CHAPTER-9

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Throughout the world, there is a growing awarness for the conservation and protection of endangered flora and fauna. Every day more and more species becoming endangered and the rate of loss of species from the biosphere is also getting higher and higher (Singh & Choudhery, 2001). This trend, today, is not restricted to any particular type of vegetation or to any particular zone of the world.

Herblands are, in general, very close type of vegetation, though very low in height. Generally, the species richness is higher in such vegetation, than well established forests or shurblands or even savanna type grasslands, specially, if it occupies a warmer and moist zone of the world. Herblands provide excellant habitat not only for numerous species of plants, numerous species of animals are also living there. Like any other type of vegetations, many endangered and endemic species also prefer to grow in such habitat. Herbland species are not just the weedy plants but they include plants of medicinal, fodder, food for man, aromatic, ornamental, etc. types of plants apart from the plants of unknown uses. May be, today's most unwanted species will be the most wanted species in future. May of these species are now in use as source of genetic materials for the qualitative improvements of economically useful plants.

The Sub-Himalayan Darjeeling region is endowed with rich biodiversity. Most of the areas in this region are now dominated by herbland vegetation after loosing their forest cover. Over the past few decades various destructive activities and ruthless exploitation by the inhabitants have disturbed the delicately balanced natural ecosystems, where, at later stage herblands have developed and maintained by very strong anthropogenic pressure. This has led to the extinction of several species, many are at the verge of extinction and some are endangered. *Sterptocaulon sylvestre* Wight is such an example which is now on the verge of extinction. This rich gene pool of this region is important not only from the point of view of conservation *per se*, but also from the point of ecological and economical security. So conserving the rich biological diversity of these herblands is crucial for maintenence the ecological balance. However, scientific knowledge of these herbland ecosystems and technical skills are vital in order to conserve their biodiversity.

9.1. REALISATION OF PLANT BIODIVERSITY

The phytosociological investigation of the diverse types of herbages growing in four different Sub-Himalayan herblands was undertaken quantitatively by random

quadrat sampling method during July 1997 to June 1999. Basic information about abundance, density, frequency and dominance of different members of the vegetation are the pre-requisites to frame a strategy to conserve them. Data collected from 360 quadrats (1m × 1m) have been analysed for the determination of abundance, density, frequency, relative density, relative frequency, relative dominance and importance value index. Moreover, some other secondary parameters including Simpson's index, Shannon-Weiner index, richness and evenness indices, similarity and dissimilarity indices, maturity index and generic coefficient have also been analysed for better understanding the ecological characters of the vegetation.

9.1.1. SIMILARITIES/DISSIMILARITIES IN VEGETATIONAL SEGMENTS

The four communities diversified in vegetation characters, although there was a broad similarity in the composition of major species. Moreover, climatic seasonality was also influenced markedly on the vegetation characters within the community. A total of 227 plant species belonging to 49 families were recorded from four different sities (sites-I, II, III and IV). This list, of course, did not include all of the species present in these herblands, since some of the species did not come under the quadrats. Out of these, 129 species were recorded in site-I, 123 species were in site-II, 98 species were in site-III and 99 species were in site-IV. Again, 33 of these species were found to occur in all the four sites (Table-3.39). Within the survey period highest number of individuals were recorded from site-II in almost all the seasons. Moreover, it occupied highest number of individuals (26,974) in monsoon 1997 (from 20 quatrats) which was the highest number among all the four different sites in different seasons. Lowest number of individuals, on the other hand, were listed from site-IV which showed maximum of 13588 individuals in summer-1999 season.

Borreria alata was recorded as most dominant species in sites-I, II and III. Again, it had the highest number of 8824 individuals (from 20 quadrats) in summer 1999 at site-II which was found highest among the four study sites in different seasons. The determined percentage frequency and relative frequency values revealed that *Sporobolus inidcus, Borreria alata, Saccharum spontaneum, Cymbopogon pendulus* and *Rungia pectinata* were the most frequently available species at sites-I and II. Besides, *Borreria alata* and *Leucas indica* were recorded as most frequent species in site-III. In site-IV none of the species showed frequent distribution in three different seasons. The maximum basal area cover was occupied by *Cymbopogon pendulus, Sporobolus indicus* and *Borreria alata* in sites-I and II. *Borreria alata* and *Saccharum spontaneum* contributed to the highest basal area cover in site-III.

