Chapter 9

CONCLUSIONS

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The survey conducted in Sikkim part of the Eastern Himalaya, covering the altitudinal range of 500 – 3300 m in the East district, which covers wide range of climatic zones from tropical to sub-alpine conditions. The work was aimed to understand the relation between species richness and biomass production with the change of altitude, that is, in turn, linked to different environmental set-up.

After completion of the work and analysis of data, it is now clear that the species composition in the study area changes with the increase or decrease of altitude. During the survey, highest number of species has been recorded from the vegetation located around the 2200 m elevation. However, highest number of tree species has been spotted at the junction of tropical and sub-tropical conditions at around 900 m altitude. At the same time, distribution pattern of different species of trees changes with change of elevation that expresses the degree of adoptability of each and every species to the altitude based changes in the habitat. With the increase or decrease of altitude most of the environmental parameters get affected and those, in turn, again lead to the modification of some other elements of the habitat including soil organic matter, rate of decomposition of rock, water holding capacity of soil, pH of soil and water etc. And, all these are basic factors for the selection of species for any particular habitat. So, a habitat with sharp change in altitude over a very small distance show quick change in nature of vegetation including the participating species of plants.

The species richness was also linked to availability of water, aspect, exposure to strong wind and, of course, with the degree of anthropogenic disturbances including location of human settlements and their type of road link with the urban areas. After altitude, in Sikkim Himalaya, water is a very important factor which is available in sufficient amount for the vegetation in most of the areas. So, apparently, water cannot be the very important factor behind the selection of species especially up to the temperate region. But, aspect of the habitat is extremely important as it is related to the availability of sun-light, facing strong wind or even the severity of snow fall.

Strong wind is very important as it is responsible for soil erosion, land slide, establishment of individual plants, distribution of seeds, availability of pollinators, accumulation and melting of snow, etc. So, in wind-facing and opposite side's vegetation formation will be completely different. Almost no soft soil will be available on the surface and that will work against the establishment of shallow rooted plants, especially those are without rhizome/ runner/ lower prostrate stem producing numerous adventitious root system. That means, strong wind interfere with the anchoring and settlement of plants in the habitat.

The Himalaya Biodiversity Hotspot is also recognised as one 'Hottest of Hotspots' due to excessive loss of natural habitat. It is also true for the Sikkim part of the Himalayas. Anthropogenic activities are the most serious influences and factors for the change of numerous habitat conditions, removal and introduction of species, selection of species, etc. Anthropogenic interference is quite high in many parts of the study area. This directly influence the species richness of an area and is also found true in the East district of Sikkim.

The direct field-based methods for determining the (i) relation between species richness against elevation, and (ii) relation between species richness against biomass accumulation, has resulted almost uniform and acceptable result. Both, species richness and above ground biomass, along the elevation gradient showing strongly positive relationships. So, direct method, in most cases, produce the most reliable and usable result where-ever it is possible to take up.

At the same time, the indirect method of determining such relations using remote sensing techniques using satellite imageries also known to produce similar and reliable results for larges geographical areas. However, for the present investigation, the result was little different mostly due to the utilization of different scales for data collection in field and in remote sensing methods or may be due to the small coverage geographical area of the study.

This proves that through the use of satellite imageries along with suitable ground trothing can also be used effectively to establish such relationships. But, for this proper adjustment between two scales need to develop with some suitable modifications in the methodology. The result produced through this method is more laboratory oriented and can be repeated in quick succession. This method also can indicate the sudden changes in vegetation if any and can raise necessary alarm so that necessary steps can be taken on emergency basis if such a situation arises any time.

However, the essence of the entire work can be summarised as:

1. The flora of the study area has been characterised with quite high species richness
2. The species richness is high in the middle and low altitude areas
3. It decreases with the increase of elevation after 2200 m elevation
4. Species richness and biomass accumulation along the elevation gradient are showing strong positive relationship
5. Tree diversity also reduces fast with the increase of altitude
6. Scaling effect has been seen in the species diversity and biomass along the altitude
7. More intensive research is needed in different scale for better understanding the relationship between species richness and productivity along the altitudinal gradient in the mountainous regions like Sikkim
8. Remote sensing (using Satellite imagery) derived biomass production not showing good relation with field derived result of biomass production, which may be due to differences in scale and also due to the smaller geographical area under study
9. In multivariate analysis of temperature showed strong relationship with species richness along the altitude that, vis-à-vis also shows relation with the biomass production
10. It is essential to conduct such studies in other districts of the state and in regular intervals to monitor the changes if any and for developing proper strategies for effective conservation that is too much important for Sikkim that is well known for its extremely high biodiversity..

