11. GENERAL DISCUSSION AND CONCLUSION:

The Darjiling-Sikkim Himalaya, an integral part of the Eastern Himalayan region is a storehouse of biodiversity, boasting of a large number of important, rare and endangered species of plants. A large section of the region is mountainous with elevations increasing northwards with two transverse ranges running south; the Singalila in the west and the Dongkya in the east, enclosing it. The region exhibits a wide range of altitudinal variations that is instrumental in creating climatic variations ranging from the tropical humid to the arctic type which consequently lead to vegetational variations. The region, however, shows a predominantly temperate vegetation. Its contiguity with other Himalayan ranges and with the plains helped it to host an extremely rich flora. However like all Himalayan regions, this region remains fragile and its vegetation remains under threats from both natural calamities and severe human exploitation. This is particularly true for the mid-hill region which is highly disturbed due to unplanned extension of settlements, faulty and agricultural practices. Thus, there is immediate need to preserve and conserve the natural vegetation of the entire region by proper planning.

11. 1. TAXONOMIC STATUS AND EVOLUTION :

The 230 taxa of *Acer* L. includes 124 species, 95 subspecies (including typical subspecies) 8 varieties and one forma placed under16 Sections, 8 of which are further subdivided into 19 series. The Darjiling-Sikkim Himalaya, where the present study was carried out, is represented by 15 taxa that include 13 species and 2 varieties belonging to 6 series, placed under 6 sections, as has been elaborated in Chapter 3. Moreover, from studies on the morphology, distribution, phenology, major and minor venation, stomata, pollen morphology etc. the position of some of the problematic taxa such as *A.osmastonii, A.caudatum* and *A.sterculiaceum* show distinct characteristics, and thus can to be accorded ranks of distinct species. This also opens a door for further research where studies on the rbcl, protein profile, isozyme studies etc. could be carried out to resolve the existing problem relating to these plants.

The different species show differences in respect to the altitudinal ranges in which they occur. The altitudinal ranges, in which the different species of *Acer* are distributed in the region, varies from the upper ranges of the sub-tropical zone at around 1000m, being the lowermost range where a few species like *A. thomsonii* and *A.oblongum* occur, extending to the sub-alpine zone where *A.pectinatum, Acaudatum, A.stachyophyllum* and *A.acuminatum* prevail. Each species of *Acer* shows a zone of predominance between a lower and higher range of occurrence .

A.campbellii is the most common species in the hills of Darjiling and Sikkim. It shows a very wide lateral and altitudinal distribution extending from 1500 – 3700m. On the other hand, other species like *A.acuminatum* and *A.stachyophyllum* show narrow lateral distribution, occurring only in the north district of Sikkim and *A.osmastonii* is restricted to a small locality in Darjiling. The other species occur in ranges between those of the occurrence of *A.thomsonii* and *A.oblongum* in the lower zone and species like *A.stachyophyllum* and *A,acuminatum* that represent the uppermost zone of ocuurence.

The different species formed associations with the predominant trees of each altitudinal range. The exotic species *A.palmatum* was found to have naturalized in some areas of Darjiling, where they had been introduced as ornamentals.

The harsh climatic conditions in the upper reaches and the low degree of regeneration coupled with high degree of parthenocarpy renders these species being unable to propagate and regenerate, making them succeptible to possible extinction. Thus steps are needed to be undertaken to conserve them, both in *in situ* and in *ex situ* conditions. This is particularly true for species like *A.acuminatum, A.caudatum, A.stachyophyllum* and *A.pectinatum.*

A.osmastonii being endemic and highly restricted to a small locality in Darjiling needs immediate measures for its conservation as the danger looms high that it may soon become extinct.

