CHAPTER – 1

Introduction

Introduction

The civilization in its applicable form of understanding would not have been possible without the existence of vegetation. Life originated on this, and the only known life-supporting planet around four billion years ago (Brack 1998; Das 2010). Since then innumerable forms of life have been differentiated, evolved, migrated over distant areas, living together and developed sustainable dependency and formed wide range of recognizable vegetation structure through the selection processes of nature and are now occupying different areas all over the globe. The earth surface has passed through regular geographical, geological, glacial, climatic and, later on, biological changes since its formation (Stouffer *et al.* 1994; Mann *et al.* 1998; Negi & Joshi 2004).Those have modified the earth surface, including the water-filled areas, and created innumerable habitat conditions (Kumar 2008). The formation of diverse habitat conditions provided suitable home to different species according to their suitability. Species preferring a particular set of environmental/ habitat conditions started growing together with mutual understanding and formed a local ecosystem. As it is understood, in any ecosystem just one species can't manage or maintain everything required for its normal survival. The functioning of a vegetation is largely dependent on its biological composition (plants, animals and microbes) at the species level (Qian *et al.* 2007).

1.1. THE HIMALAYAS

After the upheaval of the Himalayas during tertiary from the bottom of the now extinct Tethys Sea, the geological and biological pictures of this region have changed abruptly (Raina 2009). Large number of species of all the biological kingdoms started migrating into this newly formed land and established new associations, niches and ecosystems (Walter 1985). After their settlement, the existing species started mixing and modifying leading to local speciation and there on formed a new flora and fauna of its own, - characteristically Himalayan.

After crossing innumerable difficult barriers, the man, basically one African species (https://www.genome.gov), also extended its settlement in the Himalayas at a pre-historic age. This destructive species, to satisfy its unlimited requirements and to accommodate its logarithmically increasing population, started modifying the vegetation around their settlements that, eventually, expressed as destruction of natural habitat and endangering the survival of thousands of species. Man induced changes in the environmental conditions [i.e. temperature, precipitation, elemental balance of air, pollution, etc.] are also causing havoc (Ariztegui *et al.* 2010). These are now well-known facts that the phenomenon of 'global-warming' becoming dangerous not only for some stray species but even for very large ecosystems for their survival (Walker & Steffen 1997; Root *et al.* 2003).

1.2. CONSERVATION AND IUCN

Conservation efforts, round the world, especially under the guideline of IUCN have, temporarily, created little respite, through the establishment of different types of Protected Areas (PA) and Hotspots.

Establishment of PAs like National Parks, Wildlife Sanctuaries, Ramsar Sites, etc. at the narrower levels and Biodiversity Conservation Hotspots at the wider level are, at least theoretically, creating some islands where at least some species can take shelter for their survival (Manoj *et al.* 2013; Das *et al*. 2008).

Just the creation of PAs are now not looking enough for the proper conservation of huge number of species susceptible to changes in habitat conditions. In most of the cases, their migratory routs are blocked, exploitation in the form of ecotourism, (un-) sustainable utilization and extraction, etc. and the changes in environmental conditions are changing the habitat at different levels are forcing the degradation of their population structure.

1.3. RECOGNITION OF HOTSPOTS

So far, IUCN has recognized 35 Hotspots round the world (http://www.conservation.org). As much as four Hotspots are known to cover different parts of the Indian territory, those are (i) *Himalaya*, (ii) *Indo-Burma*, (iii) *Western Ghats & Sri Lanka*, and (iv) *Sundaland*. IUCN also treated India as a '*Megadiversity Country*' in a select list of 17 such countries recognized till date (CBD, 2009).