Photo Plates

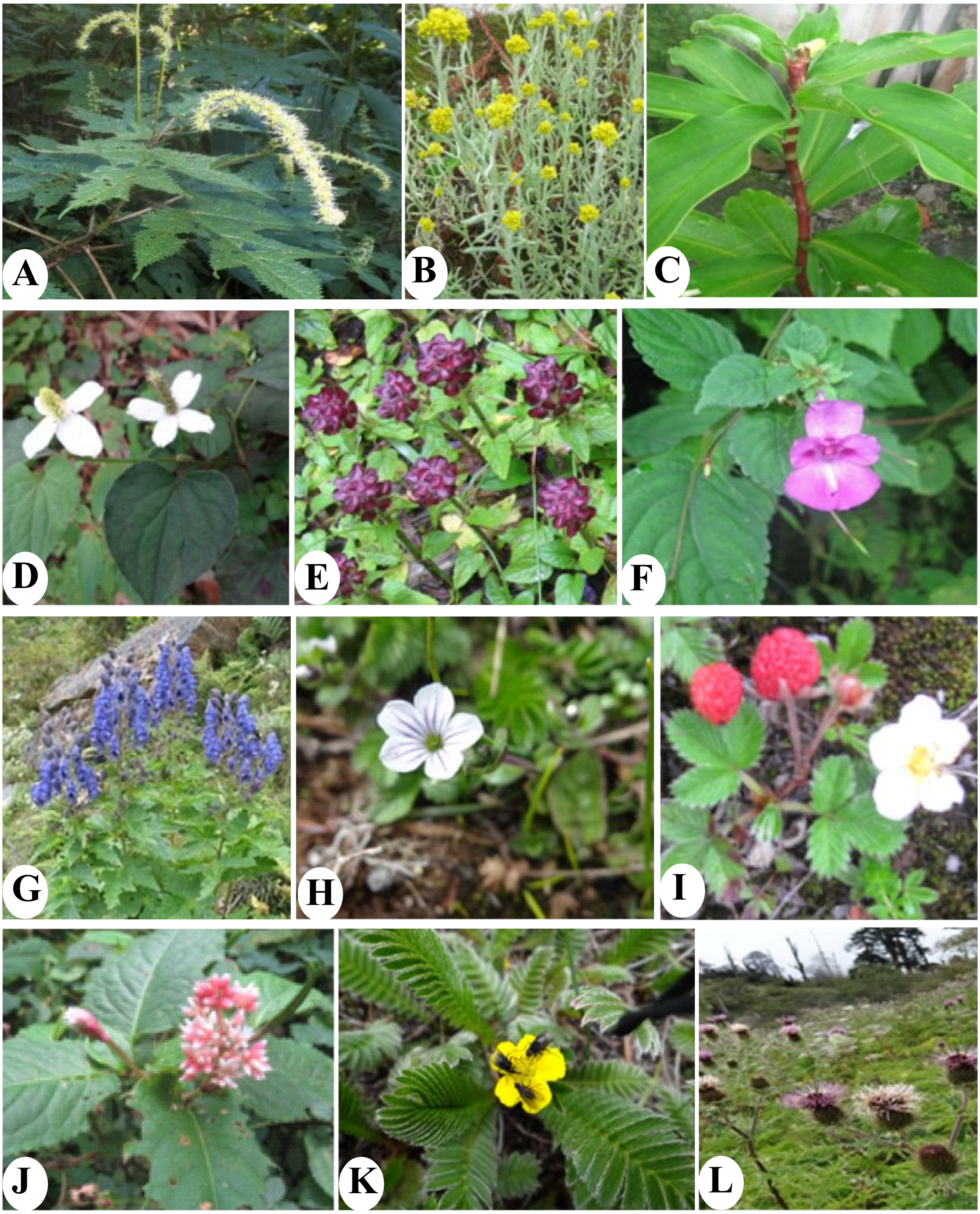


PLATE 1: A. *Girardinia diversifolia;* **B.** *Laphangium affine*; **C.** *Cheilocostus speciosus*; **D.** *Houttuynia cordata*; **E.** *Nepeta connata*; **F.** *Impatiens glandulifera*; **G.** *Aconitum ferox*; **H.***Oxalis acetosella*; **I.** *Fragaria nubicola*; **J.** *Persicaria chinensis*; **K.** *Potentilla fulgens*; **L.** *Onopordum acanthium.*

