CHAPTER - 11

General Discussion

General Discussion

Natural resources provide the basic needs of life. Human civilization has already exploited enormous reserve of biological resources of this planet for fulfilling their various purposes of daily requirement. The hills of Darjeeling and Sikkim forms an integral part of the Eastern Himalayan region and is the storehouse of biological resources, representing of a large number of important, endemic, rare and endangered plants (Das 1995, 2004; Bhujel 1996; Bhujel & Das 2002; Ghosh & Das 2009). Even today, this region attracts a large number of botanists, naturalists and tourists from different parts of the world. Terai and Duars area of West Bengal is situated under Eastern sub-Himalayan region. Due to suitable environmental set-up, the Terai-Duars region becomes one of the richest botanical diversity in India (Das *et al.* 2010). This region equally represents all the habit group of plants such as herbs, shrubs, small to large climbers and trees. Many wild species of this region are found to be of great economic significance for the local people including food and ornamental potentiality, and also having therapeutic, religious and socio-cultural values (Ghosh 2006; Sarkar 2011). On the other hand, a large number of trees belonging to the diverse families are known for their high quality timber, which are quite costly, durable and are much demanding in global market. However, many plant species of this region were found to be threatened and endangered (Das *et al.* 2010).

11.1. LAUREL FLORA

The forests of Terai and Duars region are also the ideal home for oil yielding plants, among those Laurels are predominant. The present work clearly exhibited that Lauraceae is one of the well represented families in Terai-Duars region of West Bengal, represented by the recorded 9 genera and 26 species. Among the 26 species, *Litsea* Lamarck is the highest representative with its nine species. From several protected areas of Terai-Duars region, Mahananda Wildlife Sanctuary showed highest species diversity of Laurels (Table 11.1).

Table 11.1. Present record of Laurels from different Protected Areas and other places of Terai-Duars **[BTR =** Buxa Tiger Reserve; **GMP =** Garden of Medicinal Plant, University of North Bengal; **GNP =** Gorumara National Park; **JNP =** Jaldapara National Park; **MWLS =** Mahananda Wildlife Sanctuary**]**

Species	Floristic region				Other places
	MWLS	GNP	BTR	JNP	
Actinodaphne longipes	+	-	-	-	-
Actinodaphne obovata	+	+	+	-	-
Actinodaphne sikkimensis	+	+	-	+	-
Beilschmiedia assamica	-	+	-	-	-
Cinnamomum bejolghota	+	+	+	-	GMP
Cinnamomum camphora	-	-	-	-	GMP
Cinnamomum glaucescens	-	+	-	-	-
Cinnamomum impressinervium	+	-	-	-	-

Species	Floristic region				Other places
	MWLS	GNP	BTR	JNP	
Cinnamomum tamala	-	-	+	+	GMP, commonly cultivated
Cinnamomum verum	-	-	-	-	GMP, commonly cultivated
Cryptocarya amygdalina	-	+	-	-	-
Lindera assamica	+	+	-	-	-
Litsea assamica	-	-	-	+	Falakata near JNP
Litsea cubeba	+	+	-	-	Sal Bagan, NBU Campus
Litseae longata	+	-	-	-	-
Litsea glutinosa	+	+	+	+	GMP, also widely distributed throughout Terai & Duars
Litsea hookeri	+	+	-	-	-
Litsea laeta	+	-	-	-	GMP
Litsea monopetala	+	+	+	+	GMP, widely distributed throughout Terai & Duars
Litsea panamanja	+	+	+	-	-
Litsea salicifolia	+	+	+	+	-
Machilus duthiei	+	-	-	-	-
Machilus gamblei	+	-	-	-	-
Machilus glaucescens	+	-	-	-	-
Parsea odoratissima	-	+	+	-	-
Phoebe hainesiana	-	-	+	-	-