The determined IVI values revealed that *Borreria alata, Sporobolus indicus, Saccharum spontaneum, Cymbopogon pendulus, Prunella vulgaris, Rungia pectinata, Mitracarpus verticillatus, Phyllanthus virgatus, Imperata cylindrica, Pueraria phaseoloides* and *Phyllanthus urinaria* were the most important herbages in site-I and in site-III. Based on IVI, the dominant species at site-III were *Borreria alata, Saccharum spontaneum, Cyperus alulatus, Ageratum houstonianum, Echinochloa crusgalli, Phyllanthus virgatus, Ageratum conyzoides, Imperata cylindrica, Rungia pectinata, Leucas indica* and *Cynodon dactylon.* On the other hand, *Cynodon dactylon, Imperata cylindrica, Murdannia nudiflora, Saccharum spontaneum, Sporobolus indicus, Echinochloa crusgalli, Hydrocotyle sibthorpioides, Paspalum scrobiculatum, Eleusine indica, Cyperus iria, Desmodium triflorum* and *Tonningia axillaris* showed highest IVI in site-IV.

Out of the recorded 227 species, only 33 species were found to occur (common) in all the four sites but with varying degree of abundance. These were *Ageratum conyzoides, Axonopus compressus, Borreria alata, Brachiaria reptans, Chrysopogon aciculatus, Cynodon dactylon, Cyperus alulatus, Cyperus compressus, Desmodium triflorum, Digitaria bicornis, Digitaria ciliaris, Eleusine indica, Eragrostis gangetica, Eragrostis nigra, Fimbriaria* sp. *Fimbristylis dichotoma, Hedyotis corymbosa, Hedyotis diffusa, Imperata cylindrica, Lindernia ciliata, Lindernia crustacea, Lindernia multiflora, Lindernia pyxidaria, Lobelia alsinoides, Merremia hirta, Murdannia nudiflora, Paspalum scrobiculatum, Phyllanthus virgatus, Rungia pectinata, Saccharum spontaneum, Selaginella* sp., *Sporobolus indicus* and *Vernonia cinerea.* In addition, there were some uncommon species which were found in only one site (Table-3.39). The number of these uncommon speices were 29, 19, 23 and 32 in sites-I, II, III and IV, respectively. Speices represented by one individual was considered rare. Only 19 such species were recognised, which were represented by only one individual in only one quadrat in one site. (Table-3.40). These were *Acacia auriculiformis* (seedling), *Breynia retusa, Cassia occidentalis, Centranthera indica, Centranthera nepalensis, Chromolaena odorata, Conyza canadensis, Crotalaria juncea, Curculigo orchioides, Desmodium laxiflorum, Exacum tetragonum, Ixeris polycephala, Leucaena leucocephala, Lygodium flexuosum, Mitrasacme indica, Osbeckia nepalensis, Polygala linarifolia, Stephania japonica* and *Xanthium indicum.* Although it is not that all these species are rare in this region, rather, majority of these are common in places around the demarcated sites. But, due to the special structure of selected pieces of vegetation these plants could not grow there properly or luxuriently or with a good population structure.

Almost all the study sites were showed a remarkable degree of dissimilarity in species composition among them. The flora of site-I closely resembled those of site-II was evidenced by high similarity coefficient between them (Table-3.23). In comparison with sites-III and IV, sites-I and II showed greater plant density and basal area cover. Relatively higher similarity between the sites-I and II was obviously because these two sites are adjacent and located within the same climatic region. Moreover, sites-III and IV were more disturbed as these are open fields and the anthropogenic activities are too high in the village environment. On the other hand, site-I and site-II were controlled by the University authority and was comparatively less disturbed specially during monsoon and summer.

9.1.2. IMPACT OF CLIMATE ON BIODIVERSITY

The impact of climatic fluctuations was reflected in community characteristics like floristic make-up, density, abundance, basal area and species diversity which showed marked seasonal variations within the site. Speices diversity was maximum during monsoon season at all the study sites when communities attained the optimum stage of development. Last summer and monsoon seasons were the most cogenial period for plants because of the prevalence of warm ambient temperatures, adequate moisture and less edaphic stress on the roots of plants.