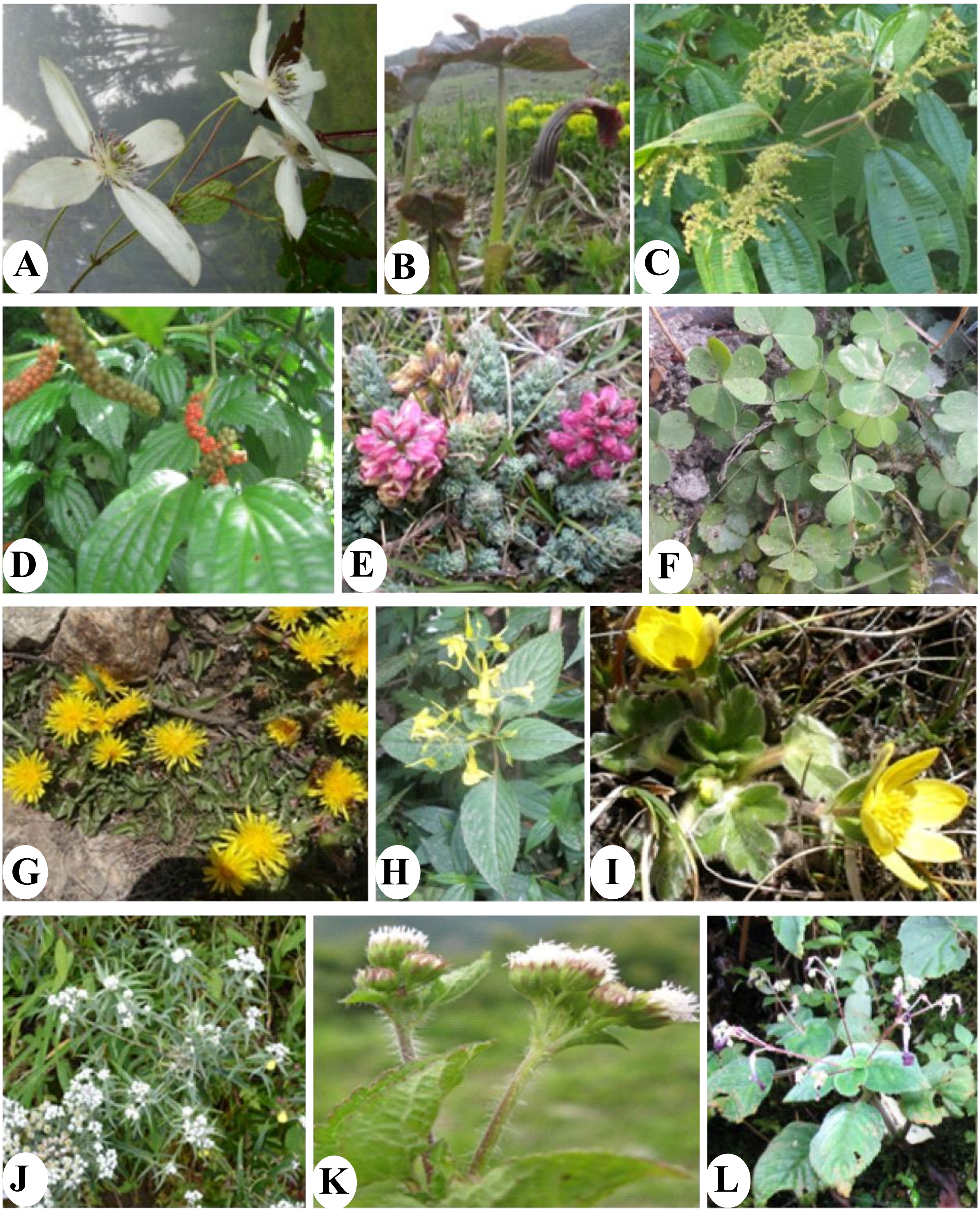


PLATE 2: A. *Clematis montana*; **B.** *Arisaema propinquum*; **C.** *Pilea umbrosa*; **D.** *Piper boehmeriifolium*; **E.** *Myricaria rosea*; **F.** *Oxalis corniculata*; **G.** *Taraxacum campylodes*; **H.** .*Impatiens urticifolia*; **I.** *Ranunculus laetus*; **J.** *Anaphalis busua*; **K.** *Ageratum houstonianum*; **L.** *Didymocarpus albicalyx.*

PLATE 3: A. *Ageratina adenophora*; **B.** *Swertia chirayita*; **C.** *Dobinea vulgaris*; **D.** *Panax pseudoginseng*; **E**. *Rheum aciminatum*; **F**. *Streptopus simplex*; **G**. *Achyranthes bidentata*; **H.** *Selinum wallichianum*; **I.** *Aster himalaicus*; **J.** *Cassiope fastigiata*; **K.** *Erigeron bellidioides*; **L.** *Rhaphidophora decursiva*; **M.** *Euphorbia sikkimensis.*

