Andrographis paniculata Gloriosa superba Phyllanthus amarus* In *Desmodium velutinum Hemidesmus indicus Sida rhombifolia Solanum indicum* number of branches was greater under garden land area In *Scoparia dulcis* more number of branches were produced in paddy field area

Table 14 Plant height of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Plant height (cm)*/ strata **			
			D	G	P	L
1	*Andrographis paniculata*	1	37	24	NP	NP
		2	44	40		
		3	75	70		
2	*Cyclea peltata*	1	30	39	NP	NP
		2	57	70		
		3	125	142		
3	*Desmodium velutinum*	1	40	46	NP	NP
		2	70	72		
		3	142	150		
4	*Eclipta alba*	1	NP	10	15	NP
		2		22	35	
		3		39	41	
5	*Gloriosa superba*	1	10	14	NP	NP
		2	29	32		
		3	165	73		
6	*Hemidesmus indicus*	1	11	12	NP	NP
		2	18	40		
		3	55	60		
7	*Phyllanthus amarus*	1	18	15	18	NP
		2	20	22	24	
		3	25	30	35	
8	*Scoparia dulcis*	1	18	20	20	NP
		2	36	36	43	
		3	54	62	65	
9	*Sida rhombifolia*	1	10	23	NP	NP
		2	23	28		
		3	32	42		
10	*Solanum indicum*	1	18	15	NP	NP
		2	34	30		
		3	90	84		

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Table 15 Number of branches of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	No of branches*/strata**			
			D	G	P	L
1	*Andrographis paniculata*	1	5	7	NP	NP
		2	21	15		
		3	29	20		
2	*Cyclea peltata*	1	0	1	NP	NP
		2	2	2		
		3	3	3		
3	*Desmodium velutinum*	1	0	2	NP	NP
		2	2	3		
		3	15	13		
4	*Eclipta alba*	1	NP	3	0	NP
		2		9	4	
		3		10	20	
5	*Gloriosa superba*	1	0	0	NP	NP
		2	1	1		
		3	3	2		
6	*Hemidesmus indicus*	1	2	2	NP	NP
		2	2	4		
		3	6	8		
7	*Phyllanthus amarus*	1	0	0	0	NP
		2	0	0	2	
		3	7	2	6	
8	*Scoparia dulcis*	1	3	5	7	NP
		2	7	7	10	
		3	23	22	22	
9	*Sida rhombifolia*	1	0	1	NP	NP
		2	1	4		
		3	9	20		
10	*Solanum indicum*	1	1	2	NP	NP
		2	3	10		
		3	16	20		

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

4 2 3 Plant spread

The data on plant spread of selected species are given in Table 16 It was observed that the plant spread increased from pre flowering to seed set stage for all the plant species

Plants growing in garden land area were found to have greater plant spread compared to other stratas in *Cycela peltata Desmodium velutinum Hemidesmus indicus Sida rhombifolia* and *Solanum indicum Eclipta alba Phyllanthus amarus* and *Scoparia dulcis* had more plant spread under paddy field area compared to other stratas In *Gloriosa superba* during pre flowering and flowering stage plant spread was more in garden land area compared to dry land area But during seed set stage plant spread was more in dry land area (306 cm^2) compared to garden land area (282 cm^2)

4 2 4 Height at which first branch is produced

The data on the height at which first branches produced for the selected spec es are given in Table 17 A slight increase in the height of the first branch was observed for all the ten plant species from the pre flowering to the seed set stage

The height of the first branch was found to be lower in dry land area and progressively higher in garden land area in *Andrographis paniculata Cyclea peltata Desmodium velutinum Hemidesmus indicus Sida rhombifolia* In *Gloriosa superba* it

Table 16 Plant spread of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Plant spread (cm^2)*/strata**			
			D	G	P	L
1	*Andrographis paniculata*	1	208	215	NP	NP
		2	320	308		
		3	422	403		
2	*Cyclea peltata*	1	50	78	NP	NP
		2	136	142		
		3	165	178		
3	*Desmodium velutinum*	1	28	96	NP	NP
		2	110	165		
		3	315	330		
4	*Eclipta alba*	1	NP	60	30	NP
		2		185	104	
		3		310	330	
5	*Gloriosa superba*	1	52	60	NP	NP
		2	78	108		
		3	306	282		
6	*Hemidesmus indicus*	1	54	64	NP	NP
		2	58	75		
		3	142	224		
7	*Phyllanthus amarus*	1	9	9	16	NP
		2	12	24	32	
		3	112	60	124	
8	*Scoparia dulcis*	1	18	36	56	NP
		2	350	320	372	
		3	410	408	525	
9	*Sida rhombifolia*	1	18	36	NP	NP
		2	35	90		
		3	408	1760		
10	*Solanum indicum*	1	84	228	NP	NP
		2	180	500		
		3	1200	2160		

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Table 17 Plant height at which first branch is produced for selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Height of first branch (cm)*/ strata**			
			D	G	P	L
1	*Andrographis paniculata*	1 2 3	0 3 5	5 8 8	NP	NP
2	*Cyclea peltata*	1 2 3	0 0 5 1	0 5 1 1	NP	NP
3	*Desmodium velutinum*	1 2 3	0 50 15	24 50 55	NP	NP
4	*Eclipta alba*	1 2 3	NP	0 2 4	0 0 5 3	NP
5	*Gloriosa superba*	1 2 3	0 0 8 7 5	0 0 5 8	NP	NP
6	*Hemidesmus indicus*	1 2 3	0 5 1 5 4	0 5 2 5 5 5	NP	NP
7	*Phyllanthus amarus*	1 2 3	0 0 1 5	0 0 0 5	0 0 5 2	NP
8	*Scoparia dulcis*	1 2 3	2 9 7	2 5 5 9	0 5 2 9	NP
9	*Sida rhombifolia*	1 2 3	0 4 5 3	4 5 7 9	NP	NP
10	*Solanum indicum*	1 2 3	0 5 1 10	0 8 1 5 8	NP	NP

* Mean values of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

was more or less equal in dry land and garden land area In *Eclipta alba* first branch was found to be at a higher level in garden land compared to paddy field In *Phyllanthus amarus* first branch was produced at more or less same height in all the three stratas

4 2 5 Number of leaves

The data on the number of leaves of the selected species are given in Table 18 The number of leaves produced was found to increase from pre flowering to the flowering stage and then it decreases in seed set stage for six out of ten plant species *viz* *Andrographis paniculata* *Cyclea peltata* *Desmodium velutinum* *Hemidesmus indicus* *Scoparia dulcis* and *Solanum indicum*

More number of leaves were produced under dry land area in *Andrographis paniculata* and *Solanum indicum* In *Eclipta alba* *Phyllanthus amarus* and *Scoparia dulcis* more number of leaves were produced under paddy field condition compared to other stratas

4 2 6 Season of flowering and fruiting

The data on season of flowering and fruiting of the selected species are resented in Table 19 It was found that *Desmodium velutinum* flowers during October November *Eclipta alba* during May July *Gloriosa superba* during August September *Phyllanthus amarus* during July November *Scoparia dulcis* during May November and *Sida rhombifolia* during July December All the other species flower throughout the year

Table 18 Number of leaves of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	No of leaves* /strata**			
			D	G	P	L
1	*Andrographis paniculata*	1	247	139	NP	NP
		2	243	160		
		3	350	305		
2	*Cyclea peltata*	1	6	8	NP	NP
		2	18	20		
		3	22	33		
3	*Desmodium velutinum*	1	17	19	NP	NP
		2	45	52		
		3	174	190		
4	*Eclipta alba*	1		23	27	NP
		2	NP	95	184	
		3		60	202	
5	*Gloriosa superba*	1	6	9	NP	NP
		2	11	12		
		3	156	69		
6	*Hemidesmus indicus*	1	7	8	NP	NP
		2	22	35		
		3	37	51		
7	*Phyllanthus amarus*	1	20	15	22	NP
		2	77	50	44	
		3	100	120	125	
8	*Scoparia dulcis*	1	50	70	70	NP
		2	170	172	230	
		3	225	298	312	
9	*Sida rhombifolia*	1	18	19	NP	NP
		2	19	22		
		3	79	159		
10	*Solanum indicum*	1	18	13	NP	NP
		2	46	44		
		3	104	95		

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Table 19 Season of flowering and fruiting of ten important medicinal plant species

Sl No	Scientific Name	Flowering and Fruiting Season
1	*Andrographis paniculata* Burm f	Throughout the year
2	*Cyclea peltata* Hook F & Thoms	Throughout the year
3	*Desmodium velutinum* L	October –November
4	*Eclipta alba* L	May July
5	*Gloriosa superba* L	August September
6	*Hemidesmus indicus* R Br	Throughout the year
7	*Phyllanthus amarus* Schum	July November
8	*Scoparia dulcis* L	May November
9	*Sida rhombifolia* L	July December
10	*Solanum indicum* Lam	Throughout the year

4 2 7 Root length

The data on root length of the selected species are given in Table 20 For all the species root length was found to increase from the pre flowering to the seed set stage

The root length was greater under dry land area for *Andrographis paniculata* and *Solanum indicum* Root length was greater under garden land for *Cyclea peltata Desmodium velutinum Gloriosa superba Hemidesmus indicus* and *Sida rhombifolia* In *Eclipta alba Phyllanthus amarus* and *Scoparia dulcis* root length was found to be higher in paddy field area

4 2 8 Number of roots

The data on the number of roots of selected species are given in Table 21 From the pre flowering to the seed set stage an increase in number of roots was recorded for all the ten species

More number of roots were produced under dry land condition in *Andrographis paniculata* and *Solanum indicum* In *Gloriosa superba* more or less same number of roots were produced under dry land and garden land condition In *Eclipta alba Phyllanthus amarus* and *Scoparia dulcis* more number of roots were produced under paddy field area In all other selected species more number of roots were produced under garden land area

Table 20 Root length of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Root length (cm)* /strata**			
			D	G	P	L
1	*Andrographis paniculata*	1 2 3	23 30 33	20 32 32	NP	NP
2	*Cyclea peltata*	1 2 3	8 5 11 31	9 5 16 40	NP	NP
3	*Desmodium velutinum*	1 2 3	14 17 25	15 8 21 5 32	NP	NP
4	*Eclipta alba*	1 2 3	NP	3 5 8 8 10	3 7 10 12	NP
5	*Gloriosa superba*	1 2 3	10 12 27	12 15 5 31	NP	NP
6	*Hemidesmus indicus*	1 2 3	13 16 5 29 5	15 8 18 30	NP	NP
7	*Phyllanthus amarus*	1 2 3	3 4 2 5	2 8 4 2 5 5	3 5 5 7 5	NP
8	*Scoparia dulcis*	1 2 3	15 17 8 28	17 18 2 28 5	18 5 19 31	NP
9	*Sida rhombifolia*	1 2 3	12 2 15 21	14 5 17 5 24	NP	NP
10	*Solanum indicum*	1 2 3	14 18 2 34	12 14 27	NP	NP