In April, the density of herbage was increased. In early April shooting was followed by early showers of monsoon which helped in the emergence of numerous seedlings, and thereafter grew rapidly during the month of June and reaching it maximum in August. Relatively higher species diversity during monsoon season may be ascribed to the establishment of seedling of a number of species both annuals and perennials, sprouting from the underground perennating rhizomes and root stocks in numerous perennials and vegetative growth leading to optimum development of the community. Generally density and frequency of herbages in December and January remain low, perhaps, because most of the plants complete their life cycle by this time and the seeds of a good proportion of Therophytes remain dormant in the soil. However, the reduction in number of species and individuals was gradual and was minimum in late February and March. The herbages density and frequency in general were reduced to a great extent during this period. The main cause for this decrease may be ascribed to the reponse of herbaceous species to moisture deficiency in soil and the climate which was characterized by low humidity and considerably low temperature.

During invesitgation, it was observed that species diversity exhibited a negative relationship with the concentration of dominance. In all the four sites highest value of Shannon-Weiner index (diversity index) and lowest value of Simpson's index were observed in monsoon season. The Shannon-Weiner index showed inverse relationship with the Simpson's index. Likewise, the Hill's diversity numbers were observed to be negatively related with the Simpson's index and positively related with the Shannon-Weiner index. Quantitative description of diversity and dominance and their relationship have been reported with reference to both aquatic (Patten, 1963; Margalef, 1967) and terrestrial ecosystems (McNaughton, 1967; Singh & Misra, 1969). The findings are contradictory with respect to both aquatic and terrestrial ecsystems. In the present study the inverse relationship between diversity and dominance is in accordance with the reports of Mc Naughton (1967); Singh & Mishra (1969) and Murthy & Pathak (1972); and Joshi *et al.* (1990). This may generalise that when a community becomes floristically diverse, its dominance value becomes more dispersed among the existing species.

9.2. DIFFERENTIAL DISTRIBUTION OF HERBLAND FLORA

The recorded 227 species comes under 141 genera and 44 families of angiosperms and 5 genera and 5 families of pteridophytes. Dicotyledons are represented by 132 species, 90 genera and 38 families and monocotyledons are represented by 90 species, 51 genera and 6 families. Dominant plant families include Scrophulariaceae, Compositae, Papilionaceae and Rubiaceae among the dicotyledons, while Gramineae (Poaceae) and Cyperaceae were dominant among the monocotyledons. Based on population, Poaceae was the most individualized family. The exceptionally broad ecological amplitude of Poaceae rendered them as the most successful family. Their modes of propagation, development of apomictic embryo, high rate of vegetative propagation by runners, sobols, tillers etc. are behind their success.

Contribution of individuals of other three families namely Cyperaceae, Scrophulariaceae and Rubiaceae were also similar. All the three families are cosmopolitan in distribution, produce easily dispersible small seeds and have wide ecological amplitude. Furthermore, members of Cyperaceae can produce numberous vegetative propagules. All these characters probably help the members of Cyperaceae, Scrophulariaceae and Rubiaceae to be successful species in herbland. However, success of other families like Papilionaceae, Compositae, Acanthaceae, Labiatae etc. are due to their wide ecological amplitude, large number of seeds, wide flowering and fruiting period etc.

9.3. *Streptocaulon sylvestre* AND ITS ASSOCIATION

The appraisement of degree of association helps in understanding the autecology and proportional distribution pattern of one species with respect to other species in the community. *Streptocaulon sylvestre* Wight is now growing in the herbland communities of site-I and site-II.

Results reveal that most of the association between *Streptocaulon sylvestre* and other species in different seasons were not strong as evident from different indices of association (Ochiai, Dice and Jaccard) and some of them exhibited no association at all. But few species namely *Borreria alata, Phyllanthus urinaria, Cymbopogon pendulus, Desmodium triflorum, Sporobolus indicus, Pueraria phaseoloides, Saccharum spontaneum, Crotalaria prostrata, Paspalum scrobiculatum, Phyllanthus virgatus, Elephantopus scaber, Rungia pectinata, Zornia gibbosa, Imperata cylindrica, Vernonia cinerea, Mitracarpus verticillatus, Schizachyrium brevifolium* etc. were highly associated with *Streptocaulon sylvestre.* Also, the type of association of most of the pairs were negative and the chi-square value for most of them were not significant. These observations corroborate the findings of many workers including Whittaker (1970), Turkington & Harper (1979), Misra & Misra (1981), Thorhallsdottir's (1990). Whittaker (1970) mentioned that "association between species are for the most part not strong; and many pairs of species in a community may show none". Turkington & Harper (1979) working in a grassland community in North Wales in 1973 observed that among the grasses, positive associatins were very few, but negative associations are abundant.