1.3.1. Himalaya Hotspot

Hottest of the Hotspots, Himalaya is spanning over six countries and covering the houses for almost unlimited diversity of life-forms and of culture. As recorded before 2004, this Hotspot is covering a total area of 741,706 km^2 in which around 185,427 km^2 area of natural habitat is 'somehow' exists. It is, however, expected that further analysis of recent imageries will produce much more serious picture as the anthropogenic pressure on the Himalayas is a continuous and accelerating process. So far, around 112,578 km^2 has been declared as PA of which 77,739 km^2 is under the IUCN categories I – IV. And, it is also important to note that 31.6% of the higher plants of the Himalayan flora are endemics (Myers *et al.* 2000; WWF & ICIMOD. 2001). Along with the progressive degradation of the habitat conditions, it is feared that this number will reduce very soon and many more endemic species will become extinct, covering all major taxa of plants, animals and microbes.

1.4. DARJEELING-SIKKIM HIMALAYAS

Darjeeling-Sikkim parts of the Eastern Himalaya, along with the contiguous thickly vegetated areas of Terai and Duars are also known to be extremely rich in biodiversity and of natural resources (Das & Chanda 1990; Das *et al*. 2010). Over the last 4 – 5 hundred years, especially during the last 150 years, migration of numerous groups of people into the area, from far and near, established their settlements and the human population in the area has increased manifold and is now increasing extremely fast. This is exerting too much pressure on local landscape as all types of existing vegetation forms are changing very fast. Establishment and extension of huge Tea Gardens and other crop fields, network of innumerable army establishments, new villages and towns, industries, communication networks, mostly illegal extraction of forest products (mostly logging), mining operations, etc. are occupying the spaces where, previously, good vegetation cover, supporting wide diversity of biological forms, were existing. The land-cover map of Darjeeling Hills presented by U. Rai (2006) showed the dangerous situation of Darjeeling forests.

1.5. CONSERVATION EFFORTS

Logically, the National and State Governments have taken ample steps to protect and to conserve the biological diversity of this area. A good number of PAs have, so far, been recognized in this region covering Himalayan hills of Darjeeling-Sikkim and of contiguous Terai and Duars (Table 1.1).

Table 1.1. Protected Areas of Darjeeling-Sikkim and Terai-Duars region

Name	District	Location/ Coordinate	Area [km^2]
SIKKIM			
Khangchendzonga BR	N,S,W Sikkim	27° 30′0″N &88° 02′ 0″E	2,620 km^2
Khangchendzonga NP	N,S,W Sikkim	27°42′0″N & 88°08′0″E	1,784 km^2
Shingba Rhododendron Sanctuary	N Sikkim	27°50′28″N & 88°44′21″E	43 km^2
Barsey Rhododendron Sanctuary	W Sikkim	27°11′ N & 88°7′ E	104 km^2
Kyongnosla Alpine Sanctuary	E Sikkim	27°22′37″N & 88°44′28″E	31 km^2
Fambong Lho WLS	E Sikkim	27°18′40″N & 88°32′1″E	51.76 km^2
Maenam WLS	E Sikkim	27°18′50″ N & 88°23′35″E	35.34 km^2
Pangolakha WLS	E Sikkim	27º 09′N & 88º 35′E	128 km^2
Darjeeling Hills, Terai & Duars [West Bengal]			
Singalila BR [Proposed]	Darjeeling	Yet to finalize	
Singalila NP	Darjeeling	27°07′N & 88°04′E	78.60 km^2
Neora Valley NP	Darjeeling	27°04′N & 88°42′E	88 km^2
Gorumara NP	Jalpaiguri	26°42′N & 88°48′E	79.45 km^2
Jaldapara NP	Alipurduar	26°37′43″N & 89°22′39″E	216.51 km^2
Buxa NP	Alipurduar	26° 30' N & 89° 20'E	117.10 km^2
Buxa Tiger Reserve	Alipuduar	26°39′0″N & 89°34′48″E	760 km^2
Senchal WLS	Darjeeling	26°59′38″N & 88°15′55″E	38.88 km^2
Mahananda WLS	Darjeeling	26°28′52″N & 88°15′50″E	158.04 km^2
Jore Pukri WLS	Darjeeling	-	0.04 km^2
Chapramari WLS	Jalpaiguri	26°53′52″N & 88°51′1″E	9.60 km^2

Apparently, total area under conservation is looking quite significant, but on closer look those might not be so appreciable. Absence of transboundary PAs and proper corridors between these PAs for the easy migration of different species and making business over the conserved areas are some of the basic but missing requirements (Das 2011; Das *et al*. 2008).