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Table 21 Number of roots of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	No of roots* /strata**			
			D	G	P	L
1	*Andrographis paniculata*	1	32	28	NP	NP
		2	40	38		
		3	67	55		
2	*Cyclea peltata*	1	8	10	NP	NP
		2	11	13		
		3	12	21		
3	*Desmodium velutinum*	1	18	22	NP	NP
		2	24	29		
		3	39	47		
4	*Eclipta alba*	1	NP	8	9	NP
		2		13	17	
		3		18	20	
5	*Gloriosa superba*	1	1	1	NP	NP
		2	2	3		
		3	3	3		
6	*Hemidesmus indicus*	1	1	2	NP	NP
		2	3	3		
		3	3	6		
7	*Phyllanthus amarus*	1	20	15	22	NP
		2	28	26	34	
		3	35	35	38	
8	*Scoparia dulcis*	1	18	19	22	NP
		2	21	24	24	
		3	32	36	41	
9	*Sida rhombifolia*	1	18	22	NP	NP
		2	20	26		
		3	38	42		
10	*Solanum indicum*	1	5	3	NP	NP
		2	18	10		
		3	33	24		

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

4 2 9 Inter nodal length

The data on inter nodal length of the selected species are given in Table 22 The inter nodal length of the plant increases from the pre flowering to the seed set stage for most of the selected plants

In *Gloriosa superba* inter nodal length was found to be more or less same in both the stratas In *Eclipta alba Phyllanthus amarus* and *Scoparia dulcis* inter nodal length was found to be more under paddy field area compared to other stratas

4 2 10 Stem girth

The data on stem girth of the selected species are given in Table 23 From pre flowering to seed set stage there was a slight increase in stem girth

Stem girth was highest for *Gloriosa superba* (2 5 cm) under garden land area in seed set stage and least for *Cyclea peltata* (0 2cm) under dry land condition in seedling stage In *Eclipta alba Phyllanthus amarus* and *Scoparia dulcis* stem girth was found to be slightly higher under paddy field area

4 2 11 Fresh and dry weight of officinal part

The data on the fresh and dry weight of the medicinally important part of the selected species are given in Table 24 It was found that the fresh and dry weight of officinal part increases from the pre flowering to the seed set stage for most of the selected plants

Table 22 Inter nodal length of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Internodal length (cm)* /strata**			
			D	G	P	L
1	*Andrographis paniculata*	1 2 3	1 5 1 8 2 5	1 1 5 2	NP	NP
2	*Cyclea peltata*	1 2 3	2 5 3 5	2 5 3 5 6	NP	NP
3	*Desmodium velutinum*	1 2 3	3 5 4 5 6	4 5 5 8	NP	NP
4	*Eclipta alba*	1 2 3	NP	1 1 5 2 5	2 1 5 2 5	NP
5	*Gloriosa superba*	1 2 3	3 5 5 5 6 5	5 5 5 7	NP	NP
6	*Hemidesmus indicus*	1 2 3	0 7 1 8 5	2 4 7 5	NP	NP
7	*Phyllanthus amarus*	1 2 3	0 8 1 1 5	0 5 1 2 2	0 7 1 5 2 5	NP
8	*Scoparia dulcis*	1 2 3	0 8 1 5 3	1 1 8 3 5	2 2 5 4	NP
9	*Sida rhombifolia*	1 2 3	0 3 0 6 1	0 5 1 1 2	NP	NP
10	*Solanum indicum*	1 2 3	0 7 1 5 3 5	0 5 1 2 5	NP	NP

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Table 23 Stem girth of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Stem girth (cm)* /strata**			
			D	G	P	L
1	*Andrographis paniculata*	1 2 3	0 5 0 8 1 5	0 4 0 5 1 3	NP	NP
2	*Cyclea peltata*	1 2 3	0 3 0 5 1	0 5 0 8 1	NP	NP
3	*Desmodium velutinum*	1 2 3	0 5 1 2	0 8 1 5 2	NP	NP
4	*Eclipta alba*	1 2 3	NP	0 3 0 5 0 8	0 6 0 8 1	NP
5	*Gloriosa superba*	1 2 3	1 1 2 1 5	1 5 1 5 2 5	NP	NP
6	*Hemidesmus indicus*	1 2 3	0 4 0 6 0 9	0 8 0 9 1	NP	NP
7	*Phyllanthus amarus*	1 2 3	0 6 0 9 1 2	0 5 0 7 1 2	0 8 1 1 4	NP
8	*Scoparia dulcis*	1 2 3	0 5 0 8 1 2	0 6 1 1 5	0 5 1 2 1 4	NP
9	*Sida rhombifolia*	1 2 3	0 8 1 1 2	1 1 3 1 3	NP	NP
10	*Solanum indicum*	1 2 3	0 7 1 4 1 6	0 6 0 9 1 2	NP	NP

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

In the case of *Andrographis paniculata Desmodium velutinum* and *Sida rhombifolia* fresh and dry weight of officinal part was more under garden land area compared to dry land area In *Cyclea peltata Gloriosa superba* and *Solanum indicum* it was more under dry land condition compared to garden land condition In *Phyllanthus amarus* and *Scoparia dulcis* fresh and dry weight of officinal part was more under paddy field area compared to other stratas Fresh and dry weight of officinal part was more in the case of *Cyclea peltata Gloriosa superba* and *Solanum indicum* compared to other species

4 2 12 Fresh and dry weight of non officinal part

The data on the fresh and dry weight of the non officinal part of the selected species are given in Table 25 For most of the species fresh and dry weight of non officinal part increases from the pre flowering to the seed set stage

In most of the species fresh and dry weight of non officinal part was more under dry land condition compared to garden land area except in *Andrographis paniculata* and *Sida rhombifolia Solanum indicum* produced highest quantity of non off cinal part under dry land condition at seed set stage followed by *Gloriosa superba* at seed set stage under the same condition

Table 24 Fresh and dry weight of officinal part of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Fresh and dry weight of officinal part (g)* /strata**				Remarks (offic nal part)
			D	G	P	L	
1	*Andrographis paniculata*	1 2 3	5(1 5) 7(1 9) 10(2 5)	7 ɔ(2 8) 17 75(4 8) 22(5 75)	NP	NP	Shoot
2	*Cyclea peltata*	1 2 3	12(3 5) 12 6(4 49) 20(6 75)	10(3 0) 12 14(4 31) 18 25(4 75)	NP	NP	Root
3	*Desmodium velutinum*	1 2 3	1 14(0 57) 4 6(2 0) 10 8(5 4)	1 4(0 70) 5 2(2 5) 15 4(5 5)	NP	NP	Root
4	*Eclipta alba*	1 2 3	NP	4 2(0 80) 5(1 05) 10 2(2 5)	3 5(0 77) 6 5(1 3) 12 5(2 5)	NP	Shoot
5	*Gloriosa superba*	1 2 3	15 5(5 25) 30(11 08) 42(15)	5(2 25) 15 5(5) 35(12 5)	NP	NP	Root
6	*Hemidesmus indicus*	1 2 3	1 03(0 45) 2(10 7) 8(2 75)	5(1 75) 3 5(1) 5(1 75)	NP	NP	Root
7	*Phyllanthus amarus*	1 2 3	0 26(0 05) 0 32(0 10) 0 92(0 18)	0 23(0 05) 0 93(0 18) 1 32(0 25)	0 26(0 05) 0 94(0 18) 1 53(0 28)	NP	Shoot
8	*Scoparia dulcis*	1 2 3	5 82(1 33) 7 5(1 75) 20(5 25)	4 52(1 03) 8 75(2 25) 18 5(4 5)	6 75(1 65) 11 8ɔ(2 7) 22 75(5 7)	NP	Shoot
9	*Sida rhombifolia*	1 2 3	2 5(1 48) 2 5(1 48) 7(3 85)	1 9(1 1) 4(2 2) 8(4)	NP	NP	Root
10	*Solanum indicum*	1 2 3	5(2 75) 11 83(3 08) 35(19 25)	3(1 65) 10(5 5) 15(8 25)	NP	NP	Root

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Data in parenthesis indicate dry weight of officinal part

Table 25 Fresh and dry weight of non officinal part of selected medicinal plants at three different stages of growth in different strata in and around Vellayam lake

Sl No	Scientific name	Growth stage	Fresh and dry weight of non officinal part (g)*/strata**				Remarks (non officinal part)
			D	G	P	L	
1	*Andrographis paniculata*	1 2 3	1 65(0 65) 5(1 85) 7(2 4)	4 75(1 76) 6(2) 8 5(2 75)	NP	NP	Root
2	*Cyclea peltata*	1 2 3	3(1 35) 10(4 0) 25(6 25)	2(0 9) 3(1 2) 18 57(4 0)	NP	NP	Shoot
3	*Desmodium velutinum*	1 2 3	2 16(0 72) 6(2) 15 05(5)	2 18(0 72) 9(3 0) 18 03(6 01)	NP	NP	Shoot
4	*Eclipta alba*	1 2 3	NP	2(0 34) 4 5(0 75) 9 75(1 63)	1 5(0 73) 5 25(0 88) 10 5(1 75)	NP	Root
5	*Gloriosa superba*	1 2 3	30(3 0) 60(6 66) 60(6 66)	15(1 75) 20 5(2 05) 35(3 75)	NP	NP	Shoot
6	*Hemidesmus indicus*	1 2 3	2 06(0 71) 3(0 9) 9(2 9)	3 5(1 25) 3(0 9) 6(1 8)	NP	NP	Shoot
7	*Phyllanthus amarus*	1 2 3	0 06(0 02) 0 06(0 02) 0 32(0 12)	0 04(0 02) 0 06(0 02) 0 20(0 03)	0 06(0 02) 0 08(0 02) 0 40(0 15)	NP	Root
8	*Scoparia dulcis*	1 2 3	2 12(0 71) 4 50(1 50) 9 50(2 95)	1 9(1 1) 2 5(0 75) 12 5(4 25)	2 75(0 75) 3 15(1 05) 12 5(4 25)	NP	Root
9	*Sida rhombifolia*	1 2 3	3(1 2) 4(1 6) 10(4 28)	4(1 6) 7 8(3 4) 10(4 26)	NP	NP	Shoot
10	*Solanum indicum*	1 2 3	15(7 5) 65 66(14 2) 150(75)	10(5) 40(20) 90(45)	NP	NP	Shoot

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

Data in parenthesis indicate dry weight of officinal part

Table 26 Shoot root ratio of selected medicinal plants at three different stages of growth in different strata in and around Vellayani lake

Sl No	Scientific name	Growth stage	Shoot root ratio* /strata				Remarks
			D	G	P	L	
1	*Andrographis paniculata*	1 2 3	2 3 1 1 03 1 1 04 1	1 6 1 2 43 1 2 1 1	NP	NP	Shoot>root
2	*Cyclea peltata*	1 2 3	1 2 59 1 1 12 1 1 08	1 3 33 1 3 59 1 1 19	NP	NP	Shoot<root
3	*Desmodium velutinum*	1 2 3	1 25 1 1 01 1 1 1 08	1 03 1 1 1 20 1 09 1	NP	NP	Shoot>root
4	*Eclipta alba*	1 2 3	NP	2 35 1 1 40 1 1 53 1	3 35 1 1 48 1 1 43 1	NP	Shoot>root
5	*Gloriosa superba*	1 2 3	1 1 75 1 1 66 1 2 25	1 1 29 1 2 44 1 3 33	NP	NP	Shoot<root
6	*Hemidesmus indicus*	1 2 3	1 58 1 1 29 1 1 05 1	1 1 4 1 1 11 1 03 1	NP	NP	Shoot>root
7	*Phyllanthus amarus*	1 2 3	2 5 1 5 0 1 1 5 1	5 0 1 9 0 1 8 33 1	2 5 1 9 5 1 1 87 1	NP	Shoot>root
8	*Scoparia dulcis*	1 2 3	1 87 1 1 17 1 1 78 1	2 1 1 3 1 1 06 1	2 2 1 2 57 1 1 35 1	NP	Shoot>root
9	*Sida rhombifolia*	1 2 3	1 1 23 1 08 1 1 11 1	1 45 1 1 53 1 1 07 1	NP	NP	Shoot>root
10	*Solanum indicum*	1 2 3	2 73 1 4 63 1 3 89 1	3 03 1 3 64 1 5 45 1	NP	NP	Shoot>root

