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Status of *Embelia ribes* Burm f. (Vidanga), an important medicinal species of commerce from northern Western Ghats of India

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***Embelia ribes* is a red-listed medicinal plant species that contains embelin, which has wide clinical applications. Its great demand in Ayurveda and the pharmaceutical industry (> 100 t/yr) has imposed tremendous pressure on natural populations from the Western Ghats of India. In this study, we have prepared a distribution map of *E. ribes* for the northern Western Ghats of Maharashtra. Issues regarding misidentification, adulteration and the status of its trade with respect to its population decline have been critically discussed.**

Keywords: Distribution map, *Embelia ribes*, population decline, trade.

INDIA has a rich repository of medicinal plant species (about 8000). More than 80% of the population of our country is dependent on medicinal plants for its primary health care[1]. India ranks second in terms of the volume and value of medicinal plants exported. Of the 960 traded medicinal plant species from India, 178 species are consumed in volumes exceeding 100 MT/yr (ref. 2). Less than 10% of the medicinal plants that are traded in the country are cultivated and about 90% are collected from the wild. These are often harvested in a destructive and unsustainable manner[3]. The biodiversity hotspot of the Western Ghats, which is ranked fifth in the world in its biological resources, harbours about 4000 species that are used in herbal drug formulations. Besides, several plant species from the Western Ghats are gaining international importance due to their newly identified pharmacological and curing properties. This has led to their indiscriminate harvest, severely threatening their existence. *Embelia ribes* Burm f., which possesses high trade potential, is one such species that needs immediate conservation attention.

E. ribes, popularly known as 'Vidanga' or 'Vavding' in Ayurveda, is a Red-listed species[4]. It yields embelin, and other highly valued secondary metabolites, which have a wide range of clinical applications (Table 1). It is a dioecious woody climber belonging to the family Myrsinaceae. It is sparsely distributed in the evergreen to moist deciduous forests of the Western Ghats and is now confined only to remnant forest pockets. *E. ribes* is listed in the 'Priority Species List' for cultivation by the National Medicinal Plant Board (http://nmpb.nic.in/index1.php?level=2&sublinkid=688&lid=246) and the Maharashtra State Horticulture and Medicinal Plant Board (MSHMPB)[5]. However, lack of knowledge about its distribution, poor natural regeneration and unknown propagation techniques has resulted in the lack of availability of 'quality planting material' (QPM) for promoting cultivation. Misidentification of this species coupled with the use of adulterants and substitutes has further aggravated the problem. It has been observed that *E. ribes* has been extensively wild-harvested, sometimes even from the protected areas (PAs). Due to the aforementioned reasons it has become essential to: (i) assess the current status and distribution of *E. ribes* from the northern Western Ghats (NWG) of Maharashtra; (ii) identify and map the existing populations of the species; (iii) assess the status of the trade of *Embelia* and (iv) give a comparative account with closely related alternative and adulterant species.

The NWG, popularly known as Sahyadri (15°30′–20°30′N lat., 73°–74°E long.) lies in Maharashtra. The vegetation here is more or less in the form of fragmented patches, in contrast to continuous stretches of forests in the southern Western Ghats. Approximately more than half of the natural habitat from NWG has now been cleared (http://www.wwfindia.org/wwf_publications/cdp_india/). As a result, highly fragmented and scattered natural populations of species such as *Dysoxylum binectariferum* (Roxb.) Hook.f. ex Bedd., *Embelia ribes* Burm.f., *Nothapodytes nimmoniana* Grah. Mabb. and *Oroxylum indicum* (L.) Vent. exist in remnant forest patches or

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Table 1. Chemical constituents and activities reported from *Embelia ribes*

Plant part used	Phyto-constituents	Activity
Fruits	Embelin, embolic acid and rapanone[12]	Anti-helminthic, anti-tumour, bronchitis, mental disorders, jaundice[13], anti-fertility[14], analgesic[15], antibacterial[16], anti-inflammatory[17] and antioxidant[18]
	Embelin	Against diabetes[19], cardio protective activity[19,20] and contraceptive[21]
	Sitosterol and daucosterol[22], embelinol, embeliaribyl ester, embeliol[22,23], vilangin[24] and christenbine[25]	–
Whole plant	Embelin	Anti-inflammatory[26]
Roots	Embelin	Influenza epidemic[27]
Seeds	Embelin	Antibiotic and anti-tuberculosis[28]
Leaves	Embelin	Skin diseases and leprosy[9]

