

Summary

SUMMARY AND SALIENT FINDINGS

The genus *Momordica L* in India assumes significance for conservation of genetic diversity by virtue of being wild relative of cultivated bitter gourd, besides its direct utility as nutritious vegetable and multipurpose medicinal plants. A perusal of its status in ex-situ holdings and genebanks indicated poor representation and neglect in the existing biodiversity conservation programmes. In order to devise a conservation strategy for the wild gene pool of *Momordica*, taking into account its present conservation status and threat of genetic erosion, this study was initiated integrating systematics, ethnobotany, ecogeography, phenology and reproductive biology of the genus.

Ecogeographic studies are considered ideal for optimizing plant germplasm collection and conservation strategies. Herbarium and passport data together provide many details of the collection sites that can be used to predict the probable locality and the most optimum collection time. Ecogeographic data were recorded throughout the geographical range in India. Herbarium specimens held in major Indian Herbaria were studied and information provided in herbarium sheets was supplemented with observations of the taxa during field trips to representative areas within the country. Selected pockets in the entire stretch of Western Ghats representing Kerala, Tamil Nadu, Karnataka, Goa and Maharashtra were visited, besides specific sites in Deccan plateau, Central India and North East for collection of germplasm and ecological data. An Ecogeographic Database for the genus *Momordica L* was constructed using BRAHMS (Botanical Research And Herbarium Management System) software incorporating information on the phyto geography, ecology and taxonomy of the genus *Momordica*. Data from 667 herbarium sheets and 176 passport data sheets were incorporated in the database. These data are summarized in the Ecogeographic Conspectus. It includes information concerning accepted names of taxa, author(s), date of publication, where published, reference to full description and iconography, botanical illustrations, phenology, chromosome number, distribution maps, ecological details including altitude, climate, soil and habitat preference, interpretative notes on ecology, taxonomy and distribution.

The similarity of the common characters taken as key to distinguish between dioecious taxa of *Momordica* has led to widely conflicting treatment of this group in South and South East Asia. A perusal of the published literature shows misidentification and wrong botanical nomenclature in dioecious group comprising *M. dioica*, *M. subangulata* and *M. cochinchinensis*. Hence, a taxonomic revision of the genus in India was carried out. The *M. dioica* specimens from Western Ghats was bifurcated and treated under *M. dioica sensu stricto* and *M. sahyadrica sp. novo*. The 'bhatkarela' of North East has been identified as *M. subangulata* subsp. *renigera*. The three species occupy distinct ecogeographical regions and has many morphological and reproductive traits that distinguish them from one another. Thus, the *M. dioica* sheets in Indian herbaria needs to be relabelled and to be placed under three distinct species. The genus could be grouped in to two clear sub generic groups, each represented by contrasting traits in relation to perennation, breeding behaviour and floral morphology. *Momordica denudata* is a doubtful species and both *M. denudata* and *M. cochinchinensis* do not occur in South India. Detailed descriptions of the genus and modified keys are presented incorporating many of the floral and fruit morphological traits, which hitherto escaped taxonomists' attention. Morphology of individual species from seedling stage to fruit ripening were worked out.

Ethnobotanical studies across Western Ghats revealed many ethnic uses of various *Momordica* species and their vernacular names in local dialects. Many tribes consistently opined about the uses of various *Momordica* species for treatment of chest congestion, anaemia, cutaneous infection, haemorrhage, bleeding piles, intestinal ulcer and as a dual purpose vegetable with nutraceutical potential. Among these, ethnic claims of abortifacient, anti-inflammatory piles curing and hypoglycemic properties are worth investigating. There is a taboo against cultivation of *M. sahyadrica* using tubers across Western Ghats of Karnataka.