* Mean value of observations of three plants

** Strata consists of four different stratas in and around Vellayani lake *viz*

D Dry land G Garden land P Paddy field L Lake area

NP Not present in that strata

4 2 13 Shoot root ratio

The data on the shoot root ratio of the selected species are given in Table 26 Out of the ten species eight species had the higher contribution of shoot They were *Andrographis paniculata Desmodium velutinum Eclipta alba Hemidesmus indicus phyllanthus amarus Scoparia dulcis Sida rhombifolia* and *Solanum indicum* But n *Hemides i us indicus* at pre flowering and flowering stage the proportion of root was higher than shoot under garden land area The proportion of root was higher than shoot in *Cyclea peltata* and *Gloriosa superba*

4 3 Chemical analysis of officinal part (s)

4 3 1 *Bacopa monnieri* and *Limnophila repens*

For both the species TLC (Thin Layer Chromatogaphy) was carried out in two solvent systems *viz* EtOAc MeOH H_2O (60 14 10) and BuOH EtOAc H_2O (4 1 5) In the chromatographic plates spots were visualized by spraying the vanillin sulphuric acid reagent and then by heating the plates with a heating mantle at 110^0 C for 15 minutes The blue coloured spot on TLC plate of *Bacopa monnieri* indicates the presence of bacoside A and the blue coloured spot is not present on the TLC plate of *Limnophila repens* (Gupta *et al* 1998) In the solvent system BuOH EtOAc H2O (4 1 5) bacoside A has a rf (Retention Factor) 0 52 (Pal and Sarin 1992) and the presence of blue spot on the TLC plate of *Bacopa monnieri* at rf of 0 5 also confirms that the blue spot indicate the

Plate 11: *Limnophila repens*

Plate 12: *Bacopa monnieri*

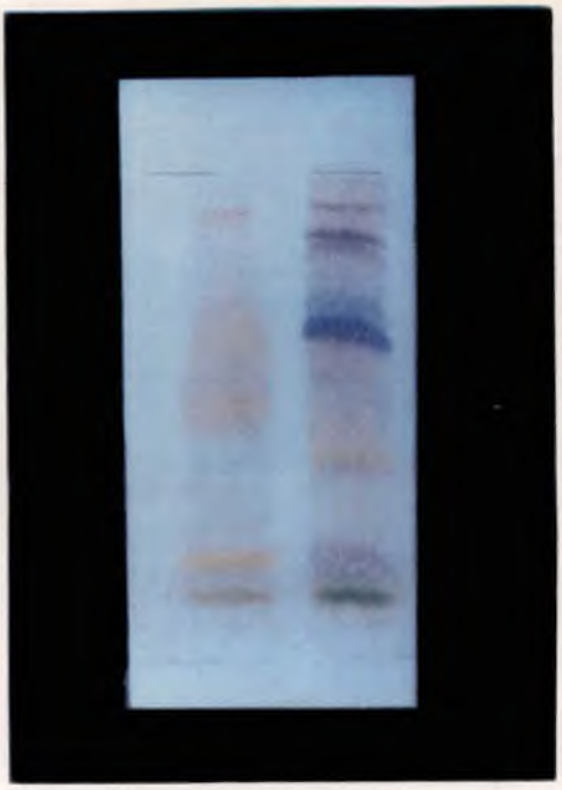


Plate 13: TLC plate of *Limnophila repens and Bacopa monnieri*
Solvent system: EtOAc-MeOH-H_2O

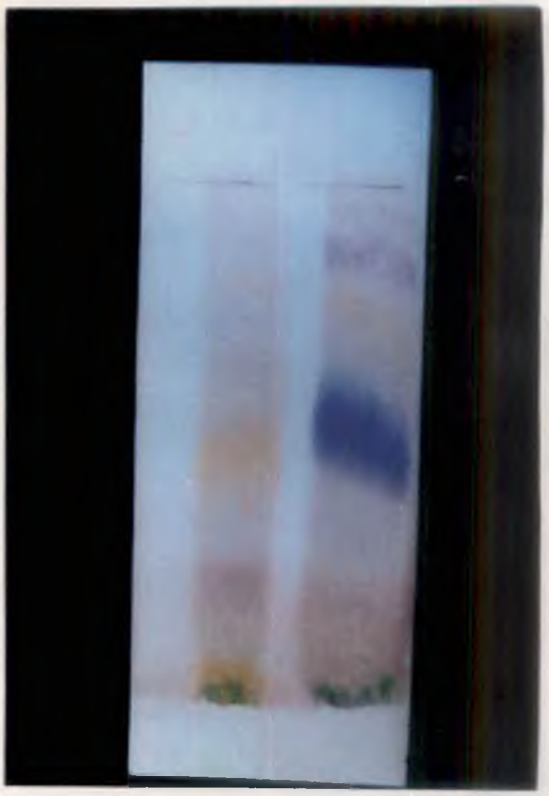


Plate 14: TLC plate *of Limnophila repens and Bacopa monnieri*
Solvent system: BuOH-EtOAc-H_2O

pres nc of bacos de A vh ch s not presen on the TLC pla ot *L*

Th s g es h resul tha bacos de A s no presen n *L opl epe* p

by l people of Vellayan nstead of *Bacop o e* (b al n Th m

spo s o TLC pla es of bo l tl e sp ec es h cl nd s a n

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4 3 ? *Andrographis paniculata*

F o l e sp c rophotome c read n of absorpt on alue n

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ot and o pl ol d dry land and garden and area s p es d

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to gard land area (0 6 5 °)

Table 27 Andrographolide content of *Andrographis paniculata* in dry land and garden land area around Vellayani lake

Sample	Andrographolide Content (%)*
Dry land	0.715
Garden land	0.685

*Mean value of three samples

DISCUSSION

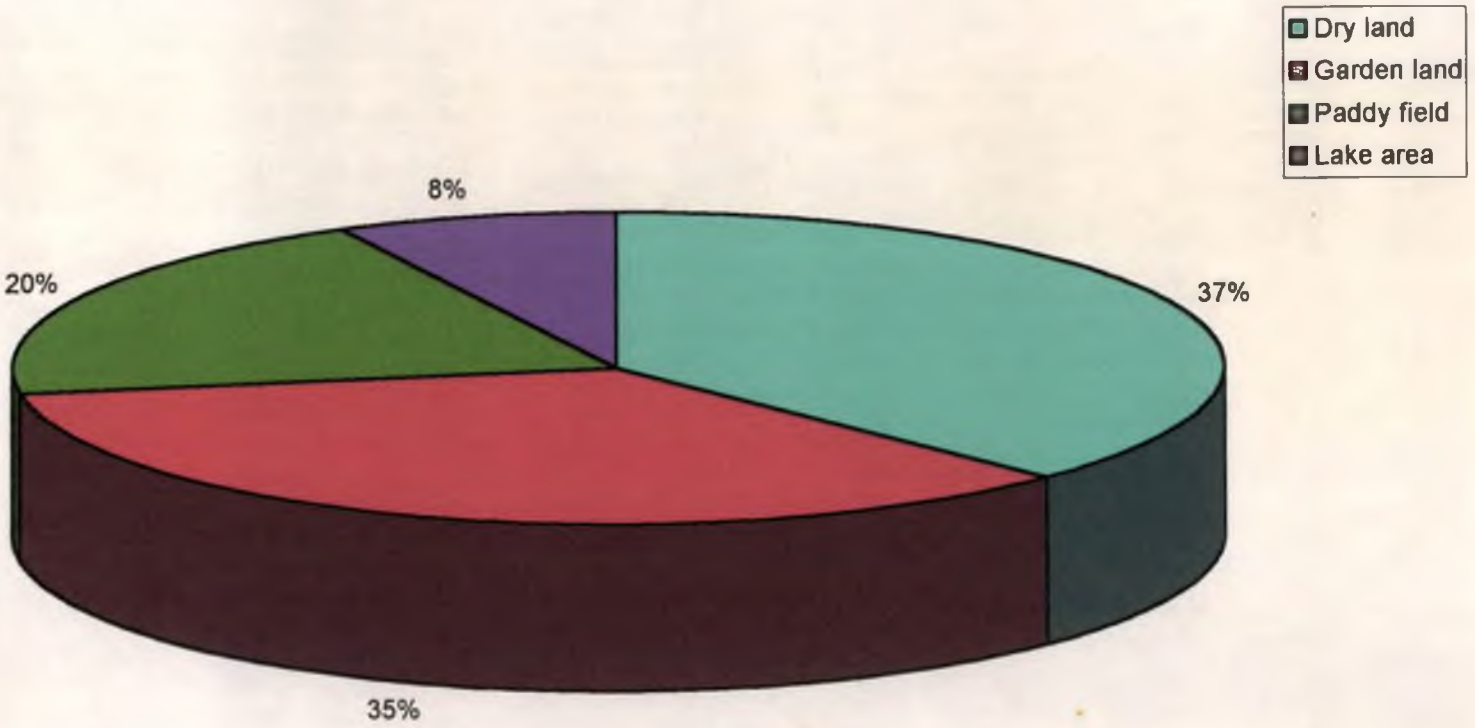
The study on "Biodiversity of medicinal plants in Vellayani" was carried out in and around Vellayani lake of Thiruvananthapuram district. The objectives of the study were to identify the medicinal plants from among the existing natural flora, to study the growth behavior of selected medicinal plants and to assess the pharmacologically active constituents of the selected important medicinal plants. The results of the study are discussed in this chapter.

5.1. Identification of flora and vegetation analysis

5.1.1. Flora

A total of 135 plant species belonging to 120 genera and 57 families were identified in the four different strata *viz.* dry land, garden land, paddy field and lake area (Table 2; Fig.2). The occurrence of the 135 species recorded from all the four strata during the present study was verified with previous reports and studies carried out by other workers. In a study on floristic diversity of Triveni Medicinal Plant Conservation Area (MPCA) 149 medicinal plants were collected (Raveendran and Pandurangan, 1997). In an attempt to document the diversity and prevalence of medicinal plants in Nicaragua's Atlantic Coast 152 plants along their common names and families were listed (Barrelt, 1994). In a floristic study on aquatic ecosystem *viz.* in temple tanks of Kerala, among the aquatic flora *Hydrilla verticillata*, *Vallisneria* Spp., *Ipomoea aquatica* etc. were found to be widely distributed, where as *Utricularia oxoeta*, *Alternanthera sessalis* , *Eleocharis pluntaginea* etc. were found confined to certain localities (Maya *et al.*, 2000).

Fig. 2 Strata wise distribution of medicinal plants



5.1.2. Study of vegetative parameters of medicinal plants

Emilia sonchifolia dominated in dry land area with high relative density, relative frequency and importance value. *Centella asiatica* was the dominant species in garden land and paddy field area with a high relative density and abundance. *Centella asiatica* was found to occur in all the four different strata indicating that it can thrive in different habitats. *Limnophila repens* dominated in lake area with a high relative density, importance values and abundance. *Synedrella nodiflora* and *Alysicarpus vaganalis* was found to occur frequently in dry land area. *Scoparia dulcis* and *Vernonia cinerea* occurred more frequently in garden land area. *Centella asiatica* was frequent in paddy field area and *Limnophila repens* in lake area.