informally protected forest landscapes such as 'sacred groves'. The present study was conducted as a part of a larger project involving the application of Geographic Information System (GIS) and remote sensing for mapping and conservation of threatened medicinal plant species. The study area comprises the Western Ghats in the districts of Pune, Satara and Kolhapur. This encompasses one ecological sensitive area (Mahabaleshwar), four PAs (Bheemashankar Wild Life Sanctuary (WLS), Chandoli National Park (NP), Koyna WLS and Radhanagari WLS), and the forested landscapes (including Reserve Forests and private forests) adjoining them. We adopted the sampling methodology standardized in a national-level survey project that assesses plant resources from the Western Ghats[6]. Grids of size 6.25 km × 6.25 km were overlaid onto the study area. A total of 212 grids were surveyed. A maximum of four belt transects of 5 m width with a total length of 1000 m (amounting to 0.01% sampling) were laid in each grid. We ensured that the survey incorporates a significant environmental gradient of the grid such as altitude and various habitat types like evergreen forest, scrub and riparian patches. Plant locations were stored in the Global Positioning System. Latitude and longitude values for each location were converted in GIS, MapInfo 7.5. These locations were projected into geographic projection. To generate the distribution maps with these locations, we used the overlay analysis from GIS program, MapInfo 7.5. We used two different thematic maps for overlay analysis. The land-use map of India was digitized from Forest Survey of India Atlas (1973) and NDVI images from AVHRR satellite were downloaded from the internet. These images were from the year 2000 and the resolution was 250 m. These images were geo-referenced to geographic projection.

Extensive literature survey that included records from floras, forest department working plans, scientific literature, and focused interactions with more than 30 researchers revealed that *E. ribes* was previously reported only from two localities, viz. Mahabaleshwar and Koyna, Satara District of NWG. During our intensive exploration of 212 grids covering an area of 106 ha, *E. ribes* was recorded from eight grids indicating a sparse and highly restricted distribution. In addition to earlier known locations, we recorded four new locations of *E. ribes*. Details and other relevant ecological parameters of sampling sites are listed in Table 2. Based on our sampling, we generated a distribution map of *E. ribes* for Maharashtra (Figure 1). The map revealed the sparse distribution of *E. ribes*. Preferred habitats were found to be evergreen, semi-evergreen and edges of disturbed evergreen forests. It was also observed that the species was mostly present in open areas and was close to water sources. Except in Chandoli and Radhanagari, individuals of species were observed along roadsides or forest paths. The population recorded during our field visits in February 2009 from Koyna WLS was found to be depleted in our subsequent visit in July 2009. This was mainly due to: (i) Being very rare in distribution, the local people were not able to locate and identify 'true' *E. ribes* and (ii) they identified *Embelia basaal* A. DC. as *E. ribes* (as the former is also known by the name 'Vavding') and therefore, *E. basaal* was spared and the actual *E. ribes* was harvested. It was observed that there were almost no survivors among 12 observed 'male' individuals. This low survival rate will have a serious impact on the overall population due to the species being dioecious. Regenerating individuals were also not encountered during the entire survey. Premature harvest time and habitat degradation were found to be other factors responsible for the population decline.

Further interaction with the local people and PA manager revealed interesting facts: distribution maps are suitable for interpretation at a larger scale, but inadequate for pinpointing the population unless they are marked on local maps called 'forest beat maps', which enable a forest guard to interpret the exact location. We therefore mapped the exact location of *E. ribes* on 'Google Earth' for easy interpretation and to assist in its protection (Figure 2).

Vidanga possesses high trade potential and its demand in the local market is greater than 100 t/yr. However,

Table 2. Sampling details and ecological parameters across sites

Location	Geographic coordinates	Altitude (m)	Average annual rainfall (mm)	No. of individuals found	Month of sampling	Phenological phase
Mahabaleshwar	17°55′8.35″N; 73°38′2.78″E	1003	3000–5000	2	April	Vegetative
Mahabaleshwar	17°55′17.2″N; 73°39′18.3″E	1234	3000–5000	1	April	Fruiting
Koyna WLS	17°42′44.7″N; 73°39′23.6″E	715	2500–5000	2	December	Vegetative
Koyna WLS	17°26′50.4″N; 73°42′45.4″E	717	2500–5000	2	April	Vegetative
Koyna WLS	17°29′1.08″N; 73°45′0.6″E	715	2500–5000	38	February, May	Flowering, fruiting
Chandoli NP	17°11′12.9″N; 73°50′31.9″E	939	2500–4500	1	July	Fruiting
Shahuwadi	16°56′21.1″N; 73°43′43.5″E	639	3000–4500	2	March, July	Flowering, fruiting
Radhanagari (WLS)	16°16′04.6″N; 73°57′22.1″E	1317	2500–5000	2	May	Vegetative

