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CONSERVATION OF PLANT DIVERSITY : HERBARIUM AND SYSTEMATICS

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ABSTRACT

Herbarium studies coupled with field investigations of species diversity are central to the conversation of plant diversity. Such investigations in two endangered taxa (*Coptis* and *Meconopsis*), of Eastern Himalaya, having potential economic value have revealed not only their correct conservation status but led to the discovery of new subspecies. It is, therefore, evident that herberia and museums are of paramount value in the conservation of biological resources, and should be considered as a part of world's cultural heritage.

INTRODUCTION

The plant diverisity contributes to human survival in many ways (i) it serves and offers a great potential as source of food, medicine, fuel, fibre, pesticides and other products of day-to-day and industrial importance; (ii) it constitutes stock of additional genetic resource for the improvement of crop plants; (iii) plays a key role in regulating hydrological cycle and climate; (iv) ameliorates and protects soil; and (v) performs essential ecological functions associated with the functional and structural stability of ecosystems. This very diversity which has productive, consumptive, non-consumptive and aesthetic value, is threatened worldwide. This is particularly true for tropical ecosystems which contain a disproportionate share of the world's plant and animal species (about two-thirds of the 5 to 35 million species). Interestingly a larger fraction of this diversity is endemic to fragile and tiny habitats. Besides constituting a rich biological heritage on earth, the tropical forests render a host of services to the two billion human inhabitants.

The magnitude of erosion of the genetic resource base is exemplified by the global awareness of what is known as species exinction crisis or biological diversity crisis. The estimates of Reid and Miller (1989) (see Heywood & Stuart, 1990) that roughly 5 to 10 percent of the world's species will be lost per decade, over the next quarter century, is a highly significant and disturbing figure. Most of the extinctions have been reported to occur in tropical forests, which are being deforested at a rate of 100,000 to 200,000 km^2 each year (Katzman & Cale, 1990). The removal of forests cancels numerous services, such as flood control (Revelle, 1979), erosion, filtration of atmospheric pollutants and the continious supply of firewood and timber (Eckholm, 1979), and degradation of climate (Charney *et al.*, 1975), besides bringing to a close the life and tenure of several biological species and the process of speciation. It is being feared now that as a result of habitat destruction and over-exploitation of biological resources, the rate of species exinction is about 400 fold that of recorded in the recent geological times. The species losses may approach the level of extinction that were caused by the great natural catastrophes that took place during the Mesozoic era. According to a recent estimate, about 19,077 plant species are known to be endangered, rare or otherwise threatened, which is nearly 15 times the number of invertebrate species (1,318), 19 times the number of bird species (1,029), and more than 43 times the number of mammal species (441) (Mlot, 1989).

In the biodiversity crisis, the herbaria repositories of dried plant specimens collected from different geographical regions have a key

role in the : (i) preparation of Red Data Books; (ii) correct identification of the species that need to be conserved; (iii) monitoring the change in the flora through time and space; and (iv) in recognising new and novel taxa evolved. Above all, the data stored in herbaria, particularly in the form of annotations on the herbarium specimens by the collectors, from the baseline information for further biological studies, including conservation biology. In the present paper some of the above aspects are illustrated with respect to the species of *Coptis* and *Meconopsis,* both of which are threatened.

Medicine from plants is one of the economic resources of biodiversity with an unlimited potential. The dependence of drug industry on the plant resources can best be explained by the fact that 25% of the drugs prescribed the world over are of plant origin (Farnsworth & Soejarto, 1985). About 75% of world population still relies on plants and plant extracts as a source of traditional medicine. In spite of the crucial role of the plants in human health there is no organised science for these natural drugs. For example, only 2% of the flowering plants have been tested for alkaloids (Rolston III, 1985). Similar is the case with a number of wild plants of horticultural value. The Himalaya one of the 'hot spots' of high biological diversity is a natural reservoir of midicinal and ornamental plants. Several important and traditionally used medicinal plants have been exploited on commercial scale from this region for a long time. The endemic ornamental plants, transported to Europe by the plant collectors during early part of this century, have become permanent features of the gardens in the West. The Eastern Himalaya has been particularly known world over as one of the important centres of genetic diversity of these economically important plant species. The data annotated on the herbarium specimens by the collectors provide clues about the potential economic importance of the taxa as well their distributions through time and space.