5.1.2.1. Vegetative parameters in dry land area

Emilia sonchifolia, *Cyperus rotundus*, *Panicum repens*, *Chrysopogon aciculatus* were the species found most frequently in dry land area (Table 3). Such a dominance by three top ranking species *viz. Chrysopogon aciculatus*, *Cyrtococcum trigonum* and *Aristida setacea* with 71.2 per cent of stand density and high Ivwas reported by Parthasarathy and Sethi (1997). The species represented by single individuals such as *Blepharis medaraspatensis*, *Cactus dilleni*, *Carissa congesta*, *Morinda tinctoria*, *Rauvolfia serpentina* and *Stachytarpheta urticaefolia* were considered as rare species. Similar conclusion was made by Parthasarathy and Karthikeyan (1997) who considered species represented by one or two individuals as rare.

5.1.2.2. Vegetative parameters in garden land area

The more frequently observed species in garden land area were *Centella asiatica* and *Scoparia dulcis* (Table 4). The relative density of *Centella asiatica* come to 7.31 per cent. *Acalypha indica*, *Aniseia martinicensis*, *Capparis brevispinus*, and *Cayratia pedata* were considered as rare species since they were represented by a single individual each as suggested by Parthasarathy and Karthikeyan (1997).

5.1.2.3. Vegetative parameters in paddy field area

The more frequently observed species in paddy field area were *Centella asiatica* and *Oxalis corniculta*, it may be due to the suitable habitat for both these species because marshy areas are more favourable for *Centella asiatica* and *Oxalis corniculta*. A number of rare plants represented by a single individual were recorded in paddy field area. They were *Borreria alata, Coldenia procumbens*, *Emilia sonchifolia* and *Portulaca oleracea*. *Centella asiatica* was also the most abundant species in paddy field area because of its habitat suitability (Table 5).

5.1.2.4. Vegetative parameters in lake area

Limnophila repens and *Bacopa monnieri* were the dominant species in the lake area with relative densities 18.15 per cent and 14.11 per cent respectively. *Hydrilla*

verticellata and *Marsilea marscecens* were also most frequently encountered in lake area. The above species occur more frequently in lake area because of their habitat suitability. *Limnophila repens* was the most abundant species in the lake area. The rare species were *Diplocyclos palmatus, Fimbristylis aestivalis* and *Trichosanthes cucumerina* (Table 6). In an aquatic biodiversity study *Hydrilla verticillata*, *Vallisneria* Spp. and *Ipomoea aquatica* were found (Maya *et al.*, 2000).

5.1.2.5. Medicinal plant vegetation pair wise analysis

From the coefficient of community, Sorrenson's similarity index (C_N) and similarity coefficient, dry land and garden land area were found to be most similar strata with more number of species in common (Table 7). Dry land and lake area were found to be the most dissimilar strata in vegetation pair wise analysis because coefficient of community, Sorrenson's similarity index (C_N) and similarity coefficient values are very small for dry land and lake area.

5.1.2.6. Strata wise vegetation analysis indices

Lake area was found to have higher concentration of dominance as expressed by Simpson's index (Table 8). Here the floristic diversity as expressed by Simpson's index was 0.08, which indicated that 8 pairs out of 100 taken at random were composed of different species. This is in confifmity with reports by Seetharam *et al.* (1999). Shannon's index represents abundant species and Simpson's index represents

very abundant species. Simpson's index gives more weightage to the common species but relatively little weightage to the rare species. It ranges values from 0 to a maximum (1 – 1/S), where S is the number of species (Raizada *et al.*, 1998). The distribution of individuals among the species is called species evenness. Evenness index was found to be maximum in dry land area. This is in conformity with the report of Hurlbert (1971)where he indicated that evenness index is maximum when all the species have the same number of individuals. Hence it can be said that in dry land area almost all species had equal number of individuals.

5.1.3. Total biomass production of medicinal plants in all the four strata

Total biomass production refers to the total weight of shoot and root. Higher biomass production in *Cardiospermum helicacabum*, *Carissa congesta*, *Kalanchoe pinnata*, *Lantana camara* and *Knoxia mollis* resulted from the luxuriant growth of shoot of these plants in dry land area (Table 9). Extensive root growth in *Curculigo orchioides*, *Cyperus deformis*, *Cyperus rotundus* resulted in higher biomass production.

Higher biomass production in *Grangea medaraspatensis*, *Kalanchoe pinnata*, *Melochia corcorifolia* can be attributed to the luxuriant growth of these plants in garden land area. Highly thickened fibrous root system in *Asparagus racemosus*, and nature of roots in *Curculigo orchioides*, *Cyperus deformis* and *Cayratia pedata* resulted in higher biomass production (Table 10). This can be augmented with the result of the biodiversity study of medicinal plants in oil palm plantation. Highly thickened, fibous root system in

Asparagus racemosus and large roots in *Terminalia paniculata* and *Wrightia tinctoria* contributed to the higher biomass production in mature oil palm plantation (Sarada, 2000). Plants such as *Biophytum sensitivum*, *Centella asiatica*, *Emilia sonchifolia* and *Phyllanthus amarus* produced lower biomass under garden land condition because of their herbaceous nature.

Luxuriant vegetative growth of shoot in *Alternanthera sessalis*, *Polygonum glabrum* and *Struchium sparganophorum* contributed to higher biomass production in paddy field area (Table 11). Tuberous nature of *Ipomoea mouritiana* contributed higher biomass yield. Herbaceous nature of *Eclipta alba*, *Emilia sonchifolia*, *Lindernia antipoda*, *Hedyotis diffusa* and P*hyllanthus amarus* resulted in lower biomass production in these plant species.

Higher biomass production in *Nelumbo nucifera* and *Nymphea nouchali* resulted from the vegetative growth of the shoot. The root contributes higher biomass production in *Cyperus iria*, *Salvinia molesta* and *Cryptocorine retrospiralis*. Small statured nature of *Bacopa monnieri*, *Centella asiatica*, *Marsilea marscecens* and *Limnophila repens* resulted in lower biomass.

Influence on biomass yield in different species in different strata was augmented by the shoot-root ratio in these plants.

5.2. Growth phases of selected medicinal plants

There has been a phenomenal increase in many characters indicating the growth behaviour such as plant height, number of branches, plant spread, height at which first branch is produced, number of leaves, inter nodal length and stem girth from pre-flowering to seed set stage. Increase in these features from pre-flowering to seed set stage has a positive co-relationship with the physiological growth and age of the plants.

5.2.1. Plant height

Among three different strata, dry land, garden land, paddy field area majority of plants growing under garden land and paddy field were found to be taller compared to dry land area (Table 14; Fig.3). The dry land area are almost similar to garden land area. In garden land area there is a lanky growth compared to dry land area. However *Andrographis paniculata* and *Solanum indicum* were shorter in height in garden land area. Existence of a tight competition for eco-physiological requirements like water, nutrient and light might have resulted in an unfavourable situation for rapid vegetative growth, there by causing a reduction in plant height (Anilkumar, 1984).

5.2.2. Number of branches

In most of the species number of branches was high in garden land and paddy field area (Table 15; Fig.4). It might be due to the more availability of water and light in paddy

Fig 3. Plant heght (cm) of selected medicinal plants at seed set stage in different strata

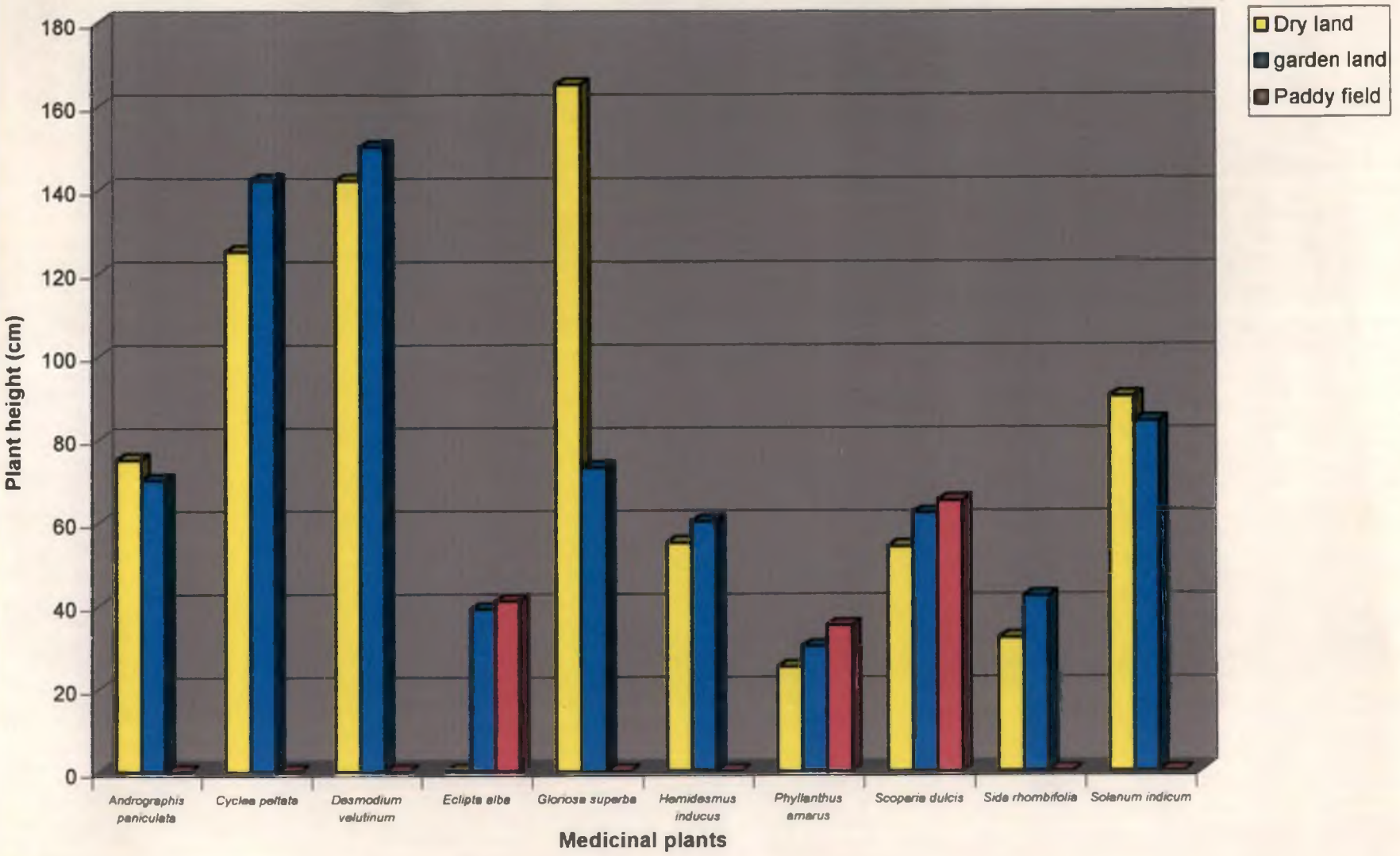
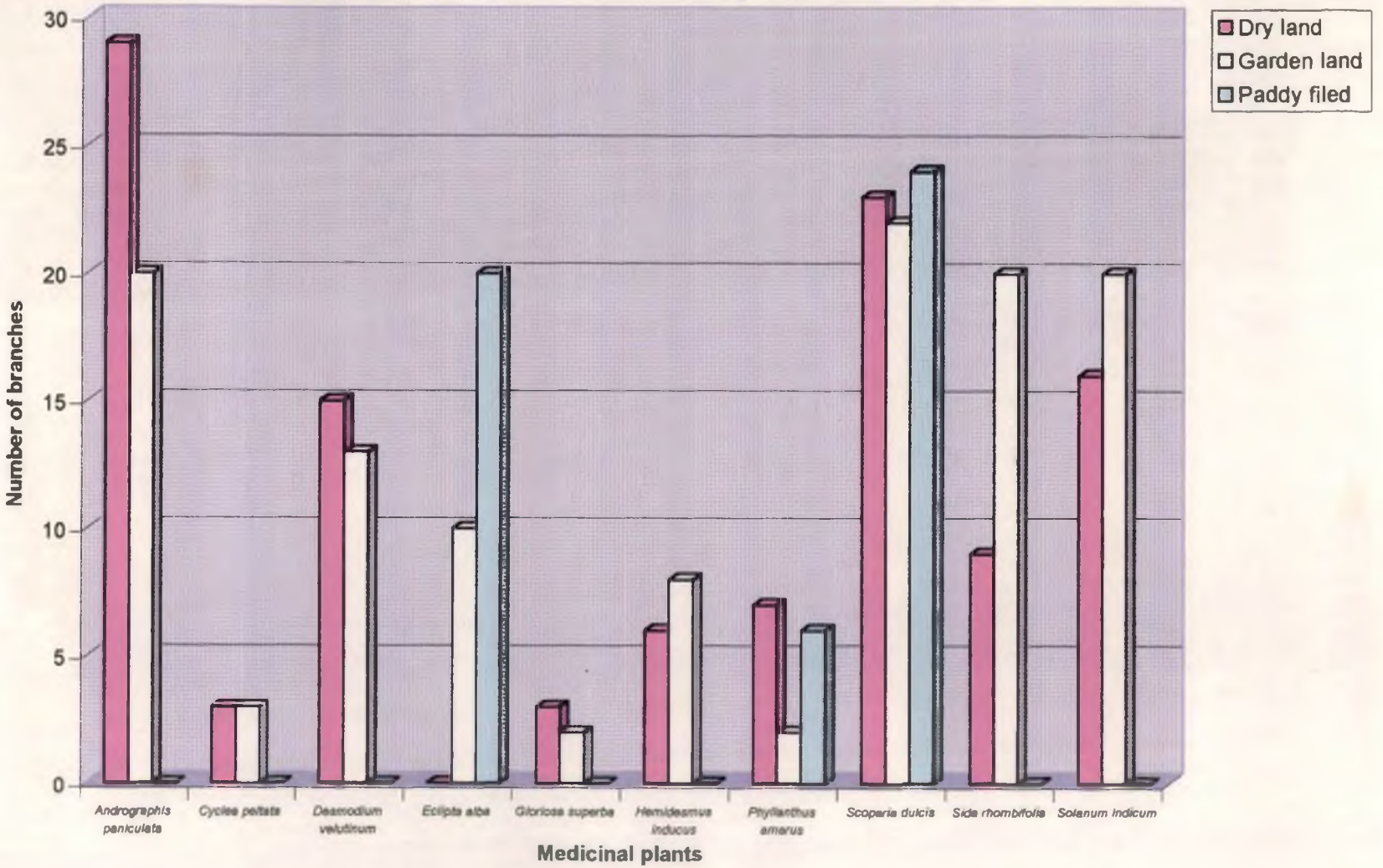