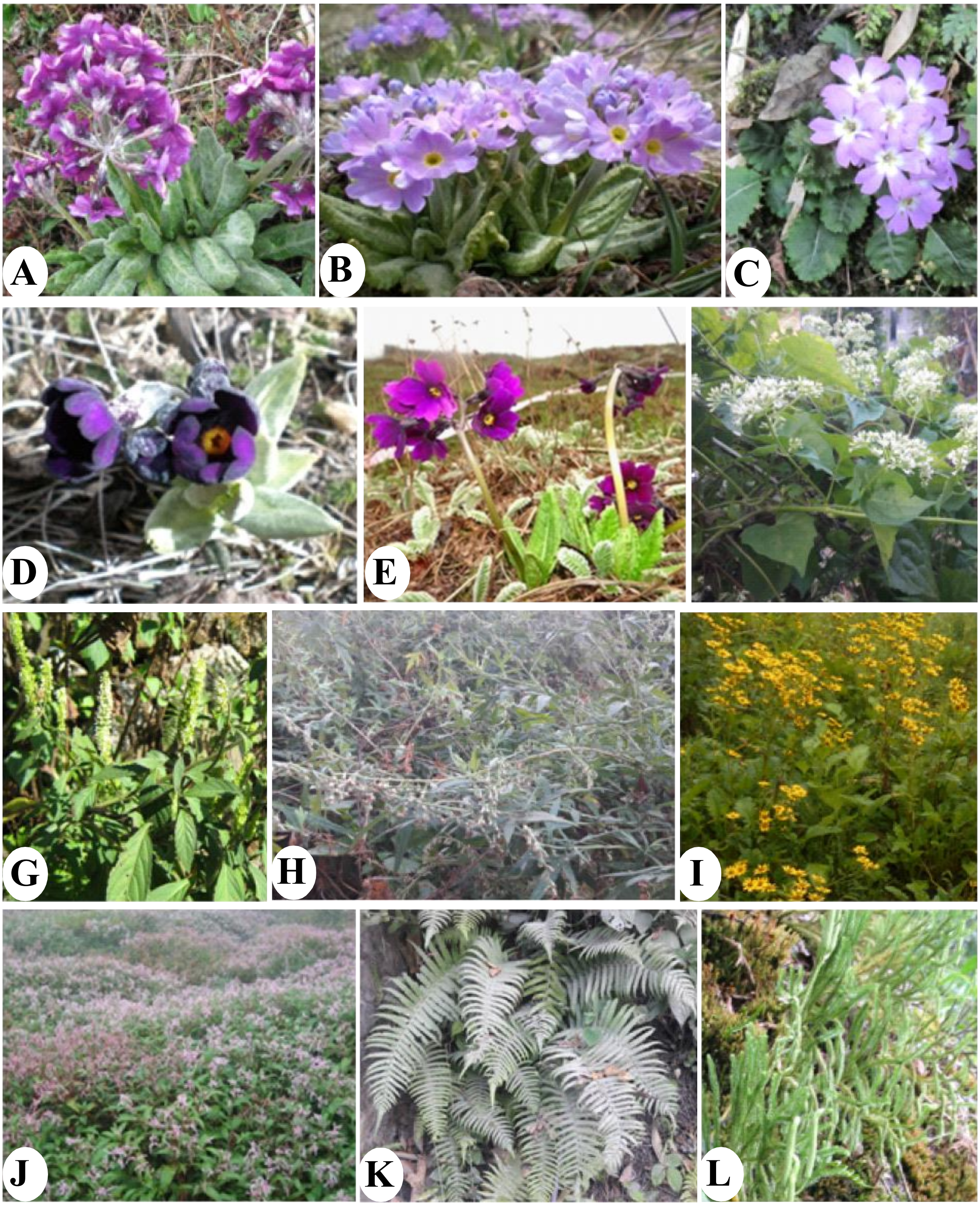


PLATE 4: A. *Primula capitata*; **B.** *Primula drummondiana*; **C.** *Primula edgeworthii*; **D.** *Primula calderiana*; **E.** *Primula macrophylla*; **F.** *Mikania micrantha*; **G.** *Elsholtzia fruticosa*; **H.** *Artemisia nilagirica*; **I.** *Inula orientalis*; **J.** *Polygonum molle*; **K.** *Pseudocyclosorus canus*; **L.** *Lycopodium japonicum.*

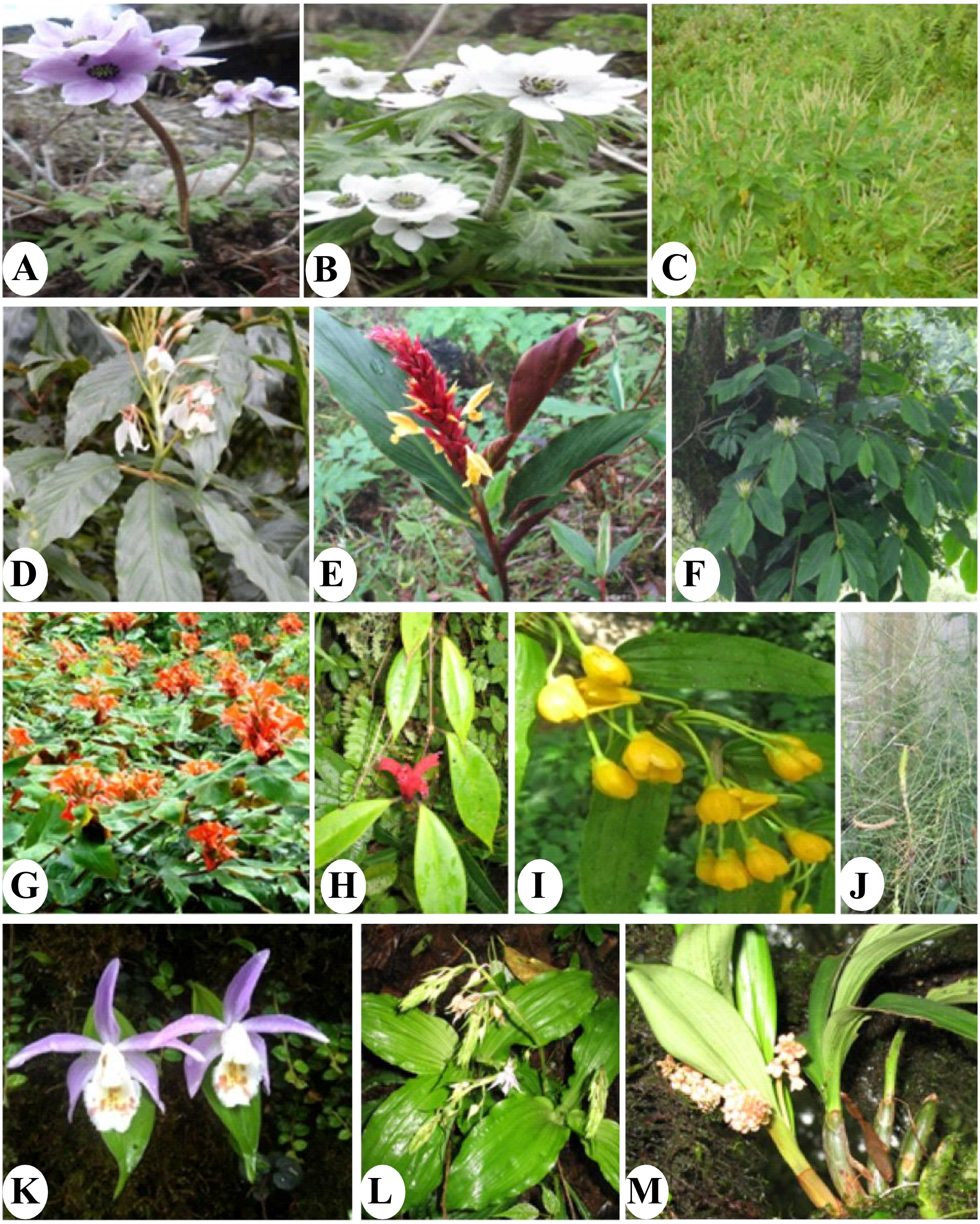


PLATE 5: A. *Anemone obtusiloba*; **B.** *Anemone rivularis*; **C.** *Elsholtzia fruticosa*; **D.** *Hedychium thyrsiforme*; **E.** *Cautleya spicata*; **F.** *Hedychium coccineum*; **G.** *Hedychium greenii*; **H.** *Aeschynanthus hookeri*; **I.** *Dendrobium denneanum*; **J.** *Equisetum arvense*; **K.** *Pleione praecox*; **L.***Clintonia* Spp; **M.** *Liparis* Spp.