Except for *A.oblongum* all the other species of the region are deciduous. Other than *A. thomsonii,* all the species shed their leaves in late autumn remaining leafless and dormant during the winter i.e. from December to mid February. In the temperate region, the earliest leaf emergence were found in *A.palmatum* and *A.sikkimense* that occurred in mid-February, while in the sub alpine region break in the domamcy take place much later, in May–June. Thus break of dormance appears to be related to temperature as their emergence of the same species at lower altitudinal ranges are earlier than at upper altitudinal reaches. Only in the case of *A. thomsonii* was the leaf fall found to occur at the end of August, with fresh crops occurring in November. Based on the time of emergence of inflorescence, the different species of *Acer* of the region could be broadly categorized into two groups:

i. Species in which the inflorescence emerge along with the new leaves : This group includes most of the species of the region where 10 of the 13 species that includes *A.caudatum, A.hookeri, A.laevigatum., A.oblongum, A.palmatum,*

A.pectinatum, *A.sikkimense*, *A.stachyophyllum*, *A.sterculiaceum*, and *A.thomsonii* ;

ii. ii) Species in which the inflorescence appear after the initial flush of leaves that is exhibited : *A.campbellii*, and *A.laevigatum*.

The flowering period for the different species occurred from mid February to the end of May except in the case of *A.thomsonii* that flowered in November.

The samaras showed considerable difference in sizes being smallest in *A.palmatum* and *A.hookeri* with the largest found in *A.thomsonii* and *A.sterculiaceum*. Moreover, based upon the angle of divergence of the wings three classes could be recognized.

Class I Angle divergence of wing very acute i.e. less than 45 °: It included species like *A palmatum* 23-25 °, *A. stachyophyllum* 35-37°, *A.pectinautm* 35-40°, *A.laevigatum* 35-40° and *A.caudatum* 37-40°;

Class II : Angle of wing divergence close to around 45°: It included *A.sikkim*ense 44-46°; *A.hookeri* 45-47°, *A. sterculiaceum* 45-47° and

Class III the angle of wing divergence is wide being more than 45°: It included *A.acuminatum* 67-70°, *A.osmastonii* 68-70°, and *A. campbellii* which exhibited the widest wing divergence varying between 70-130°.

Different species showed differences with respect to parthenocarpy, which is regarded as an advanced character. While species like *A. campbellii*, *A. hookeri*, *A. laevigatum*, *A.osmastonii* and *A.palmatum* exhibited weak parthenocarpic tendencies, with most of the fruits enclosing seeds, the tendency was moderate in case of *A.caudatum* and *A.pectinatum*, being high in *A.oblongum*, *A.sterculiaecum*, *A.thomsonii* and the highest *A.acuminatum* and *A.stachyophllum:* where most of the fruits were devoid of seeds. The extremely low rate of seed production i.e. the production of mostly parthenocarpic fruits will certainly have a bearing on the population structure and the conservation strategies of these species.

The winter bud in the different species shows two types of the arrangement of the scales *viz* valvate and imbricate. In the valvate arrangement there is no overlapping of the scales and the outermost remains the largest, completely enclosing the smaller scales along with the leaf and or the inflorescence primodia. Such valvate arrangements were exhibited by *A.acuminatum*, *A.caudatum*, *A. hookeri*, *A.pectinaum*, *A.sikkimense* and *A. stachyophyllum*. In the other species *viz. A. campbellii*, *A.laevigatum*, *A.oblongum*, *A. osmastonii*, *A.sterculiaceum* and *A. thomsonii* the scales overlap showing imbricate

nature of the scales. The species also exhibited a variation in the number of the scale leaves and the manner of their arrangement. The number ranged from 2 pairs as in *A.acuminatum, A. caudatum, A. hookeri, A. pectinatum, A.sikkimense* and *A. stachyophyllum;* 4 pairs in *A.laevigatum* and *A.palmatum* ; five pairs in *A.campbelii* and *A. osmastonii* ; six pairs in *A. oblongum* ; and 10 pairs in *A. thomsoni* and *A. sterculiaceum* These were in conformity with the range of the numbers for the different sections and series that species belong to.

All their morphological observations including venation pattern and stomata showed wide range of differentiation in the genus inhabiting the Eastern Himalaya. The species can be placed under six sections and the other species of all these sections are widely distributed in other countries of the world. This is an indication that more than one species of the genus migrated to this region and then led to the origin of new and local species.