Fig. 4. Number of branches of selected medicinal plants at seed set stage in different strata



field area compared to dry land area. However in *Andrographis paniculata* more number of branches were produced under garden land area. More branches were thus observed in *Cyclea peltata*, *Hemidesmus indicus*, *Sida rhombifolia* and *Solanum indicum* in garden land area.

5.2.3. Plant spread

Greater plant spread was observed for most of the species in garden land and paddy field area compared to dry land area, it might be due to the more availability of water and light (Table 16). In *Eclipta alba*, *Phyllanthus amarus* and *Scoparia dulcis* more plant spread was observed under paddy field area because of vigorous vegetative growth.

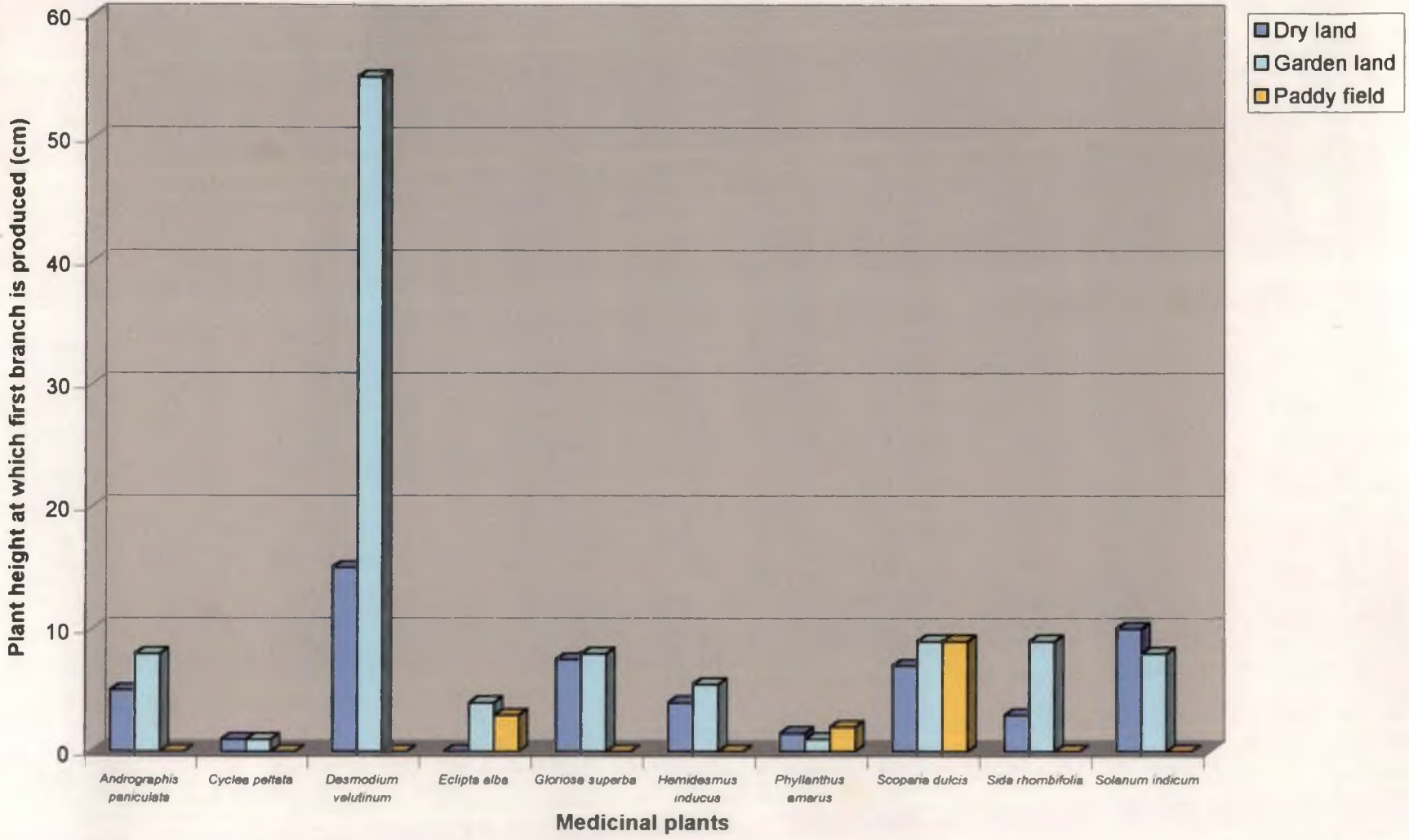
5.2.4. Height at which first branch is produced

The height at which first branch is produced was found to be higher in garden land in majority of the species (Table 17; Fig.5). In *Eclipta alba* the height of the first branch was found to be lower in paddy field area than in garden land, because of more favourable habitat in paddy field area. There is an increasing trend of height of first branch from flowering to seed set stage.

5.2.5. Number of leaves

The number of branches and leaves is usually related to the height of the plant (George, 1981). Hence in the species where the plant height was more, number of leaves was also more. But there was a reduction in number of leaves from flowering to seed set

Fig.5. Plant height at which first branch is produced (cm) for selected medicinal plants at seed set stage in different strata



stage (Table 18). It may be due to the transition from vegetative to reproductive stage, which is characterized by leaf senescence and leaf fall. For majority of species greater number of leaves was found in garden land. In *Eclipta alba*, *Phyllanthus amarus* and *Scoparia dulcis* more number of leaves were found under paddy field area, may be due to the suitable habitat for their growth.

5.2.6. Season of flowering and fruiting

The data on season of flowering and fruiting of the ten important medicinal plant species are presented in Table 19. The flowering characters of medicinal plants are species specific. *Eclipta alba*, *Phyllanthus amarus*, and *Scoparia dulcis* flowered during the rainy season. *Desmodium velutinum* has a lower flowering period October to November. *Gloriosa superba* flowered during North - East monsoon August-September and *Sida rhombifolia* flowered during July-December. All other species studied flowered and fruited throughout the year.

5.2.7. Root characters

Root length and number of roots produced was greater under garden land area in majority of the species (Table 20 & Table 21; Fig.6 & Fig.7). This might be due to vigorous and faster growth rate under this condition compared to dry land condition. From pre-flowering to seed set stage there was a gradual increase in the root length and number of roots. It was also found that there is a positive correlation between the root length and the number of roots.

Fig. 6. Root length (cm) of selected medicinal plants at seed set stage in different strata