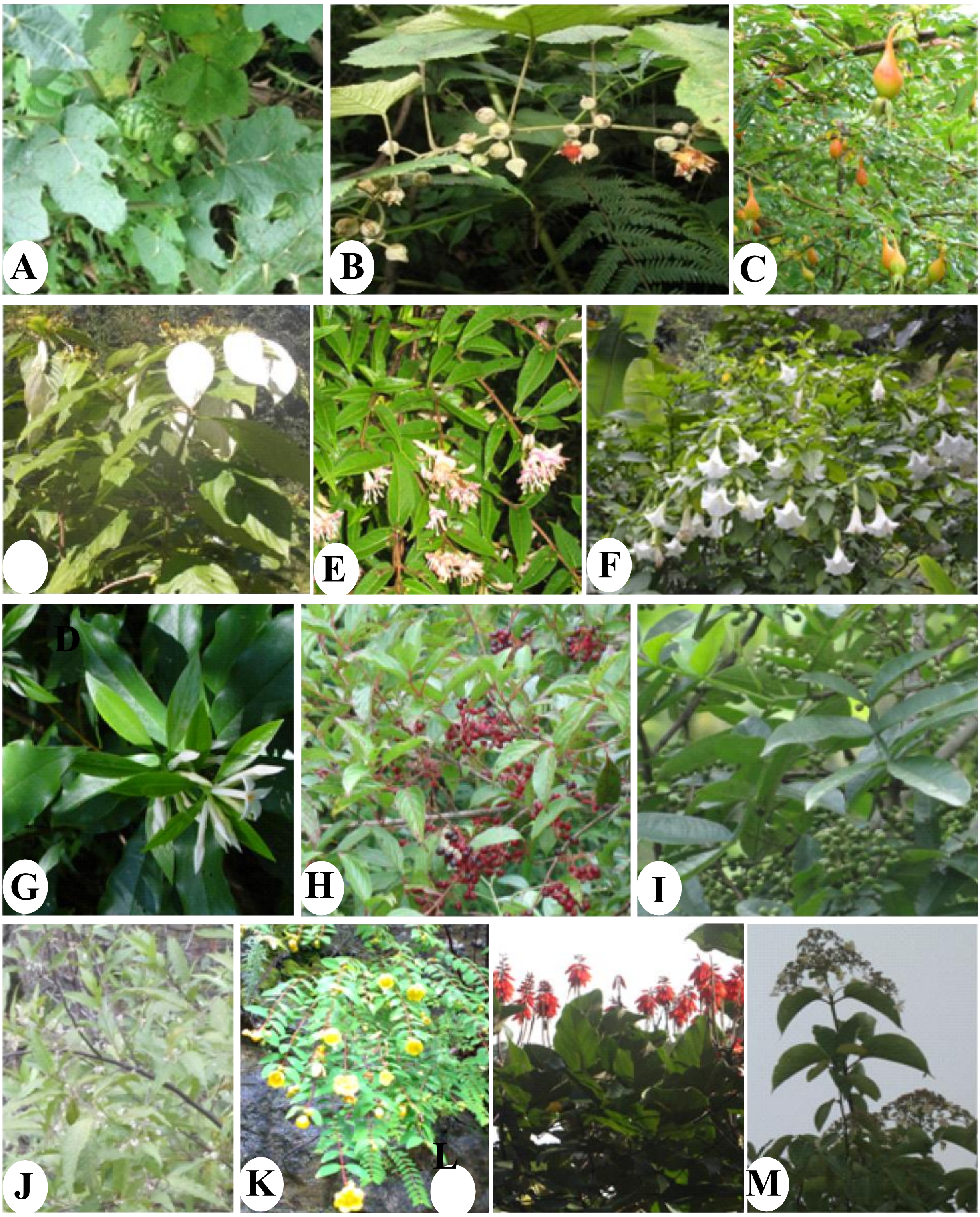


PLATE 6: A. *Solanum viarum*; **B.** *Rubus buergeri*; **C.** *Rosa brunonii*; **D.** *Mussaenda* roxburghii; **E.** *Aster albescens*; **F.** *Brugmansia suaveolens*; **G.** *Daphne bholua*; **H.** *Viburnum erubescens*; **I.** Zanthoxylum nepalense; **J.** *Maesa chisia*; **K.** *Hypericum uralum*; **L.** *Erythrina arborescens*; **M.** *Callicarpa macrophylla*.