1.6. VEGETATION

Floristically, the Sikkim-Darjeeling Himalayas [part of the Eastern Himalaya] is one of the richest regions in the world and is literally considered as *Botanist's Paradise*. Some scientists treat this region as the treasure house of diversified plant species (Das 1995; Lama 2004; Rai 2006). None other than Sir Joseph Dalton Hooker (Hooker 1904) introduced the beauty and the floristic richness of this region to the world. The occurrences of a variety of physiographic, climatic and edaphic conditions often aided by biotic factors are responsible for such richness. The configuration of the hills and mountains, pattern of rainfall distribution over the lower, middle and upper elevation ranges and high humidity have a great role for the development of wide diversity of vegetation of this area (Bhujel 1996; Rai 2001; Bhujel & Das 2002). The altitude of the hill ranges varies markedly between the altitude and vegetation. Thus, altitude is one major factor that determines the range of distribution of different plant species and the associations that they form at different elevation ranges. Various workers have put forth the classification of the vegetation of this region *viz*. Gamble (1875), Hooker (1906), Cowan (1929), Champion (1936), Das (1995), Bhujel (1996). These authors have essentially classified the flora and vegetation according to altitudinal ranges, although they differ considerably in detail. Six major types of vegetation can be recognized as in Table 1.2.

Table 1.2. Different types of vegetation along with their altitudinal range in Darjeeling–Sikkim Himalayas

Vegetation types	**Altitudinal ranges**
Tropical and plains	Plains to 800 m
Sub-tropical	800 – 1600 m
Temperate	1600 – 2400 m
Cold temperate	2400 – 3200 m
Sub-alpine	3200 – 4000 m
Alpine	Above 4000 m

1.6.1. Dominant Taxa

The foothills or tropical region of Darjeeling-Sikkim Himalayas are covered with forest consisting of *Tectona grandis* Carl Linnaeus,*Shorea robusta* Gaertner,*Dalbergia sissoo* A.P. de Candolle, *Dillenia pentagyna* Roxburgh, *Terminalia myriocarpa*van Heurck & Mueller-Arg., *Syzygium cumini* (Linnaeus) Skeels, *Lagerstroemia parviflora* Roxburgh, *Litsea glutinosa* (Loureiro) C.B. Robinson, *Litsea monopetala* (Roxburgh) Persoon, *Artocarpus lacucha* Buchanan-Hamilton, etc. This type of forest is characterized by the presence of a good number of climbers (some of those are liana) such as *Argyreia roxburghii* (Wallich) Arnott *ex* Choisy, *Bauhinia vahlii* Wight & Arnott, *Mikania micrantha* Kunth, *Tetrastigma planicaule* (Hooker *f.*) Gagnepain, *Thunbergia grandiflora* (Roxburgh *ex* Rottler) Roxburgh, *Tinospora sinensis* (Loureiro) Merrill etc (Das *et al.* 2010). The ground cover vegetation is also very rich, which include annuals, perennial herbs, root parasites, saprophytes etc. like *Ageratum conyzoides* (Linnaeus) Linnaeus, *Blumea balsamifera* (Linnaeus) A.P. de Candolle, *Urena lobata* Linnaeus, *Commelina benghalensis* Linnaeus, *Oxalis corniculata* Linnaeus, *Urena lobata* Linnaeus, *Triumfetta rhomboidea* Jacquin etc (Ghosh 2006).

In sub-tropical region the forest chiefly include *Schima wallichii* Choisy, *Castanopsis indica* (Roxburgh *ex* Lindley) A. de Candolle, *Alangium chinense* (Loureiro) Harms,*Callicarpa arborea* Roxburgh, Duabanga grandiflora (A.P. de Candolle) Walpers, etc. *Cryptomeria japonica* (Thunberg ex Linnaeus *f.*) D.Don is introductedand extensively cultivated in these areas. Several Bamboos may also be found near habitations (Chowdhury & Das 2011).