In most of the cases *S. sylvestre* was highly associated and showed positive association with *Zornia gibbosa, Pueraria phaseoloides, Crotalaria prostrate* and *Desmodium triflorum* all of which are leguminous herbs. This can perhaps be attributed to the nutritional requirement of *S. sylvestre* being met by the supply of nitrogenous substances fixed by its leguminous associates. Similar type of positive association between *Trifolium (Legume)* and *Lolium* (grass) has been reported by Kershaw (1958, 1959). Misra & Misra (1981) have also been reported similar type of association between *Zornia* and *Desmodium* with non leguminous forbs.

Both test of association and indices of association showed that *S. sylvestre* and *Cymbopogon pendulus* were positively and highly associated in almost all seasons. This was probably due to shade requirement and nutrition facilities of *S. sylvestre. Cymbopogon pendulus,* a perennial tall grass species, reaching a maximum height of 2.0 - 3.0 m during September to January and form a very dense umbrella

over the vegetation which cuts the supply of enough sun light for the plants growing in lower strata, specially the ground covering ones. While *S. sylvestre* a prostrate suffrutescent which never produce even a slightly upright stem, perennial, also sprouts throughout the year but maximum branching started in the early March which matured during late monsoon, form a carpet like growth around the base of *C. pendulus* on the ground. However, most of the plants of *S. sylvestre* fruiting under the shade of *C. pendulus* during this period.

Borreria alata, Phyllanthus virgatus, Phyllanthus urinaria, Rungia pectinata, Vernonia cinerea, Elephantopus scaber and *Mitracarpus verticillaus* were highly associated with *Streptocaulon sylvestre* in almost all seasons. This was probably due to similar type of habitat requirement, particularly that for soil moisture. Five grass species viz. *Sporobolus indicus, Imperata cylindrica, Saccharum spontaneum, Schizachyrium brevifolium* and *Paspalum scrobiculatum* were highly associated with *S. sylvestre*. This was probably due to protection and nutrition facilities received of *S. sylvestre* on their good responses to similar type of habitat conditions. The growth of these species form a vegetation cover over the ground and considerably stabilize the soil and save the land. Their presence in the habitat conservs the soil which otherwise would get eroded if the land is bare. They are also found to very effective soil binders and definitely add a good amount of humus to the soil. Their underground parts are found to be far more effective in binding the soil. They provide home for a large number of species. These species provide protection and create an environment for nursing the *S. sylvestre* growing near them which other wise would have been easily eleminated.

However, the causal factors for the positive and negative association of species have been postulated by different authors including Kershaw (1958, 1959, 1973), Greigh-Smith & Cottam (1964), Smith & Cottam (1967), Pielou (1969), Whittaker (1970). Kershaw (1973) mentioned three main causal factors for the positive and negative association of different species, viz. (i) similar or dissimilar environmental requirement, (ii) modification of the environment by one species allowing the establishment of other species, (iii) production of toxic substances by plants (i.e. allelopathic effect), and competition. Singh (1969), while studying the interspecific association of two forb species, *Murdannia malabarica* and *Fimbristylis schoenoides* in the grasslands of Varanasi, attributed the differential associations to the overlapping habitat requirement, and site condition. However, many factors are functioning for the association of species in a community. A slight variation in the environment can lead to positive or negative association between species. Of course, the microhabitat

of the area can play a major role in bringing the positive and negative association between species, though it has not been analysed in the present study. As the herblands under study were under heavy grazing, one must consider the important historic factors such as grazing, mowing, soil compaction, small drains and other biotic disturbances, which might have influenced the vegetation in the past.