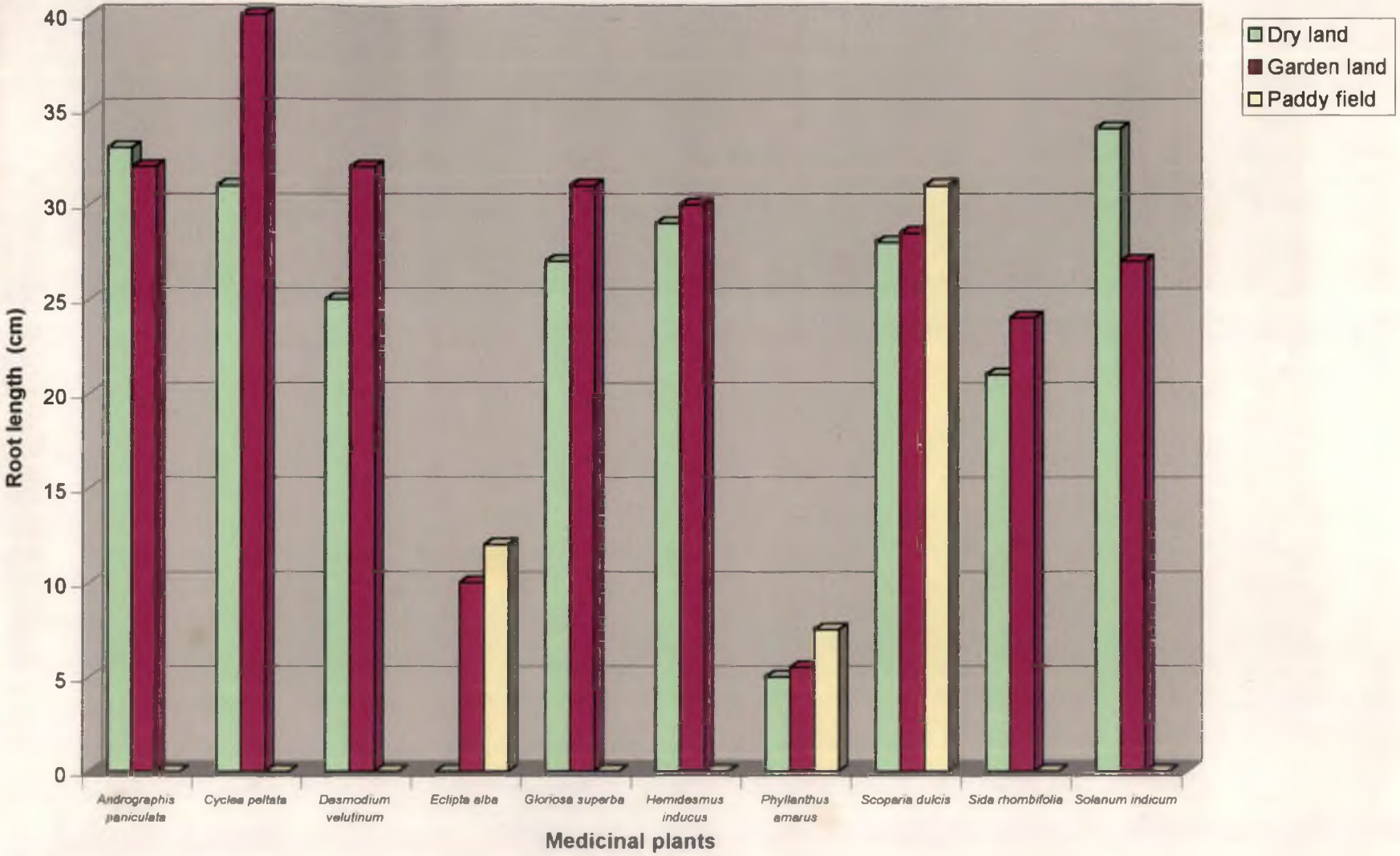
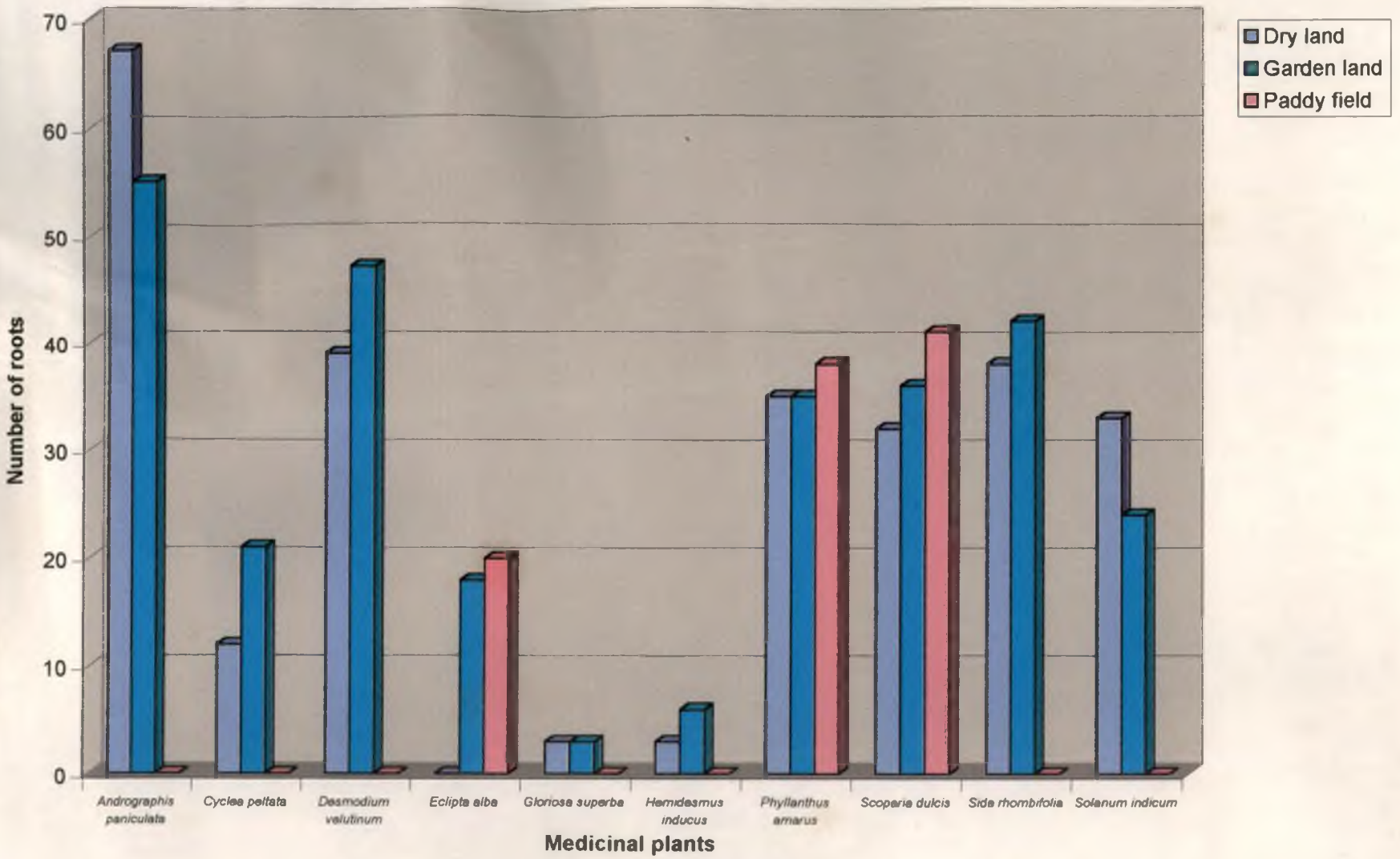


Fig. 7. Number of roots of selected medicinal plants at seed set stage in different strata



5 2 8 Inter nodal length and stem girth

Inter nodal length and stem girth are usually related to the height of the plants From pre flowering to seed set stage there was a gradual increase in inter nodal length and stem girth (Table 22 & Table 23) In *Eclipta alba* and *Phyllanthus amarus* the inter nodal length was more or less same under the garden land and paddy field area might be due to similar growing habitats Stem girth was found to be lower in *Cyclea peltata* which is in conformity with lesser stem girth of *Cyclea peltata* in a biodiversity study in oilpalm plantations (Sarada 2000)

5 2 9 Fresh and dry weight of officinal part

Fresh and dry weight of the species vary accordmg to the strata they grow (Table 24) In majority of the species it was more under garden land area This is due to their better vegetative growth in terms of number of branches and number of leaves in the case of plants where shoot is the officinal part and in terms of root growth in plants where root is the officinal part

Under uniform conditions of growth the dry matter accumulation is more or less similar to that of green matter out put This explains why the fresh weight and dry weight of shoot follow the same pattern under all conditions Tuberous nature of root contributes to the increase in weight of the officinal part in the case of *Cyclea peltata* and *Gloriosa superba* This is confirmed by the higher fresh and dry weight of officinal part of *Cyclea*

peltata in a biodiversity study in oilplam plantations by Sarada (2000) In *Hemidesmus indicus* and *Solanum indicum* the thick and sturdy growth of roots resulted in increase n weight

5 2 10 Fresh and dry weight of non officinal part

Fresh and dry weight of the non officinal part varied according to the strata (Table 25) For *Eclipta alba Phyllanthus amarus* and *Scoparia dulcis* it was more under paddy field area because of vigorous vegetative growth due to more water availability and light availability In *Solanum indicum* the weight of the berries also contributed to the increased weight of non officinal part

5 2 11 Shoot root ratio

A higher contribution of shoot was obtained in *Andrographis paniculata Desmodium velutinum Eclipta alba Hemidesmus indicus Phyllanthus amarus Scoparia dulcis Sida rhombifolia* and *Solanum indicum* due to better vegetative growth (Table 26) Thickened tuberous nature of roots was found in *Cyclea peltata Gloriosa superba* contributes to higher proportion of root

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5 3 Chemical analysis of official part(s)

5 3 1 *Bacopa monnieri* and *Limnophila repens*

The presence of bacoside A content which is responsible for memory enhancing was tested in *Bacopa monnieri (brahmi)* and *Limnophila repens* by using TLC (Thin Layer Chromatography) But in *Limnophila repens* there was no constituent similar to *Bacopa monnieri* (Plate13&14) It may be due to seasonal influence There may be chances of similar constituents in flowering season or any other season Bacoside A is a bacosaponin found in *Bacopa monnieri* The biosynthesis of secondary metabolites though controlled genetically is affected strongly by environmental influences (Milka 1962)

5 3 2 Andrographis paniculata

The percentage of andrographolide content which is the main constituent of *Andrographis paniculata* was found to be higher in dry land area compared to garden land area (Table 27) The alkaloid content in many species was found to be higher when they are water stress condition (Trease and Evans 1972 Waller and Nowacki 1978) This can be the reason for slightly higher alkaloid content in dry land compared to garden land area Spectrophotometric method of estimation was done Because this method was found to be more rapid and more accurate than the official method and other methods so far reported Even samples containing 0 2 mg or less of andrographolide content can be satisfactorily estimated by this method (Gaind *et al* 1963)

Study on medicinal plant flora plant diversity distribution vegetation analysis growth behavior of selected plants and chemical analysis of officinal part in selected medicinal plants gave interesting results As discussed above these results when augmented with further research data would be of tremendous application in evolving suitable strategies for sustainable utilization of important plant resources particularly medicinal and aromatic plants occurring as indigenous or naturalized in and around Vellayani lake So that many of the weed species that are very valuable medicinal plants can be conserved The present study thus yielded some significant insights as to the need for emulating similar case studies in watershed areas elsewhere in other regions of the state and the country

SUMMARY

SUMMARY

A study on Biodiversity of medicinal plants in Vellayani was carried out in and around Vellayani lake of Thiruvananthapuram district Kerala The objectives of the study were to identify the medicinal plants from among the existing natural flora, to study the growth behaviour of selected medicinal plants and to assess the pharmacologically active constituents of selected medicinal plants The period of study was from January 1999 to March 2000

Stratified random sampling was adopted the strata being dry land garden land paddy field and lake area The medicinal plants in dry land garden land and paddy field were identified and quantified by random sampling technique using 1 0 m^2 frame In the lake area it was difficult to use the frame so the plants were collected directly from the lake area A total of 80 such sampling units were taken randomly giving sufficient representation to the area covered A total of 135 plant species were identified in the four different strata belonging to 120 genera and 57 families None of the plants were endemic There were 118 indigenous and 17 exotic or naturalized plants Ten important medicinal plant species were selected for detailed study and their growth behaviour was momtored for one year They were *Andrographis paniculata Cyclea peltata Desmodium velutinum Eclipta alba Gloriosa superba Hemidesmus indicus Phyllanthus amarus Scoparia dulcis Sida rhombifolia* and *Solanum indicum* The results of the study are summarized below

Emilia sonchifolia was the dominant species in dry land with high relative density and relative frequency *Abrus precatorius Blepharis medaraspatensis Carissa congesta Rauvolfia serpentina* were considered as rare species since they were represented by a single individual More frequent species were *Emilia sonchifolia Chrysopogon aciculatus* and *Phyllanthus amarus*