Temperate forests are evergreen with medium sized trees. There are a number of deciduous species but these form only a small proportion. Laurels and Oaks form large patches. The dominant plant species observed in this zone include *Acer acuminatum* Wallich *ex* D. Don, *Salix sikkimensis* Andersson,*Sorbus microphylla* (Wallich*ex* Hooker *f.*) T. Wenzig, *Rhododendron arboreum* Smith, *Magnolia cathcartii* (Hooker*f.* & Thomson) Nooteboom, *Quercus lamelllosa* Smith, *Quercus lineata* Blume, *Eurya acuminata* DC,*Acer sikkimense* Miquel,*Taxus wallichiana* Zuccarini etc. Laurels like *Cinnamomum impressinervium* Meisner, *Machilus gamblei* King *ex* Hooker *f.*, *Machilus duthiei* King, *Litsea cubeba* (Loureiro) Persoon, *Litsea elongata* (Nees) Hooker *f.*, *Litsea laeta* (Nees) Hooker *f.* are common in this zone (Lama 2004).

Cold temperate forest of the upper hill region comprises of trees like *Quercus lamellosa* Smith, *Magnolia campbellii* Hooker *f.* & Thomson, *Lithocarpus pachyphyllus* (kurz) Rehder, *Rhododendron arboreum* Smith, *Rhododendron falconeri* Hooker *f.*, *Acer campbellii* Hooker *f.* & Thomson *ex* Hiern, *Abies spectabilis* (D.Don) Mirbel etc. (Bhujel 1996; Rai 2001).

Sub-alpine region is clearly dominated by different species of *Rhododendron* and Conifers with few patches of other trees. The commonly occurring trees of this region include *Rhododendron arboreum* Smith, *Rhododendron cinnabarinum* Hooker *f.*, *Rhododendron campylocarpum* Hooker *f.*, *Rhododendron campanulatum* D. Don, *Juniperus squamata* Hamilton *ex* Lambert, *Juniperus communis* Linnaeus, *Quercus lineata* Blume, *Acer campbellii* Hooker *f.* & Thomson *ex* Hiern, *Magnolia campbellii* Hooker *f.* & Thomson, *Abies spectabilis* (D. Don) Mirbel, *Betula utilis* D. Don etc (Bhujel 1996; Ghosh 2006).

Alpine zone is lying just below the permanent snowline. Stunted bushy growth of *Juniperus squamata* Hamilton *ex* Lambert, *Rhododendron lepidotum* Wallich *ex* G. Don, *Rhododendron setosum* D.Don, *Salix calyculata* Hooker *f. ex* Andersson, *Berberis concinna* Hooker *f.* occur in this region (Dhar 2002). Herbs such as *Sanguisorba filiformis* (Hooker *f.*) Handel-Mazzetti, *Primula sikkimensis* Hooker, *Primula tibetica* Watt, *Lancea tibetica* Hooker *f.*& Thomson, *Anaphalis xylorhiza* Schultz Bipontinus & Hooker *f.* etc. cover the grounds every years from April to June (Lama 2004).

1.7. LAURELS

The Lauraceae or the Laurel family comprises a group of flowering plants included in the order Laurales in the Magnoliophyta of the kingdom *Plantae* (Cronquist 1981). The Angiosperm Phylogeny Group classification (Chase & Reveal 2009) puts Lauraceae in Laurales under the clade Magnoliids, which is one of the major clades of angiosperms. Different numbers of genera and species have been considered assigning to this family by different authors in different times. Van der Werff & Richter (1996) included a total number of 55 genera and 2500 to 3000 species under the family, distributed world-wide. According to Takhtajan (1997) this family includes 54 genera and 2500 to 3500 species. Cronquist (1981) estimated that around 2000 Laurels are present in the world. Hutchinson (1964) recognized 47 genera and about 1900 species and Judd *et al.* (2002) reported 50 genera and 2500 species as the global representatives.