11.1.1. New records of distribution

The present work exposed the presence of quite a few species as new record of distribution for this region. As much as 16 species *viz*., *Actinodaphne longipes*, *A. sikkimensis*, *Beilschmiedia assamica*, *Cinnamomum camphora*, *C. impressinervium*, *C. tamala*, *C. verum*, *Lindera assamica*, *Litsea assamica*, *L. elongata*, *L. hookeri*, *L. laeta*, *L. panamanja*, *Machilus duthiei*, *Parsea odoratissima* and *Phoebe hainesiana* were not recorded in earlier accounts for this region (Cowan & Cowan 1929; Long 1984) are now reported here for the first time to occur in the Terai and Duars belt of West Bengal. However, apart from *Litsea assamica*, all other species were known to grow from different other localities of the state. The distribution of *Litsea assamica* was earlier known only from North–East India (Kanjilal *et al.* 1940; Bhuinya *et al.* 2009); therefore, the present collection of the species from Terai and Duars is a new record of its occurrence in West Bengal.

11.1.2. Endemics

A species which is only found growing naturally in a given region and nowhere else in the world is known as endemic. It must be make prominent that the concept of the endemism is very much dependent on the knowledge of geographical range of a species. From the recorded Laurels of Terai and Duars regions, three species, namely *Actinodaphne longipes*, *Cinnamomum impressinervium*, *Phoebe hainesiana* are endemic to Eastern Himalaya and three more species, *viz*. *Beilschmiedia assamica*, *Cinnamomum glaucescens* and *Lindera assamica* are endemic to north-eastern region of the Indian subcontinent. Also, another economically important species i.e. *Cinnamomum tamala* is basically a tropical Himalayan plant.

11.1.3. Exotics

Migration of plant species from one part to other distant part is a continuous process and is assisted by various geographical, climatic and ethnic factors. Various connecting links like land-bridge and vast marine carriages might be the probable route for migration of exotics among several countries. Migration appears to be a long process for many of the plants. Exotics, once migrated need to acclimatise itself, establish, propagate and naturalise to a new habitat. Exotic species forms important component of Eastern Himalayan flora, many of them being already naturalized and some is being in the process of naturalization. Some of these exotic species are desirably introduced for food, fibre, fruits, flowers and drug values (Cowan & Cowan 1929).

Three exotic species *viz*. *Cinnamomum camphora*, *Cinnamomum verum* and *Litsea cubeba* were recorded from study area. Among these, *C. camphora* is native to China as well as in Japan, *L. cubeba* is from China and Indonesia (Ara *et al.* 2007), and *C. verum* is native to Sri Lanka (Li *et al.* 2008a). *L. cubeba* has become truly naturalized in this zone and now represented with good population structure. On the other hand, *C. verum* is commonly planted in this region for the spice *Daruchini* (i.e. Cinnamon-bark) and cinnamon oil.

11.2. IMPORTANCE

The Laurels of Terai-Duars are of high value assets from the economic point of view. Some of these species have been found to be economically very important and are precious medicinal plant resources (Das *et al.* 2010). Besides, many others have high economic value like aromatic, edible, spice, timber and more being used for various domestic purposes as well as industrial uses (Choudhury *et al.* 2013b). The importances of these species have shown in the Table 11.2.

11.3. PHYLOGENETIC RELATIONSHIP OF STUDIED LAURELS

Among the 26 recorded economically important species of Lauraceae, 4 species of *Litsea* and 4 species of *Cinnamomum* are commonly available in the belt of Terai and Duars. Morphologically these eight species are quite overlapping. From the numerical data of morphology, a relationship was drawn through the production of a dendrogram in the Chapter 5. But it is not always possible to depend on morphological characteristics as for the substantial numbers of species, the fruits or flowers are difficult to procure. This makes generic placement of many species uncertain, since most taxa are defined mainly by floral characters. A second problem lies with the difficulties associated with timely collection of flowers and fruits required for identification of specimen as flowering and fruiting period of Laurels are very short and most of the characters for arrangement of generic key are taken from reproductive parts of Lauraceous specimen.