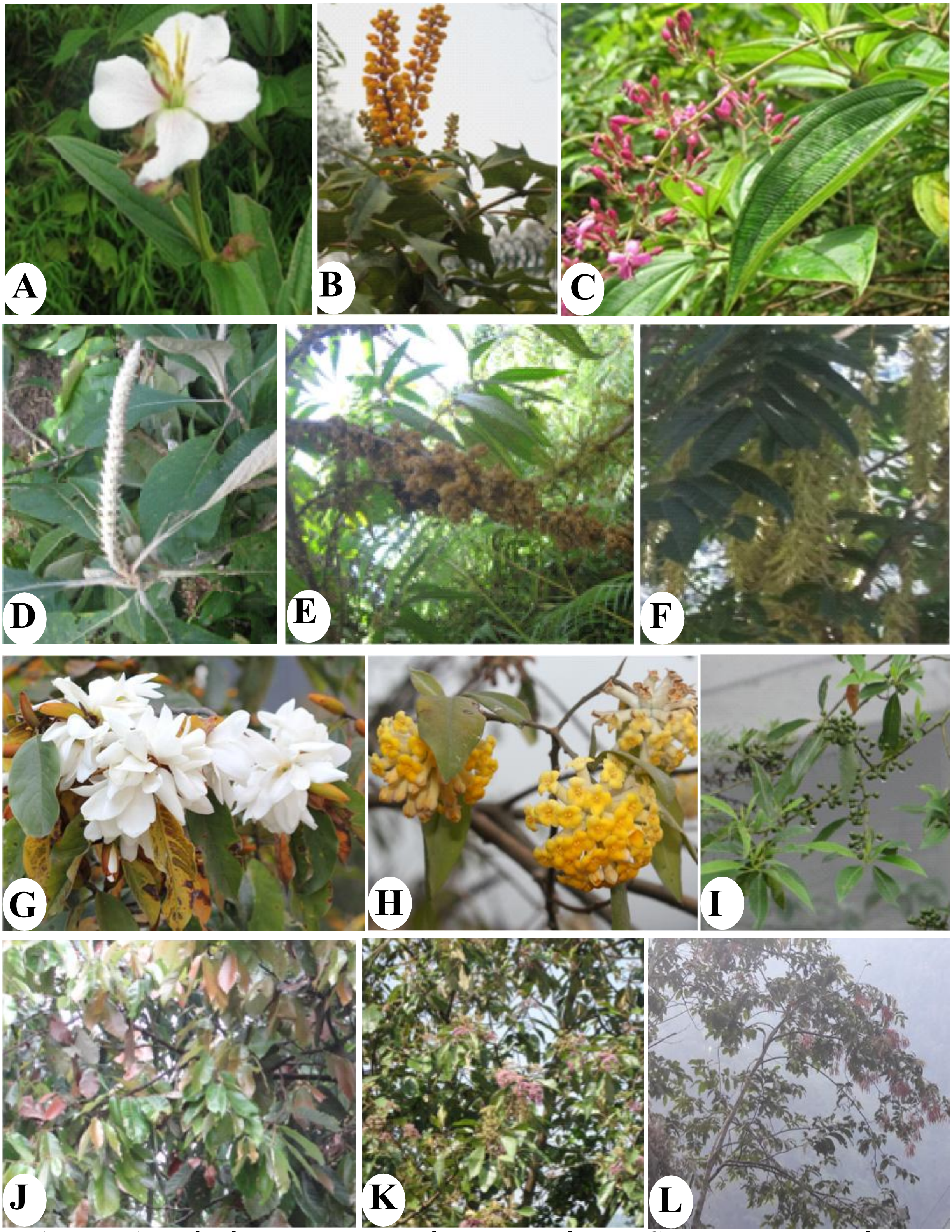
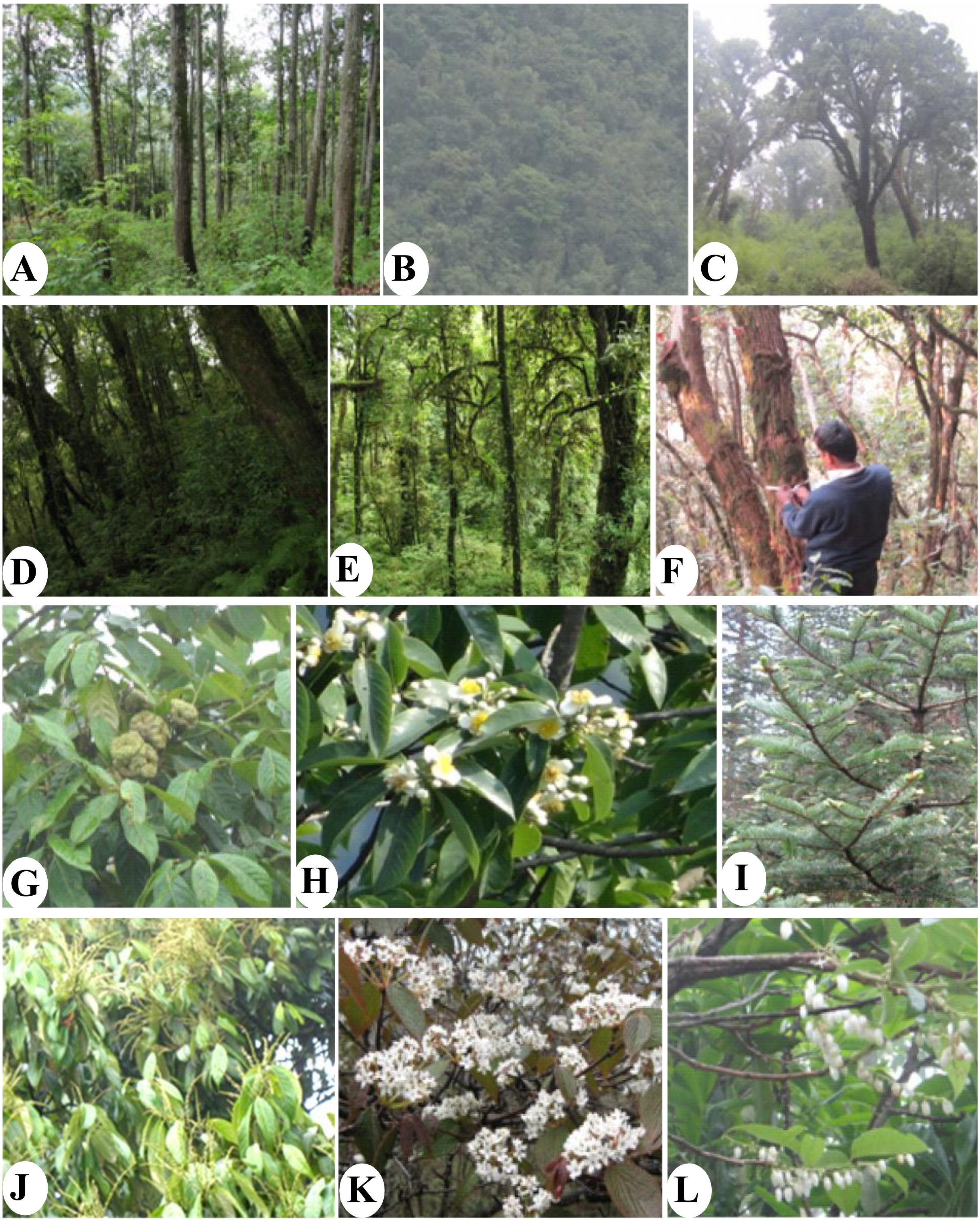