Centella asiatica was the most abundant species in garden land followed by *Scoparia dulcis* with high relative density *Acalypha indica Aniseia martinicensis Capparis brevispinus Cayratia pedata* and *Catharanthus roseus* var *alba* were found to be rare as they were represented by a single individual The more frequently observed species were *Scoparia dulcis* and *Vernonia cinerea*

Centella asiatica was the most dominant species in paddy field followed by *Oxalis corniculata* with high relative density *Borraria alata Coldenia procumbens* and *Portulaca oleraceae* were the rare species as they were represented by a single individual The more frequently observed species in paddy field area were *Centella asiatica* and *Eclipta alba*

Limnophila repens was the most dominant species in lake area followed by *Bacopa monnieri* with high relative density *Diplocyclos palmatus* was found to be the rare species as it was represented by a single individual The most frequently observed species were *Hydrilla verticellata Cyperus iria* and *Nymphea nouchali Limnophila repens* was found to be the most abundant species with high importance value

Emilia sonchifolia dominated in dry land area *Centella asiatica* dominated in garden land and paddy field In lake area *Limnophila repens* was found to be the most dominant species *Centella asiatica* was found to occur in all the four strata *Emilia sonchifolia* occurred more frequently in dry land and *Scoparia dulcis* in garden land *Centella asiatica* was more frequent in paddy field *Hydrilla verticellata* also occurred more frequently in lake area

Dry land and garden land were found to be the most similar strata with more number of species in common Dry land and lake area were found to be the most dissimilar strata in vegetation pairwise analysis

Lake area was found to have higher concentration of dominance as expressed by Simpson s index Shannon s index was maximum in dry land area Abundant species occurs more in dry land area In dry land almost all species had equal number of individuals since Evenness index was maximum

Growth characters like plant height plant spread height of the first branch number of leaves number of roots and root length were found to increase from pre flowering to seed set stage These characters were found to be high in garden land compared to other strata in most of the species The fresh and dry weight of officinal part were more in garden land condition in most of the species The fresh and dry weight of officinal part were more in *Cyclea peltata Gloriosa superba* and *Solanum indicum*

compared to other species The fresh and dry weight of non officinal part was also found to increase from pre flowering to seed set stage In most of the species proportion of the shoot was found to be higher than the root except in *Cyclea peltata* and *Gloriosa superba*

In the chemical analysis it was found that in *Limnophila repens* there was no similar chemical constituents as that of *Bacopa monnieri* (brahmi) There was no bacoside content in *Limnophila repens* which is present in *Bacopa monnieri* So *Limnophila repens* cannot be used as a substitute for Brahmi

The andrographolide content in *Andrographis paniculata* was found to be slightly higher in dry land compared to garden land The andrographolide content was higher in dry land area because of the water stress condition in dry land

The results when amplified and augmented with further research data would be of tremendous application in evolving suitable strategies for sustainable utilization of medicinal and aromatic plants occurring as indigenous and naturalized in and around the Vellayani lake So that we can conserve many of the weed species which have very h gh medicinal values

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APPENDICES

APPENDIX I

Parameters for obtaining site vegetation analysis indices in dry land area around Vellayani lake

Sl No	Scientific Name of plant	$(Y/N)^2$	Pi – ni/N	Pi ln Pi
1	*Abrus precatorius*	0 0000057	0 0038	0 021
2	*Abutilon indicum*	0 000028	0 0057	0 029
3	*Acalypha indica*	0 000049	0 012	0 053
4	*Achyranthes aspera*	0 00027	0 0067	0 034
5	*Adina palmata*	0 00018	0 0019	0 012
6	*Aerva lanata*	0 00032	0 028	0 1001
7	*Alysicarpus vaginalis*	0 00064	0 013	0 056
8	*Andrographis paniculata*	0 00032	0 0082	0 039
9	*Aristolchia indica*	0 000007	0 0057	0 029
10	*Asystacia gangetica*	0 00049	0 012	0 053
11	*Atylosia scarabaeoides*	0 00056	0 0044	0 024
12	*Boerhavia diffusa*	0 00046	0 0114	0 051
13	*Borraria alatat*	0 00014	0 086	0 211
14	*Blepharis medaraspatensis*	0 0000046	0 0019	0 012
15	*Biophytum sensitivum*	0 000046	0 0114	0 051
16	*Cactus dillenii*	0 0000046	0 0019	0 012
17	*Cardiospermum helicacabum*	0 0001	0 0048	0 012
18	*Carissa congesta*	0 0000046	0 0019	0 012
19	*Cassia occidentalis*	0 000015	0 0152	0 064
20	*Cassytha filiformis*	0 00023	0 0038	0 021
21	*Centella asiatica*	0 0000046	0 019	0 012
22	*Centrosema pubescens*	0 000031	0 0066	0 033
23	*Chromolaena odorata*	0 00018	0 0061	0 031
24	*Chrysopogon aciculatus*	0 00072	0 0111	0 049
25	*Cissampelos Pereira*	0 000052	0 0038	0 022
26	*Cleome rutidosperma*	0 000007	0 0057	0 029
27	*Cleome viscosa*	0 0028	0 0069	0 034
28	*Clerdendrum viscosum*	0 00013	0 0071	0 035
29	*Clitoria ternatea*	0 0000057	0 0019	0 012
30	*Commelina clavata*	0 00034	0 021	0 081
31	*Curculigo orchioides*	0 000046	0 0114	0 051
32	*Cyclea peltata*	0 00017	0 0057	0 029

Sl No	Scientific Name of plant	$(Y/N)^2$	$P_1 - n_1/N$	$P_1 \ln P_1$
33	*Cyperus deformis*	0 00063	0 049	0 147
34	*Cyperus kullinga*	0 000032	0 0285	0 101
35	*Cyperus rotendus*	0 0 026	0 050	0 149
36	*Cynadon dactylon*	0 00029	0 0114	0 051
37	*Dactyloctenium aegyptium*	0 000091	0 022	0 084
38	*Desmodium gangeticum*	0 0000099	0 0095	0 133
39	*Desmodium triflorum*	0 00022	0 042	0 044
40	*Desmodium velutinum*	0 00112	0 031	0 108
41	*Emila sonchiflia*	0 0065	0 088	0 214
42	*Euphorbia hirta*	0 000068	0 0063	0 032
43	*Gloriosa superba*	0 000007	0 0057	0 029
44	*Hemidesmus indicus*	0 00063	0 024	0 089
45	*Hiptis sauviolens*	0 00017	0 005	0 026
46	*Indigofera tinctoria*	0 000064	0 0057	0 029
47	*Ionidium suffruticosum*	0 00029	0 0114	0 051
48	*Ixora cocinea*	0 00003	0 0066	0 033
49	*Eleusine indica*	0 0012	0 018	0 072
50	*Justicia japonica*	0 00063	0 0128	0 056
51	*Kalanchoe pinnata*	0 000019	0 019	0 075
52	*Lantana camara*	0 00014	0 0034	0 019
53	*Leucas aspera*	0 000012	0 0114	0 051
54	*Mimosa pudica*	0 00016	0 0049	0 026
55	*Mitracarpus verticellata*	0 0001	0 0052	0 027
56	*Morinda citrifolia*	0 0000046	0 0019	0 012
57	*Ocimum basilicum*	0 0000057	0 0038	0 21
58	*Hedyotis corymbosa*	0 000036	0 0085	0 041
59	*Oxalis corniculata*	0 00007	0 0057	0 029
60	*Panicum repens*	0 0019	0 042	0 133
61	*Phyllanthus amarus*	0 0021	0 024	0 089
62	*Phyllanthus urinaria*	0 000025	0 0048	0 025
63	*Polygala javanica*	0 000015	0 0152	0 064
64	*Psidium guajava*	0 0000046	0 0019	0 012

Sl No	Scientific Name of plant	$(Y/N)^2$	$P_1 - n_1/N$	$P_1 \ln P_1$
65	*Scoparia dulcis*	0 0001	0 011	0 049
66	*Sebastiana chamalea*	0 00003	0 0076	0 037
67	*Sesamum indicum*	0 00003	0 0067	0 034
68	*Sida acuta*	0 00015	0 0171	0 0069
69	*Sida rhombifolia*	0 0000057	0 0038	0 021
70	*Solanum indicum*	0 000053	0 0038	0 021
71	*Knoxia sumatrensis*	0 00018	0 011	0 049
72	*Stachytarpheta urticaefolia*	0 0000046	0 0019	0 012
73	*Rauvolfia serpentina*	0 0000057	0 0038	0 021
74	*Tephrosia purpurea*	0 00002	0 0029	0 017
75	*Tiliacora acuminata*	0 00002	0 0029	0 017
76	*Todalia asiatica*	0 000042	0 0019	0 012
77	*Trianthema portulacastrum*	0 00014	0 0038	0 021
78	*Tridax procumbens*	0 00056	0 0155	0 065
79	*Tragia involucrata*	0 000029	0 0267	0 097
80	*Synedrella nodiflora*	0 00082	0 013	0 056
81	*Urena lobata*	0 000016	0 0019	0 012
82	*Vernonia cinerea*	0 00055	0 0111	0 049
83	*Zyzyphus oenoplia*	0 000016	0 0019	0 012

APPENDIX II

Parameters for obtaining site vegetation analysis indices in garden land area around Vellayani lake

Sl No	Scientific Name of plant	$(Y/N)^2$	$P_i - n_i/N$	$P_i \ln P_i$
1	*Abrus precatorius*	0 000019	0 0067	0 034
2	*Acalypha indica*	0 000012	0 0022	0 013
3	*Aerva lanata*	0 000075	0 027	0 097
4	*Alysicarpus vaginalis*	0 000068	0 0056	0 029
5	*Aniseia martinicensis*	0 000012	0 0022	0 013
6	*Asparagus racemosus*	0 000068	0 0056	0 029
7	*Andrographis paniculata*	0 0003	0 0067	0 034
8	*Asystacia gangetica*	0 00015	0 045	0 139
9	*Atylosia scarabaeoides*	0 0001	0 010	0 046
10	*Borraria alata*	0 00058	0 024	0 059
11	*Biophytum sensitivum*	0 00048	0 089	0 215
12	*Capparis brevispina*	0 000012	0 0022	0 013
13	*Cassia occidentalis*	0 000076	0 0067	0 034
14	*Carissa congesta*	0 000024	0 0022	0 013
15	*Cayratia pedata*	0 000012	0 0022	0 013
16	*Catheranthus roseus var alba*	0 000012	0 0022	0 013
17	*Catheranthus roseus*	0 000018	0 0067	0 034
18	*Centella asiatica*	0 0026	0 034	0 115
19	*Centrosema pubescens*	0 000015	0 0045	0 024
20	*Cleome rutidosperma*	0 00018	0 018	0 072
21	*Gloriosa superba*	0 00024	0 0045	0 024
22	*Clerodentrum viscosum*	0 00011	0 0111	0 049
23	*Chrysopogon aciculatus*	0 00084	0 013	0 056
24	*Commelina clavata*	0 000012	0 0022	0 013
25	*Croton bonplandianum*	0 000068	0 0056	0 029
26	*Curculigo orchioides*	0 00017	0 017	0 069
27	*Cyclea peltata*	0 00023	0 0038	0 021
28	*Cynodon dactylon*	0 0007	0 017	0 069
29	*Cyperus deformis*	0 00029	0 067	0 181
30	*Cyperus kallinga*	0 00019	0 0082	0 039
31	*Cyperus rotendus*	0 00052	0 0076	0 037
32	*Dactyloctenium aegyptium*	0 0013	0 020	0 078
33	*Desmodium velutinum*	0 00095	0 022	0 084
34	*Desmodium triflorum*	0 000012	0 0022	0 013
35	*Elephantopus scaber*	0 00015	0 045	0 139