9.4. PROMINANCE OF CLIMATE MEDIATED PHENOLOGY

Phenology comprehends all studies of the relationship between climatic factors and periodic phenomena in organisms. The concept and significance of phenological investigations have been discussed in detail by Lieth (1970), Lieth & Radford (1971). During the present investigation different phenological parameters including seedling appearance, vegetative growth, flowering, fruiting, seed dispersal and death and / or resting periods of different species of the Sub-Himalayan herblands were studied. Phenological observations of different species showed nearly a similar pattern of response to the local climatic coditions. Majority of the species studied for the purpose broke their dormancy between April and October and their seedlings or new shoots appeared after resting within this period. The peak period of seedling or new shoot appearance was May when about 74.77 % species showed their juvenile stage in these herblands. However, rainfall and temperature are the main controlling factors for breaking the dormancy of these plants in the study area. Seedling appearance was followed by vegetative growth which continued till the initiation of flowering. Vegetative growth of most of the species was observed between April and October, with a peak during May to July, when about 92.03 % species of plants grew vegetatively.

As the majority of the herbaceous species are with short life span, so, flowering and fruiting are simultaneous process in them. Maximum number of species opened their flowering buds in late July or early August and, generally, continued upto winter. Moreover, at least 20 species flowered more or less throughout the year (Table-4.1). Most of the species selected the post monsoon period for their fruit development. About 73 % species showed the peak of fruiting during this period. Seed dispersal period was almost simultaneous with the fruit ripening period. Seed dispersal occurred within 4 - 6 weeks after fruiting. Most of the species selected the winter period for their seed set and dispersal. In winter sharp decline in temparature and low soil moisture content prevented plant growth and almost all the species were found to die or rest at the middle of this season. However, germination, sprouting, vegetative growth, flowering, fruiting, seed maturation and dormancy induction of different

species appeared to be directly regulated by soil moisture and atmospheric temperture of the study area.

Various ecological factors influenced the phenology of *Streptocaulon sylvestre.* It reproduced exclusively sexually by means of seeds during May to August and then entered a short resting period in winter when most of its areal parts dies. It initiated sprouting from the hiden perennating stem, situated almost at the ground levels, during February to June which is followed by vigorous growth. Sprouted plants flowered during March to February with a peak during March to May. Fruitification also took place from March to February and only 9.21 % plants produced fruits. However seed dispersal was observed during September to March after which most of the plants entered into dormant stage. The periodicity of these phenophases reflects seasonal distribution of specific kind of resouces such as flower, pollen, fruit, seeds etc. of this specific species. This kind of informations would be a great help in implementing scientific multiplication / developmental programmes, proper utilization and management of resources as well as for the conservation of the species.

9.5. REALISATION THROUGH BIOLOGICAL SPECTRUM

The life forms of an association indicate the characters of the habitat and the nature of the climate. Raunkiaer (1934) believed that llife form spectrum or biological spectrum of the area is a reflex of its climate. Warm climates have higher percentage of Phanerophytes, cold climate have more of Chamaephytes and Hemicryptophytes, deserts have predominance of Therophytes (Smith, 1980) Biotic disturbance and relative dryness tend to increase the percentage of Therophytes (Cain, 1950; Daubenmire, 1968). The highest percentage of the life-form spectrum of these herblands was contributed to Therophytes (75.33 %) and the lowest by Phanerophytes (3.52 %). Again, most of these Phanerophytes achieve normal habit in these herblands. Thus increase in Therophytes compared to normal proportion indicates biotic disturbance or degradation of these vegetation. When compared to other community spectra observed by Singh & Ambasht (1975), Misra & Misra (1979a), it was noted that life forms in the present sites mostly resembled the tropical grasslands. Similar types of phytoclimates have also been reported by Varma & Das (1980) and Devi *et al.* (2000) in the grasslands of Madhya Pradesh and Manipur, respectively.