Table 11.2. Importance of different Laurels of Terai and Duars

Species	Uses
Actinodaphne longipes	Timber used for light construction and interior furnishing
Actinodaphne obovata	Bark used to treat fractured bones
Actinodaphne sikkimensis	Timber used for light construction
Beilschmiedia assamica	Wood used for making boats and boxes
Cinnamomum bejolghota	Leaf and bark used as condiment
Cinnamomum camphora	Camphor oil used in perfumery and treatment of nervous depression, acne, inflammation, arthritis, cold and fever
Cinnamomum glaucescens	Produce essential oils to use in perfumery and cosmetics; locally used against various skin diseases
Cinnamomum impressinervium	Bark used as substitute for or as an adulterant of *Cinnamomum verum*
Cinnamomum tamala	Leaves used as spice; bark and leaves also used to treat several disease e.g. diarrhoea, colic, vomiting, cardiac disorder, etc.
Cinnamomum verum	Produce important spice 'cinnamon-bark' of commerce; used medicinally to treat stomach-ache; bark and leafy branch lets contain volatile oil
Cryptocarya amygdalina	Timber used for light construction
Lindera assamica	Wood used for house construction
Litsea assamica	Wood used for making match boxes
Litsea cubeba	Fruit oil is added to food for flavouring and also used as bio-pesticide
Litsea elongata	A good fodder for cattle; wood used for construction works, making furniture, etc.
Litsea glutinosa	Bark used to treat diarrhoea, dysentery, rheumatic joint pain etc.; bark powder used as an adhesive paste in incense stick production
Litsea hookeri	Timber used for house construction and for making furniture
Litsea laeta	Seed oil is with high antioxidant activity
Litsea monopetala	Leaves used to treat arthritis and for rearing muga-silk moth larvae
Litsea panamanja	Wood used for house construction, making furniture and as fire wood
Litsea salicifolia	Seed oil used as bio-pesticide; leaves as good food for muga-silk moth larvae
Machilus duthiei	Roots used to treat inflammation, asthma, pain, bronchitis, vomiting and blood diseases
Machilus gamblei	Produce good quality firewood
Machilus glaucescens	Used as firewood
Persea odoratissima	A red dye is prepared from its bark
Phoebe hainesiana	Wood used for making furniture and plywood

A drastic remedy for this problem would be to use the different other attributes like anatomy, leaf architecture and chemotaxonomy.

11.3.1. Anatomical characterization

Anatomical attributes have long been used for solving many taxonomic disputes (Agbagwa & Ndukwu 2004; Kharazian 2007). Like morphological characters, anatomical features also can provide distinguishable characters for the preliminary identification of different species. For this purpose stem, lamina and petiole anatomy played crucial role (Metcalfe & Chalk 1950). Lersten & Curtis (2001) indicated that stem anatomical studies support to solve many systematic problems. In 2012 Rao *et al*. applied anatomical characteristics for the identification of economically important *Litsea glutinosa*. Baruah and Nath in 2006 also investigated the leaf anatomy of *Cinnamomum pauciflorum* Nees and in 2012, Bhatt and Pundya examined the leaf anatomy of *Litsea chinensis* Lamarck. They noticed that uniseriate epidermal layer, anisocytic stomata and presence of abundant mucilage in developed vascular bundle might eventually help in recognition as well as standardization of the circumscription for a species. Therefore, the valuable anatomical characters are helpful in designated taxonomical structures of some Laurels. In Chapter 6, it was established that the anatomical characters of leaf, petiole and stems of eight Laurels of Terai-Duars region can also provide very significant data, if recognized from taxonomic view point.

11.3.2. Characterization through Leaf Architecture

Similarly, Leaf-architecture is also frequently used as important aspects for solving many taxonomic disputes (Moore 2008; Todzia 1991). Leaf-architecture was initially used by Hickey to represent the placement of plant species by leaf-structure with leaf shape, gland position, venation pattern and marginal configuration (Hichey 1973). After that many authors created categories, groups and subgroups on the basis of lamina venation. Todzia and Keating (1991) have showed the link between Lauraceae and Chloranthaceae by using the leaf-architecture data. Beside these characters, stomata also provide many taxonomically important diagnostic characters, like stomatal index, stomata type and the occurrence of stomata on the adaxial or abaxial leaf surface. (Tripathi & Mondal 2012).

So, in Chapter 7 a study was undertaken to produce a comprehensive account of the leaf-architecture in eight species under two genera, *Cinnamomum* Schaeffer and *Litsea* Lamarck of the Lauraceae of Terai-Duars region. It was noticed that the minor venation pattern and F.E.Vs are distinctly different in *Litsea* and *Cinnamomum,* also notable differences are observed in the size and numbers of areoles. Therefore, quantitative differences in minor venation pattern might embrace physiological or adaptive significance. As principal characteristics of the leaf venation pattern of a species are genetically fixed. So, this study can also be used as important pharmacognostic tool.