Evaluation of various propagation methods proved the efficiency of vine cuttings in propagation of all species. Midlevel cuttings collected from actively growing plants at early flowering and fruiting stages establish well in all taxa. Use of leaves as a propagule

in *M. subangulata* subsp. *renigera* offer good scope for rapid multiplication and as an alternate germplasm collection strategy. Morphology of the tubers is different in the dioecious group; *M. dioica* and *M. sahyadrica* produce taproot tubers with apical meristem whereas *M. subangulata* spp. *renigera* produce both tap root tubers and many adventitious tubers with buds. Adventitious root tubers in *M. dioica* and *M. sahyadrica* produced artificially do not sprout. *M. subangulata* ssp. *renigera* was the most successful species adapted to vegetative and seed propagation in nature. It has no tuber dormancy whereas *M. dioica* and *M. sahyadrica* have 4-5 months tuber dormancy that can be broken by enhanced aeration and soil temperature.

Intra specific diversity in *Momordica charantia* var. *muricata* fall under two distinct morphotypes, here designated var. *sponanea* and var. *muricata*. The West Coast-Western Ghat high rainfall type much resembling cultivated bitter melon and the dry Deccan type characterized by small less sculptured seeds, heavy branching, late senescence and high drought tolerance. *M. dioica* also showed ecogeographic variations for morphological features. floral scent, seed shape, sculpturing and ornamentation. Monoecious species do not exhibit any seed dormancy whereas the dioecious group has varied seed dormancy. *M. subangulata* sssp. *renigera* had short dormancy of 1-3 months whereas *M. dioica* and *M. sahyadrica* had prolonged seed dormancy. Of the various physical and chemical methods used to break this dormancy, none was found significant, whereas seeds exposed to natural weathering for 5-6 months or deposited in ant hives was found to show enhanced the germination percentage. High infra specific variation for seed germinability was observed in *M. sahyadrica*.

Ecology of individual species were studied from seed to seed and various abiotic and biotic factors such as soil preference, climate, rainfall, pollinators, dispersal agents and pests and diseases were documented. All species have good soil seedbank in nature. *M. balsamina* acclimatized well under Kerala conditions even though highly susceptible to fruit fly infestation. Pollinators are species specific, thus preventing interspecific pollen foraging and natural hybridization. Association of specific species of birds in seed dispersal and ant predation in seed germination was observed and recorded.

Descriptor and descriptor states for monoecious and dioecious groups were prepared and 64 representative accessions comprising *M.charantia* var. *muricata*, *M. balsamina*, *M. dioica*, *M. sahyadrica* and *M. subangulata* ssp. *renigera* were characterized using these descriptors. Numerical analysis of qualitative characteristics (99 traits) revealed higher levels of inter specific variability. The semi-wild species *M.charantia* var. *muricata* was distinct, away spatially from *M subangulata* var. *renigera*, *M.sahyadrica* and *M.dioica*. *M.charantia* var.*muricata* has more morphological resemblance to the cultivated form *M.charantia* than *M. balsamina*. None of the other species showed significant morphological resemblance among them, thus preserving their distinct individual species identity. This point corroborates the taxonomic validity of six *Momordica* species established following natural taxonomy system. However, the correlation coefficients among accessions within a species were greater than 70 percent, signifying closeness or similarity among them except in *M. charantia* var. *muricata*. Multivariate analysis for 18 quantitative characters showed significant differences between species invariably for all the characters suggesting presence of high inter-specific variability among the species. Comparison of coefficient of variation for these characters indicate that leaf area, fruit weight and fruit yield per plant had highest variance as compared to other traits. There are significant infra-specific mean differences among the accessions for most of the yield and yield contributing characters, conferring agronomic potential.

High interspecific variability for tolerance to fruit fly, pumpkin caterpillar, lady birdbeetle, red pumpkin beetle and rootknot nematode was observed under natural epiphytotic conditions. *M. sahyadrica* for mid and high ranges and *M. dioica* for low elevations proved worth domestication potential vegetables for monsoon season. *M. subangulata* ssp. *renigera* also had good potential but needs hand pollination for good fruit set. Interspecific crossability between all the species was worked out and viable F1 plants were produced in crosses involving the dioecious taxa. Nevertheless, the F1 hybrids failed to set fruits. However, they offer good potential as leafy vegetables and ornamentals and could be propagated easily through vine cuttings and adventitious tubers ensuring its ratoonability.