Sl No	Scientific Name of plant	$(Y/N)^2$	Pi – ni/N	Pi ln Pi
36	*Eleusine indica*	0 00065	0 010	0 046
37	*Emilia sonchifolia*	0 000068	0 0056	0 029
38	*Euphorbia hirta*	0 00019	0 019	0 075
39	*Evolvulus alsinoides*	0 000024	0 0089	0 042
40	*Grangea medaraspatana*	0 000019	0 0067	0 034
41	*Hemidesmus indicus*	0 00085	0 0078	0 038
42	*Heliotropium indicum*	0 000019	0 0067	0 034
43	*Hiptis sauveolens*	0 00077	0 029	0 103
44	*Indigofera tinctoria*	0 000015	0 0045	0 024
45	*Ionidium suffruticosumhult*	0 000047	0 0022	0 013
46	*Ixora coccinea*	0 00025	0 011	0 049
47	*Justicia japonica*	0 00049	0 012	0 053
48	*Jasminum rottlerianum*	0 000046	0 018	0 072
49	*Kalanchoe pinnata*	0 000015	0 0045	0 024
50	*Leucas aspera*	0 0047	0 012	0 053
51	*Lycopodium flexosus*	0 000015	0 0045	0 024
52	*Lantana camara*	0 000012	0 0022	0 013
53	*Melochia corchorifolia*	0 000012	0 0022	0 013
54	*Mimosa pudica*	0 000012	0 0022	0 013
55	*Mollugo pentaphylla*	0 000019	0 0067	0 034
56	*Hedyotis corymbosa*	0 000024	0 0089	0 042
57	*Hedyotis herbacea*	0 00017	0 047	0 144
58	*Hedyotis umbellata*	0 0009	0 057	0 163
59	*Panicum repens*	0 00058	0 0089	0 042
60	*Phyllanthus amarus*	0 00078	0 019	0 075
61	*Phyllanthus urinaria*	0 000019	0 0067	0 034
62	*Sebastiana chamaelea*	0 00092	0 022	0 084
63	*Scoparia dulcis*	0 0026	0 020	0 078
64	*Sida rhombifolia*	0 00022	0 021	0 081
65	*Solanum indicum*	0 000053	0 0033	0 019
66	*Stachytarpheta urticaefolia*	0 000015	0 0022	0 013
67	*Struchium sparganophorum*	0 000019	0 0067	0 034
68	*Synedrella nodiflora*	0 0011	0 017	0 069
69	*Tenospora cordifolia*	0 000053	0 0033	0 019
70	*Thumbergia mysorensis*	0 000012	0 0022	0 013
71	*Tiliocora acuminata*	0 000061	0 0045	0 024
72	*Trichodesma indicum*	0 000015	0 0045	0 024
73	*Tricosanthes cucumerina*	0 000012	0 0022	0 013
74	*Tridax procumbens*	0 000024	0 0089	0 042
75	*Urena lobata*	0 000015	0 0045	0 024
76	*Vernonia cineria*	0 0014	0 011	0 049
77	*Vigna trilobata*	0 000012	0 0022	0 013

APPENDIX III

Parameters for obtaining site vegetation analysis indices in paddy field area around Vellayani lake

Sl No	Scientific Name of plant	$(Y/N)^2$	Pi ni/N	Pi ln P
1	*Achyranthes aspera*	0 000064	0 0108	0 0489
2	*Adiantum pedatum*	0 00094	0 022	0 084
3	*Alternanthera sessalis*	0 00064	0 0108	0 0489
4	*Borreria alata*	0 000043	0 0036	0 0202
5	*Bulbostylis barbata*	0 00062	0 0144	0 0611
6	*Centella asiatica*	0 038	0 1616	0 2945
7	*Chrysopogon aciculatus*	0 000077	0 0144	0 0611
8	*Cleome rutidosperma*	0 002	0 028	0 1001
9	*Coldenia procumbens*	0 000043	0 0036	0 0202
10	*Commelina bengalensis*	0 0013	0 029	0 1026
11	*Crassocephalum crepioides*	0 000053	0 0072	0 0355
12	*Cryptocorine retrospiralis*	0 000077	0 0144	0 0611
13	*Cynodon dactylon*	0 00023	0 0089	0 042
14	*Cyperus deformis*	0 000077	0 0144	0 0611
15	*Cyperus iria*	0 00021	0 0072	0 0355
16	*Cyperus kallinga*	0 000089	0 018	0 0723
17	*Cyperus rotundus*	0 00058	0 0108	0 049
18	*Desmodium triflorum*	0 00042	0 072	0 189
19	*Eclipta alba*	0 002	0 015	0 063
20	*Emilia sonchifolia*	0 000043	0 0036	0 0202
21	*Evolvulus alsinoides*	0 00026	0 0108	0 049
22	*Hedyotis diffusa*	0 000064	0 0108	0 049
23	*Heliotropium indicum*	0 00044	0 0059	0 0303
24	*Ipomoea mauritiana*	0 00023	0 0089	0 042
25	*Leucas aspera*	0 000053	0 0072	0 0355
26	*Limnophila repens*	0 00089	0 0448	0 139
27	*Lindernia antipoda*	0 00058	0 031	0 1077
28	*Lindernia crustaceae*	0 000064	0 0108	0 0489
29	*Ludwigia parviflora*	0 0014	0 0323	0 1109
30	*Marselia marsescens*	0 00062	0 0323	0 1109
31	*Mitracarpus verticellata*	0 002	0 0072	0 0355
32	*Mollugo pentaphylla*	0 0003	0 0162	0 0668
33	*Monochorea vaginalis*	0 0005	0 0084	0 0401
34	*Oxalis corniculata*	0 0031	0 1088	0 2413
35	*Panicum repens*	0 00033	0 0162	0 0668

Sl No	Scientific Name of plant	$(Y/N)^2$	$P_1 - n_i/N$	$P_1 \ln P_1$
36	*Phyllanthus amarus*	0 00036	0 0179	0 072
37	*Polygonum glabrum*	0 000064	0 0108	0 0489
38	*Portulaca oleraceae*	0 00004	0 0035	0 0202
39	*Rungia parviflora*	0 00026	0 0502	0 1502
40	*Scoparia dulcis*	0 00045	0 023	0 0867
41	*Solnum nigrum*	0 00021	0 0072	0 0355
42	*Struchium sparganophorum*	0 00021	0 0072	0 0355
43	*Synedrella nodiflora*	0 00026	0 0233	0 0876
44	*Vernonia cinerea*	0 00081	0 0179	0 0720

APPENDIX IV

Parameters for obtaining site vegetation analysis indices in Vellayani lake area

Sl No	Scientific Name of plant	$(Y/N)^2$	$P_i - n_i/N$	$P_i \ln P_i$
1	*Bacopa monnieri*	0 010	0 1631	0 2957
2	*Centella asiatica*	0 0028	0 0582	0 1655
3	*Cryptocorine retrospiralis*	0 0019	0 0396	0 1279
4	*Cyperus iria*	0 0066	0 0315	0 1089
5	*Diplocyclos palmatus*	0 0002	0 0047	0 025?
6	*Fimbristylis aestivalis*	0 00057	0 047	0 1437
7	*Hydrilla verticellata*	0 011	0 093	0 2209
8	*Limnophila heterophyllus*	0 0028	0 0528	0 1655
9	*Limnophila repens*	0 0152	0 2097	0 3276
10	*Lindernia antipoda*	0 0023	0 0467	0 1431
11	*Marselia marsescens*	0 0083	0 1398	0 2751
12	*Monochoria vaginalis*	0 00086	0 007	0 035
13	*Nelumbo nucifera*	0 0021	0 0093	0 0435
14	*Nymphea nouchali*	0 0061	0 028	0 1001
15	*Salvinia molesta*	0 0025	0 0155	0 0646
16	*Trichosanthes cucumerina*	0 00026	0 0139	0 0594
17	*Utricularia aurea*	0 0018	0 035	0 1173

BIODIVERSITY OF MEDICINAL PLANTS IN VELLAYANI

By

JYOTHILEKSHMI L

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
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ABSTRACT

A study on Biodiversity of medicinal plants in Vellayani was carried out in and around Vellayani lake of Thiruvananthapuram district Kerala The objectives of the study were to identify the medicinal plants from among the existing natural flora to study the growth behaviour of selected medicinal plants and to assess the pharmacologically active constituents of selected medicinal plants

A total of 80 sampling units were taken using stratified random sampling technique the strata being dry land garden land paddy field and lake area The medicinal plants in dry land garden land and paddy field were identified and quantified by random sampling technique using 1 0 m^2 frame In the lake area as it was difficult to use the frame the plants were collected randomly giving sufficient representation A total of 135 plant species were identified in the four different strata belonging to 1?0 genera and 57 families None of the plants were endemic There were 118 indigenous and 17 exotic or naturalized plants Ten important medicinal plant species were selected for detailed study and their growth behaviour was monitored for one year They were *Andrographis paniculata Cyclea peltata Desmodium velutinum Eclipta alba Gloriosa superba Hemidesmus indicus Phyllanthus amarus Scoparia dulcis Sida rhombifolia* and *Solanum indicum*

Emilia sonchifolia dominated in dry land area with high relative density and relative frequency *Centella asiatica* was the dominating species in garden land and paddy field with high relative density *Limnophila repens* was the dominant species in lake area

Most frequently occurring species in dry land was *Emilia sonchifolia* and n garden land *Scoparia dulcis* and *Vernonia cinerea* *Centella asiatica* and *Eclipta alba* occurred more frequently in paddy field where as in lake area *Hydrilla verticellata* occurred more frequently

The rare species in dry land were *Abrus precatorius* *Blepharis medaraspatensis* *Carissa congesta* and *Rauvolfia serpentina* In garden land *Acalypha indica* *Capparis brevispina* *Cayratia pedata* *Catharanthus roseus* var *alba* were found to be rare In paddy field *Borraria alata* *Coldenia procumbens* and *Portulaca oleraceae* were found to be the rare species *Diplocyclos palmatus* was the rare species in lake area

Dry land and garden land were found to be the most similar strata with more number of species in common Dry land and lake area were found to be the most dissimilar strata in vegetation pair wise analysis

Lake area was found to have higher concentration of dominance as expressed by Simpson s index Shannon s index was maximum in dry land area Abundant species occurs more in dry land area In dry land almost all species had equal number of individuals since Evenness index was maximum

Growth characters like plant height plant spread height of the first branch number of leaves number of roots root length were found to increase from pre flowering to seed set stage These characters were found to be high in garden land compared to other strata in most of the species The fresh and dry weight of officinal part was more in garden land condition in most of the species

In the chemical analysis it was found that in *Limnophila repens* there was no similar chemical constituents as that of *Bacopa monnieri* (brahmi) There was no bacoside content in *Limnophila repens* which is present in *Bacopa monnieri* So *Limnophila repens* cannot be used as a substitute for brahmi

The andrographolide content in *Andrographis paniculata* was found to be slightly higher in dry land compared to garden land The andrographolide content was higher in dry land area because of the water stress condition in dry land

The results of this study will be helpful in evolving suitable strategies for sustainable utilization of medicinal and aromatic plants occurring as indigenous and naturalized in and around the Vellayani lake Such an effort would also help to conserve many of the weed species which have very high medicinal values