11.3.3. Phytochemical Characterization

Similar to the structural characteristics of different plant parts the chemical constitutions in plants are also constant.

11.3.3.1. Studies on antioxidants and polyphenols

As we know, polyphenols are secondary metabolites and are differentially distributed in the plant kingdom. Taxonomically related species might show considerable similarity in qualitative polyphenol profile. Though, quantity of individual polyphenols could differ widely in different species of the same family or same group, both qualitative and quantitative polyphenol profiling together with total antioxidant capacity measured by various methods could be used to classify plants. The application of chemometric tools for characterization and determination of geographic origin of species has recently become a very active research area (Arvanitoyannis *et al.* 1999; Downey *et al.* 2003; Woodcock *et al*. 2007). Wang*et et al.* (2009) presented an overview of the similarities and differences among ten algal species and also investigated the relationships between total phenolic content and different antioxidant activity assays by chemical properties. Agglomerative Hierarchical Clustering (AHC) is a mathematical tool which can represent relationships between data and samples. In Chapter-8, a study was performed to make relationship among the selected species based on antioxidant activity and levels of total polyphenols and flavonoids. Polyphenols are naturally occurring antioxidant components of plants. These phenolic compounds are found in almost all plants and play important roles in preventing aging diseases like inflammation, cancer, and arteriosclerosis (Sato *et al*. 1996; Li *et al*. 2008b). In Chapter 8, it was noticed that the total phenolic contents of the bark extracts was much higher than those of the leaf extracts (except *L. assamica*) of eight different Laurels of Terai and Duars region. In different studies it was suggested that plant polyphenols, which showed antioxidant activity *in vitro*, also function as antioxidants *in vivo* (Lee *et al*. 2005; Shin *et al*. 2008). Li *et al.* (2008b) and Ozsoy *et al.* (2008) showed a positive linear correlation between the total phenolic content and antioxidant activity of the plants. The results suggest that these two genera of Lauraceae, which contained higher levels of polyphenols might have high antioxidant properties. It was already established that *L. glutinosa and Cinammomum verum* and *C. tamala* had high DPPH scavenging capacity (Kshirsagar & Upadhyay 2009; Chen *et al*. 2012). As we have already discussed that, the secondary metabolite-based chemotaxonomic technique can be used as an important tool for identifying and classifying these eight economically important plants according to species-specific metabolites, the chemotaxonomic importance and potential of secondary metabolites i.e. antioxidants in this family were confirmed by this study. Though the leaves and barks of eight plants were collected from same individual plants, the dendrogram was slightly dissimilar (Showed in Chapter 8) because the deposition pattern of the secondary metabolites in barks are more stable than leaves (Ahmad *et al.* 2009). Thus we selected barks of these plants in further chapters.

11.3.3.2. Antioxidant Activities of Essential oils

The plants of Lauraceae are directly related with the cosmetics and food additives industries for the presence of essential oils (Wang 2009). So in Chapter-9, the antioxidant activities of the essential oil of eight Laurels were determined and a relationship was established among these species. Several authors worked on antioxidant capacity of the oils of different lauraceous plants (Schmidt *et al.* 2006). The results of present investigation were similar to other contributors. When comparing the eight Laurels, with the cladogram based on the antioxidant profile of oil of Lauraceae, it was found that the genus *Litsea* is separated from the genus of *Cinnamomum*, which is parallel to the grouping developed by the morphological characteristics.

11.3.3.3. Chromatographic profiling data

It is already known that thin layer chromatography is another widely applied chemotaxonomic tool to constitute one of the most important methods of determining the taxonomic positions of taxa. So, it is now possible to study secondary metabolite profiles of low or high taxonomic levels, even of individual genotypes (Zafar *et al.* 2011). In 2010, Mohy-Ud-Din *et al.* stated that TLC is a major tool for investigating accession structures, species, taxonomic problems and phylogenetic relationships at the generic level.