11.2. CONSERVATIONAL REQUIREMENT:

As species like *A.osmastonii, A.stachyophyllum, A.caudatum, A.stachyophyllum* are rare; they deserve immediate attention for their conservation. If the desired amount of seedlings and saplings can be produced, then these plants can be saved through plantation programs. Keeping this in view experiments were carried out to try vegetative propagateion through cuttings. The different species differed with respect to the rooting of cuttings of soft and hard wood when treated with commercially available rooting hormones While the species like *.A. campbellii, A. oblongum, A.laevigatum* and *A.osmastonii,* did not produce roots , moderate rooting was obtained for soft twigs in *A.acuminatum,* and *A. sterculiaceum.* Hard wood rooting occurred in *A. hookeri, A. oblongum, A.pectinatum, A. sikkimense* and *A. sterculiaceum.* Rooting occurred rapidly after 29-31 days in *A.sterculiaceum* but was delayed and took long period over 40 days in *A. acuminatum.* Thus the multiplication of the species through vegetative means is not easy as most of the cuttings which rooted could not establish properly during winter with high degree of mortality.

In most of the *Acer* habitats, fruits are much disturbed and degraded. Insects and fungi readily attack the seeds. Such habitats fail to protect the seedling in natural condition and therefore, the rate of seedling survival is low. It is thus important to grow seedlings of species in controlled environment and carrying out planting at the beginning of favourable seasons for their chance of survival. Some of the species however need to be propagated completely in laboratory conditions through micro propagation techniques.

11.3. INTERACTION WITH OTHER PLANTS IN THE HABITAT :

The genus *Acer* shows allelopathic domination, although it is not as virulent as the domination of certain other trees like *Juglans* and *Quercus.* A large number of chemicals have been reported from the different species of *Acer* ,many of which may have inhibitory effect on the germination and growth of other plants. Moreover as the species are deciduous,their leaves can carry along some of the inhibitory substances to the soil which could affect the germination of other plants. To determine this, seven species of *Acer* belonging to the different sections were chosen and their effects determined on the germination of five test plants that included cultivated and wild species. It was found that there was a differences in the degree of inhibition or stimulation on the different species of test plants by the different species of *Acer.* Broadly speaking, both the leaf extracts and the leaf leachetes showed inhibitory effects at lower dilution but were stimulatory at higher dilution, with the effect of the extracts being more pronounced than those of the leachetes at the same dilutions with a few exceptions. The effects were more pronounced in the cultivated plants as compared to the wild plants. *A. sikkimense* and *A.caudatum* exhibited the highest degree of inhibition .

This allelopathetic effect of the different species of *Acer* maybe responsible for the survival of the species, helping it to propagate by controlling the growth of certain competitors in the habitat. If these allelopathic chemicals could be identified and isolated from these plants, they could be effectively used in controlling weeds in nearby crop fields.

11.4. GENERAL DISCUSSION AND CONCLUSION :

The maples of Darjiling and Sikkim Himalaya thus represent a mixed group of species representing a number of taxonomic sections of the genus. It could be probable that a number of species of *Acer* migrated into the Himalayas from China, the region of its origin. The migrated species, on their arrival differentiated further and produced a number of local species. These local species of *Acer* show wide diversity in their phylogenetic relationship. Not only the habitats of *Acer* are be constantly disturbed, the habitats have turned hostile towards the survival of their seedlings. So, strategies for the conservation of these plants need to be formulated in controlled condition and planting saplings in appropriate seasons so that they get enough time to establish prior to winter, has to be carried out. This has to be done at the earliest to save these wonderful trees. As conservational measures for their protection the different species can be used in different ways. They could be used as road-side trees or as shade trees in the tea gardens which is being initiated in case of *Acer thomsonii* by some of the tea gardens.

Moreover, the maple trees, renowned all over the world for their beauty and glorious colours can also be used for ornamental purposes in landscaping and town planning: this would not only enhance the aesthetic aspect of the region but would also protect the fragile hill slopes from landslides. After all, whether we opt for a green Himalaya or a dry desert – the choice is ours!

At a time, when rampant deforestation, unplanned and excessive growth of settlements are ravaging the delicate equilibrium in the *fragile Himalayan environment,* the author has come to appreciate and understand the indispensable worth of these majestic, stately and awesome maple plant. For *Acer* represents one of the earliest angiosperms to have evolved about 120 milllion years ago in the early Cretaceous and the present species found in the study area are the descendants which chose to migrate toward the Himalaya from the place of origin in China. To lose such a valuable and priceless bounty of nature through ignorance and exploitation would indeed be disastrous not only for the locals of Darjiling and Sikkim but for the entire humanity.