EASTERN HIMALAYA AND ITS PLANTS OF POTENTIAL MEDICINAL AND HORTICULTURAL VALUE

Eastern Himalaya is one of the unique biogeographical ranges of the world constituting the major catchment area of Brahmaputra and Teesta the two prominent features of the region. The climate of the eastern Himalayan ranges varies from tropical to the cold desert and the vegetation types range from tropical rainforests to alpine tundras. Several species are endemic, restricted to highly specialised habitats and niches, and represented by extremely small populations. The increasing anthropogenic activities such as deforestation, road building, shifting cultivation throuogh slash and burn methods,and grazing by bovine populations are disrupting the ecology of these fragile habitats and threatening the biodiversity they contain. It is in this context of rapid depletion of biological species diversity and destruction of their natural ecosystems, conservation biological studies, involving both herbarium and field investigations in eastern Himalaya (Pandit, 1991; Sulaiman, 1991), were undertaken on two taxa endemic to a narrow range. The two taxa choosen were : *Coptis teeta* an important medicinal plant - and *Meconopsis* spp. - well known ornamental plant species. Since both the taxa have been listed in Red Data Books, the information on various aspects was gathered from herbaria, and field and laboratory studies to evolve conservation strategies for their sustainable utilisation. In the present communication the results on the systematics of the taxa, based on herbarium and field investigations, have been discussed.

COPTIS TEETA WALL.

Coptis teeta Wall. (Ranunculaceae) commonly known as 'Mishmi Tita' is an important herbal drug in native medicine throughout northeastern region of India and the adjoining countries. It is a little known species, except for its medicinal use in traditional medicinal system. Because of its high berberine content it was exported to countries such as Japan and other Far-

east countries, and Germany by harvesting from the wild. Within a couple of decades the natural populations of the species dwindled and the species was, therefore, on the verge of extinction. Realising the commercial importance of the species the Government of India banned the export of the resource and the species entered into the Red Data Books (Nayar & Sastry, 1987). Its distribution range outside India has been assessed, with the help of annotations on the herbarium specimens.

Recent conservation biological programmes have demonstrated that sound taxonomy is the basis for evolving effective conservation strategies for endangered species. A recent example of the conservation of a spurious species instead of a nearly extinct dusky sparrow, based on poor taxonomy, led to the latter's extinction (Appenzeller, 1989). It is, therefore, evident that the correct identification of the species and establishing its taxonomic affinities are integral components of conservation biology and this can be achieved by comparing the specimens with authenticated collections found in herbaria and museums. Although *Coptis teeta* is a well known herbal drug plant, yet its botanical description is rather too inadequate to circumscribe it. Its taxonomic affinities with other species, found in neighbouring countries, are not yet established. This is also possible only by examining the herbarium specimens collected from different countries.

The genus *Coptis* comprises 15 species which are distributed in North temperate and arctic regions. One species is endemic to India with the possibilities of its extension to Yun Nan province of China and south east part of Tibet. About 4 species have been reported from Japan (Ohwi, 1965) and about 6 species (including *C. teeta* and *C. quinquefolia)* from China (Chen Sing-che pers. comm.). The critical evaluation of Asian species of *Coptis* suggests that the different species are distinguished essentially by the thickness of the rhizome and the degree of dissection of lamina, shape and size of sepals and petals. But the morphological variations observed among different populations indicate that there is continuous variation among the taxonomic key characters used by Chinese taxonomists (Chen Sing-che pers. comm.). The Japanese species have been distinguished by additional characters, such as, nervation and shape of the follicles, length of style and shape of stigma. Among the Japanese species, *Coptis trifolia* and *C. trifoliolata* are closely related to *C. teeta* which differs from both in having petioluled, ovate-elliptic leaflets that are 1-2 pinnatipartite. The different Chinese species appear to be variants of one species *C.chinensis* which is most likely the geographical counterpart of *C. teeta.* There is a remarkable phenotypic similarity between *C. teeta,* especially of western ecozone (Dibang Valley) populations, and *C. chinensis.* These studies are indicative of the fact that the different Asian species, particularly the Indian *C. teeta* and Chinese species, could be components of an agamic complex.

To facilitate easy identification of *C. teeta* from other closely related Chinese and Japanese species, an indented key is provided.

1a. Leaves always 3-folioate :

1b. Leaves 3-5 foliolate :

2a. Leaflets sessile and of equal size; style slender, rather elongate; stigma narrow; follicles not ribbed .... *C. trifolia*

2b. Leaflets petioluded; middle leaflet larger than the lateral ones; style rather short, compressed with stigma; stigma beak-like, punctate; follicles prominently ribbed :

3a. Rootstock rhizomatous, thick short with condensed internodes .... *C. chinensis*

3b. Rootstock rhizomatous or stoloniferous, if stoloniferous, slender with elongate internodes .... *C. teeta*

4a. Leaflets sessile, ternately or palmately arranged; flowers solitary or rarely 2 ; sepals obovate or elliptic; petals obovate :

4b. Leaves once to thrice ternately compound, if simply ternate leaflets distinctly petiolulate; flowers 1-3; sepals lanceolate; petals spathulate .... *C. japonica*

5a. Leaves 3-foliolate; leaflets firm with rather prominent veinlets beneath .... *C. trifoliolata*