In addition, different plant compounds like flavonoids have been used as a chemotaxonomic marker (Yang 1998). With flavonoids, other secondary metabolites like anthraquinone, bitter principles, phenolics, essential oils and DPPH based free radical screening with TLC fingerprint of eight Laurels were performed which is showed in Chapter 10. Like Chapters 8 and 9, free radical scavenging screen through TLC was showed a beautiful yellow band against DPPH solvent. Like DPPH Screening, different secondary metabolites produced various coloured bands against different solvents with different spraying reagents. By calculating the hR*f* values, a dendrogram was constructed through Agglomerative Hierarchical Clustering (AHC) method.

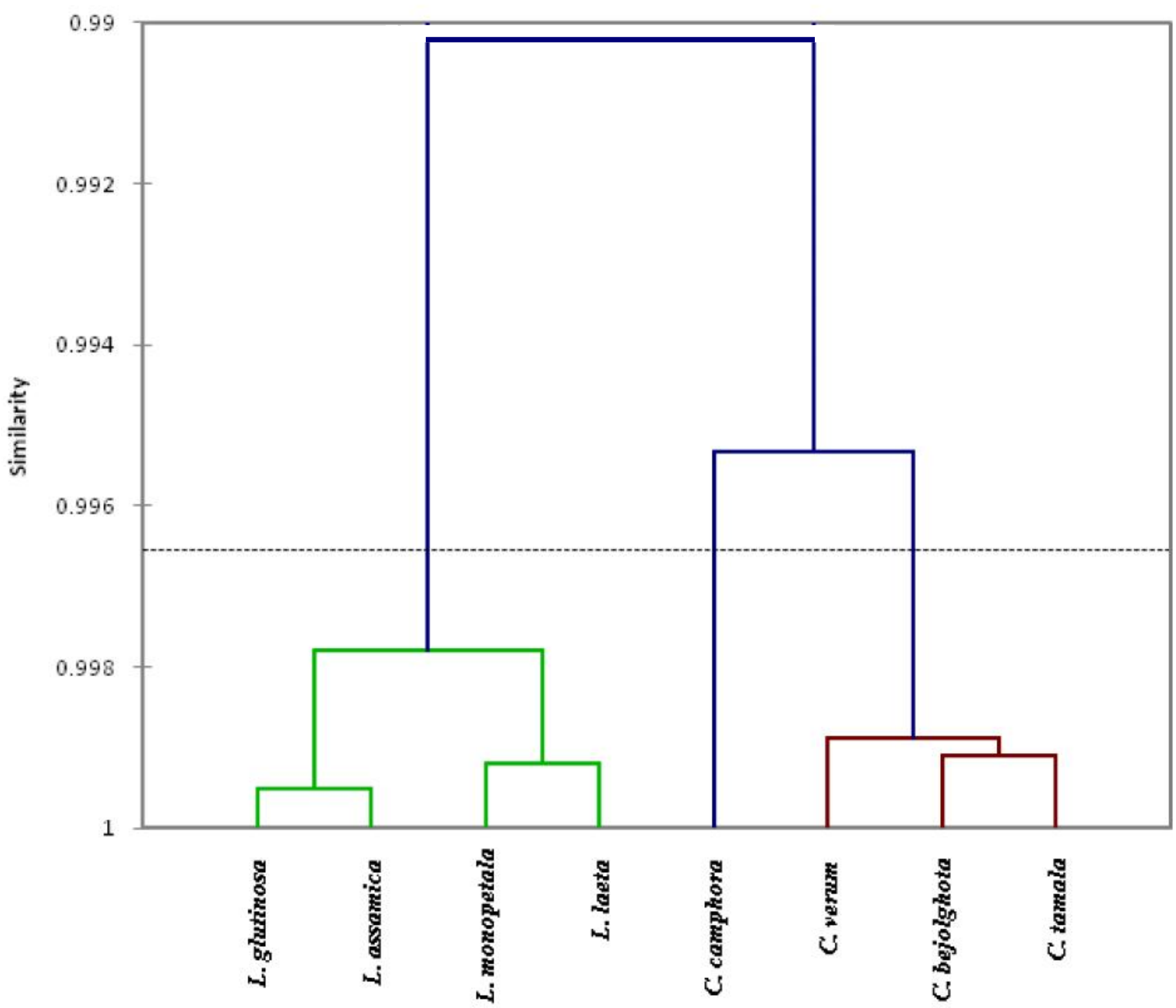

Figure 11.1. Dendrogram of eight species of Laurels from two genera from the Terai-Duars region with the combination of morphological, anatomical and chemical records

11.4. DETERMINED RELATIONSHIP

Although all chapters represent a standard relationship among the eight species of Lauraceae under intensive study but the representation of dendrogram was somewhat different from each other.