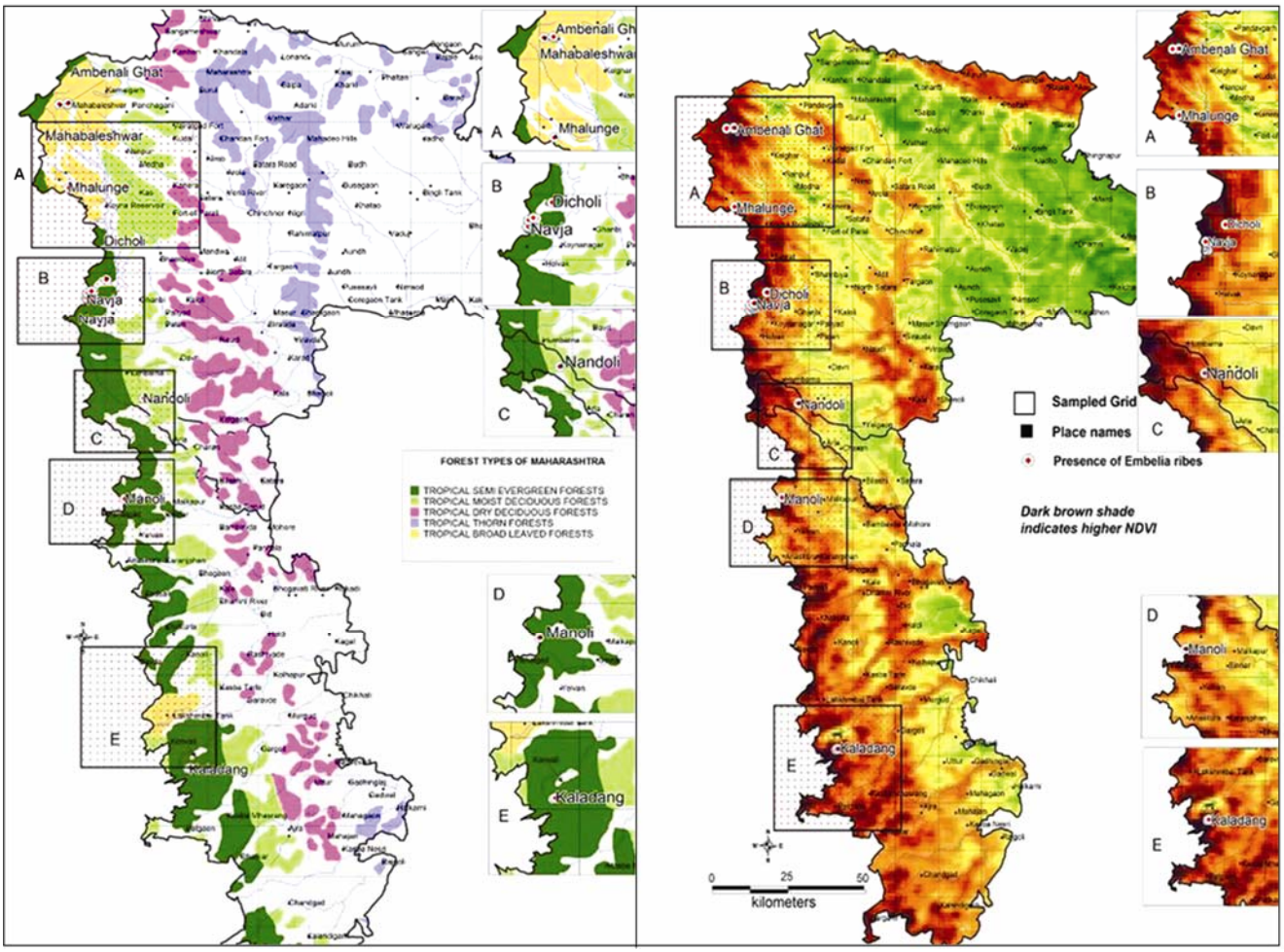


Figure 1. Distribution of *Embelia ribes* overlaid on forest cover and NDVI of Satara and Kolhapur districts.