PLATE 7: A. *Osbeckia crinita*; **B.** *Mahonia napaulensis*; **C.** *Oxyspora paniculata*; **D.** *Leucosceptrum canum*; **E.** *Symplocos ramosissima*; **F.** *Engelhardtia spicata*; **G.** *Magnolia doltsopa*; **H.** *Edgeworthia gardneri*; **I.** *Litsea cubeba*; **J.** *Castanopsis indica*; **K.** *Callicarpa arborea*; **L.** *Terminalia myriocarpa.*



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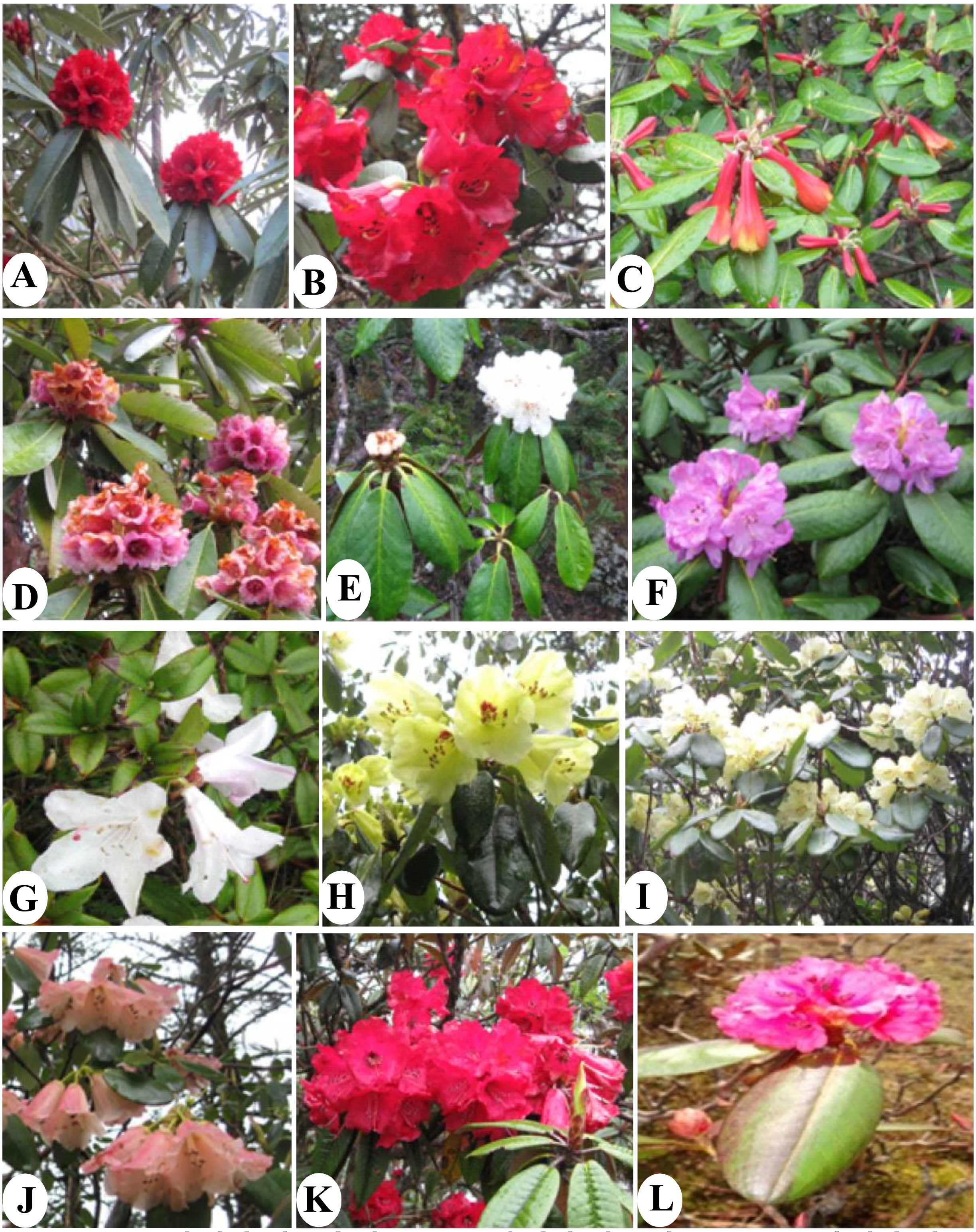