1.7.1. Diagnosis

Laurels can be identified by their aromatic nature of bark and foliage as well as unique floral morphology. Flowers typically consist of six alternating, trimerous whorls; two whorls of three tepals each, four whorls of three stamens each, adnate to perianth tube and a gynoecium. In the androecium, stamens from the third whorl frequently bear a pair of additional glands and stamens from the fourth whorl are usually reduced to staminodes or are absent. The basifixed anthers are either two celled or four celled and dehisce by flap-like valves opening upward. The pistil is monocarpellary with a single pendulous anatropous ovule and the ovary is generally superior. The fruit is a berry or drupe that is often subtended or completely surrounded by a fleshy cupule.

Most of the Laurels are aromatic deciduous evergreen trees or shrubs, but *Cassytha* Linnaeus is a genus of partial-parasitic vines.

1.7.2. Fossil history

The Lauraceae has a wide fossil history particularly in Asia and America signifying that the family was dominated in the extinct vegetation of these regions (Yang 1998). Most fossils are leaves, flowers and wood from early tertiary era (Ferguson 1974; Wheeler *et al.*1977; Taylor 1988), but Drinnan *et al.*

(1990) discovered Laurel fossils of mid-cretaceous from Maryland, USA. This fossil has provided the earliest evidence of trimerous flower parts in angiosperms. The flower and inflorescence are surprisingly well preserved and described as *Mauldinia mirabilis* by Drinnan *et al.* (1990). The flowers have three small outer and three larger inner tepals and nine 2-celled anthers in three whorls with well-developed staminode like appendages. This unique floral structure is also present in some extant members of Lauraceae. Drinnan *et al.* (1990) hypothesized that *Mauldinia* like Laurels were originated around the mid-cretaceous in North America.

1.7.3. Distribution

The greatest diversity of Laurels is seen in the lowland rain-forests which is the preferred habitat of these plants. But, some species also occur at high altitude areas in tropical mountain forests where they are dominating the vegetation. So, the Lauraceae is widespread in tropical and subtropical regions throughout the world (Cronquist 1981). However, it is most commonly found in tropics of America and Asia. Whereas in Northern Asia Laurels are widely distributed from China to Japan. In south, Lauraceae occurs in Argentina and southern Chile. The family is inadequately represented in most part of the Africa but several species occur in Madagascar. Numerous species of Lauraceae are scattered in Australia while only one genus, *Beilschmiedia* Nees is found in New Zealand (Yang 1998). The Laurels has a wide range of distribution in India stretching from the coastal plains to the subtropical and temperate regions. Unfortunately, few works were performed on these members particularly, in Terai-Duars belt of West Bengal which is falling under the Himalaya Biodiversity Hotspot (Conservation International 2005). No complete floristic database of Lauraceae of this region was obtained through literature survey. As the study on Laurels has not yet completed in the extremely rich and diverse Terai-Duars vegetation, so there are still some confusions of taxonomic representation of this family, thus, the present study will support the taxonomic clarification of this taxon and will enrich the floristic and systematic database for this entire region.

1.7.4. Importance

Laurels are economically very significant as sources of medicine, timber, nutritious fruits (e.g. *Persea americana* Miller), spices (e.g. *Cinnamomum verum* J.Presl, *C. tamala* (Buchanan–Hamilton) T. Nees & Eberm, *Laurus nobilis* Linnaeus), and perfumes [*C. verum* , *C. cassia* (Linnaeus) J. Presl, *C. burmanni* (Nees & T. Nees) Blume]. The fruits of *Actinodaphne* Nees, *Cinnamomum* Schaeffer, *Cryptocarya* Brown, *Lindera* Thunberg, *Litsea* Lamarck, and *Syndiclis* Hooker *f*. contain abundant oils and fats. *Cinnamomum* trees, such as *C. camphora* (Linnaeus) J. Presl, *C. glanduliferum* (Wallich) Meisner, and *C. porrectum* (Roxburgh) Kostermans, yield camphor and essential oils, which are used for making perfumes and medicines. The bark of *C. cassia* and the roots of *Lindera* sp. are famous for traditional medicines against cold and flu in China (Li *et al.* 2008a).