Table 3. Comparative account of *Embelia ribes* with its allied species

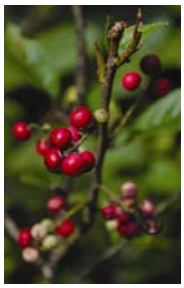
Parameter	*Embelia ribes*	*Embelia basaal* (Syn. *Embelia tsjerium-cottam*, *Embelia robusta*)	*Maesa indica*	*Myrsine africana*
Habitat	Liana	Scandent shrub	Shrub	Shrub
Fruits	Black	Red	Green	Reddish-brown
Local name	Vavding	Vavding	Vavding	Vidanga/Chhota mendhru
Trade name	Kala Vavding	Lal Vavding	Vavding	Vidanga/Baibidanga
Unit price	Rs 110–160/kg, sometimes as high as Rs 326/kg (http://www.indiamart.com/chandraayurved/)	Rs 60–110/kg	Rs 25–30/kg	–
Embelin content (%)	2.3–3.1 (ref. 7)	1.6 (ref. 7)	Absent (ref. 29)	1.2–3.4 (ref. 10)
Extent of occurrence (km^2)	> 20,000	> 20,000	> 20,000	–
Occupancy (km^2)	10–500	> 2000	> 2000	–
Species population density	1–5/100 ha	2–5/ha	Not evaluated	–
Population decline/decade (%)	> 50	> 30	Not evaluated	–
Threat status (IUCN) according to CAMP	DD	VU	–	–
Threat	Habitat loss, local use, trade, immature harvest time	Habitat loss, destructive harvesting	–	–
Cultivation practice	Unknown	Unknown	–	–
Remarks	Rare, adulterants used, cultivation needs to meet current demand	Systematic cultivation practice needs to be standardized	Used as adulterant to *E. ribes*	Used as adulterant to *E. ribes* (ref. 30)
Image				

Figure 2. *Embelia ribes* scenario from Koyna WLS. (*Highlighted area: *E. ribes* population that was found 'cut' because of lack of knowledge about its presence in the catchment.)

during 1990–2000 the demand for Vidanga increased tremendously and the export increased to 250 t/yr. Due to their resemblance, the fruits of *E. ribes* are used as an adulterant in black pepper and exported in larger quantity[7]. However, for last few years a decline in demand is seen in the market and the traders attribute this to the decline in export orders; the crude drug market received its supply of Vidanga from other species like *E. basaal*. Being a large shrub, with maximum fruit-bearing capacity and wide distribution, coupled with non-availability of genuine *E. ribes*, the market of *E. basaal* has increased[8]. *E. basaal* and *Myrsine africana* L. are used as substitutes as they possess embelin, whereas *Maesa indica* Roxb. is used as an adulterant owing to its similarity with fruits of *E. ribes*[9]. It is interesting to note that the local people identify *M. indica* also as Vavding. There is no evidence that other species of *Embelia* are used as adulterants or substitutes. It is surprising to note that within a span of a few years when export demand increased, an 'adulterant'

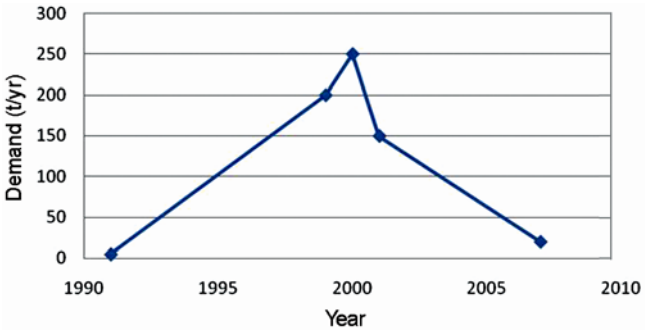


Figure 3. Demand for *E. ribes* across years in Mumbai market.

was not only found, but also a parallel market was established[10]. A market study revealed that many a times traders misidentified *E. basaal* as *E. ribes* (http://www.indiamart.com/chandraayurved/)[11]. Due to the supply of Vidanga from alternative species and decline in export orders, market demand for *E. ribes* has markedly decreased (Figure 3). Table 3 provides a comparative account of *E. ribes* with its substitute and adulterant species. The price of authentic *E. ribes* fruits is at least two times more than the substitute and adulterant species sometimes reaching values as high as five and ten times respectively.