Genetic erosion of the wild species and semi domesticates was quantified through a field study of habitat specific, taxon specific and anthropogenic factors. Landraces of *M. charantia* var. *muricata*, *M. dioica* and *M. sahyadrica* were found vulnerable at several sites across Western Ghats. Habitat destruction due to fast spread of alien weeds and cover crops such as *Mikania micrantha*, *Mimosa incisa* and *Mucuna pruriens* was found the single largest factor in natural habitats. *Ex situ* conservation status and prospects of *in situ* conservation are discussed based on the field collection experience. Exploratory home garden trials at thirteen sites across Kerala showed good scope for cultivation of *M. dioica*, *M. sahyadrica* and *M. charantia* var. *muricata* in home gardens. Good soil seedbank population indicated operation of natural biological processes thus proving the feasibility of domestication through cultivation as an *ex situ* conservation strategy. Several farmers across Western Ghats in the forest habitats were found cultivating *M. sahyadrica* and rare landraces of *M. charantia* var. *muricata* offering *in situ* protection and hence on-farm conservation as a viable strategy for germplasm conservation is proposed. Spotting of various *Momordica* species in wildlife sanctuaries and protected areas has been highlighted with a view to formulate *in situ* genetic reserves.

Salient Findings

Revision of the genus *Momordica* L. in India was carried out bringing clarity in the systematics of the genus. A new taxa, *M. sahyadrica* sp. nov. Joseph & Antony was created. Bhatkarela (Assam Kakrol) is placed under *M. subangulata* ssp. *renigera*. *M. cochinchinensis* and *M. subangulata* do not occur in South India. *M. denudata* is of doubtful existence.

An Ecogeographic Database from 667 herbarium data records and 176 passport datasheets with distribution maps for all species was created. An Ecogeographic Conspectus, which is a summary of the findings with direct utility in conservation of genetic diversity, has been prepared. Indigenous traditional knowledge related to various uses of *Momordica* species across Western Ghats has been recorded along with vernacular names in tribal dialects.

Assemblage of representative diversity in *Momordica charantia* var. *muricata*, *M. balsamina*, *M. dioica*, *M. sahyadrica* and *M. subangulata* ssp. *renigera* and rescue collection of rare semidomesticated landraces such as 'methipavai', 'kuttathipaval', 'rudrakshahagali' and 'karandakapaval' has been carried out.

Descriptor and descriptor states for dioecious and monoecious groups have been prepared. Trait specific genetic stocks for fruit fly tolerance and root knot resistance have been identified. Interspecific hybrids with potential as leafy vegetable and or ornamentals have been produced.

Production of leaf microtubers as propagule in *M. subangulata* ssp. *renigera* is an innovative technique. Suitability of various vegetative propagation techniques and reproductive biology of individual species was studied. Role of specific species of birds, ants and insects as dispersal agents and pollinators has been brought out.

Genetic erosion and threat analysis was carried out from habitat specific, anthropogenic and taxon specific angles. *M. dioica*, *M. sahyadrica* and semidomesticated landraces of *M. charantia* var. *muricata* were found vulnerable in Western Ghats and West Coast.

Based on the analysis of diversity, gaps in existing collections, areas of higher concentrations and occurrence of trait specific germplasm have been highlighted. Specific recommendations for exploration and collection has been proposed. A complementary approach to conservation of diversity integrating *ex situ* and *in situ* approaches has been proposed. Possible sites for establishment of genetic reserves in protected area network have been suggested. Exploratory home garden conservation for maintenance of wild genepool was attempted and found successful. Spotting of on-farm conservation attempts in tribal hamlets in forest habitats has been highlighted.