9.6. SOIL PROVIDES THE BASIC FRAMEWORK FOR THE VEGETATION

Soil, the loose outer crust of the earth's surface, provides a substrate as well

as an environment for the growth of plants. Characterisation of soils is essential for conservation and management practice of plant biodiversity. Some physicochemical properties of the soils of four herblands have been studied. They were loamy sand in sites-I and II and sandy loam in site-III. These soils contained varying proportions of sandstone and shells. The soils were silty loam in site-IV. All the soils under study were acidic in nature (pH 4.10 - 5.65) and contained low clay content (6.50 to 8.25 %). The percentage of the soil orgainc matter of four different sites ranged from 1.00 to 2.15. The organic matter content of the soil was generally high in sites-I, II and III. Surface layer of the soil contained high amount of organic matter and total nitrogen which were decreased with the increase of soil depth. According to the critical levels (Viets & Lindsay, 1973) almost all the soils were rich in iron and coper and were deficient in manganese and zinc. However, the results in general, indicate that the soils of sites-I, II and III are almost similar in nature. The higher amount of organic matter content in these soils is probably due to the accumulation of large amount of various herbage roots and comparatively low temperature and heavy rainfall of the Sub-Himalayan region.

9.7. REPRODUCTION AND VULNERABILITY OF *Streptocaulon sylvestre*

Ecophysiological study of seed germination is fundamental for understanding the growth and development of a plant species under a set of enviromental conditions. *Streptocaulon sylvestre* Wight is now known to grow only in two very small herblands. It is very much essential to findout the difficulties in its propagation and dispersal. It reproduces exclusively sexually by means of seeds which are produced annually and the species never reproduces asexually. In the present study, an attempt has been made to investigate seed germination capacity and seedling survivability of this critically endangered species.

From the observation it is seen that seeds of *S. sylvestre* have low (or lack of) initial dormancy and 90.00 % seeds remain viable for more than three years. This lack of early dormancy is of much disadvantage to the continuance of the species because it has no capacity to prevent germination under circumstances uncongenial to seedling survival. Seeds of this species were adapted to germinate in relatively wide range of temperature. Range of temperature suitable for germination was 10 ° to 30 °C. However, 25 °C was the most suitable temparature. Results revealed that light is not a necessity for the germination of seeds of this species. Percentage of germination was almost equal in complete darkness and in day light condition.

However, germination was fastest in continuous dark condition.

It was observed that seeds of *S. sylvestre* germinated poor in soil. Soil moisture, nutrients and microbial activities might be the probable causes of low rate of germination. During investigation, it was seen that the moisture in the surface layer of the soil was continuously depleted due to evaporation and seeds lying on soil surfaces were exposed to the risk of dehydration and thus caused delayed or less germination in the soil. Variation of pH levels also had some effect on seed germination of *S. sylvestre*. This species was tolerant to pH 5.00 to 8.00 and also showed more tolerance to lower pH instead of higher. During investigation it was seen that sodium chloride stress decreased its germination percentage and seedling growth. Increase in salt concentration progressively reduced the percentage of germination. Although seedlings can be grown successfully with 88 % seed germination and satisfactory shoot growth was observed in NaCl solutions up to 2.00 g/l concentration.

Gibberellic acid was observed to be ineffective or slightly promotive to limited extent on seed germination of *S. sylvestre*. Maximum germination percentage of 98.00 ± 2.00 was achieved at 0.2 and 0.5 mg/l GA_3 solutions. It enhanced the shoot growth at some specific concentrations (0.1, 0.5, 1.0 and 2.0 mg/l) but decreased root length in all the concentrations under experiment (Table-6.12). Likewise, BAP and IAA solutions also showed better germination percentage in some specific concentration. As far as the seedling growth is concerned, BAP reduced the seedling elongation of *S. sylvestre*. Total length of seedlling, on the other hand, was appeared to be promoted at almost all concentrations of IAA. Although shoot length was observed to be inhibited but root length was remarkably enhanced at all the concentrations of IAA used in the present investigation. However, seed germination and seedling growth of *S. sylvestre* could be inhibited by the treatment of 2, 4-D and the degree of inhibition was concentration dependent. The root growth of the seedling was more affected than the shoot in 2, 4-D treatment.