PLATE 9: **A.** *Rhododendron barbatum*; **B**. *Rhododendron thomsonii*; **C.** *Rhododendron cinnabarinum*; **D.** *Rhododendron decipiens*; **E.** *Rhododendron wightii*; **F.** *Rhododendron wallichii*; **G.** *Rhododendron lanatum*; **H.** *Rhododendron campylocarpum*; **I**. *Rhododendron tubiforme*; **J.** *Rhododendron cyanocarpum*; **K.** *Rhododendron arboreum*; **L.** Form of *Rhododendron thomsonii*.

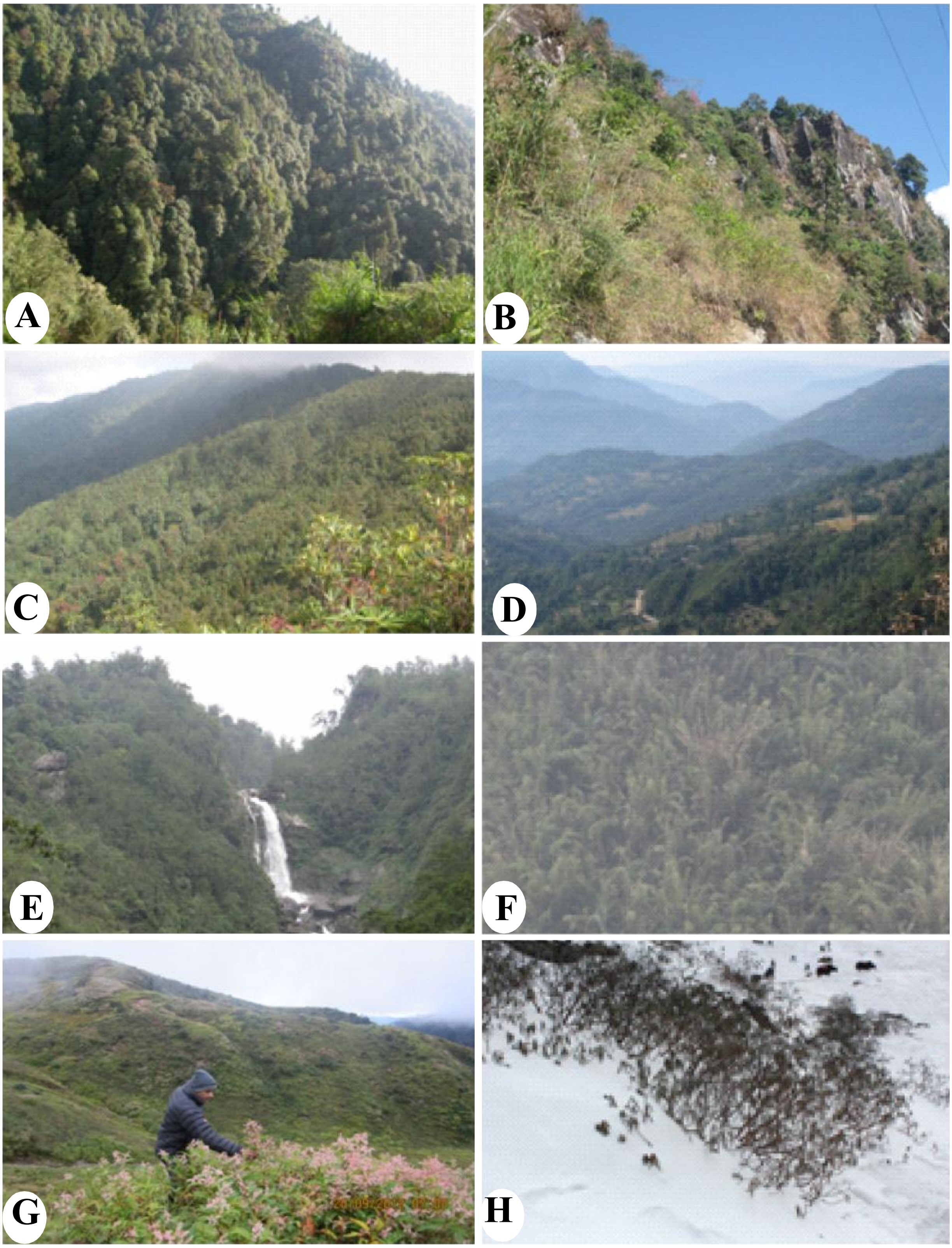

PLATE 10: A. Dense subtropical forest; **B.**Steep slope rockey area of the study area; **C.** Dense Temprate forest of East District Sikkim; **D.** Vegetations near by village; **E.** Vegetation along the river side; **E.** Dense bamboo forest along the hill; **G.**Collection of specimen from alpine area; H. Alpine area covered by snow.