5b. Leaves 5-foliolate; leaflets firmly chartaceous with faintly raised veinlets beneath .... *C. quinquefolia*

Within *C.teeta* of Arunachal Pradesh, two distinct morphological variants can be recognised. These two variants are found in the western ecozone (Dibang Valley) and the eastern ecozone (Lohit Valley). The western ecozone populations constitute the typical *C. teeta,* whereas the eastern ecozone population represent a distinct microspecies or subspecies. Both the subspecies can be distinguished in the following way :

1a. Root-stock rhizomatous, thick, short with condensed internodes; axillary/apical buds 1 or 2. Reproduces both sexually and asexually. .... Subspecies represented by western ecozone populations

1b. Root-stock stoloniferous, slender with elongated internodes; axillary/ apical buds 4-13. Reproduces mostly asexually .... Subspecies represented by eastern ecoone populations

MECONOPSIS Spp.

The genus *Meconopsis* belongs to the family Papaveraceae and is represented by 41-43 species; the distribution of the genus ranges from Himalaya to west China, with one species in Europe (Debnath & Nayar, 1986). Of the 41-43 species 22 are found in India and all of them are confined to Himalaya between 2,135 and 5,795 m altitude; the bulk of species are restricted to Sikkim Himalaya. In fact, Sikkim Himalaya could be the centre of genes diversity for the genus, and the genes that are widely distributed among European cultivers of *Meconopsis* have been derived from the gene pools of wild species found in Sikkim. These valuable gene pools are threatened due to habitat destruction. Except for the taxonomy of *Meconopsis* (Taylor & Cox, 1934; Debnath & Nayar, 1986), the scientific studies on the biology of species populations are lacking.

The members of Papaveraceae (commonly known as poppies), to which the genus *Meconopsis* belongs, have attracted the attention of the biologist because of their : (i) horticultural importance; (ii) utility in medicine; and (iii) use as narcotic and hallucinogenic agents. In spite of their importance, the knowledge on taxonomy, ecology and biology of most of the members of the family is still scarce (Debnath & Nayar 1986). The family comprises 26 genera with over 200 species; the members are distributed both in temperate and subtropical regions of the Old and New World, and ascend from sea level to 5,800 m elevation in Himalaya.

The genus *Meconopsis* was created by Viguier in 1814 (see Debnath & Nayar, 1986) for accommodating a west European species of *Papaver, P. cambricum,* established by Linnaeus (1753), and distinguished it from the genus *Papaver* by the presence of distinct style and the absence of a sessile, stigmatic disc surmounting the ovary. He considered it as an intermediate between *Papaver* and *Argemone.* The three genera can be distinguished in the following ways :

1a. Style distinct; stigmas forming a globular mass over the ovary; capsule dehiscene by short valves .... *Meconopsis*

1b. Style absent or inconspicuous if present; stigma discoid or forming globular mass over the ovary :

2a. Capsule dehisces by apical pores; style absent; stigma discoid .... *Papaver*

2b. Capsule dehisces by short valves; style inconspicuous; stigmas radiating with 3-7 lobes .... *Argemone*

The genus *Meconopsis* is represented by 22 species which show highly localized distribution

within Himalaya. All of them are endemic to Himalaya; the species are concentrated in three disjunct areas within the ranges : (i) from central Nepal, south eastern or south central Tibet to Bhutan; (ii) from south eastern Tibet, north eastern Yunnan to northern upper Burma (iii) from north western frontier province to Kumaon (Debnath & Nayar, 1986). There are about 11 species in Sikkim Himalaya, of which all the species are distributed from central Nepal, south eastern or south central Tibet to Bhutan, except a few species extending to China and north west Himalaya. This information is derived from herbarium specimens.

Detailed field investigations coupled with herbarium studies revealed several interesting aspects of the varibality found in the genus.

Two types of life forms are observed in the genus *Meconopsis :* (i) monocarpic perennials (biennial), and (ii) polycarpic perennials. The monocarpic perennials produce tuberous root-stock, whereas polycarpic perennials produce stout, fibrous rootstock. Further, the monocarpic perennials showed leafy stems, whereas the scapose or subscapose stems are observed among polycarpic perennials. Of the five species investigated, two species (*M. paniculata* and *M. sinuata)* are monocarpic, whereas the other three species (*M. horridula, M. simplicifolia, M. villosa*) include polycarpic life forms. The monocarpic perennials inhabit open scree slopes, whereas the polycarpic perennials are either found inside the forest or along the forest fringes and in subalpine and alpine pastures. These observations suggest that the diversity in life forms is the consequence of ecological specilization in relation to habitat conditions. As evident from their distribution ranges, abundance and ecological amplitude, and chromosome numbers, the evolutionary trends in *Meconopsis* appears to be from polycarpic perennials to monocarpic perennials. Such evolutionary trends in life forms have also been recognised by other workers (Hutchinson, 1969; Takhtajan, 1969; Stebbins, 1971). *Meconopsis* species have a rhizomatous rootstock, which is not stoloniferous, and have mostly persistent leaf crowns. Such a life form might have evolved in response to highly specialized niches. The basal stout stem is simple and elongated as in monocarpic forms, whereas it is stout, short and dichotomously branched at the base in polycarpic forms. The leafy stems are mostly simple as in *M.paniculata, M. simplicifolia* and *M. sinuata* or rarely branched as in *M. villosa* and *M. horridula.* The herbage is mostly bristly, hairy or even prickly; the hairs are mostly simple in many species, but barbellate in *M. paniculata.*