If an non-timber forest produce is coming from two closely related plant species, correct identification is the first and foremost criterion for sustainable utilization of resource. *E. basaal* is one such species often mistaken as *E. ribes* which is in high demand in Ayurveda. This becomes more serious when one species is threatened and possesses high conservation significance. Lack of knowledge on the distribution or population status may make the species vulnerable to extinction due to overexploitation, especially when the population is small or has restricted distribution. Population density and occupancy of *E. ribes* according to the Conservation Assessment and Management Plan (CAMP; Table 3) and actual survey (presence in 8 out of 212 grids) indicate that it shows a very narrow and restricted distribution. Our distribution map will help identify potential watershed areas where: (i) the species can find a refuge, or (ii) cultivation can be taken up. Further field studies will be focused on the natural population to identify the specific extrinsic (e.g. habitat loss, fragmentation and degradation) and intrinsic factors (e.g. narrow genetic base, breeding system and population structure) which are responsible for decline in population of the species. This will help design a conservation action plan to address the causes of population decline in an appropriate manner. If suitable agronomy practices are developed, the pressure on wild populations will decrease. Cultivation and domestication will help tackle problems that are inherent in herbal medicines, such as misidentification, instability in the supply of material and contaminants.

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Nestedness pattern in stream diatom assemblages of central Western Ghats

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Community diversity and the population abundance of a particular group of species are controlled by immediate environment, inter- and intra-species interactions, landscape conditions, historical events and evolutionary processes. Nestedness is a measure of order in an ecological system, referring to the order in which the number of species is related to area or other factors. In this study we have studied the nestedness pattern in stream diatom assemblages in 24 stream sites of central Western Ghats, and report 98 taxa from the streams of central Western Ghats region. The communities show highly significant nested pattern. The Mantel test of matrix revealed a strong relationship between species assemblages and environmental conditions at the sites. A significant relationship between species assemblage and environmental condition was observed. Principal component analysis (PCA) indicated that environmental conditions differed markedly across the sampling sites, with the first three components explaining 78% of variance. Species composition of diatoms is significantly correlated with environmental distance across geographical extent. The current pattern suggests that micro-environment at regional levels influences the species composition of epilithic diatoms in streams. The nestedness shown by the diatom community was highly significant, even though it had a high proportion of idiosyncratic species, characterized with high numbers of cosmopolitan species, whereas the nested species were dominated by endemic species. PCA identifies ionic parameters and nutrients as the major features which determine the characteristics of the sampling sites. Hence the local water quality parameters are the major factors in deciding the diatom species assemblages.

Keywords: Diatoms, idiosyncratic species, nestedness, stream sites.

IN an era of human impact on natural ecosystems, a major challenge for ecologists is to understand the structure and dynamics of biological communities in relation to environmental variability[1]. Community diversity and the population abundance of a particular group of species are controlled by immediate environment, landscape conditions, inter- and intra-species interactions, historical events and evolutionary processes[2–5]. The diversity of community is not only important from basic science of ecology, but is also fundamental to conservation biology[6]. Although attempts to understand the spatial patterns have been documented in many studies of plant and animal diversity, it has not been done for microbial species. This is a serious omission given that microorganisms constitute much of the biodiversity on earth[7] and have vital functional roles in biogeochemical cycles as well as ecosystem functioning[8,9]. With limited information on macro-ecological patterns of micro-organisms, theories were built and tested, but lack facts[10]. However, Martiny *et al.*[11] concluded that microbial diversity is partly decided by the environment and the processes that generate and maintain biogeographic patterns in macroorganisms could operate in the microbial world.

Diatoms (division Bacillariophyta), one of the largest groups of microorganisms, are among the most successful groups of photosynthetic eukaryotic microorganisms. They occur in almost all wet/damp places with a diverse range of habitats across the continents. Diatoms grow as single cells, or form simple filaments/colonies. They form the base of aquatic food webs in marine and freshwater habitats. Diatom species are sensitive to the physical and chemical parameters of water such as pH, nutrients, salinity, temperature and water current in which

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