Considerable variations were thus observed between different spices of Lauraceae in terms of morphological, anatomical, leaf-architecture as well as different chemical constitutions. So, for obtaining more reliable results all data like morphological, anatomical, chemical and numerical data were applied. After the application, a dendrogram was found where two genera i.e. *Litsea* and *Cinnamomum* were separated (Figure 11.1). In case of *Litsea* two branches were produced first and each branch was further divided into two sub-groups. Total four sub-groupings were formed where *L. glutinosa* and *L. assamica* were more related, and in other branch it was noticed that *L. monopetala* and *L. laeta* were closely associated. On the other hand, for genus *Cinnamomum*, single node was divided into two branches. One branch was represented by *C. camphora* and the other branch split into three lines where the *C. bejolghota* and *C. tamala* exhibited more proximity than *C. verum.*

11.5. THREATS

It is now clear that the plant diversity of Laurels is significant and the ecosystem of Terai-Duars region is somewhat dependent on the wide range of Laurels. Along with other floristic elements, the Laurels of the region at present are under severe threat of losing their habitat mostly due to anthropogenic reasons. Such threats can be perceived only after detailed scientific investigations at different corners of diversified areas of Terai-Duars. The reasons of threats may be -

- The rapid extension of human settlement grabbing the natural habitat areas
- Too much of cattle grazing is destroying seedling and sapling of different plants including Laurels
- Establishment of large tea gardens replacing the natural habitat
- Continued extension of metalled roads and rail-links cris-crossing the forests of Terai and Duars
- Rampant legal and illegal extraction of timber and other plants and plant products
- High fragmentation of ecosystems of the area that has developed there due to their existence in the area for millions of years
- Monoculture plantations (mostly with fast growing exotic species) replacing the local natural forests over wide areas; the dense plants keep extremely limited scope for local species to enter and establish there
- Insect and fungi readily attack the seeds of Laurels
- Extensive socio-economic developmental activities and eco-tourism are adversely affecting the rich diversity of pristine vegetation structure of the entire area where most of the presently recorded species of Lauraceae are surviving
- The pressure for removal or death or extinction of many of these species, along with numerous other important and interesting non-laurel species, is increasing at every moment threatening the existence of the basic vegetation itself.

11.6. CONSERVATION STRATEGIES

As the species of Lauraceae are very important in different manner, so the existence of these species becomes in threat. Human beings are the main culprit for this situation. In one hand the availability of these plants is desirable but, on the other hand, their existence is now highly threatened. So, Laurels deserve special attention for their conservation. The conservation strategies of these species can be as follows-

- The strict regulation need to be strictly imposed to prohibit the entry of unauthorised people into protected areas
- The cattle grazing in the protected areas should be banned
- Illegal and legal extraction of timber and trees for any purpose should not be allowed at any cost
- The entry into the forests for the poachers, hunters and plant collectors should be prevented
- Collection of NTFP (including wild edibles fruits and medicinal plants) need to be controlled efficiently
- Tourism activities should be either minimised or efficiently managed. Eco-friendly procedures or initiatives should be built up in each and every tourism activity;
- Tourists need to be trained and given proper awareness about their activities while they are within the natural vegetation
- Any short of cultivation inside the protected areas should not be allowed
- Artificial forests should be developed only with the local species of different habit groups and not only with very few economically important species of trees
- Rare species need to be propagated through *in vivo* and *in vitro* methods and their populations need to be increased in the vegetation very carefully with extremely careful planning
- Natural habitat need to be saved at any cost not only to save some rare species of plants and animals but also the entire biosphere.