From the present set of experiments it is seen that the reproductive capacity of *S. sylvestre* was also very low. This was due to very low seed output and low germination percentage of the species in soil. Moreover, the percentage of seedling mortality was much higher than the seedling survivability in *S. sylvestre*. Absence of early dormancy allowed rapid germination of dispersal seeds to a ephimeral favourable condition which was uncongenial to seedling survivability. Immediately after germinatioon the seedling might be expose to extremes of many environmental factors. In April and May temporary rainfall favoured rapid germination of seeds

which subsequently experience dryness or water stress around seedling roots causing permanent damage. The low water retention capacity of soil creates the condition untolerable. In addition, heavy rainfall during June to September washed off the seeds and young seedlings of this species. However, biotic agents like unknown soil fauna, microorganisms, insects and grazing animals also damaged young seedlings of *S. sylvestre.*

9.8. ATTEMPT TO *IN VITRO* PROPAGATION

In vitro propagation has been conducted to find out suitable media for initiation of seed germination and growth. The characteristics of callus initiation and growth was also studied. The frequency of callus induction and shoot regeneration of *S. sylvestre* was influenced by the type of explant and kind and concentration of hormore added to the medium. Highest percentage of callusing was obtained when the cotyledons were cultured on MS medium supplemented with 0.5 mg/l 2, 4-D.

9.9. ASSOCIATES AFFECT THROUGH ALLELOPATHY

Allelopathic effect of 16 herbaceous species commonly associated to *S. sylvestre* were examined on seed germination and seedling growth of this endangered species for better understanding the problems hindering its quick propagation and development. From the observations made with the leachates and extracts of different species individually and the leachates of different species in combination, it is seen that none of the leachates or extracts or mixed solutions at highest concentration (1 : 2.5) showed promotory effect instead, wide degree of inhibitory effects were expressed clearly on the germination of seeds and subsequent seedling growth of *S. sylvestre*. The inhibition was progressively decreased with the increase of the dilution of test solutions. Results revealed that *Pueraria phaseoloides* was a highly toxic plant which strongly inhibited the germination and seedling growth of *S. sylvestre* though this is a very common associate species. Moreover, other four associate species viz. *Desmodium triflorum, Carex indica, Lindernia crustacea* and *Saccharum spontaneum* were also found to be highly inhibitory to the seed germination and seedling growth of *S. sylvestre.* It may be intimated that these plants not only compete with *S. sylvestre* but also interact effectively due to their allelopathic potentialities.

It was also phenomenal and interesting that leachates or extracts of *Cymbopogon pendulus* and *Elephantopus scaber* at lower concentrations showed better rate of germination and stimulated seedling growth of *S. sylvestre.* Likewise,

Mitracarpus verticillatus, Sporobolus indicus, Vernonia cinerea, Mnesithea laevis, Prunella vulgaris and *Rungia pectinata* at lower concentrations also stimulated the seedling growth. The results inferred that the growth inhibitory compounds due to autotoxic principles contained in the plant tissue were concentration rate dependent which varied from species to species. At lower concentrations, with some species, these compounds did not inhibit the germination or seedling growth or rather tended to stimulate, whereas at higher concentrations they inhibited the germination and seedling growth of *S. sylvestre*. Tripathi *et al.* (1981) found that the phenomenon of allelopathy varies with species. The variability depends upon the nature of the test species and concentration of allelochemics.

Since the effect of leachates or extracts were concentration dependent, the compound (s) responsible for inhibition or stimulation are supposed to be water soluble. It is verisimilar that these compounds leach out from the plants during monsoon or during the decomposition of residues and then get absorbed into the soil. If sufficient moisture is available in the soil, it is being consumed heavily by the plants. There is every likelyhood of the release of water soluble substances from the plant system when it is enjoying the precipitation. This would result in the occurrence of the most potent plant inhibitors as well as other water soluble substances into the soil which may exhibit a kind of allelopathic effect on the associate plants. However, the allelochemicals present in associated plants get released into the soil through the residue incorporation or leach out from the plants, are inhibitory or stimulatory to seed germination, growth and development of *S. sylvestre*. As suggested by Pellissier (1993), Rao *et al.* (1994), Kaur *et al.* (1999), here also, field experiments are necessary before any final conclusions are made on allelopathic effect of associate herbs on the propagation and development of *S. sylvestre*.