The leaves are in a basal rosette in all the species; the rosettes are persistent throughout the life period in monocarpic species whereas in polycarpic species majority of the leaves perish during winters. The leaves vary in shape, size, dissection of lamina, and the kinds and amount of indumentum.

The inflorescence is either scapose with solitary flower or subscapose receme like cyme with basal flowers arising from the axils of basal cauline leaves or leafy paniculate cymes. The flowers are showy and are of different shades of yellow or blue, without horn appendages and caducous and usually covered with the same type of hairs found on the herbage. Petals are 4 in number and do not show marked variations except in size and shades of blue and yellow.

The stamens are numerous. The ovary exhibits variation in size and shape. The length of style and the nature of stigma also vary. The shape and size of capsule, the length of dehiscene sutures vary among different species. The seeds are uniform in shape but vary in size.

The flowering (June-Aug.) and fruiting (Sept.-Oct.) seasons are, more or less uniform for all the species irrespective of the latitudinal gradients of the regions and localities selected for sampling.

The species do not show any marked variation in distribution patterns across the latitudinal and altitudinal gradients except for *M. horridula:* the distribution ranges of some species

(M.paniculata, M. simplicifolia, M. sinuta, M. villosa) are contiguous.

Based on the observed variability, the following indented key to the species is constructed :

1a. Monocarpic perennials with tuberous rootstock and persistent basal rosette of leaves; stems elongated and leafy :

1b. Polycarpic perennials with stouter tap root and stout short stem base bearing a crown of persistent leaves which often die during winter; inflorescence scapose or subscapose :

2a. Flowers yellow; leaves pinnatilobed to pinnatipartite, basal ones entire, all covered with bristles mixed with stellate pubescence; restricted to open scree and moist habitats between 2,135 and 4,575 m.

.... *M. paniculata*

2b. Flowers blue, purple or violet; leaves entire to sinuate-lobed not covered with stellate indumentum; restricted to open steep slopes between 3,660 and 4,575 m.

.... *M. sinuata*

3a. Flowers on leafless scapes, decurved, blue restricted to subalpine and alpine meadows between 3,050 and 5,000m. .... *M. simplicifolia*

3b. Flowers on subscapose stems forming a raceme like cyme, not derived :

4a. Flowers yellow, leaves broadly ovate-cordate or orbicular, cuneate or cordate at the base, the basal rosette dies every year; confined to forests and along the forest fringes between 2,745 and 4,270m.

.... *M. villosa*

4b. Flowers blue; basal rosette persistent; leaves linear-lanceolate or obovate - elliptic with a decurrent base, and acute or rounded at the apex; confined to alpine meadows between 3,965 and 5,795 m.

.... *M. horridula*

The two life forms have different growth patterns and reproductive efficiencies. For example, the monocarpic species have leafy stems and higher number of flowers and capsules per plant as compared to polycarpic forms. Such life history strategies are the consequences of effective and efficient resources utilization (Wines, 1984). The evolutionary trends recognized within the genus are : (i) species showing caespitose habit with basal stout stems of alpine meadows to those of tall aerial leafy stems of open habitat (scree slopes) (ii) scapose inflorescence to paniculate leafy cyme; and (iii) fewer larger fruits with a fewer number of larger seeds to many smaller fruits and many smaller seeds. It appears that adaptive radiation in response to ecological diversity might have played a significant role in the origin and evolution of the major evolutionary trends which in turn have led to the taxonomic diversity. Such patterns of differentiation have been reported in other taxa (Stebbins, 1950, 1971). It may be mentioned that some new subspecies are recognised within *M. simplicifolia* and *M. paniculata.*

The herbarium and field studies on both the taxa suggest that the species : (i) are represented by small populations which occupy highly specialized habitats; (ii) include well-defined subspecies; (iii) have evolved in response to adaptation to different ecological niches; and (iv) are likely to be endangered if efficient conservation measures are not practised. These results substantiate that herbarium and field studies complement each other and play a significant role in averting biodiversity crisis. Consequently, herbarium must be treated as an important facility in biological research leading to the conservation of plant diversity.

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