1.7.5. Difficulties in taxonomic delimitation

Although it is economically very important, the species of Lauraceae remains poorly recognized and are difficult to distinguish taxonomically. The main reason is that many species are tall trees with minute, inconspicuous flowers that are difficult to collect (Van der Werff & Richter 1996) and of considerable small reproductive season. This is clearly shown by recent reports of newly discovered species and genera throughout the globe. Three new species of *Ocotea* (*O. disjuncta* Lorea-Hernández, *O. iridescens* Lorea-Hernandez & Van der Werff, and *O. rovirosae* Lorea-Hernandez & Van der Werff) from southern Mexico are described and illustrated by Lorea-Hernandez & Van der Werff in 2002. Yushi *et al*.(2006) have described and illustrated a new species (*Cinnamomum purpureaum* H.G. Ye & F.G. Wang) of Lauraceae from Guangdong, China. A new species from Thailand, *Litsea phuwuaensis* Ngernsaengsaruay was described and illustrated by Ngernsaengsaruay in 2004. Like other countries new species of Lauraceae are discovered also from several regions of India. *Litsea beei* N. Mohanan & E.S.S. Kumar, species of Lauraceae from India was described and illustrated by Mohanan and Santhosh Kumar in 2008. Nine new taxa were described and illustrated belonging to the genera *Actinodaphne* Nees, *Beilschmiedia* Nees, *Cinnamomum* Schaeffer and *Cryptocarya* Brown from India and Myanmar by Gangopadhyay in 2008. *Beilschmiedia tirunelvelica* Manickam, Murugan, Jothi & Sundaresan was reported from Western Ghats, India (Manickam *et al*. 2005). *Phoebe hedgei* M. Gangopadhyay & A. Sarmah a new species of Lauraceae from North-East India was identified by M. Gangopadhyay and A. Sarmah in 2007. Kumar *et al*. (2011) recorded *Cinnamomum alexei* Kostermans from India. *Litsea kakkachensis* R. Ganesan a new species from Agasthyamalai, Western Ghats, India was described and illustrated by R. Ganesan in 2011.

1.7.6. Classification

Multiple classification design base on a variety of morphological characteristics have been proposed but most of those are not accepted in their totality. Van der Werff and Richter (1996) provided the most conventional classification regarding Lauraceae. Although, according to Judd *et al*. (2007), the classification of Van der Werff and Richter (1996) is presently the authority but it is not fully accepted by the scientific community because this classification is based mainly on one morphological character i.e. inflorescence structure. But the problem is that for a substantial number of species of Lauraceae the fruits or flowers are not known which makes generic placement of their species uncertain, since most genera are defined by floral characters. Another problem is that attributes of both flowers and fruits are utilized in most generic keys. But the specimens almost never bear both flowers and fruits, so the identification of such specimens often become almost impossible.

For the solving difficulties of identification as well as classification, now a day's many authors worked with different techniques *viz*. anatomy, leaf architecture, chemotaxonomic approaches such as antioxidant, phytochemical screening, thin layer chromatographic figure print etc. Considering this knowledge gap of identification the following objectives has been framed which will enlighten the more accurate taxonomic interpretation among the members of this family.

1.8. OBJECTIVES FOR THE RECENT WORK

- Floristic survey and recognition of economically important Laurel species of Terai and Duars region
- Construction of distribution map of those Laurel species
- Recording of exact flowering and fruiting periods for different Laurels of the area
- Leaf architectural study of same species
- Evaluation of antioxidants of same species
- Extraction of aromatic principles of same species
- Phytochemical screening of some members and profiling through TLC
- Reconstruction of similarity dendrogram and cluster analysis on the basis of various taxonomic characters.