However, the present set of investigation on the herbland vegetation of the Sub-Himalayan Darjeeling region has accumulated a considerable amount of data on floristics, their habit and habitat, phytosociological characters, phenology, edaphic characters etc. Moreover, the study on *Streptocaulon sylvestre* Wight has contributed some relevent informations including the basic ecological conditions of its past and present areas of distribution, nature of association, *in vitro* and *in vivo* propagation strategies, phenological periodicity, allelopathic responses etc. towards the academic as well as applied venture. The knowledge of all these informations are remarkable requirements for the scientific approach of conservation of the Sub-Himalayan herbalnds which in turn will save the existance of many rare and endangered plants of the locality including *Streptocaulon sylvestre* Wight.

9.10. CONCLUSION

Sub-Himalayan herblands of Darjeeling, though generally secondary in nature, are known to nurture a very rich flora, which has been substantiated in present set of survey in four discrete harblands, which are known as present and/or past habitats of a Critically Endangered species, *Streptocaulon sylvestre* Wight (Asclepiadaceae). If surveyed extensively over the wide areas the existence of many more such threatened and endangered plants will be discovered in the widely distributed herblands (including grasslands) of Terai and Doars (adjacent to Terai). Habitat of each of such plants need to be studied properly to perceive the nature of threat they are facing, which will certainly help to develop strategies for their conservation. During present set of investigation some of these points have been taken up to understand the reasons behind such an extremely restricted distribution of S. *sylvestre*.

The habitat structure of *S. sylvestre* is so specific that the species do not grow properly on earthen pots (even with soil from its habitat) or in a different type of habitat situated only about 150 m away from its only known natural habitat.
A species may become threatened due to many reasons which may include its genetic weakness, absence of proper pollinator, problems of seed germination in the local environmental set-up, problems in seedling establishment, too much of anthropogenic and other type of biotic interferences, allelopathic effects of associate flora on different stages of life cycle etc. and for developing a conservation strategy for such a species all these points are to be looked after.

However, from the present set of observations it is inferred that the implementation of following set of suggestions may help the conservation of this Critically Endangered Asclepiad.

1. In the present study, Sites I & II are the only known places where *Streptocaulon sylvestre* is known to grow. These two sites may be conserved to check the further loss.
2. A barbed wire fencing to keep away the grazing animals and to remove the seedlings of any tree species growing there are enough to protect these two sites.
3. Introduction of highly associated species (e.g. *Cymbopogon pendulus, Saccharum spontaneum, Borreria alata, Sporobolus indicus* etc.) in other herblands of the area may create a condition congenial for the growth of *S. sylvestre*.
4. Trials may also be given in the habitats of other species of this genus.
5. Nearly similar type of herblands (looks like Savanna during September to

February) are not rare in Terai and Doars, if these are protected from anthropogenic activities including their modification (mainly for developing tea gardens and habitations), grazing and fire a large number of species will be conserved there.

6. Researches related to the propagation and utilisation of *S. sylvestre* and such other rare species and their introduction in cultivation may be helpful in their conservation.
7. *S. sylvestre* can be used as an ornamental plant if its cultural practice can be developed.
8. Creation of public awareness and their involvement in the conservation practices is also extremely important in the present day scenario.
9. A motivated syllabus at school level to insert the ideas related to the importance of wild species and conservation of endangered plants and animals at the young age.
10. Botanic Gardens, Science Clubs, Nature Study Camps, electronic media etc. can play very effective role in this regard.
11. Mandatory training programs for tourists interested to visit the biodiversity rich areas, specially Wild Life Sanctuaries, National Parks and other types of conservatories are to be undertaken so that the nuisance caused by them can be controlled in a much better way.
12. Establishment of a local *ex situ* conservatory may save many interesting floristic elements of this area.
13. Further research on the ecosystem structure, allelopathy, soil characteristics (with much stress on micronutrients/trace elements), pollination biology, micropropagation etc. may be taken up to understand the restriction in behaviour pattern of these rare and endangered plants of this region.
14. As rare plants rarely come in contact with man so researches are essential to find out any possibility to use them for our benefit.
15. Similar treatments are also essential for the rare and endangered plants of other types of vegetation not only of the foothill region, but also for the entire hill region of Darjeeling and Sikkim Himalayas, and
16. Establishment of national, regional and international policy frameworks that foster the sustainable use of herbland resources and the maintenance of biodiversity.

If all these steps are followed seriously, then, it is expected that most of the rare and endangered species of plants can be saved for the future exploitation by man and, one day, many of these plants may be proved as extremely useful even for the survival for the mankind.